

THE FUTURE OF DISRUPTIVE TECHNOLOGIES:

Impacts on Business, Workforce, and Societies

Dr. Srikanth Gaddam

Copyright © 2020

All rights reserved. No portion of the book may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording, or by any other information storage and retrieval system, without permission in writing from the author.

PREFACE

I can vividly remember when my 15-year-old son, Yash, asked what people in my company do when it comes to technology solutions. My first answer was that some are subject-matter experts who provide business solutions to customers, while others are programmers who implement these solutions with coding.

He was quite curious to know more. He asked about what kinds of qualifications the coders had, and I told him that most of them had their bachelor's or master's degree in computer engineering. The follow-up question, however, left me totally amazed. He looked at me and asked, "Do they really need to have a formal college degree? Even Bill Gates or Steve Jobs did not complete college but became billionaires."

Yash continued this train of thought: "If I learn programming in the next 3-4 years," he said, "and develop some apps and master coding, can I get a decent-paying job in your company, or any other company? What if I specialize in one or two technologies and master them? I read somewhere that it takes 10,000 hours to master anything, so why do I need to waste my four years of college and tuition fees on something I can learn without it?"

At the time, I didn't have an easy answer for him. There were so many ways to approach what Yash was asking, and it got me thinking about the best technologies for young people to begin to study and master—whether or not they decide to go to college. As I started to do my research on various technologies, reading hundreds of articles and books, I soon found that there were so many different technologies to choose from.

This spurred me to gather together some of my findings in the hope that I can educate or provide useful information for kids and professionals in their mid-careers stuck with old technologies. I want to encourage everyone who reads this book to think of new and innovative technologies to adapt as they adjust in their careers, and also to get an understanding of how these technologies impact our future especially businesses and societies.

CONTENTS

PREFACE.....	3
INTRODUCTION: How Technology Changed Our Lives.....	9
CHAPTER 1 - Cloud Computing: Leveraging Cloud to Innovate Cheaper and Faster	17
1.1 Cloud Computing: Impacts on Business.....	19
1.2 Cloud Computing: Impacts on Workforce	22
1.3 Cloud Computing: Impacts on Societies.....	24
Conclusion	27
CHAPTER 2 - Big Data: Data is the New Raw Material for Business	29
2.1 Big Data: Impacts on Business.....	32
2.2 Big Data: Impacts on Workforce	33
2.3 Impacts on Societies	35
Conclusion	37
CHAPTER 3 - Artificial Intelligence (AI): Reinventing the Future.	39
3.1 Impacts on Business.....	42
3.2 Impacts on Workforce	45
3.3 Impacts on Societies	46
Conclusion	48

CHAPTER 4 - Autonomous Driving: The Future of Transportation	51
4.1 Impacts on Business.....	55
4.2 Impacts on Workforce	57
4.3 Impacts on Society.....	59
Conclusion	61
 CHAPTER 5 - Internet of Things (IoT): New Way People Behave and Interact with Machines	 63
5.1 Impacts on Business.....	66
5.2 Impacts on Workforce	69
5.3 Impacts on Societies	71
Conclusion	73
 CHAPTER 6 - Cybersecurity: Data Privacy Must be a Priority	 75
6.1 Impacts on Business.....	78
6.2 Impacts on Workforce	81
6.3 Impacts on Societies	82
Conclusion	85
 CHAPTER 7 - Virtual Reality (VR) and Augmented Reality (AR): Where Dreams Becomes Reality	 87
7.1 Impacts on Business.....	90
7.2 Impacts on Workforce	93
7.3. Impacts on Societies	95
Conclusion	97

CHAPTER 8 - Blockchain: Faster, Safer and Most Reliable Transactions in Real-Time.....	99
8.1 Impacts on Business.....	103
8.2 Impacts on Workforce	106
8.3 Impacts on Societies	108
Conclusion	111
CHAPTER 9 - 3D Printing: Digitalization of Entire Manufacturing Process	113
9.1 Impacts on Business.....	116
9.2 Impacts on Workforce	118
9.3 Impacts on Societies	120
Conclusion	122
CHAPTER 10 - 5G Network: Transforming Lives at High Speed	123
10.1 Impacts on Business.....	127
10.2 Impacts on Workforce	129
10.3 Impacts on Societies	131
Conclusion	134
SUMMARY	135
ABOUT THE AUTHOR.....	137
REFERENCES.....	139

INTRODUCTION:

How Technology Changed Our Lives

“If future generations are to remember us more with gratitude than sorrow, we must achieve more than just the miracles of technology. We must also leave them a glimpse of the world as it was created, not just as it looked when we got through with it.”- Lyndon B. Johnson

I believe that the first step to grasping both the present and future impacts of technology is to understand the scope of technology and the role it has played in shaping and molding history.

Since "the past is the key to the present," following the scope and influence of technology throughout history will enable us to comprehend the technology around us and anticipate future trends.

The term “technology” encompasses early inventions—such as crude farm and hunting tools, calculators, compasses, calendars, batteries, ships, chariots—all the way to sophisticated modern innovations such as computers, tablets, printers, robots, and smart cities. Every society that has existed from the Stone Ages to the digital era has been influenced by technological innovations, inventions, and engineering applications in varying magnitudes, both positively and otherwise.

Technological innovations have been invaluable to the growth, progress, and evolution of any society, at the same time the cultural traditions, ideals, and aspirations of human societies have determined

how civilizations have developed, benefited from, and are threatened by, technology. Because technological innovations are invented by humans and represent the very essence of a population's needs and traditions, human societies/civilizations and their technology have become intertwined and inseparable from one another. The relationship between society and technology is largely cyclical as technologies are developed to meet the ever-changing societal needs. The invention of steam engines and electricity in the first and second industrial revolution significantly transformed civilization from a rural world into an urban society by increasing the concentration of factories, accelerating the appearance of new technologies, and profoundly altering both the production of goods and the social structure.

The intensive use of oil at the latter half of the second industrial revolution leveraged the evolution of transportation: cars, trains, ships, and airplanes. It is safe to say that technology is tied to the development and rapid acceleration of all landmark achievements from communication to transportation, medicine, education, trade, and so on.

Among other things, history has taught us that "necessity is the mother of inventions." Over the centuries, our ever-increasing needs have resulted in remarkable technological breakthroughs which in turn have given rise to the enhanced innovations and applications that we use in everyday lives. Arguably, the most significant and revolutionary of these breakthroughs is the invention of the computer in the middle of the 20th century. The computer was an innovation necessitated by the number-crunching crisis that plagued many societies in the 19th century. There was a pronounced need to solve number problems faster, but the resulting invention ended up achieving much more than data codification.

With the invention of microprocessors and the miniaturization of computers into microcomputers in the 1970s, the popularity of computers surged globally—although it was still largely limited to hobbyists and technicians at the time. The introduction of the internet and the World Wide Web in the 1980s also had humble beginnings, with only 2.8 million users globally in 1990, making up less than 1% of the world's population.

However, the adoption of computers and the internet dramatically increased over the next two decades, creating a paradigm shift from mechanical and analog technologies to digital electronics. This shift represented the third industrial revolution, with the “digital” revolution shaping the dawn of the 21st century. People began to use digital technologies more often at home, school, work, or anywhere in their lives.

Today, cell phone and internet users constitute 62% (4.78 billion subscribers) and 59% (4.54 billion subscribers) of the world's population, respectively. The explosive adaptation of computers and the internet led to unprecedented developments in the late 20th century and beyond.

Besides computers and the internet, smartphones, smartwatches, and wireless technologies were also widely adopted and utilized for their many benefits. The proliferation of smartphones over the last decade has led to the massive adoption of social media and networking platforms like Facebook, Instagram, Twitter, YouTube, WhatsApp, and so on, all of which have completely revolutionized human interaction and communication.

The graph below shows the increasing usage of social media forums from 2010—2019:

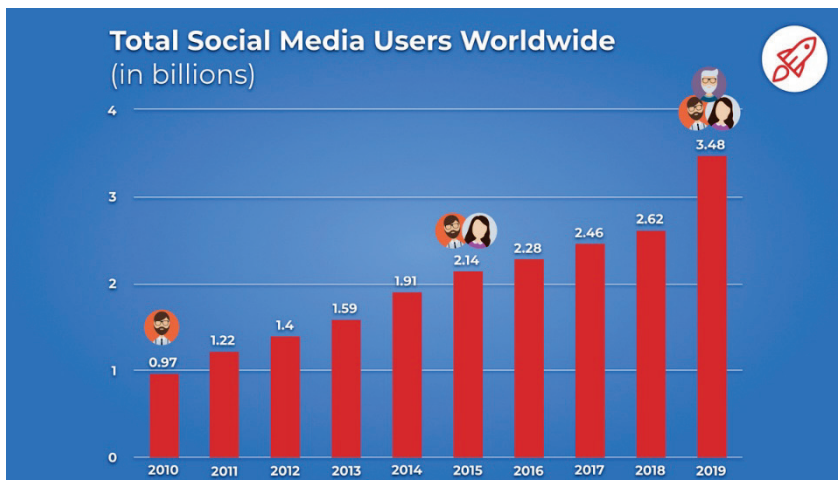


Figure 1.1: Source: www.broadbandsearch.net

From the image above, we can see a steady rise in the adoption of social media, with the largest increase occurring between 2018-2019. The number of users grew from 970 million in 2010 to a staggering 3.4 billion in 2019. As of this writing, there are over 3.6 billion users regularly using social media. Thanks to these social media platforms, it is now easy to find long lost friends, send instant messages, communicate globally, and stay abreast of current events.

Social media is also an important tool for advertising that has helped many companies achieve drastic growth and expansion. According to a recent report by the World Federation of Direct-Selling Associations, the global direct-selling industry generated USD 189.7 billion in 2019 and provided self-employment or supplemental income opportunities to approximately 116 million people worldwide in the same year thanks to the proliferation of social media platforms and search engines. The retail industry, which formerly thrived based on the power of human relationships and in-person sales, now advertise their products to an endless number of customers on the internet, leading to unprecedented growth in the past decade.

The 21st century has also seen the introduction and proliferation of cloud computing, big data analytics, 3D printing to blockchain networks, artificial intelligence, automation of vehicles, extended reality, quantum computing, distributed ledger, Internet of Things, and so on. The modern technological space has improved our lifestyle, enhanced productivity in the field and at the office, created new employment opportunities and remote working environments, facilitated better health care services, developed learning processes, introduced automated vehicles, and provided faster communication networks. While most of these technologies are found all around us—in our homes, offices, banks, shopping malls, roads, airports, and everywhere else you can think of—others such as quantum computing and Level 5 vehicle automation are still at the testing phase.

Modern technology has made our lives increasingly easier and convenient to the point that most people, especially millennials, cannot imagine a world without smartphones, automated teller machines, fast

internet, and other everyday technologies. But despite the many benefits, digital technologies can also threaten jobs, erode privacy and security, fuel inequality and agitation, sow discord, and impede world peace. That is to say that, there are two sides to technology, and its ultimate impact on society will be determined by how we—government, businesses, and individuals—adapt, manage, harness, and regulate it.

Presently, societies, businesses, and individuals that have adapted and adjusted to modern technology are reaping its enormous benefits. Now, students can access a wide range of information on any subject, and distance learning is fast replacing the mundane and outdated classroom learning system. With your smart devices, you can register for online classes and interact and learn from teachers all over the world.

There are also legitimate online higher institutions where you can obtain a degree in almost any field. To assist personal learning, companies have developed apps powered by learning analytics and artificial intelligence that offer a plethora of tools and resources that children and teachers can benefit from, and more are underway. Leveraging AI technology, tech firms like Content Technologies and Carnegie Learning are developing intelligent instruction design and digital platforms. These systems will identify gaps in a student's learning and provide targeted testing and feedback to students from pre-K to college level, giving them the challenges, they are ready for and redirecting to new topics when appropriate.

With these apps, children can learn better and at a convenient time and pace. According to the Artificial Intelligence Market of the US Education report, AI in US Education is expected to grow by 47.5% from 2017-2021. As AI continues to mature, it will become an integral part of the classroom. It will drive efficiency and streamline admin tasks to allow teachers the time and freedom to provide understanding and adaptability—uniquely human capabilities where machines would struggle.

Artificial intelligence tools can also provide education for all by making global classrooms available to everyone, including those who speak different languages or who might have visual or hearing

impairments. This also opens possibilities for students who might be absent from school due to illness or who require learning at a different level or on a particular subject that isn't available in their own school.

Through new technologies like extended reality (or XR for short), the learning process from kindergarten through college is enriched as students can interact with real-life situations via simulation. XR immerses students into a world of unlimited learning possibilities, where they can visit the moon, learn about the solar system, travel inside the human body, walk around museums, and even prepare for life-saving surgical operations. Thanks to virtual reality, stroke patients who need rehabilitation can re-learn and practice real-life daily activities in a simulated setting with the assistance of their healthcare teams while in the hospital.

Our health care system has also significantly benefited from digital advances. These innovations have provided enhanced diagnostic equipment, digital record systems, exceptional patient care, and ease of workflow for doctors and nurses, lower health care costs, and advancements in medical knowledge and treatments.

AI-enabled frontier technologies, for instance, assist doctors in making better data-driven decisions, improving the efficiency of disease diagnosis, treatment, and management while also reducing infant and maternal mortality rates. AI systems for health care are designed to address specific, real-world use cases that make the diagnosis, monitoring, and treatment of patients more efficient, accurate, and available to populations around the world.

According to Accenture analysis, the synergy of critical clinical health AI applications can potentially create \$150 billion in annual savings for the US healthcare economy by 2026. Beyond healthcare, businesses are also adopting digital technologies at an unprecedented pace, with spending on digital transformation expected to reach a staggering \$2.3 trillion by 2023. As a result of these efforts, digital technologies are expeditiously powering core business operations and processes. Of the more than 6,600 business and IT executives worldwide that Accenture surveyed for its 2019 report, 79% say that digital innovations—specifically social, mobile, analytics, and

cloud (SMAC)—have now moved beyond adoption silos to become part of the technology foundation for their organizations. To retain their competitive edge and meet the rapidly evolving demands from customers, business organizations are now applying a new generation of technologies and innovations to their operations, including distributed ledger, quantum computing, extended reality, and artificial intelligence. In line with the latest technological trends, mega food companies like Unilever and Nestle use blockchain applications to perform logistical tracking that ensure transparency in the supply chain. Walmart is also applying similar technology to keep track of their produce—where it came from, where it was processed and stored, and what its expiry date is.

Also worthy of recognition are the advancements that have been made in the area of autonomous vehicles. Cars have moved from Level 0 automated systems (manual control) to Level 2 automation capabilities that allow the vehicles to control both steering and acceleration partially, made possible by the use of sensors, software, machine learning, LIDAR technology, and artificial intelligence. Elon Musk, CEO of Tesla, believes that no fundamental challenges are holding back the realization of fully automated vehicles, and he is optimistic that his company will have Level 5 cars (full automation) soon.

As stated earlier, technology innovations are not without their impediments and drawbacks. Perhaps the most worrisome concern is the fear that automation will displace millions of employees in the workplace, and potentially quite soon. These concerns are further compounded by projected studies, such as a recent report by McKinsey that suggests 800 million people could lose their jobs to automation by 2030. To make matters worse, our educational systems have not kept pace with the changing nature of work, resulting in many employers saying they cannot find enough workers with the skills to succeed with advanced automation.

However, drawing from history, some experts are optimistic about the impacts that automation will have on jobs. Historically, the introduction of new technology created a short transition period, and within this time, some workers were displaced. However, there is a silver

lining; this period also provides an opportunity for workers to up-skill and re-skill so that they can be reintegrated into the workplace to function side-by-side with cognitive machines and robots.

As evident in the present workplace landscape, rather than wiping out jobs, AI is improving the productivity, efficiency, and skillsets of workers, which in turn has resulted in higher wages across a wide range of industries from healthcare to clerical. Artificial Intelligence is also promoting better workforce conditions. According to a recent report in the Economist, AI will help eliminate unconscious and conscious biases in the hiring and remuneration of staff. It also suggests that AI will benefit employees in other ways, such as ensuring the appropriate safety gear is being worn using intelligent scanning technology.

Finally, with all that has been uncovered, I strongly believe that the best approach to modern technological trends is to build a system that will be responsive to the emerging changes as well as structures that will encourage mass redeployment of displaced workers. The future demands that the professionals in every field be trained, keeping adaptability in the focus and forefront.

CHAPTER 1

Cloud Computing: Leveraging Cloud to Innovate Cheaper and Faster

“I don’t need a hard disk in my computer if I can get to the server faster... carrying around these non-connected computers is byzantine by comparison.”
- Steve Jobs

Technological advancements are poised to make all aspects of our lives easier, better, and simpler, and this includes the way we store and access data. Two decades ago, engineers developed a system that allowed users to store enormous data virtually and helped them avoid losing vital documents or files (which happened all too often with storing data on physical storage units like floppy disks and hard drives). They called this invention “cloud computing.”

Today, 90% of all businesses in the US have adopted cloud services, and more than one-third of all global market IT spending is geared towards building infrastructures that support cloud computing. In the first half of 2019, cloud services generated over \$150 million in revenue, which represented 24% growth from the previous year. Cloud computing adoption rates are growing faster than analysts anticipated, and for good reason. Not only can you remotely store all your important files using cloud services, but you are also offered access to your stored information from any digital device, including laptops and smartphones from anywhere in the

world. For instance, even if you suffered from data loss while using your iPhone, you can retrieve all the files using a different iPhone or IOS device to access your iCloud backup (so long as you turned on that function when you got your phone!).

However, storage is just one function of cloud services. Businesses use cloud computing for a vast range of purposes, from the basics of networking and standard office procedures through to natural language processing and artificial intelligence. Virtually most services that does not require you to be physically close to the computer hardware that you are using can now be delivered via the cloud. By definition, cloud computing is the delivery of on-demand computing services over the internet on a pay-as-you-go basis. Companies that offer these services are known as cloud service providers or vendors such as Amazon Web Service, Microsoft Azure, IBM Cloud, and Google Cloud. These “public cloud services providers” offer all types of cloud solutions, including Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS). These public cloud services are the most popular and most used cloud solutions, primarily because they are more cost-effective than private or hybrid solutions. For instance, rather than owning their computing infrastructure or data centers, companies rent access to cloud computing services from a cloud service provider, thereby reducing or eliminating the upfront cost and complexity of owning and maintaining IT infrastructure.

A study by RightScale on the state of cloud in 2019 found that 94% of the businesses use cloud solutions. Organizations of all sizes in all business sectors have adopted cloud computing as their core technology strategy to ensure elastic scalability, faster service delivery, greater IT efficiency, and a subscription-based accounting model. Cloud computing has broken down many of the physical and financial barriers to aligning IT with evolving business goals by delivering better business models and services quickly and cheaply.

In today’s cloud space, the leading tech giants are always eager to unleash breakthroughs to dominate the industry. In October

2019, one of the foremost cloud service providers, Google, announced a “quantum breakthrough” that could revolutionize cloud computing. The functions of this quantum machine make our current supercomputers look like toys. Google claims that this machine can perform a mathematical calculation that would take a modern supercomputer more than 10,000 years in under three-and-a-half minutes. However, this was just the beginning; a month later, Google launched yet another revolutionary technology, but this time with greater impacts in the gaming industry. Stadia is a cloud gaming service where users can stream and play high-end (AAA) games on the go. All processing is done on the cloud, and users can play the games without specialized gaming hardware. This is a major breakthrough for gamers who now do not have to invest in expensive hardware.

Cloud technology has come a long way from the mid-2000s, and based on many experts’ predictions, its adoption rates and market share will continue to grow and expand. Based on forecast reports by Gartner, the cloud industry which accounted for USD\$227.8 billion in 2019, is expected to reach USD\$266.4 billion by the end of 2020, and USD\$354.6 billion in 2022, with a compound annual growth rate (CAGR) of 29.2% during 2021-2026. Although relatively small in the grand market scheme, the steady growth percentages over the last decade, combined with the projected growth percentages over the next decade, turn these numbers into something remarkably promising.

1.1 Cloud Computing: Impacts on Business

The first rule of any technology used in a business is that automation applied to an efficient operation will magnify the efficiency, businesses worldwide are increasingly incorporating cloud technologies to improve their day-to-day operations. Since 2009, the annual spending on cloud infrastructure services has grown from “virtually zero” to almost \$100 billion, as illustrated in the graph below.

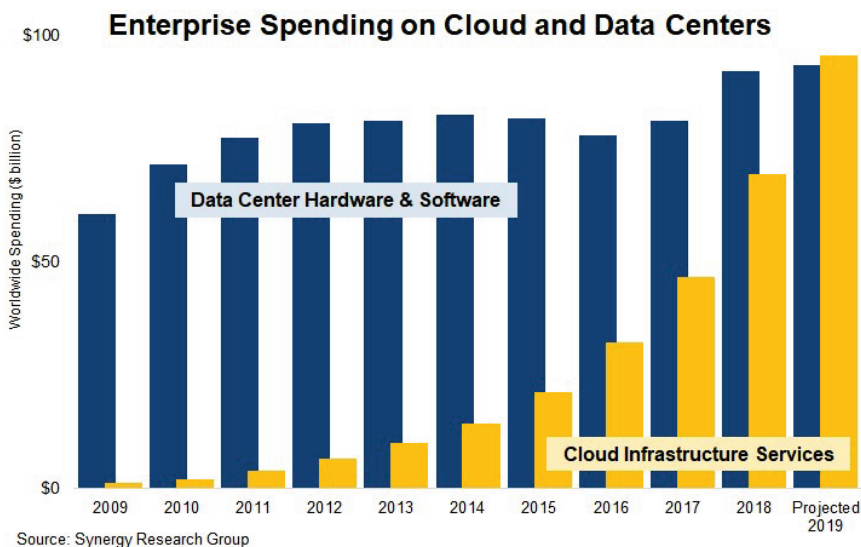


Figure 1.2: Source Synergy Research Group

Meanwhile, enterprise spending on data center hardware and software stagnated over much of the last 10 years, which should come as little surprise given the growth and popularity of its cloud-based competitors. 2019 also saw an almost 40% increase in enterprise cloud adoption and marked the first time that enterprises spent more on cloud services (including IaaS, PaaS, and hosted private cloud) than they did on data center equipment, according to Synergy Research.

By moving all their data, digital assets, and day-to-day activities to the cloud, organizations realize higher productivity, improved customer experience, and better discovery of the full potential of data assets in a fast and cost-effective manner. Borrowing from the words of Bart McDonough, CEO of Agio, the recent rapid adoption of cloud is mainly due to the understanding of "ease of use and scalability" of the technology. In other words, cloud computing is so successful because it gives the client the flexibility to upscale or downscale based on the needs of the organization. As the firms grow, they can expand their Infrastructure and capabilities without worrying about forecasting server requirements or buying extra storage space. They just have to adjust their subscription with the cloud service provider, which will, in turn, allocate

more space according to their requirements. By also enabling the organization to scale down with market changes, the cloud promotes efficient utilization of existing resources and opens up a plethora of opportunities for both small and large businesses.

Toyota, for example, is applying cloud technology to scale up by converting its cars into a connected platform through apps. These apps, which are hosted on Microsoft Azure, not only connect the company's vehicles to social media sites but also track reward points for using an electric vehicle, thus enhancing customer experience. Another relevant example is Etsy, an e-commerce site for handmade products. Etsy uses cloud computing to process and analyze data from its monthly website views to offer individualized product recommendations. This analysis is performed at flexible costs which enables Etsy to be agile and scale up with ease.

Over the years, cloud services have been helping businesses reduce infrastructure costs by promoting remote working environments. Since files and data assets are now stored remotely on the cloud, and employees can access them from anywhere at any time, businesses no longer need a physical office to exist. Therefore, the cost of starting a business is reduced remarkably. In the same vein, a study by Backspace reveals that 88 percent of cloud users reported cost savings, and 56 percent of respondents said that cloud services have helped them increase their profit margins.

Additionally, cloud computing is redefining the way companies design and model their products. Advances in cloud technology have made it easier for companies to create products and services within the cloud, or model new products or marketing campaigns as cloud-based software prototypes. The cloud is also a common repository for the collection and analysis of new data, and the place where a rising number of artificial intelligence operations, like image and speech recognition, are performed. Uber, for instance, is using the hybrid cloud model to ensure not just constant uptime, but an integral relationship between product development and deployment. Thanks to cloud computing, Uber can model a virtual fleet of taxis from private cars through a

combination of mobile software, large-scale data analysis, mapping, and social networking. Industrial products are also witnessing a similar dynamic of refined process and constant iteration.

Recently, Oden Technologies—a startup that builds sensor systems that enable factories to track complex processes—developed a tablet-based system for carrying out complex calculations in real-time. This project would usually require six months to complete, but by leveraging cloud computing, Oden was able to complete the development in under ten weeks. This was the result of accelerated testing and direct communication with the customer about needs and specifications during the design and construction phases.

Another significant benefit of cloud computing to businesses is constant reliability. Cloud storage solutions offer built-in data redundancy that allows employees to access and obtain files at any time or in any situation, even during times of network recess, power failures, etc. It is this unique feature of cloud computing that helped Netflix to stay buoyant online, regardless of AWS failure in 2011. This reliability function of cloud computing is crucial to all businesses, but it is more critical to the productivity and growth of large-scale enterprises.

1.2 Cloud Computing: Impacts on Workforce

Cloud computing, like other evolving technologies, has profound impacts on the productivity and effectiveness of the workforce. Perhaps the most prevalent advantage of cloud platforms is their ability to ensure and enhance worker collaboration. Collaboration is an integral part of many businesses, and cloud computing can offer fast, secure, and dependable partnership for team members, irrespective of their location. With cloud storage capacities, all files or documents needed to execute a project or design are securely stored on a platform that is easily accessible to all employees for review, updates, or feedback. According to a survey by Forbes, 64% of the respondents claimed that cloud-based collaboration tools assisted their teams in executing tasks better and faster.

Today, a remote worker can attach a scene to a multimedia file or webisode, save it on the cloud, and a team of designers can all have immediate access to it. A graphic artist can change an element in an advertisement or flyer based upon an unforeseen request, have it approved by management or the client, and then pass it along to the printer without presenting any physical package.

Not only does unlimited accessibility free up employees from the potential constraints of the traditional office, but it also encourages employee learning via training tools available on the cloud. Cloud computing enables workers to access course content and applications, and it also allows them to take actions like enrolling in courses and participating in group activities, anywhere and at any time. Thanks to cloud computing, some companies are moving towards 100% remote working environments that offer greater flexibility and increased access to a virtual workplace. This increasingly borderless workforce, which includes contingent workers, gig workers, part-time employees, independent contractors, and partner employees, is contributing to the rising popularity of bring-your-own-device (BYOD) policies and cloud technology adoption.

As mentioned earlier, cloud computing enables easy and cost-effective scalability of an organization. This is important to employees because while scaling up applications and experiences, businesses can accommodate increasing learner populations, usage peaks resulting from large volumes of database queries, or massive spikes in traffic due to things like an event, a course, or a training registration. They can also immediately scale down to accommodate periods of low activity and avoid having to maintain idle systems, which can be quite expensive. Further, cloud technology helps employees stay up to speed with emerging technological trends, as it allows businesses to update all software or platform as new versions are released. This levels the playing field for companies—from startups to Fortune 500—by giving them all access to the same technologies.

As cloud's dominance in business continues to grow, IT staff are becoming increasingly concerned about its impacts on their job security.

Hence, the big question is: will increased adoption of cloud technologies replace IT workers over the next 5-10 years? The answer is no.

The cloud will not eliminate the IT workforce; instead, they will be reconfigured, and IT employees with reduced demands will migrate to other jobs where their skills are required. For instance, since cloud computing remotely centralizes networks, the need for in-house systems and database administrators will decrease. However, IT talents with this experience will likely be sought after by cloud providers as more businesses rely on cloud computing for administration. On the brighter side, project managers with IT experience, business analysts, business and cloud computing providers and software developers are expected to remain relevant and witness continuous demand in a cloud-centric workplace.

Additionally, the increased global spending on cloud services is expected to benefit the job market drastically by creating a plethora of new job opportunities. In a 2016 study, Robert B. Cohen, Ph.D., a senior fellow at the Economic Strategy Institute, predicted that the spending on cloud technologies in the US would increase to \$1.7 trillion by 2025, which has the potential of creating eight million new jobs. Cohen also predicts that associated job growth will be centered on data science, as cloud technologies will enable artificial intelligence, machine learning, and the Internet of Things. This new employment landscape will be most favorable to IT personnel who are willing and eager to acquire new skill sets in line with emerging trends.

1.3 Cloud Computing: Impacts on Societies

Before the proliferation and massive adoption of cloud systems in society, there was a high rate of data loss because of computer system crashes or theft. But as cloud technologies became popular, loss of data became a thing of the past at a fraction of cost.

Furthermore, if the cloud adoption rates continue to soar as predicted by experts and analysts, the gains of cloud computing on the society will be far-reaching and immense. Cloud technology will be

responsible for the digital infrastructure of tomorrow's cities, where an estimated six billion of the world's population will live by 2045. Smart elevators and parking lots, driverless cars and drone taxis, trains and subways, farms and power plants—all will be safer and effectively managed, thanks to the cloud's ability to store and analyze data.

The cloud will also assist society in coping with growing volumes of data. This includes applications like high-definition video, which tech giants estimate will account for 89% of individual user traffic by 2025. In a few years to come, network bandwidth and storage demands will be driven more by what IDC's Data Age 2025 white paper calls "image and video content for non-entertainment purposes"—in other words, driven less by user-generated cat videos. Lastly, cloud computing will support emerging technologies such as artificial intelligence and help them to adapt to new platforms such as mobile as well as speed up the realization of fully automated vehicles.

The health care industry has also hugely benefited from the proliferation of advanced technologies like cloud computing. Cloud technologies are one of the most frequently used healthcare applications today, with over an 83% percent adoption rate. These massive adoption rates are the result of increasing demand by physicians, hospital administrators, and patients for secure access to information in a cost-efficient way and the role of cloud solutions in improving and personalizing patient care.

The reasons behind this aggressive growth are illustrated in the recent case of the Mount Sinai physicians who adopted AWS solutions to conduct breast and ovarian cancer research that requires massive amounts of information. As Mount Sinai researchers hunt for the genetic causes of these cancers, their cloud-based research platform helped them meet three fundamental needs: 1) a secure platform that maintains the confidentiality of patient information, 2) scalability that allows economic growth as the data set increases and performance needs change, and 3) collaboration that enables researchers to work with external partners.

In the area of education, learning institutions have also been quick to realize the advantages of cloud technology. Thanks to cloud services, students can now access data anywhere, anytime, to enroll in online classes and participate in group activities. Advances in cloud computing have helped educational institutions combine business automation processes to streamline subscription, class enrollments, and assignment tracking, thus reducing expenses significantly. These institutional bodies are also leveraging cloud storage solutions to securely store the daily 2.5 quintillion bytes of data, all without the need to cater to a complicated infrastructure. An estimated report, suggests that cloud spending in the education market will grow from \$8.13 billion to \$25.36 billion between 2016- 2021, at an estimated CAGR of 25.6%

While these educational benefits are probably most apparent in a mature and developed market, cloud computing technology also provides new and great learning opportunities to students from developing countries. Access is now available and, in many instances, free, thanks to the rise of websites dispensing educational material and cloud knowledge-sharing communities such as Khan Academy, Coursera, etc., As Marshall McLuhan rightly stated, "the new electronic interdependence recreates the world in the image of a global village," and cloud computing is playing significant roles at the global stage.

This is particularly true during the global COVID-19 pandemic, where cloud computing has become extremely important for businesses and individuals alike. This technology is helping businesses and individuals adhere to social distancing regulations while also facilitating a continuance of business operations and daily activities. A new reality has unfolded as the COVID-19 virus spread across the globe, one that has sped up the infrastructural shift to the public cloud and forced many small, medium, and large businesses to adopt cloud technologies at a rapid pace. Organizations that wish to survive this challenging period must holistically embrace remote work—a phenomenon that has remained a minority over the years, with only 3.4% of the global workforce operating remotely.

Conclusion

The future looks bright for businesses in light of advancement in cloud technologies. Experts believe that in the next ten years, every company will be operating primarily from the cloud, making way for more flexible—yet more productive and efficient—ways of working. However, others believe that the future will present a synergy of cloud-based software products and on-premises compute to create a hybrid IT solution that will balance the scalability and flexibility associated with cloud and the security and control of a private data center.

Despite the numerous benefits explored above, cloud computing still has its limitations. For one, your experience with the service is dependent on the speed and reliability of your internet connection, which can negatively impact your business. Cloud technologies have also introduced additional security concerns in a world where data privacy is increasingly vulnerable, with cases like the recent hacking of 90 percent of WordPress sites as evidence. In 2019, the average organization experienced 31.3% cloud-related security incidents each month, a 27.7% increase over the same period in the last year, says McAfee. Fortunately, service providers like Jeff Bezos's AWS offer incredible security and capability to keep your information and IT infrastructure safe. Therefore, the only way cloud providers will thrive is by monitoring emerging challenges and tackling them head-on.

CHAPTER 2

Big Data: Data is the New Raw Material for Business

“The goal is to turn data into information, and information into insight.”
- Carly Fiorina

Did you know that every two days we create as much data as we did from the beginning of time until 2000? According to IBM, humans create 2.5 quintillion bytes of new data every day, and 90 percent of all the data in the world today was generated over the past two years alone. In fact, the amount of digital information available globally is expected to reach 50 zettabytes by the end of 2020, and 434 exabytes by 2025—which is equivalent to 434 billion gigabytes.

While computers, the internet, and IoT create immense volumes of data, data mining, machine learning, natural language processing, and statistics make it possible to store, analyze, and use it to get significant value. Many businesses today are leveraging this data to develop new products and services and to improve operations and processes, decision-making, resources and energy utilization, consumer experience and satisfaction, marketing strategies. Healthcare institutions are also applying data-driven strategies to analyze vast numbers of medical records and images for patterns that can help spot diseases early and develop new medicines.

All these aptly capture the concept and essence of Big Data. Therefore, Big Data is the collection of all digital data and our ability to use it to our advantage across a wide range of areas, including business, health, education, finance, marketing, industry, engineering, politics, and so on. Gartner sees Big Data as high-volume, high-velocity, and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision-making. This definition captures the three fundamental components of Big Data: Volume, Velocity, and Variety (3Vs). Big Data is enormous data that is rapidly increasing in size (volume) and relative accessibility (velocity). It also comprises all forms of data, both structured and unstructured (variety).

In the past, humans could only document and use structured data—i.e., data that has a defined length and format, such as numbers, dates, and groups of words and numbers called strings. As a result, data was limited to spreadsheets or databases, and any information that wasn't easily organized into rows and columns was too challenging to work with and often ignored. But with advances in storage and analytics, we can now capture, store, and work with all types of data, both structured and unstructured. Therefore, “data” can now mean anything from databases to photos, videos, sound recordings, written text, and sensor data.

Today, data is generated with every digital action we take. We create data whenever we communicate with our friends via social media or chat apps, share pictures or videos on Facebook, Twitter, and Instagram, carry our GPS-enabled smartphones, use the ATM, book a flight, or shop online. The internet is the most significant channel of data generation, with over 4.5 billion daily users, which is about 60 percent of the world's total population. This means that, currently, there is plentiful data on more than half of the world's population.

Data is generated by machines and at a rapid pace, too. Thanks to advances in Internet of Things (IoT) technologies, devices are continually producing, sharing, and exchanging data among themselves. For instance, a moisture sensor installed in the soil can transmit information about the current water level to the farmer's smartphone or

another sensor embedded in the irrigation system, thereby generating data on soil moisture. To understand and efficiently utilize this messy and vast data, organizations, and businesses are applying cutting-edge analytics with AI, machine learning, and image recognition capabilities. In other words, they are using Big Data tools to analyze the wealth of information generated through business processes and operations and to produce results that will offer new insights and opportunities. These advanced technologies can build models based on the data they collect, rapidly run millions of simulations, and manipulate all the possible variables until they find a pattern—or an insight—that helps solve the problem they are working on.

Presently, there is massive adoption of big data and analytics by companies, agencies, and governments all over the world. Big data technologies such as Hadoop and cloud-based analytics are helping companies across all sectors reduce the cost of massive data storage. By collecting and analyzing a wide range of data from everywhere, businesses can now gauge consumer choices, behaviors, and satisfaction, and then tailor their products and services to better suit consumer needs. For instance, Target, a US retail company, is now able to very accurately predict when one of their customers will expect a baby. By using Big Data, telecom companies can now better predict customer churn, Wal-Mart can predict what products will sell, and car insurance companies understand how well their customers drive.

Big Data is also used today to forecast and prevent natural and human-made disasters. For instance, sensor data can be analyzed to predict where earthquakes are likely to strike next, and patterns of human behavior can give clues that help organizations provide faster relief to survivors. Using Big Data technology, the movement of refugees from war zones to safer regions can now be monitored and safeguarded.

With the dawn of every day, big data is growing bigger, and forward-thinking businesses, governments, and individuals continue to leverage it. A majority of Big Data experts predict that more and more businesses will migrate big data from open-source ecosystems to the cloud for

improved storage and processing. The graph below illustrates the forecasted transition:

2.1 Big Data: Impacts on Business

Companies that collect, analyze, and use data from these channels can get a full view of their customers and fine-tune their operations accordingly, from marketing to customer service. Hence, it is no coincidence that moments after you searched Louis Vuitton wristwatches in Google's search engine, your Instagram feed suddenly had advertisements for very similar watches.

Data pulled from social media and browsing activities as well as from call logs, store visits, text messages, media files are used to "personalize" the consumer experience of the product or service. According to a study by Oracle, 81% of the executives surveyed believe that the modern customer is more interested in a highly individualized experience. Netflix, for example, is using big data technology to analyze the massive amounts of data collected from their 100 million subscribers to predict each customer's interest and tailor recommendations specifically to their viewing preferences. Today, big data directly influences 80% of all the movies and shows watched on Netflix and has saved the company \$1 billion each year from 2009 through customer retention.

The exciting news is that these data assets are not only available to Amazon-like giants but smaller brick-and-mortar businesses, too. According to Jessica Smith from aifora, a product development company, "traditional brick-and-mortar have long struggled to collect data from multiple sources, but the advent of new technologies such as RFID, NFC, AI-cameras, people counters, etc., now enables them to collect far more data on their customers' buying journeys."

Thanks to big data analytics, the e-commerce industry is witnessing radical transformations in the area of product and service development. Businesses can now offer improved products and services based on new insights unlocked by the observation and analysis of business data

trends from multiple channels such as social media, customer reviews, and clickstream data from a website or mobile application. To illustrate this example, let's say your company sells sneakers. By using data generated from users on social media, sentiment analysis can be conducted to determine their likes and dislikes about your sneakers. By combining this data with demographic data, you can create segmentations of customers to better understand how certain groups of customers feel about products, thus guiding your company's product development decisions. According to NewVantage, 11.6% of executives are investing in big data to find means of innovation.

In addition to enhanced marketing, customer experience, and product offerings, big data is increasingly used to optimize business operations. Estimates propose that by better integrating big data, retailers can increase their operating margins by as much as 60%. Retailers can now optimize their stock based on predictions generated from web search trends, social media data, and weather forecasts. Supply chain or delivery route optimization is one business process that has seen the massive growth of big data analytics. Here, geographic positioning and radio frequency identification sensors are applied to monitor goods or delivery vehicles and optimize routes by integrating live traffic data.

2.2 Big Data: Impacts on Workforce

Big data is not only drastically changing business operations and processes, but it is also transforming today's workforce. Since 2012, big data has created over eight million jobs in the US alone and an additional six million worldwide. These figures are increasing, and the demand for professionals skilled in data science and analysis is rapidly accelerating among companies across numerous industries. However, the availability of these specialists is very low in comparison to the need. According to a 2019 executives survey by KPMG, 67% of the respondents reported that they were experiencing skill shortages, with the top three scarcest skills being in big data/analytics, security, and AI. The image below illustrates the five most lacking skills today:

Top 5 most scarce skills



Data source: The Harvey Nash/KPMG CIO Survey—The charts, 2019

Many organizations rely on the internet to communicate with their customers, make sales, and improve productivity. This huge unstructured data set, along with those generated from connected devices and platforms—needs to be controlled, thereby creating demand for data scientists. Concurrently, IT executives, business analysts, and software developers are learning big data tools and techniques to grow with the market of jobs and opportunities. To meet the high demand of data scientists, many institutions are now offering on-campus and online courses in big data analytics, and experts say that this trend will not slow down in the future but instead will evolve.

Additionally, big data is also helping HR to make better-informed choices for which candidates to hire. Today's technology places big data at the fingertips of HR, making it possible to collect and analyze data after, during, and before the hiring process. This empowers organizations to make smarter hiring decisions and develop a more efficient workforce. For instance, talent acquisition software allows HR teams to collect relevant information on candidates, offer attractive benefits packages aligned to their needs, and narrow down the pool of candidates to only the highly qualified applicants.

Big data analytics is also improving HR business processes by optimizing the measurements of company culture and employee engagement. In today's workforce, human capital management is a big deal. Organizations that make effective use of their resources, including their talent, can maintain a competitive edge over competitors who are wasteful with their resources. For example, poor scheduling can mean the death of a field services company as field techs become frustrated

with ineffective routes and customers who are angry that they did not arrive within the scheduled service window.

Spending on big data analytics and services has grown exponentially over the past four years as more and more industries continue to leverage it. As of this writing, banking, professional services, process manufacturing, and federal government are making the largest investments in global big data analytics solutions. According to International Data Corp. (IDC), worldwide revenue for big data and business analytics (BDA) solutions will reach \$260 billion by 2022, with a CAGR of 11.9%. The big data industry offers numerous solutions from security services to storage infrastructure, networking, data center infrastructure, discovery tools, big data applications, and so on. If you are planning your career right now, you might want to consider moving into the enormous big data and business analytics space.

2.3 Impacts on Societies

There has been so much talk and so many studies on the impact of big data on businesses, so it is easy to forget that big data also plays a significant role in an individual's development. Today, many people are benefiting from the data generated from wearable devices such as smartwatches or smart bracelets. Take the Up Band from Jawbone, for instance: the armband collects data on calorie consumption, activity levels, and sleep patterns. While it gives individuals a wealth of insights, the real value is in analyzing the collected data. Jawbone is also looking to gain new insights on sleeping patterns as the firm now gathers and examines 60 years' worth of sleep data every night.

Another area where we benefit from big data analytics is finding love online. Most online dating companies like Match.com, eHarmony, and OkCupid use big data software to collect online dating data from Facebook profiles and online shopping pages to determine the likes and dislikes of a person. They believe that the data from these sites are much more reliable in predicting human behavior than user questionnaires.

The computing power of big data analytics is also revolutionizing healthcare and public health systems. These technologies enable us to decode entire DNA strings in minutes and will allow us to find new cures and better understand and predict disease patterns. By harnessing the full potential of big data, health scientists can collect all the individual data from smart and wearable devices and apply it to millions of people and their various diseases. Recently, Google teamed up with a non-profit organization called Malaria No More to use Big Data analytics to eradicate malaria. This disease kills about 40,000 children annually in African countries. From Martin Eldud's (NGO CEO) standpoint, "Lack of information and data is why [malaria] is among one of the deadliest diseases on the planet."

What's more, big data techniques are already being used to monitor premature and sick babies in a specialist health unit. By recording and analyzing the heartbeat and breathing patterns of every baby, the unit was able to design algorithms that can now predict infections 24 hours before any physical symptoms appear. That way, the team can provide prompt medical attention and help save fragile babies. Furthermore, many health institutions and centers in the US are leveraging the vast patient data generated through Electronic Health Systems (EHS) to reduce health care costs. McKinsey, a major international business consulting firm, estimated that big data analytics adoption could save up to 17% of healthcare costs.

Law enforcement and security agencies are also applying big data to protect lives and properties. For instance, the National Security Agency (NSA) in the US uses big data analytics to monitor and prevent terrorist attacks. Police forces now apply big data techniques to apprehend criminals (and even predict criminal activity), and credit card companies use big data to detect fraudulent transactions.

Big data technology is also enabling smart cities, homes, factories, industries, and other smart infrastructure. A typical example is the use of smart water meters to detect illegal watering in real-time by the city of Long Beach, California. Los Angeles is also applying big data and IoT innovations to regulate and reduce traffic. The state uses data from

magnetic road sensors and traffic cameras to control 4,500 traffic signals and has reduced traffic congestion by an estimated 16 percent.

Conclusion

Big Data is rapidly revolutionizing every facet of our lives. It is the primary driving force behind the waves of digital transformations, including cloud computing, the Internet of Things, Artificial Intelligence, data science, and machine learning. As more and more devices are being connected to the cloud, experts believe that big data will grow remarkably over the next ten years. Soon, companies and industries will migrate from public cloud service adoption to hybrid and multi-choice environments. Also, the technologies that enable big data will become entirely invisible—seamlessly woven into the fabric of both your daily and business-focused life. However, this growth is not without its concerns. Issues of data privacy, data security, and data discrimination have become hot debate topics since the explosion of big data. Organizations that intend to take advantage of big data must adequately address these challenges to avoid the legal, financial, and business risks.

CHAPTER 3

Artificial Intelligence (AI): Reinventing the Future

“The development of full artificial intelligence could spell the end of the human race; It would take off on its own, and re-design itself at an ever-increasing rate. Humans, who are limited by slow biological evolution, couldn't compete, and would be superseded.”

- Stephen Hawking

As technology continues to advance, the gravest fear of humanity is that, someday, almost all jobs will be replaced by machines. Today, these concerns are centered on a newer technology known as artificial intelligence. The continuous shift from human labor to automation across industries, coupled with the frightening predictions made by credible sources, affirms that these fears are not unfounded.

A few years ago, there were check-out cashiers in every mall, railway ticket sellers at every station, drivers in every taxi, and millions of factory workers in charge of numerous manufacturing processes. But today, the numbers of these workers have drastically fallen due to the introduction of AI-centric systems and other intelligent machines. In 2015, a factory in China replaced 90% of all its human workers with robots. A two-year study from the McKinsey Global Institute suggests that intelligent agents and robots could replace 30% of the world's current human workforce by 2030. McKinsey reckons that automation

will displace between 400 and 800 million jobs by 2030, requiring as many as 375 million people to switch job categories entirely.

According to The Brookings Institution, even if automation only reaches the 38 percent means of most forecasts, some Western democracies are likely to resort to authoritarian policies to stave off civil chaos as they did during the Great Depression. Brookings states that "the United States would look like Syria or Iraq, with armed bands of young men with few employment prospects other than war, violence, or theft." Despite these scary predictions, history has taught us that wherever technology takes, technology gives. Even though advances in technology lead to job loss or displacements, it has always created many more employment opportunities than it destroyed.

When tasks are automated, more human workers will be needed to do the other functions in the process that haven't been automated. For instance, during the second industrial revolution, more and more tasks in the weaving process were automated, prompting workers to focus on things machines could not do, such as operating a machine and tending multiple mechanisms to keep them running smoothly. This caused output to grow dramatically while also creating more jobs than it displaced. During the 19th century in the US, the amount of coarse cloth one weaver could produce in an hour increased by 50%, and the amount of labor required per yard of cloth fell by 98%. As a result, cloth became cheaper, and there was increased demand for it, which created more jobs for weavers. In fact, their numbers quadrupled between 1830 and 1900. Technology changed the nature of the weaver's job, and the skills required to do it, rather than replacing it altogether.

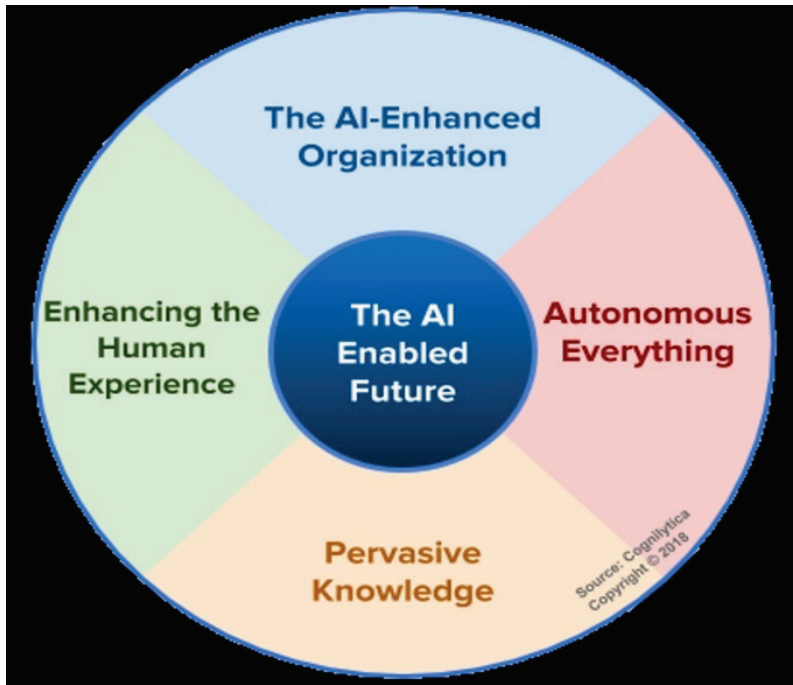
Automation doesn't only open up more and better job opportunities—it also makes work easier and faster, increases productivity, and promotes affordability. Instead of replacing the human workforce, AI-based machines will provide valuable assistance to humans. But what exactly is AI? Broadly speaking, AI is a branch of computer science concerned with the simulation of human intelligence in machines that are programmed to think like humans and mimic

their actions. According to Jeremy Achin, DataRobot CEO, "AI is a computer system able to perform tasks that ordinarily require human intelligence... Many of these artificial intelligence systems are powered by machine learning; some are powered by deep learning."

However, AI is not a single technology but a broad range of techniques, tools, and methods that can learn, self-improve, and adjust to new inputs. Although AI has multiple approaches, advancements in machine learning and deep learning have the most profound impacts on businesses and societies. Intelligent systems are all around us, from smart assistants like Siri and Alexa to manufacturing and drone robots, Google search engines, chatbots, spam filters on emails, and self-driving vehicles. These technologies have had unprecedented impacts on all facets of our lives.

In the workplace, AI machines are taking over repetitive and dangerous tasks, thereby freeing up workers to handle more creative jobs. As more and more people perform more engaging tasks, employee retention and job satisfaction will increase. AI is also helping companies save their resources. For example, smart energy management systems powered by AI can collect and analyze the troves of data from the company's assets and conceptualize this data to enable human decision-makers to better understand energy usage and maintenance demands.

Due to the numerous advantages of AI technology, its adoption by businesses worldwide leaped from 48% to 72% between 2018-2019, says RELX. A survey of 1,338 companies by O'Reilly revealed that 85% of the respondents were using AI technology in production, while only 15% were not. According to PricewaterhouseCoopers (PwC), 54% of executives say AI solutions implemented in their businesses have already increased productivity. The future looks bright, as the AI market is set to reach \$125 billion by 2025, says Statista. In the area of trends, experts believe that AI will have four significant impacts on our future lives, as illustrated in the image below.



An AI-enabled organization will be one where the number of software and hardware bots will be equivalent to the number of workers, if not more. These cognitive machines will be able to handle both back and front office business operations, and as a result, there will be advanced customized customer experience and maximized business productivity. Furthermore, AI has the potential to revolutionize our interactions with humans and data. In the not-too-distant future, instead of just sending a message of an imminent hurricane, AI-based machines will know if you are in the path of the storm, guide you to a safe place to seek shelter, and notify first responders of your location in case of emergency.

3.1 Impacts on Business

The reduced cost, optimized operations, data-driven decisions, improved customer service, and increased productivity are some of the benefits of AI in today's business world. According to a McKinsey report, financial services is one industry that has significantly adopted AI

practices. Consequently, some firms have witnessed a profit margin of ten percent higher than the industry average. Besides increasing revenue and cutting cost, AI is being used in the financial industry to prevent fraud. In 2016 alone, \$16 billion was stolen due to fraud and identity theft, which is why fraud detection is one of the most prominent applications in AI, says CNBC. AI-enabled systems can analyze clients' activities, location, and buying habits to detect suspicious or unusual events and alert appropriate authorities.

Financial trading is limited by the inability of traders to manage their emotions and follow through with a trading strategy due to personal or business problems. Hence, financial firms are now adopting algorithmic trading powered by machine learning and AI technology. These technologies have significantly improved algorithmic trading capabilities, allowing algorithms to learn and grow each day as it's fed more data while eliminating the emotional aspect of trading.

Thanks to the proliferation of the internet, connected devices, and other IoT applications, businesses can now gather massive data on customer behaviors, preferences, and needs. With the help of AI machines, this data can be used to design personalized marketing strategies that will target consumers' exact needs and improve their experience. For instance, in the financial sector, many companies are leveraging AI to provide personalized banking services. A customer can get a unique portfolio of financial tools based on their risk appetite, and he/she can also get an individualized business plan based on their spending patterns, income, and goals. By helping decision-makers implement data-driven strategies, AI saves resources that would otherwise be put into ineffective approaches.

Today, many consumers demand that their retail experience be supported by accessible customer service for added convenience—especially when it comes to shopping trips that are perceived more as a necessity than as an entertaining way of passing the time. This has prompted many retail businesses to incorporate robot assistants into their stores. These human-like bots are enhancing efficiency, workflow, and creating experiential purchase journeys for customers. A primary

example is Pepper, a robot being used to engage customers and provide assistance in several physical retail stores in the US.

AI-enabled virtual assistants such as chatbots are also used by businesses to facilitate the customer experience. Chatbots can drive human-like conversations and solve customer queries in a simplified, elaborated, and interactive way. According to Gartner, 85% of customers' relationships with business enterprises will be managed without human involvement by the end of 2020. Similarly, Servion Global Solutions predicts that AI will power 95% of all customer interactions by 2025, including live telephone and online conversations. Additionally, AI technologies enable retailers to collect, rework, and standardize data, automatically enter it into spreadsheets, and transform it into digestible visuals such as charts. In turn, this helps build efficient business plans and reduces the time to compile reports or forecasts sales figures.

As noted in the previous section, one of the most significant impacts of AI on business is the massive takeover of mundane and repetitive jobs by robots. This transition is not only occurring in the manufacturing and assembly-line industries but also many business warehouses. Amazon, for instance, now has several automated warehouses where thousands of mobile robots move inventory from one point to another, a job that was previously done by humans. These robots also help Amazon and its employees get products shipped out faster than their competition. Besides the improved packaging process and faster distribution, automated warehouses also mean using data to optimize inventory levels, resulting in less warehouse space needed, lower transportation costs, and lower costs overall.

As AI technology continues to develop, there will soon be fully automated vehicles. Automobile giants like Tesla and Audi are currently driving the automation revolution by deploying partial self-driving cars and developing plans for fully autonomous vehicles. The actualization of automated driving will have several impacts on the business world, especially the logistics industry. Self-driving cars can eliminate driver-related errors, improve vehicle safety, and ensure that goods reach their

destinations safely. With the use of AI technology, an autonomous vehicle can identify the best travel routes to minimize time on-road and drive at optimum speed, thereby improving the efficiency of logistics companies.

According to Accenture, AI is capable of increasing productivity levels by 40% in 2035. One way AI will enhance productivity is by powering the "always-on organization." Soon, businesses will have very little reason to close, as conversational agents and autonomous bots can cater to consumer demands round the clock. Even after the humans go home, bots will be operating, providing both the expectation and the reality that users can do business at any time they choose. An AI-enabled future will feature 24-hour coffee shops that are fully automated and banks that no longer operate on "bankers' hours."

3.2 Impacts on Workforce

When most people think of the future impacts of AI technology on the workforce, they imagine massive unemployment and factories, stores, and organizations entirely dominated by machines. According to ZipRecruiter, one-in-five job seekers (one-in-three for those between the ages of 18 and 22) fear they will one day lose their job to AI. To make matters worse, many studies, surveys, op-eds, and policy papers predict that AI will replace millions of workers globally.

One recent study by Oxford Economics suggests that robots could replace up to 20 million manufacturing jobs worldwide by 2030, but, as stated earlier, this is only a one-sided view of the potential impacts. If the past is any indication, AI, like technologies before it, will create more jobs than it will displace, and there are studies to support this assertion. For instance, a report by the World Economic Forum indicates that automation will replace 75 million jobs but generate 133 million new ones worldwide by 2022. With sufficient economic growth, innovation, and investment, there will be enough new job creation to offset the impact of automation globally, says McKinsey Global Institute. In addition to creating a job, AI will augment workers' roles and help them

carry out their duties more efficiently. Presently, AI is also enabling workers to move from low-level jobs to value-added tasks, and experts are encouraging organizations to create an environment that will help workers learn the necessary skills and enable a smooth transition. Forward-thinking companies like Amazon are already developing plans to help their workers transition. In 2019, Amazon announced that it would spend \$700 million to train about 100,000 workers in the US by 2025, helping them move into more highly skilled jobs.

Machine learning and AI innovations are also radically changing the way organizations hire talents. They have enhanced every stage of the hiring process by equipping HR teams with personalized research tools to find the best talent in the industry. An applicant tracking software (ATS) can relieve the HR recruiter from the trouble of going through numerous resumes, thereby reducing blunders and ambiguities during the recruitment process. The software can analyze countless resumes based on keywords, location, skills, and experience and instantly recommend the right candidate for the vacant position. The HR department is also leveraging AI and machine learning to gather data on employee morale and emotions. These technologies have face-recognition features that can recognize gender and measure employees' emotional traits on a scale from sad to excited. With the aggregated data, organizations can develop a closer bond with their employees by using the derived insights to empower employees to identify their true potential.

AI will be a game-changer in the workforce landscape and completely transform working cultures, but for the full potential of AI to be realized in the workplace, organizations must prepare their employees for the new technology.

3.3 Impacts on Societies

The synergy of AI techniques, the internet, and connected devices is revolutionizing the way we live, learn, and experience life in general. They have created conveniences and methods of problem-solving that

were never possible before. Today, AI has taken human comfort to a whole new level with smart assistants like Alexa, Siri, Cortana, and Google Assistant. At present, it is estimated that every one-in-six Americans owns a smart assistant, and eMarketer forecasts that nearly 100 million smartphone users will be using voice assistants by the end of 2020. These systems are unique because they perform a wide range of tasks simply through voice commands.

Alexa, for instance, is capable of music playback, making to-do lists, setting alarms, streaming podcasts, playing audiobooks, and providing weather, traffic, sports, and other real-time information such as news. This AI-powered device can also control smart IoT devices, making itself a home automation system. With only your voice, you can control your home's lighting, adjust the room temperature, make coffee, and so much more. Soon, these devices will offer even better-individualized experience as they learn how to differentiate voices.

As previously stated, AI is transforming transportation by promoting and enhancing automated vehicles. Self-driving cars will help people with disabilities or mobility problems to go wherever they choose, and they will also greatly assist the elderly. Thanks to autonomous vehicles, the time that would have been spent on driving can now be used for other productive or leisure activities. According to NHTSA, human error causes 94 percent of all motor vehicle crashes in the US due to mistakes like speeding, fatigue, and drunk and distracted driving. By removing humans from the driving process, self-driving vehicles can significantly reduce the number of our loved ones killed and injured in crashes annually. Smart cars also have the potential of reducing traffic congestion and carbon footprint, thereby enabling a greener society.

Presently, the global healthcare ecosystem is experiencing massive transformations due to the adoption of AI systems. AI helps people stay healthy and reduce the need to visit a doctor through consumer health applications. These apps encourage healthier behavior in individuals and help with the proactive management of a healthy lifestyle. Additionally, AI increases healthcare experts' ability to understand better the day-to-day patterns and needs of the people they care for. With that

understanding, they can provide better feedback, guidance, and support for maintaining our health. AI can also be used to detect diseases, such as cancer, more accurately and in their early stages. According to the American Cancer Society, a high proportion of mammograms produce false results, leading to 1-in-2 healthy women being told they have cancer. AI enables the review and translation of mammograms 30 times faster with 99% accuracy, reducing the need for unnecessary biopsies.

Since cognitive machines can access unlimited medical data and information, they will have the capacity to make accurate and precise diagnoses of illnesses. Today, IBM'S Watson For Health can store and review far more medical information—every medical journal, symptom, and case study of treatment and response around the world—exponentially faster than any human. Google's DeepMind Health combines machine learning and systems neuroscience to build powerful general-purpose learning algorithms to solve real-world health problems.

According to a report by Grand View Research, Inc, the global market size of artificial intelligence in healthcare is expected to reach \$31.3 billion by 2025 due to the numerous benefits the technology brings to the health care industry.

Conclusion

Today, we live in a world where non-human systems can perform tasks that previously only humans could. Some of these systems are more efficient than humans, and experts say their capabilities will continue to expand. The future will also see more smart homes, smart factories, smart infrastructures, smart cars, and smart cities as the lines between technology and non-technology continue to blur. In other words, advancements in AI will ensure a smarter and more productive life for everyone worldwide.

However, this growth won't be devoid of challenges. Aside from the concern that AI will wipe out the workforce in the future, experts also fear that AI can become a tool for manipulation, segregation, and injustice. They believe that organizations that own and control the most

powerful digital systems in the future will have a great deal of control over the rest of us. To address this challenge, governments must establish laws and regulations that will set boundaries on AI applications and hold tech companies to account for when they slip up.

CHAPTER 4

Autonomous Driving: The Future of Transportation

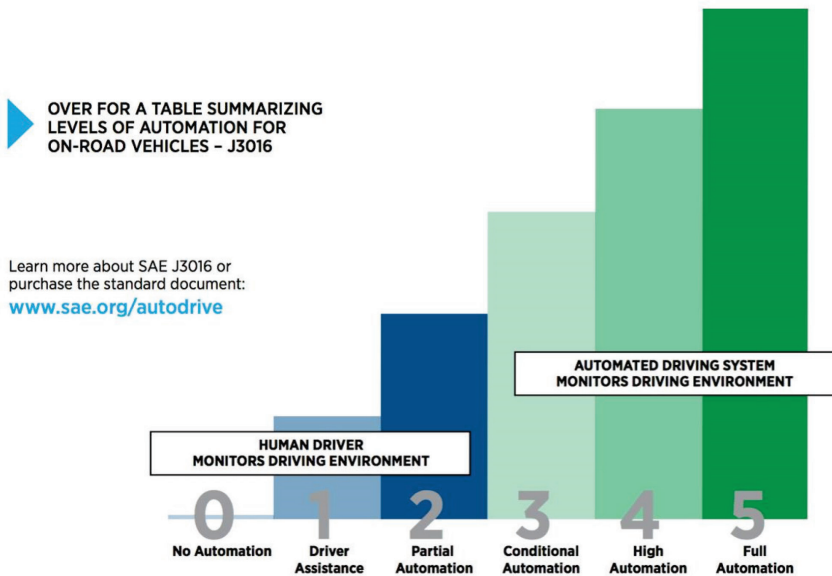
“Let’s go invent tomorrow instead of worrying about what happened yesterday.” - Steve Jobs.

Automation is the future of humanity, and autonomous vehicles are a big part of that future. Self-driving cars are poised to offer myriad opportunities to businesses, industries, and individuals alike. But for all of the possibilities, many people are afraid of autonomous cars even though they will be much safer than human-driven vehicles.

Between 2015 and 2018, the number of people killed in automobile accidents grew from 35,092 to 36,560 in the US alone. According to the National Highway Traffic Safety Administration (NHTSA), 94% of all serious crashes are caused by human error. Besides the human toll, car crashes have a substantial impact on the US economy, costing an estimated \$871 billion per year. A recent McKinsey & Company study revealed that autonomous vehicles and advanced driver assistance systems could reduce motor vehicle deaths by 90 percent, saving thousands of lives and roughly \$190 billion annually in health care costs. Improved vehicle safety will also boost business operations and save costs by significantly lowering the number of goods damaged due to road accidents and ensuring quicker delivery of products and services. Roads filled with automated vehicles will ensure smooth traffic flow and reduce traffic congestion, thereby saving commuters time and money. A report

from the Texas A&M Transportation Institute suggests that the average American wastes 54 hours a year in traffic delays, cutting into time at work while increasing fuel costs and vehicle emission. According to McKinsey, automated vehicles could free up as much as 50 minutes each day that was previously dedicated to driving. Hence, autonomous cars can increase worker productivity, reduce carbon emissions, and increase fuel economy.

Today, the autonomous vehicle (AV) industry is progressing rapidly as automakers and tech companies such as Tesla, Audi, Nissan, Uber, and General Motors continue to invest billions of dollars in improving the technology. Both Apple and Google's parent company Alphabet are also rushing to stake a claim on the market with their new self-driving projects. By definition, a fully automated vehicle is a car or truck in which human drivers are never required to take control to operate the vehicle safely. According to the Society of Automotive Engineers (SAE), there are six levels of driving automation ranging from Level 0 (fully manual) to Level 5 (fully autonomous), as illustrated in the image below.



Most of the cars driven today fall between Level 0 and Level 2 functionalities. In other words, the majority of vehicles used by the general public are either manually operated or feature some kind of

machine-corrective or machine-assisted technologies like lane correction, possible collision detection, and automated parking.

However, newer cars from automakers, including Tesla and Audi, already include semi-autonomous driving features that fall in the Level 3 functionality tier. Commercially available vehicles with true Level 4 and 5 automation are still in the development and testing phases.

To function, self-driving and semi-autonomous cars rely on AI technologies, sophisticated software, sensors, actuators, complex algorithms, cameras, machine learning systems, and powerful processors. The sensors and cameras collect data from the surroundings and feed it to the car software, which then processes all the input, plots a path, and sends instructions to the car's actuators. Sophisticated algorithms, predictive modeling, and object recognition help the software follow traffic rules and navigate obstacles.

Presently, Alphabet's Waymo subsidiary is leading the AV industry, as measured by the number of vehicles operating, the number of kilometers driven (32 million in the real world, and more than 16 billion in simulation), and the sophistication of its technology. In addition to cameras, LiDAR, and radar sensors, Waymo cars also use microphones to detect sirens from emergency vehicles for autonomous functionality. In 2018, Waymo carried out successful autonomous taxi trials in California, where it drove 1.2 million miles with only 0.09 disengagements every 1,000 miles. It also transported over 6,200 people in the first month of testing and many thousands since. Now, Waymo is testing both Level 4 and Level 5 robo-taxis in Phoenix, Arizona (most of which have a person upfront serving as a backup driver). Phoenix was chosen to test Waymo's fleet because of its ideal conditions of weather, traffic, and environment compared to other locations around the world. However, the automobile company intends to acclimate vehicles to harsher weather and other conditions by setting up additional testing locations in Michigan.

After Waymo, General Motors' Cruise division has the world's second-largest autonomous fleet undergoing testing. So far, they have 180 cars that have driven more than 1 million miles. Mo ElShenawy, vice president of the division, is confident that the AV company will soon be able to deploy thousands of self-driving cars annually. Tesla is another manufacturer making huge steps toward taking autonomy into mainstream use, both in terms of real-world application and potential monetization of self-driving vehicles. Since its launch, Tesla has delivered more than 780,000 cars, most of which arrive with pre-installed self-driving capabilities available to users who purchase the necessary software. Tesla autonomous vehicles have recorded massive levels of miles driven since their introduction, rising from 0.1 billion miles in May 2016 to an estimated 1.88 billion miles as of October 2019.

As the AV industry advances, there are divergent views on when fully automated vehicles will become legal, commercially available, and operational. While some tech leaders believe that autonomous driving is still a long way off (perhaps 10-30 years from now), others maintain that the future of AV has already arrived. Tesla co-founder and CEO, Elon Musk, falls into the latter category and, in 2019, announced that his company would deploy fully automated electric cars before the end of 2020. In the same vein, Ford, Baidu, and Volvo expect to launch high-automation Level 4 robo-cars in 2021. Henrik Green, Volvo senior vice president, recently revealed that the next-generation Volvo XC90, which should hit the market around 2021, will be able to transport sleeping passengers to their destination on limited roadways (likely highways and freeways).

Judging by the current progress, the AV industry will undoubtedly continue to expand, and so too will its benefits. The global market size for Level 4 and 5 autonomous vehicles is expected to reach \$60 billion by 2030, says Statista. Based on a forecast study by BCG, 12 million fully autonomous vehicles and 18 million partially autonomous vehicles will be sold globally by 2035.

4.1 Impacts on Business

Autonomous vehicles are set to radically transform business operations across many industries. Today, mining and farming industries are already benefiting from the technology through the deployment of autonomous fleets. Unmanned vehicle fleets enable mining companies to increase worker safety in high-risk environments by removing operators from areas where they can be submerged or trapped in collapsing tunnels. For instance, mining giant Rio Tinto has a fleet of autonomous haul trucks capable of moving over one billion tons of waste and ore materials across its five sites in Pilbara, West Australia. On average, each autonomous truck operated an additional 1,000 hours at a 15% lower load and haul-unit cost than conventional haul trucks. Highlighting the technology's significant safety advantage, Rio Tinto has not recorded any accidents involving its autonomous fleet, since the first trial operation in 2008. Borrowing from the words of Sean McGinnis, product manager at Caterpillar Mining Technology, autonomous hauling systems "have demonstrated how safety can be enhanced by eliminating truck operating errors and reducing the number of people working in the active mining area."

Mining companies are also adopting AVs to boost efficiency, save labor costs, and reduce carbon dioxide emissions (shown to cut emissions by as much as 60 percent) while moving large quantities of materials. In 2018, the Komatsu Front Runner autonomous haulage system (AHS), which allows the unmanned operation of ultra-class mining trucks, achieved a major milestone: autonomously moving more than two billion tons of material in the copper, iron ore, and oil sands industries. By implementing autonomous haulage, more material can be transported efficiently and safely, translating into a direct increase in productivity. McKinsey predicts that construction, warehouse, and manufacturing sectors will benefit from the next wave of AV vehicles such as tractors, bulldozers, cranes, excavators, forklifts, and loaders.

AVs will redefine the retail space by helping retailers reduce delivery cost and time, increase logistics efficiency, and improve last-mile connectivity, among others. The introduction of AVs is expected to

significantly lower the time of delivery of online orders. In the US, over 75% of shipping costs are associated with labor, which includes regulations that limit drivers to 11 hours on the road per day, delaying delivery time. At present, Amazon relies on the US Postal Service and delivery companies such as UPS to deliver goods on demand. However, the proliferation of AVs and the introduction of longer shipping hours into the delivery process will result in faster deliveries, encouraging customers to opt for home delivery services rather than traveling to brick-and-mortar stores. To cater to these needs, autonomous technology companies such as Nuro and Starship Technologies are now building new autonomous delivery vehicles.

Retailers are turning their attention towards AVs to bridge gaps in their supply chain. With the use of natural language processing, AI, and cloud computing, AVs can improve the speed and efficiency of last-mile deliveries. These systems can efficiently identify best travel routes to minimize time on-road, avoid traffic jams by following lanes rules, and drive at optimum speed and maximize fuel economy.

In 2018, China's e-commerce giant Alibaba began using driverless robots, G Plus, to deliver online orders to secured e-lockers. The following year, the German automotive manufacturing company Continental AG announced a new solution to autonomously deliver packages to customers' doorsteps: robot delivery 'dogs.' Meanwhile, automobile manufacturer Ford estimates that AVs will reduce delivery cost per mile from \$2.5 to \$1 as more and more retailers strive to apply autonomous technology across all their logistics processes.

By adopting AVs, online retailers will drive down the cost of deliveries considerably as they will no longer need to hire drivers. Quick and low-cost delivery options encourage shoppers to increase the frequency of online purchases, thereby enhancing the sales and profitability of e-commerce businesses.

Besides enhancing existing businesses, AVs can create new business opportunities within the entertainment, retail, and e-commerce space. In a world where AVs are fully operational, transportation will become a widespread service-on-demand, transforming passengers into

customers. Passengers and drivers will be able to engage in shopping, listening to music, exercising, and eating in an AV. According to a Capgemini survey of more than 5,500 consumers from around the world, 46 percent expressed interest in shopping while being driven in an AV, indicating new opportunities for e-commerce businesses. Further, 58 percent shared an inclination to eat, potentially creating (challenging yet new) opportunities for the food and beverage industry. In line with this trend, Uber has successfully expanded into food delivery with UberEats, while GM's Cruise has begun exploring driverless delivery with DoorDash. The study also revealed that 58 percent of respondents indicated an interest in consuming various media content while commuting—listening to music, watching movies, reading digital books, reading the news, or playing online games. This will usher in a wealth of new opportunities for entertainment providers, and for advertisers and tech companies, this will mean a huge opportunity to present audiences with location-based advertising and marketing for goods and services.

Due to the vast benefits and potential opportunities of AVs, the demand for the technology is expected to grow exponentially in the next decade. According to a new report by Grand View Research, the global autonomous vehicle market demand is will reach 4.2 million units by 2030, expanding at a CAGR of 63.1% over the forecast period.

4.2 Impacts on Workforce

As with most modern technology that we will discuss in this book, there are concerns that fully automated cars might displace workers, especially those in the transportation sector. As mentioned earlier, AVs offer numerous opportunities to employers, such as increased productivity and profitability, improved safety, and limited environmental damage without human input and cost. Therefore, it will be no surprise that when AVs reach peak saturation, many companies will be quick to adopt it and lay off their human labor. In fact, a report by Goldman Sachs estimates that autonomous cars could eliminate 300,000 driving jobs annually, beginning from 2025. In the US, driving

occupations—including delivery and heavy, truck drivers, bus drivers, taxi drivers, and chauffeurs—would be hit hardest, according to a report by the Center for Global Policy Solutions. The report also states that most of these workers have lower educational attainment levels, with a vast majority (93.2 percent) possessing less than a bachelor's degree. In many cases, their driving jobs are the only thing keeping them out of poverty.

However, the loss of specific human jobs to autonomous vehicles represents only one side of the possible impacts on the workforce. Experts believe that the AV industry will create more jobs, especially as multiple companies race to market the first self-driving car. Investments plunged into the development and improvement of AV technology are massive and expected to grow in the not-to-distant future. Ford recently announced that its plans to spend \$4 billion on autonomous vehicles by 2023. GM intends to pour \$100 million into self-driving cars, and Toyota launched a \$2.8 billion self-driving car company in Tokyo. To achieve and maintain fully automated systems, these companies will need engineers, technicians, software developers, and designers, thereby increasing the demand for these workers.

Waymo, for instance, is already employing dispatchers, technicians, customer representatives, and a response team that will manage the operation of its self-driving car service in the Phoenix area. According to ZipRecruiter, job listings associated with the autonomous driving industry grew by 27 percent in 2018. Commenting on the impacts of AVs on the future of the workforce, Ian Siegel, co-founder and CEO of ZipRecruiter, says, "Autonomous cars are going to largely eliminate job seekers weren't interested in and create opportunities in work that people will find more rewarding." This means that the workforce changes will be most felt in the increased need for higher skill (quality) rather than a reduction in quantity. Therefore, workers in the driving occupation who might be displaced by advancements in AV technology will need to upskill to secure comparable or better jobs.

Furthermore, increased traffic speeds and a greater willingness to travel as a result of AV adoption could create more job availability in

economically disadvantaged communities in the US, according to a report by SAFE. Similarly, a winning proposal in the US Department of Transportation's \$40 million Smart City Challenge for Columbus, Ohio, uses autonomous vehicles to connect unemployed residents in the Linden neighborhood to a nearby job center.

With the need to drive being eliminated by autonomous driving, employees can have more time to work while commuting, thereby increasing their productivity. Hence, people will get more done within a day than ever before. The introduction of autonomous electric vehicles (EVs) can also facilitate remote working. It is expected that today's digital nomads will flourish as EVs will increasingly resemble mobile offices with redesigned service stations to support their live-work lifestyles. Companies like Shanghai-based Yanfeng Automotive Interiors is already exploring the transformation of the car as new modes of living and working become better integrated.

4.3 Impacts on Society

Do you think you spend too much time driving? Well, you might be right. According to a report by the AAA Foundation for Traffic Safety, Americans spend over 70 billion hours behind the wheel, over a year, primarily due to traffic congestion and delays. However, the realization of self-driving cars is projected to improve traffic flow and reduce traffic delays, creating more time for you to spend with your family, catch up on your favorite TV show, or hang out with your friends.

The social effects of AVs are widespread and far-reaching, from soft advantages like reducing parking lots to more serious implications such as economic growth and increased safety of lives and properties. Aside from encroaching into your time, long hours behind the wheel could lead to issues such as fatigue, distraction, and impatience for other drivers, all of which are contributing factors for vehicle crashes. Global statistics show that over 1.3 million lives are lost through road accidents per year, and over 90% of these crashes are caused directly or indirectly

by humans. By replacing human drivers with AVs, road carnage can be drastically reduced, and you can expect your loved ones to arrive home safely. Improved vehicle safety and convenience due to car automation will encourage recreational travelers to use road transportation and avoid the hassles of plane and train travel, says Forbes.

Additionally, AVs can ensure a cleaner and healthier environment by improving fuel efficiency and lowering global carbon emissions. This is particularly true for EVs, but even cars using fossil fuels will still see a reduction in emissions through more efficient driving behaviors led by AI. Collectively, cars and trucks account for nearly one-fifth of all US emissions, emitting around 24 pounds of carbon dioxide and other global-warming gases for every gallon of gas according to a report by the Union of Concerned Scientists. These substances can have devastating effects on the environment, climate, and human health, but thankfully they can be mitigated by vehicle automation.

The actualization of autonomous driving will also lead to an economic boom, especially in the US. According to a recent report by Securing America's Future Energy (SAFE), autonomous vehicles will contribute about \$800 billion annually in economic and societal benefits when they are fully deployed. The report predicts that these benefits will come from cost savings related to reduced crashes, fuel efficiency, and better access to transportation.

Similarly, the growing expectation is that when AVs are fully realized, more consumers and businesses will opt for ride-sharing (mobility-as-a-service) instead of car ownership. This will lead to a new and broad range of commercial services like onboard dining and retailing, thereby triggering economic growth. Based on a projected study by Intel Corporation and Strategy Analytics, the economic effects of autonomous vehicles will total \$7 trillion in 2050.

In the future, autonomous shuttles could be used continuously after they have reached their destination, thus dramatically reducing the need for parking space. For instance, in Los Angeles, a 2015 study found that 14% of the land is used for parking alone, equivalent to some 1,702 hectares (4,210 acres). This, combined with the potential reduced need

for road space due to improved traffic flow, could free up large land in urban areas, which could then be used for parks, recreational centers, buildings, and other uses.

According to a report by The Ruderman Family Foundation, approximately one in every five persons in the US, or more than 57 million people, have a disability of some kind, and about six million of these people encounter difficulty in getting the transportation they need. As self-driving cars and on-demand mobility solutions enter the mainstream, they can reduce transportation obstacles for people with disabilities. The report suggests that autonomous cars can facilitate new employment opportunities for approximately two million individuals with disabilities and save \$19 billion annually in healthcare expenditures from missed medical appointments. This technology will also enable older citizens and people with vision impairments to go to work, keep doctor's appointments, and visit stores, family, and friends.

Conclusion

As the former president of the United States, Barrack Obama, rightly said, "The technology (autonomous vehicle) is essentially here... We have machines that can make a bunch of quick decisions that could drastically reduce traffic fatalities, drastically improve the efficiency of our transportation grid, and help solve things like carbon emissions that are causing the warming of the planet." But despite the overwhelming benefits of the technology, there are some concerns bordering on safety and cybersecurity, the ethicality of machines, the displacement of workers, and the use and monetization of data and AV systems by key automakers. To overcome these challenges, tech companies, automakers, and the government must work closely together to tackle these problems and implement regulations that will benefit the transportation industry and the general public.

CHAPTER 5

Internet of Things (IoT): New Way People Behave and Interact with Machines

“If you think that the internet has changed your life, think again. The Internet of Things is about to change it all over again!”
- Brendan O'Brien

Imagine a world where the line between technology and non-technology is increasingly blurred, where every object you can think of can communicate and exchange information. Sounds like a movie, right? Well, it isn't. It is the new reality we live in, powered by the Internet of Things (IoT). The core of IoT is connectivity, and with this new technology, every physical object can be connected. Now, your smartphones can be connected to the lightbulb and used to control its functions. The soil can transmit data to the irrigation system or the farmer, and smart assistants like Alexa can regulate the lighting and the temperature of your room, all thanks to IoT applications.

IoT connected devices are used across all key sectors—from health to agriculture to manufacturing and logistics and construction—and are causing massive changes in operations. As of 2018, seven billion devices

were connected to the internet, and by 2025, the number will grow to 41.6 billion says the International Data Center (IDC). According to an IoT growth report by McKinsey, 127 new IoT devices are connecting to the internet every second. Transportation and logistics, discrete manufacturing, and utility industries are projected to spend \$40 billion each on IoT platforms, systems, and services before the end of 2020, according to Forbes. Based on predictions by Statista, the global agricultural Internet of Things (IoT) market size will rise from \$14.79 billion to \$28.64 between 2018 and 2030. The consumer market for IoT devices is also rapidly expanding as more and more people continue to invest in smart homes. For example, smart speaker devices like the Amazon Echo are already in 31 percent of US broadband households as of Q1 2019, up from a mere seven percent in 2017, says Statista.

The ubiquitous connectivity now witnessed globally is the result of decades of development and improvements of IoT technologies. Throughout the 1980s and 1990s, the idea of adding sensors and intelligence to basic objects was a fascination of many companies, but apart from some early projects—including an internet-connected vending machine—progress was slow because the necessary technology wasn't available. At that time, computer chips were too big, bulky, and expensive, and the internet was not as pervasive and fast as it is today. However, some of the issues were resolved with the development and adoption of Radio Frequency ID tags (low-power chips capable of communicating wirelessly) and the IPv6 system, which can provide enough IP addresses for every device in the world. With these new technologies, chips became cheaper and wireless networks proliferated, thereby enabling interconnectivity among objects.

The phrase Internet of Things was coined in 1999 by British technologist, Kevin Ashton. According to him "the IoT integrates the interconnectedness of human culture—our 'things'—with the interconnectedness of our digital information system—the internet." Today, IoT refers to the vast network of smart objects which work together in collecting and analyzing data and autonomously performing actions. While most of these intelligent devices can process data, some are designed to only gather and transmit data elsewhere for processing.

The technology stack supporting the function of the IoT can be categorized into four layers: the device hardware, the device software, communication elements, and the IoT platform.

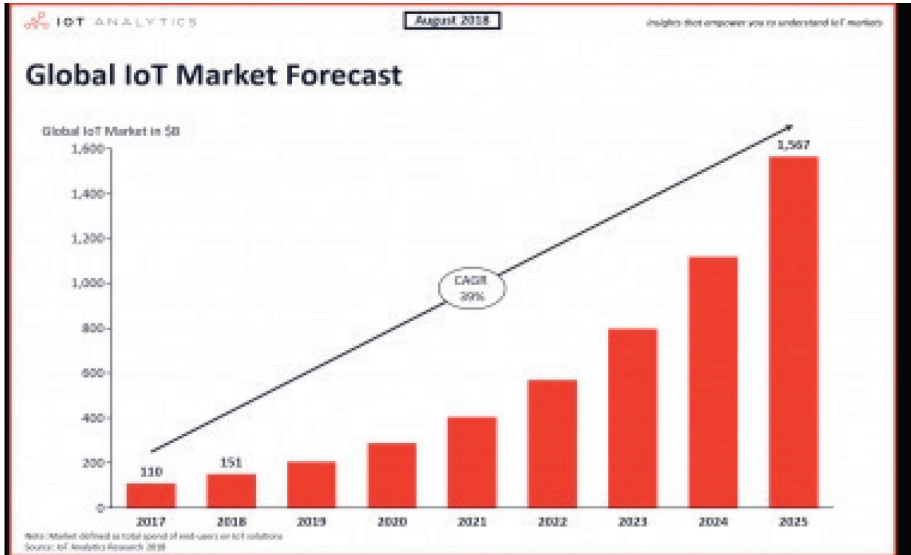
The device is the object or "thing" that serves as an interface between the real and digital world, which could be anything from a pinhead-sized microphone to a heavy construction machine. Sensors, actuators, and other telemetry gears installed in the device are the hardware and are responsible for the aggregation of data from the device's environment. On the other hand is the software—the technology that makes the device “smart” by implementing communication with the cloud, enabling data collection, integrating tools, and performing real-time data analysis within the IoT network. Communication elements include both physical connectivity solutions (cellular, satellite, LAN) and specific protocols used in varying IoT environments (ZigBee, Thread, Z-Wave, MQTT, LwM2M). All the data is gathered onto an IoT platform (i.e., the cloud), where it is managed, processed, analyzed, and presented in a user-friendly way.

One of the initial applications of IoT in the 21st century was adding RFID tags to expensive medical equipment, drugs, and patients to help keep track of their location. Since then, the cost of installing sensors and an internet connection to objects has continued to fall, and experts predict that this basic functionality could one day cost as little as ten cents, making it possible to connect nearly everything to the internet.

Today, many companies are utilizing IoT technology across numerous business operations, such as using smart sensors to monitor products flowing through their supply chains and to predict (or even prevent) system malfunctions. IoT is also the future of the automobile industry, as significant stakeholders are hard at work to produce vehicles that will be able to self-optimize its operation using onboard sensors and internet connectivity.

Research by the McKinsey Global Institute indicates that IoT will continue to experience rapid growth even though many of the most promising applications of the technology have yet to be fully deployed. In fact, McKinsey reckons that the total economic impact of IoT will

range between \$4 and \$11 trillion per year by 2025. According to IoT Analytics, the global IoT market was worth \$150 billion in 2018 but is expected to exceed \$1.5 trillion by 2025 (with a CAGR of 39%), as illustrated in the image below.



However, complementary technologies such as more versatile cloud technology, edge computing architecture, and the proliferation of 5G technology will likely enable rapid expansion of IoT applications in the coming years.

5.1 Impacts on Business

Thanks to the arrival of cost-effective hardware and the expansion of wireless connectivity, many businesses and industries already benefiting from IoT technology. Global company spending on IoT hardware and software was expected to hit a staggering \$1.1 trillion by 2023, according to a report by IDC. Companies are adopting IoT technology for its numerous benefits, including process optimization, increased efficiency, reduced cost, and enhanced customer experience. Worldwide, the manufacturing and industrial industries are the early and fast adopters of IoT technology, a trend currently known as Industry 4.0 or Industrial

Internet of Things (IIoT). This new trend has a heavy focus not on people using machines, but on machine automation with minimal human input thanks to robotics. Hence, human-operated machinery is decreasing in these sectors while the application of IoT continues to expand. These intelligent systems or robots can collect an enormous amount of data on the status of the environment and equipment that allows companies to make insights and optimizations never before possible.

With IoT, the idea of a "smart factory" is not just a concept that might be possible in the distant future, but a reality today. According to The Atlantic, 67% of industrial manufacturing companies currently have an active smart factory initiative, such as using IoT devices to monitor the entire production process in real-time from the refining operation down to the packaging of the final products. Manufacturers can now use the information gathered from close observation to make necessary adjustments in procedures for better management of operational cost and to eliminate waste and unnecessary work-in-progress inventory. Furthermore, internet-connected machinery can transmit operational information to primary partners like original equipment manufacturers and field engineers. This will enable operation managers and factory heads to monitor and manage the factory units remotely and take advantage of process automation and optimization.

IoT technologies are also improving facility management for manufacturing companies through condition-based maintenance alerts. Many critical machine tools are designed to function within specific temperature and vibration ranges. Embedded IoT sensors can actively monitor these machines and send a signal when the equipment deviates from its prescribed parameters. By ensuring the specified working environment for machinery, manufacturers can conserve energy, save costs, eliminate machine downtime, and increase operational performance. According to a survey conducted by PwC, companies expect IoT alongside complementary technologies to improve business efficiency by 12%.

Today, every piece of inventory at every phase of the production and delivery process can be tracked with IoT technology, making it possible to locate goods no matter where they are at any given time. From sensor-equipped manufacturing equipment to RFID-tagged clothing, IoT edge devices present a level of transparency that wasn't even imaginable in previous decades. Many organizations are already using IoT solutions in fleet management. For instance, IoT can track semi-trailer trucks making long-haul and last-mile deliveries, government vehicles transporting valuable personnel, and service vehicles performing their scheduled job functions. Old-fashioned barcode scanners are becoming obsolete as smart inventory sensors offer enhanced functionality for asset tracking. The days of logistical guesswork are fast coming to an end, as expanding fog networks and edge computing ("Edge computing is typically referred to the location where services are instantiated, fog computing implies distribution of the communication, computation, storage resources, and services on or close to devices and systems in the control of end-users – Prof. Jonathan Numhauser"). architecture make it possible for more devices to be continuously connected to cloud infrastructures.

According to a report by Gartner, 89% of businesses expect customer experience to be their primary competitive advantage in the coming years. Thus, companies must invest in technologies that can provide more engaging customer service. The data collecting power of IoT is an invaluable asset for enhancing customer experience. For instance, data generated from voice-activated virtual assistant devices like Amazon's Alexa and Google's Home helps companies advertise and promote services that meet the needs of specific customers, cutting down on ad spending that would have been wasted on disinterested people outside the target audience. Mobile apps also offer an essential platform for the generation of customer data. They serve as an interface between business and clients and help companies anticipate exactly what customers want, where they want it, and how they want it presented, thereby fostering better-personalized experiences.

On the other hand, some connected devices can process data and act autonomously. Consider, for example, the smart printer that automatically places delivery orders when ink levels are low. By

leveraging these advancements in IoT technologies, businesses will soon be able to deliver everyday items like groceries and cleaning supplies at the customer's doorstep without them ever having to place a single order. For durable goods with extended lifecycles, IoT integration powered by edge computing architecture will enable manufacturers to build and cultivate long-term relationships with consumers. Remote monitoring, predictive analytics, and predictive maintenance—all powered by internet-connected devices—will introduce a whole new range of service-oriented business models that create brand loyalty and promote higher engagement.

Away from the impacts of connected devices on business processes, analysts believe that the global IoT market represents a major growth opportunity for a variety of industries. Based on predictions by GrowthEnabler & MarketsandMarkets, the industrial IoT market is expected to grow to \$457 billion before the end of 2020, with business to business (B2B) applications of assorted IoT ideas forecast to generate more than \$300 billion. A recent Euromonitor International survey of over 1400 industry professionals revealed that more than half of respondents expected their companies to spend more on IoT and the cloud than any other technology. As investments into IoT solutions continue to expand each year, it will be imperative for organizations across all industries to think about how IoT can lead to new business opportunities. While manufacturing and transportation are expected to see the most rapid growth in IoT ideas, according to IDC, the data aggregated by internet-connected devices will also open up entirely new markets. Better data means better segmentation and targeting, and with the assistance of sophisticated analytics, companies can gain enormous insights from unstructured data that can be used to identify new opportunities and areas of need.

5.2 Impacts on Workforce

The fear of massive unemployment has snowballed in recent times due to the increasing automation of tasks and processes across industries powered by the IoT. With the continuous evolution in the field of IoT,

where more devices are going online every day, the need for human intervention is decreasing across a number of business processes. Today, a single machine can carry out the functions of many laborers; a flying drone can scan a vast area in a shorter period than humans, and comprehensive security systems have taken over the tasks of guards protecting various premises. According to a report by Zinnov consulting firm, IoT will impact over 120,000 jobs and eliminate 94,000 by 2021. In a PwC survey of 1896 experts, almost half of the respondents (48 percent) envision a future where robots and digital agents have displaced significant numbers of both blue and white-collar workers. Carl Frey and Michael Osborne, two researchers at the University of Oxford, found that 47 percent of US workers have a high probability of seeing their jobs automated over the next 20 years. Similarly, a McKinsey Global Institute analysis of 750 jobs concluded that 45% of paid activities could be automated using currently demonstrated technologies and 60% of occupations could have 30% or more of their processes automated. However, there is a consensus among experts that low-skilled or unskilled jobs are more likely to feel the impact of automation than high-valued positions.

Borrowing from the words of Scott Dobroski, tech expert at Glassdoor "themes people should be aware of include low-skilled jobs being likely replaced by automation first, such as telemarketer or typist. In contrast, jobs requiring creativity or a social aspect to them are not as at risk." Despite this grim picture, there are positive aspects to the adoption of automation in the workplace. First, human involvement is, and always will be, integral, since intelligent machines do not possess the power to think spontaneously and tentatively like a human mind—yet. And as we have discussed at length in previous chapters, new technologies will invariably lead to increased productivity and margins that provide companies with funds to expand their size and employment offerings. Hence, IoT-enabled automation can create new job opportunities than it will take away.

And experts agree. According to the World Economic Forum, automation will replace 75 million jobs but generate up to 133 million new ones worldwide by 2022. Also, IoT and AI-related job creation is

expected to reach two million net-new jobs by 2025. Agricultural technologists, software engineers, IoT managers, and data scientists are highly in-demand on today's job market thanks to IoT. The proliferation of connected devices means web data will need to be scraped, repackaged, and restored to make it consumable, thus offering plenty of opportunities for IT professionals with data-scraping skills. Since the types of jobs that will be in demand in the future are changing due to IoT applications, the education system and its curriculum will have to adapt. Students should be counseled on the changing dynamics of the world and urged to hone themselves on the rapid advancements in technology. Because of this shift, many experts advise educational institutions to embrace the STEM-approach to teaching.

However, IoT is presently driving increased employee productivity via automated processes. Connected devices allow teams to be better equipped with faster and more efficient solutions, providing the opportunity to significantly minimize wasted resources across myriad industries and gain more timely insight into team workflows. The increasing prevalence and adoption of connected, non-smartphone devices, combined with AI advances, faster processors, and wireless networks can also foster better collaboration and innovation in the workplace of the future.

5.3 Impacts on Societies

The possibilities of IoT connected devices are endless. Today, we are witnessing these transformations not only in business but in every facet of human existence. Smart homes comprise intelligent devices that can be used to automate lighting, climate, appliances, entertainment, and security systems—popular examples include home voice assistants like Amazon's Echo, smart TVs like Apple TV, and Kwikset smart locks. These devices are revolutionizing the way people live and interact with their homes, while also rapidly increasing in prevalence worldwide. In 2017, over 663 million smart home devices were used in homes around the world, and the number is expected to surpass 1.94 billion by 2023, with devices sales exceeding \$78 billion at the same time. According to

Statista, the number of smart homes is expected to surpass the 300 million mark, while its global market revenue will reach a value of more than \$141 billion by 2023. With these numbers, you can expect every household function to be automated soon.

In a broader sense, IoT is creating and supporting smart cities. Smart surveillance, automated transportation, smarter energy management systems, water distribution, urban security, waste disposal systems, and environmental monitoring are all IoT applications geared towards building smart cities. By 2030, 70% of automobiles will be connected to the internet, translating to increased automation of vehicles according to Statista. This will improve road safety, reduce accidents, and reduce traffic congestion and carbon monoxide emissions. Soon, buildings will also have the ability to redirect and redistribute energy to places that need it the most, thereby improving energy supply.

Products like a cellular-communication-enabled “smart” trash can will send alerts to municipal services when bins are full. Governments and organizations are already hard at work to create IoT-powered cities as 23 percent of current large-scale IoT projects are smart city-related says IoT Analytics. IoT is also leading to drastic changes in the agricultural sector as the IoT agricultural market continues to expand. Market & Market estimates the smart agricultural market will grow from \$12.7 to \$20.9 billion between 2019 and 2024, at a CAGR of 10.4% during the forecast period. Farming is an extremely unpredictable enterprise, thanks to everything from weather to commodity prices. Equipment is expensive, land and water are scarce, and millions of dollars can be lost each growing season by making the wrong decision. Today, farmers are already confronting these challenges using sensors, GPS, tablets, and cloud servers to map yields, time plantings, and know exactly how much fertilizer to apply. FieldView from The Climate Corporation is a cylindrical device that connects to a tractor and allows the driver to view real-time images of their acreage through their iPads. This enables them, for example, to identify where fertilizer needs to be applied to achieve yield targets. In the future, many experts foresee innovations to entirely transform agriculture, and IoT will be central in this change. For example, there are a few trial runs for “vertical farming,”

which cultivates plant life skyscraper-style. This would allow farms to be located in or near cities, shortening the time for growing, transporting, and distributing food.

Conclusion

The impacts and advantages of the Internet of Things on society are overwhelming, both now and in the future—and a vast number of forward-thinking organizations, businesses, industries, and individuals are already reaping these benefits. However, there is one primary concern with the increasing prevalence of IoT devices: cyberattacks. With over 40 billion devices or objects expected to be connected to the internet in the next five years, the risk of data being compromised and stolen is rapidly increasing.

According to a study by Aruba HPE, 84% of companies that have adopted IoT have reported security breaches. Also, over 80 percent of healthcare organizations that use IoT devices have suffered a security breach of their IoT devices or infrastructure, says the Institute of Electrical and Electronics Engineers (IEEE). These breaches have damaging economic, reputational, and legal consequences on these organizations. To thrive in an IoT-centric world, companies must tackle these challenges head-on and design systems and IoT products fortified with advanced security protocols that match or exceed the increasing sophistication of cyberattacks.

CHAPTER 6

Cybersecurity: Data Privacy Must be a Priority

“Information is the oxygen of the modern age. It seeps through the walls topped by barbed wire; it wafts across the electrified borders.”

- Ronald Reagan

In recent times, there have been growing concerns about cybersecurity threats and data privacy. According to The Ponemon Institute of Research, cybersecurity breaches have increased by 11% since 2018 and 67% since 2014. There is a cyber-attack every 39 seconds, amounting to an average of 2,244 attacks daily, says the University of Maryland. In brief, cyberattacks are assaults launched against a digital device by a malicious actor to access, change, destroy, steal sensitive information, disable computer systems, extort money from users, interrupt normal business processes, or use the breach as a launch point for other attacks. People who commit cyberattacks are known as cyberattacks, malicious actors, and if the attack is successful, cybercriminals. No one is immune to cyberattacks, as individuals, businesses, industries, institutions, and governments alike all suffer from its crippling effects.

According to cybersecurity researchers from Kent's School of Computing and the University of Oxford, there are at least 57 different ways in which hacks can negatively impact organizations and societies.

They range from threats to life, increased rates of depression, damaged infrastructure, loss of customer trust, reduced profits, regulatory fines, and disruption of daily activities. The researchers drew attention to high-profile attacks against Sony, JP Morgan, and online dating website Ashley Madison as examples of a wide range of adverse outcomes from reputational loss and financial damage for exposed individuals. Similarly, in 2016, Uber reported that hackers stole the information of over 57 million riders and drivers and forced them to pay \$100,000, according to Bloomberg.

Events bordering on cybersecurity and cybercrime have increased in the past decade, and as a result, many people assume that these concepts are new vectors. However, the origins of cybersecurity and hacking incidents date back to 1834 when a pair of thieves “hacked” the French Telegraph System and stole financial market information, effectively conducting the world's first cyberattack. Throughout much of the 19th century, most hacks were centered on primitive communication devices and didn't cause much harm. The introduction and evolution of computer systems and the internet in the 20th century, however, fueled cyber-attacks and its use for espionage. In 1988, Robert Thomas Morris, a researcher at BBN technologies, realized the possibilities of creating a program capable of moving in a network and leaving behind a trail. This discovery led to the invention of the first computer worm called Creeper, which is regarded as a milestone in the history of cybersecurity because it was the first cyberattack program to have severe impacts on connected systems and the internet. Morris's worm infected machine after machine at a rapid pace, leading to network clogs and system crashes. Beyond these effects, the computer worm triggered the evolution of newer types of malicious programs, which became increasingly dangerous to networks and computer systems. These early inventions paved the way for the modern and sophisticated landscape of cyber-attackers and hackers prevalent today. Borrowing from the words of Robert Herjavec, founder and CEO of several IT companies, "the early hacking incidents were a glimpse of the future."

Massive connectivity and advancements in digital technology are the most significant factors driving today's cybercrime landscape. Digital

devices, the internet, and the cloud have transformed the world into a connected village. The communication barriers that once plagued us are rapidly being obliterated as more and more people, objects, and gadgets get connected to the internet. According to Statista, there are over 41 billion active internet users and 9.9 billion connected devices in use today. The implication: cybercriminals can hack every one of these people and compromise their information and data. Additionally, individual and organizational negligence of basic actions such as vulnerability assessments, patching, and password hygiene also enable cyber-attacks.

Presently, there are numerous types of cyber threats. According to Symantec Security Center, some of the most common are malware, phishing, ransomware, social engineering, Denial-of-service (DoS), distributed denial-of-service (DDoS) attacks. Symantec reports that in 2018, Mirai distributed denial of service (DDoS) was the third most common threat, and the number of global ransomware hacks increased by nearly 25% between 2018 and 2019. These threats have prompted the adoption of cybersecurity solutions, such as antivirus and anti-malware software, encryption, and firewalls. However, with the uptick in machine learning and other continuously-emerging technologies, the variety of attacks are becoming more sophisticated, organized, and harder to detect. Consequently, traditional security measures such as firewalls and antivirus software are now incapable of handling the evolving threat landscape, and many of the devices and technology used for protection are being exploited and modified into cyber-weapons.

The good news is cybersecurity specialists are also using these advanced algorithms and technologies to prevent breaches before they happen. Thanks to AI and machine learning, these professionals can now protect information more effectively by examining data on threats, automating defenses that act faster than viruses, and detecting threats already present in a system. In response to the ever-growing trends of cyber-threats, local law enforcement in places such as New York City and Atlanta are already heavily invested in new technology and personnel to combat cybercrime.

Cybersecurity experts agree that technology created these cybersecurity risks, and only technology can eliminate them. Many analysts expect that the application of AI and related technologies in promoting and ensuring cybersecurity will continue to expand in the coming years. Experts also believe that government policies and data privacy regulations that are more robust than the already existing CCPA (California Consumer Privacy Act) and GDPR (General Data Protection Regulation) will play essential roles in shaping the future of cybersecurity. These laws will oversee the collection, use, retention, and disposal of personal information and create vital protocols for organizations to follow, especially those in industries collecting sensitive information, such as healthcare and finance. Cybersecurity will also open windows of employment opportunities for trained professionals in the field. The US Bureau of Labor Statistics (BLS) forecasts a 28% growth between 2016 and 2026 for information security analysts, who safeguard their companies' data. This is significantly higher than the 7% average growth the BLS anticipates for all jobs.

6.1 Impacts on Business

As the number of businesses connected to the internet grows, the need to adopt effective cybersecurity solutions becomes even more crucial. CSO's report on top cybersecurity trends showed that attacks on IoT devices tripled in the first half of 2019. In 2017, the number of cyberattacks on companies doubled worldwide, and organizations of all sizes, in virtually every industry on earth, were hit, says Online Trust Alliance (OTA), a subsidiary of the Internet Society. These attacks affected shipping giant Maersk to the ride-sharing giant Uber, all the way to Equifax, a credit rating agency recognized as one of the largest proprietors of private customer data in the world.

The devastating impacts of cyber intrusions range from exposure of sensitive information, financial incursions, reputational damages to loss of customers, bankruptcy, and sometimes closure. A recent report by the International Business Machine Corporation (IBM) suggests that the average financial impact of a data breach is \$3.9 million, but for

companies at the enterprise level with at least a thousand employees, it can reach ten times or even over 100 times that number. Google and McAfee estimate 2,000 cyber-attacks every day around the world, costing the global economy about £300bn annually.

These financial losses arise from the theft of corporate information, financial data (e.g., bank details or payment card details), funds, the disruption to trading (e.g., inability to carry out transactions online), or loss of business or contract. Ransomware is another common cause of financial loss as it involves the extortion of large sums of money from companies by cyber attackers. These attackers then threaten to expose vital information such as crucial consumer, employee, and tactical data public unless a ransom is paid. According to SafeAtLast, the average cost of a ransomware attack on businesses is \$133,000. Organizations that encounter cyber breaches will also generally incur expenses associated with repairing affected systems, networks, and devices.

On the other hand, there is the cost of protection. Companies aware of the dangers of cyber-attacks must protect themselves from online thieves, and to do so, they must pull out their wallets. Identifying risks, constructing new and safer operating procedures, and buying protective software and hardware all come at a cost. Businesses that handle complex or sensitive operations often spend more because they need to hire a cyber-security consultant to develop a customized solution. Not only are the upfront costs of protection expensive, but the systems must be continually tested and monitored to ensure that they are still effective against rapidly evolving cyber-attacks. Customers usually bear the burden of these costs through higher prices of goods and services.

Today, there is an emerging subculture in the cybercrime space: the cyber-activist or hacktivist. According to experts, they are the online equivalents of protesters who chain themselves to buildings or trees. They aim to disrupt and shut down a company's online operations to send a message about the company's business practices. In the last decade, giant organizations, such as PayPal and MasterCard, were affected by these criminals. For instance, in December 2010, the PayPal e-commerce website was attacked by dozens of hackers claiming to be

part of the hacktivist group Anonymous. They attempted to execute a denial of service (DoS) attack in retaliation for PayPal shutting down payment services to WikiLeaks, an NPO that publishes news leaks and classified media provided by anonymous sources. While PayPal did not experience a full shutdown, many other businesses aren't so fortunate. A DoS attack results in fewer sales as it prevents customers from reaching the company's online checkout or accessing a company's online store. On a long-term basis, it can lead to less revenue or reduction in profit if customers decide to no longer do business with a company vulnerable to attack.

Aside from financial burdens and costs, cyberattacks can also damage a business's reputation and erode customer trust. The importance of an organization's reputation can't be overstated—a good reputation encourages customers and clients to continue their business transactions with a company and attracts new and potential customers. Deloitte's 2014 global survey of over 300 executives on reputation risk found that security (physical or cyber) was one of the three critical drivers of reputational risk. Similarly, the findings of a recent study by Alva Group on the reputational impacts of three data breaches suffered by TalkTalk established that data breaches do indeed negatively affect a company's reputation.

The research also pointed out an incremental reduction in stakeholder trust when a company is repeatedly exposed to the same risk. Hence, the reputational dent caused by a cyber breach can also negatively affect a company's relationship with third parties or stakeholders such as suppliers, partners, and investors. According to a study conducted by a group of British researchers, reputational impacts can also include losing key staff and intense negative media scrutiny. Furthermore, data breaches lead to customer lawsuits, fines, and regulatory sanctions. In the event of a data security breach, customers can lay claims in cases where their personal data or confidential information has been released. Consumers sue on the ground that they were promised their information would remain secure, but the defendant companies failed to deliver. In some instances, a defamation claim may also be involved, in which a data breach ruined an individual's

personal reputation. The result has been millions of dollars paid out by companies each year, and many of these businesses never recovered.

6.2 Impacts on Workforce

The economic and social impact of the COVID-19 pandemic left no industry untouched. With many nations' shelter-in-place orders and self-distancing restrictions forcing workers and social interaction online, the importance of cybersecurity at all levels of our networked world is particularly highlighted. Since mid-March 2020, when the crisis rampaged throughout the United States, the online tools, apps, devices, and networks we now use every day are at greater risk than ever. This is why the Cybersecurity and Infrastructure Security Agency (CISA), an agency within the Department of Homeland Security, published its guidelines for cybersecurity professionals as essential workers during the crisis. Responding to the CISA guidelines, John Miller, Senior Vice President of Policy for the Information Technology Industry Council (ITI), says, "Workers across the information technology sector are playing a more essential role than ever in enabling critical infrastructure, helping businesses stay online, and keeping citizens connected." As a result of the critical roles they're playing during the global pandemic, the demand for qualified cybersecurity personnel is higher than ever. These personnel include engineers, technicians, and managers who are skilled in the analysis, deployment, implementation, and maintenance of cybersecurity systems.

However, there is a serious gap in the cybersecurity workforce. According to an article by Tripwire, the shortage in the US alone is already estimated at around 500,000 qualified workers. Citing the (ISC)2 Cybersecurity Workforce Study, the report says the cybersecurity workforce needs to grow by 62% to meet the current demand of US businesses. On a global scale, the sector is estimated at 4.07 million, so the global workforce needs to grow by an estimated 145%. "Cybersecurity jobs are in high demand but, as many organizations are all too aware, it continues to be a real struggle to find the right candidates with the right skills and experience to meet the demands of these roles,"

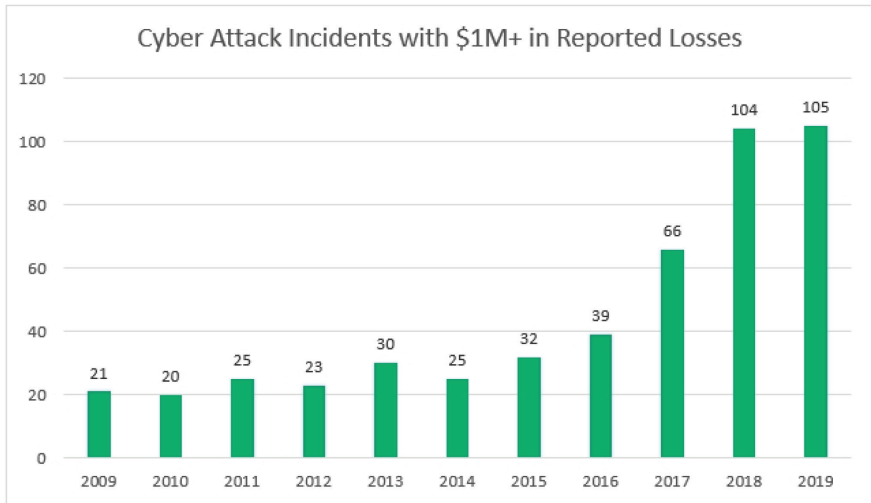
says retired Brigadier General Greg Touhill, ISACA board director and head of the AppGate Federal Group. Borrowing from the words of Sandy Dunn, chief information security officer for Blue Cross, most cybersecurity candidates “lack good communication skills, proper understanding of security architecture, awareness of risk as a discipline, project management knowledge, and critical thinking skills.”

To meet this ever-increasing demand and fill the skill gap in the face of these new realities, experts underscore the urgent need for a trained workforce of STEM technology professionals. Companies must also embed themselves in the college curriculum and partner with college educators to influence the skills required in a cybersecurity program. On a grimmer note, employees are among the most significant vulnerabilities to cybersecurity attacks perpetrated against companies. Believe it or not, the number-one threat to cybersecurity is workers leaving laptops and mobile devices unattended in vulnerable places, such as public transport, cars, and restaurants. They're practically rolling out a welcome mat for hackers, putting the company's network and data at risk—especially if they use weak, easy-to-guess passwords or store crucial information on the local hard drive instead of the server. Many companies have incorporated IT security policies to mitigate these cyberthreats, but merely having a policy in place isn't enough. Organizations must adopt a proactive and continuous approach to educating their entire workforce about cybersecurity threats and countermeasures before someone or something compromises their systems, data, reputation, or even livelihood.

6.3 Impacts on Societies

The scourge of cybersecurity threats has not left any facet or sector of society unscarred. Businesses, health and education institutions, the defense sector, governments, nations, and individuals alike have all be devastatingly affected by this growing trend. Over the past decade, the Center for Strategic & International Studies (CSIS) has tracked 490 significant cyber-attacks on government agencies, defense, and high-tech

companies that have resulted in losses that exceed \$1 million. The image below illustrates these findings.



According to the White House, in 2016 alone, malicious cyber activity cost the US economy between \$57 billion and \$109 billion. A report by the US Cyberspace Solarium Commission revealed that the country faces multiple threats from cybercriminals and nation-states ranging from IP theft that hinders long-term growth to critical infrastructure attacks, ransomware, espionage for geopolitical advantages, and attacks designed to undermine democratic institutions.

Cyberattacks are also on the rise in the healthcare industry, and the most problematic vector is ransomware. According to a report by HealthCareITNews, more than 4,000 ransomware attacks occur daily, and healthcare is the largest target. The healthcare industry increasingly relies on technology with internet access, ranging from patient records and lab results to radiology equipment and hospital elevators. While this is good because it facilitates data integration, patient engagement, clinical support, and generally improves patient care, these technologies are often susceptible to cyberattacks, which can siphon off patient data, hijack drug infusion devices to mine cryptocurrency, or shut down an entire hospital until a ransom is paid. In 2019, the healthcare industry lost an estimated \$25 billion due to cyberattacks, says SafeAtLast.

Examining the impacts of the COVID-19 pandemic on global cybersecurity, researchers from The World Economic Forum have pointed out that this crisis shows that the world is far more prone to disruptions by epidemics, cyber-attacks, or environmental tipping points than history indicates. Hence, a cyber-pandemic is inevitable. According to the researchers, we should expect a future global cyber-attack with characteristics similar to the coronavirus that would spread faster and further than any biological virus. The cyber equivalent of COVID-19 would be a self-replicating attack using one or more "zero-day" exploits, methods for which mitigating patches and specific antivirus software are not available. Most likely, the attack will affect all devices running a single, standard operating system or application.

Because zero-day attacks are rarely detected immediately, it would take a while to identify the virus and even longer to stop it from spreading. Suppose the vector was a popular social networking application with, say, 2 billion users. In that case, a virus with a reproductive rate of 20 may take five days to infest over 1 billion devices, according to a report by Arizona State University (ASU). If cyber-COVID mirrored the pathology of the novel coronavirus, millions of tools would be taken offline in a matter of days. The only way to stop the exponential growth of cyber-COVID would be to entirely disconnect all vulnerable devices from the internet (and one another) to avoid infection. As a result, the whole world could experience cyber lockdown until a digital vaccine was developed. All business communication and data transfers would be halted, and social contact would be reduced to people contactable by in-person visits, copper landline, snail-mail, or short-wave radio.

Based on a calculation system by the Netblocks organization and the Internet Society, a single day without the internet would cost the world more than \$50 billion, and a 21-day global cyber lockdown could cost over \$1 trillion. Recovery from the social and economic impacts of the widespread digital shutdown and destruction would be arduous. The research reckons that replacing only 5% of the world's connected devices would require about 71 million new devices. And it would be impossible

for manufacturers to rapidly scale up production to meet demand, especially if manufacturing and logistics systems were affected.

Conclusion

The ubiquity of cybersecurity attacks and malicious intrusions pose a threat to us all. Their impacts are devastating and far-reaching and can disrupt operations at every level of society. Despite the frightening statistics and facts around these threats, many companies and individuals still take them for granted. Based upon expert consensus, the cybersecurity trends and impacts will continue to expand in years to come, but in a much greater magnitude. The COVID-19 pandemic provides insight into how stakeholders and relevant leaders can prepare for the impending dangers. To do this, public and private sector leaders should anticipate these cybersecurity risks and invest in scenario exercises to reduce reaction time and appreciate the range of strategic options in the event of an attack.

CHAPTER 7

Virtual Reality (VR) and Augmented Reality (AR): Where Dreams Becomes Reality

When we get to this [AR] world, a lot of the things we think about today as physical objects, like a TV, will be \$1 apps in an AR app store.”
- Mark Zuckerberg

Immersive technology, the all-inclusive term for describing augmented reality (AR) and virtual reality (VR), is rapidly changing the way we interact among ourselves and how we experience the world. These technologies have moved on from enabling millennials to chase and catch Pokémon to revolutionizing communication, enhancing business operations, transforming travel and shopping, and improving medical and military training. Decades ago, we could only speak to our friends who lived far away via phone calls. Thanks to the internet and video conferencing software, we can now see our friends and enjoy an enhanced communication experience. However, VR multiplies this linear communication medium a hundred-fold. With VR goggles, you could have a weekly poker night with friends from college who live in five different states and "sit down" with your parents who live 400 miles away to reminisce about your childhood.

In 2016, VR was utilized by the United Kingdom's National Autistic Society (NAS) to address some of the challenges faced by people living with autism. According to UK surveys, while 99% of people have heard of autism, only 16% understand what it means and more than a quarter of autistic people have been asked to leave a public place, such as a restaurant, due to their condition. To foster understanding and develop empathy for autistic people, the NAS made a VR film that mirrored what it was like to live with the ailment. The film takes viewers on a journey with a young autistic boy as he walks around a shopping center and allows them to experience the sensory overload of his experiences. At the same time, Alzheimer's Research UK also released a VR film intended to put the public in the shoes of someone with dementia. With global revenue spending of \$5.2 billion in 2016 and projections of \$20 billion by 2021 according to the International Data Center, soon everyone will be impacted by AR and VR to some degree.

Despite the successful and notable applications of AR and VR over the years, not many people grasp their meaning and *modus operandi*. So, let's explore it. Everything that we know about our reality comes by way of our five senses: taste, touch, smell, sight, and hearing, plus other unique perceptive systems such as a sense of balance. Hence, our entire experience of the world around us is simply a combination of sensory information and our brains' sense-making mechanisms for that information. It stands to reason, then, that if you can provide your senses with made-up data, your perception of reality would also change in response to it. You would be presented with a form of reality that isn't really there, but from your perspective, it would be perceived as real. This is the concept behind virtual reality—computer-generated content designed to simulate a real presence through senses. Technically, it is a user interface, but one entirely unlike the traditional interface of a computer, phone, or tablet. A VR interface immerses a person in a digital 3D environment where the user can interact and explore its features. Imagine playing a car racing game, but this time you are not just controlling the vehicle, you are *in* the car.

A VR simulation requires two major components: a source of content and a user device—i.e., software and hardware. Standard VR

systems today include headsets, all-direction treadmills, special gloves, goggles capable of providing realistic, natural, high-quality images, and interaction possibilities. With a headset, the source of content is usually a PC that transfers images to be displayed on the headset's screen via an HDMI cable.

Augmented reality, on the other hand, is like VR with one foot in the real world. In other words, AR simulates artificial objects in the real environment, whereas VR creates an artificial environment to inhabit. AR applies algorithms and sensors to detect the position of the camera and then overlays 3D graphics/objects into a user's view via smartphones, glasses, or other projections. For AR to function optimally, it must have access to a suitably powerful processor, a feasible display or monitor, several different types of sensors, and input options. Snapchat filters, used to enhance or alter the physical features of the environment being captured, are typical examples of AR applications. AR and VR fall under a branch of technology called Extended Realities (XR).

The foundations of AR and VR can be traced to 1838 when Charles Wheatstone invented the stereoscope. This innovation used a pair of separate images, depicting left-eye and right-eye views of the same scene, creating an impression of a single three-dimensional image for the viewer. Since then, the technology has rapidly evolved but has largely stayed on the fringes of society. However, in the past few years, AR and VR have experienced a renaissance due to advancements in graphics and computing technologies, according to a recent infographic from HistoryDegree.net and NowSourcing. Big brands such as Facebook, Samsung, Microsoft, and Google are pioneering developments in the AR and VR industry. Facebook acquired Oculus, a VR game company, in 2014 and since then has been producing consumer headsets such as Oculus Rift and Oculus Quest. These headset lines are helping gamers and designers reinvent their interface. Google also uses VR and AR-enabled apps on its platforms. Google Translate, for example, utilizes AR to translate languages on the fly whenever a user points his or her smartphone camera at a sign, page, or screen written in a foreign alphabet.

Currently, there are an estimated one billion global AR users according to New Gen Apps. Emarketer anticipates that in the US, 52.1 million people will use VR, and 83.1 million will use AR at least once per month before the end of 2020. This encompasses 15.7% and 25% of the population, respectively. Based on a recent report by marketresearch.com, the adoption of VR products was valued at \$1.37 billion in 2015 and is expected to reach \$33.9 billion by 2022. On the other hand, the overall AR market was estimated at \$2.35 billion in 2015 and expected to increase to \$117.4 billion by the year 2022. However, experts argue that the growth of VR will be contingent on three factors: the improvement of the technology, consumers adoption rates, and application development. Presently, VR devices have only been able to successfully create simulations that fulfill the senses of sight and hearing. But if VR can master all five senses, it's hard to imagine a world without it. Consumer adoption goes hand-in-hand with application development. As more people start using VR, there will be greater incentives for tech companies to design applications.

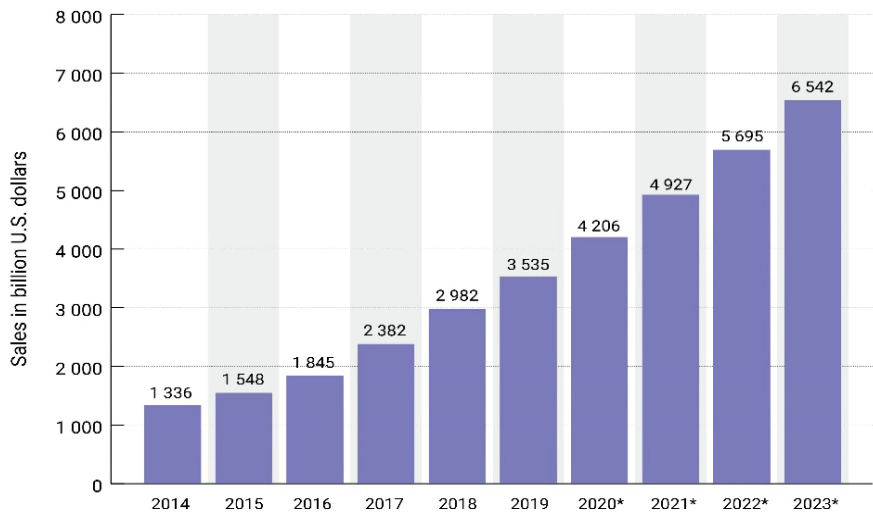
Commenting on the future of AR, Tim Bajarin, tech industry consultant, says, “For AR to become truly useful, somebody will have to make a platform for it that could host a variety of apps and services.” This means that the full potential of AR technology can only be realized when it is applied as a significant component of a mobile device instead of an afterthought. As per trends, experts anticipate increased AR activity in digital marketing, e-commerce, geolocation, and military and health industries in the years to come.

7.1 Impacts on Business

Forward-thinking businesses are already leveraging VR and AR technologies to improve their internal processes and create an enhanced customer experience. This competitively-differentiated customer experience provides the opportunity for significant growth and market-share gain. According to a recent study by Statista, 35 percent of business executives surveyed had adopted augmented or virtual reality

(AR/VR) technology into at least one business unit, with 13 percent having adopted the technology across multiple departments.

Retail e-commerce sales worldwide from 2014 to 2023 (in billion U.S. dollars)



Presently, these technologies are disrupting the retail sector by revolutionizing the way consumers choose and buy products. It accommodates large corporations and SME businesses and enables them to expand their customer reach on a global scale. During the last five years, the total amount of purchases has increased by sixfold, indicating revenue growth for giant and start-up companies alike. In 2019, retail e-commerce sales amounted to \$3.5 billion, and e-retail revenues are projected to grow to \$6.5 trillion by 2023. Analysts suggest that VR and AR technologies can significantly improve e-retail market share if adequately adopted. ABIResearch's virtual reality market report shows VR and AR are estimated to generate \$1.8 billion in the retail and marketing segments in 2022.

These immersive technologies offer improved customer engagement and involvement. AR can offer in-store navigation to customers, help

them find the products they are looking for, and provide detailed information on products they want to purchase. Virtual reality takes customer engagement to the next level by providing them with virtual tours of the store from the comfort of their homes. While AR can be leveraged to project the products in the real world, VR headsets can provide an immersive buying experience, thereby entirely transforming the way we look for, buy, and sell products online. Besides increased sales, a positive AR and VR experience can lead to high customer return rates, which usually translate into increased customer retention and profit margins. Augmented and virtual reality also generated accurate data on consumer preferences that help retailers provide curated shopping options to its customers.

According to a study cited in Bizreport, nearly two-thirds (61%) of the 1,000 U.S adults surveyed said that AR has influenced where they shop. With spatial awareness of augmented reality, furniture retailers can apply this technology to assist customers in finding the right furniture according to their apartment space. Shoppers can project the exact size or gauge the color and style of the furniture to determine if it will fit into a particular place or suit their interior décor. Giant retailers like Ikea and Amazon have already provided augmented reality-assisted buying options for their consumers.

Experts believe that VR is particularly useful for marketing because it creates an opportunity for businesses to establish a strong emotional connection between target consumers and their products. Commenting on the efficiency of VR as a marketing tool, Maria Korolov, editor and publisher of business tech publication Hypergrid Business, says "You take a little bit of your product, put it into a virtual environment and have people use it. It's particularly popular with movies. You get the eye contact; you feel like you're in a different location."

The enterprise impact of VR and AR also includes enhanced working spaces and better ways to work remotely. Besides enabling virtual meetings with teams across the world (which is already happening on a broad scale), VR technology is improving business procedures from design to development. Using VR modeling tools to design a product—

such as a car, a computer, a space station, etc.—allow companies to predict how a new concept might perform before actually producing it in real life. As reported by CNN, military-hardware producer Raytheon uses a VR product-simulation chamber called a CAVE to help engineers and designers interact with a digital prototype. Thus, virtual prototyping saves time and cost in industries and means mistakes are discovered early.

One of the major obstacles of AR and VR adoption in the business space is cost. However, as the Extended Reality industry advances, its price point will drop, enabling more businesses to employ VR and AR techniques. Moreover, Kirwan McHarry, marketing director for drone manufacturer Mota Group, predicts that VR sensors will become smaller and lighter in the future while computing power will increase. "This could mean greater image fidelity, more precise motion detection, along with lighter weight and lower cost," McHarry said. "Another development may be the increased adoption of very lightweight goggle frames, such as the carbon-fiber headsets used in aviation." If McHarry's prediction is correct, VR and AR will rapidly develop into a powerful tool that can be coupled with the genesis of "smart objects" in the IoT to create a radically different business landscape than the one we're used to today.

7.2 Impacts on Workforce

AR and VR offer endless possibilities and opportunities in the workplace, ranging from improved training experience to reduced cost of training, enhanced productivity, and customer service. Employee training is often a complicated process, and it can become costly if the employee makes mistakes or damages a piece of equipment during the training process. Besides money, training also costs time and effort. Companies can employ VR and AR to mitigate these risks and cut costs. With VR technology, workers can be immersed in a simulated real-world environment where they will be trained to react to various situations, like helping customers find a particular product or operating a conveyor belt. Since 2017, retail giant Walmart has used VR applications to train and assess the skills of its employees. The

applications incorporate 360-degree video taken from one of the stores that test the ability of an employee to solve interpersonal conflicts unfolding in front of them. The trial helps managers evaluate the social skills of an employee and how he or she might deal with a problematic customer without the need for any real-life drama. Similarly, the celebrated automobile manufacturer Porsche uses VR training processes to educate their employees about the various components that make electric vehicles work.

As mentioned in the introduction of this chapter, virtual reality possesses the ability to help people empathize with others, and businesses can leverage this technology to improve the relationship between employees and customers. By creating VR experiences that simulate the daily life of prospective buyers, workers can learn to understand the customers and provide better services. Presently, companies make employees conduct live interviews, listen to recorded phone calls, or take over customer support channels in a bid to get closer to consumers. However, in the future, organizations will simply ask employees to regularly watch recorded VR experiences.

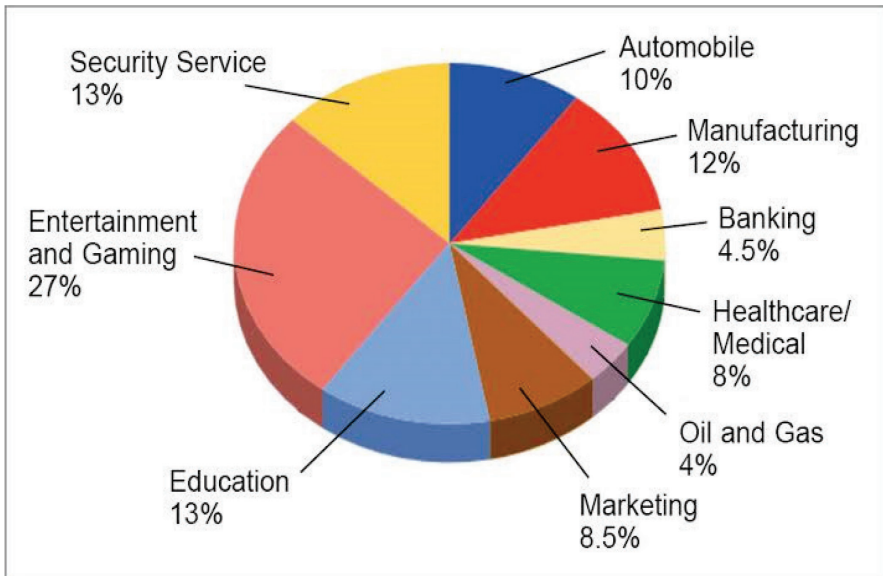
The COVID-19 pandemic has drastically disrupted the traditional office model, as many employees are mandated to work from home, and this trend is expected to continue beyond the epidemic. According to a Conference Board survey, 77% of respondents (company executives) predict that the number of employees working primarily from home (at least three days a week) will increase post-pandemic. Experts believe that VR will further accelerate the remote-working culture by making it easier for employees to connect digitally. Facebook is already using this technology to creating virtual chatrooms.

While there are many advantages of adopting XR techniques in the modern workforce, some disadvantages exist. A recent study cited in the Economist suggests that video games are responsible for a major decline in workforce participation. The study found that a significant portion of young men who play video games had chosen to work less and play videogames more, and as a result, this group will likely live at home longer and marry later in life. Now, think of the impact VR videogames

could have on the same segment of the population. There is a possibility that today's collection of VR videogames could cause even more young people to drop out of the workforce or to work less than they do today.

7.3. Impacts on Societies

AR and VR are rapidly changing the way we learn, work, and play. Today, these technologies are having massive impacts on various industries and practical fields including healthcare, military, education, entertainment, gaming, and so on. However, the gaming and entertainment sector is the by far biggest adopter of AR and VR techniques, as illustrated in the image below.



AR in the gaming industry incorporates advanced features that make games extremely addictive. VR, on the other hand, provides many benefits to its gamers, such as offering appealing virtual objects and possesses the capacity to take the user into the game of real-time. These benefits have enriched the gaming environment and have introduced the digital world into reality which has boosted the attention and retention of gamers. As of 2019, the global virtual reality in gaming market size

was valued at \$11.56 billion in 2019 and is expected to grow at a compound annual growth rate (CAGR) of 30.2% from 2020 to 2027

In healthcare, VR is used as a teaching aid and to treat mental illness. Due to its interactive nature, medical and dental students have begun using VR to practice surgeries and procedures, enabling a consequence-free learning environment; the risk of inflicting harm or making a mistake while practicing on real patients is eliminated. Virtual patients are used to allowing students to build skills necessary for real-world applications. Using VR technology in the medical industry is an effective way to not only enhance training skills but also provide an excellent opportunity to optimize costs, especially since the health sector continuously faces financial constraints due to tight budgets.

VR is also used as a primary method for treating post-traumatic stress, anxiety, phobias, and depression. Using Virtual Reality Exposure Therapy (VRET), for instance, a person is immersed in a simulated version of a past traumatic event in an attempt to come to terms with the event and heal. According to the recently published market intelligence report by BIS Research, the AR and VR market in healthcare is projected to reach \$11.14 billion by 2025, up from \$2.14 billion in 2018.

These revolutionary technologies are also utilized in improving teaching and learning processes in the education sector. Thanks to VR, students can interact with each other and within a three-dimensional environment. VR also supports virtual field trips—for example, exploring a famous museum, taking a tour of the solar system, or going back in time to different eras in history. Research has found that VR can be particularly beneficial for a student with special needs such as autism. One study found that VR can be employed as a motivating platform to safely practice social skills for children, including those with Autism Spectrum Disorders (ASD).

The military in the UK and the US have both embraced virtual reality in their training as it allows them to undertake a wide range of simulations. Today, VR is used across all branches of the military and can transport a trainee into several different situations and environments

for a range of training purposes, including flight simulations, battlefield simulations, medic training, vehicle simulation, and virtual boot camp. By offering a completely immersive visual-and-sound-based experience, VR can safely replicate dangerous training situations to prepare and train soldiers without putting them at risk until they are ready for combat. Similarly, it can also be applied to teach soldiers softer skills such as communication with local civilians or international counterparts when out in the field. A significant benefit of using virtual reality technology in the military is the reduction in costs for training.

Conclusion

Virtual reality and augmented reality are here to stay. Experts anticipate the continued advancement and adoption of these technologies in the future as more people and businesses catch wind of their benefits. VR and AR will soon become more prevalent outside of the entertainment industry as it evolves into corporate business solutions, the retail sector, and even real estate. It is also going to have a far-reaching impact on our education system. Like every other invention, immersive technology is accompanied by challenges, and those peculiar to it include escapism, anti-social behavior, gaming and pornography addictions, and suicide, among others. Parents, teachers, tech leaders, governments, and other primary players must be aware of these dangers and work collaboratively to tackle them.

CHAPTER 8

Blockchain: Faster, Safer and Most Reliable Transactions in Real-Time

“In the blockchain world, each user can and should own their data, and 'central' players are less vulnerable to data losses and breaches.”
- William Mougayar

Blockchain is an evolving technology poised to have enormous impacts across numerous industries, from supply chains, financial services, healthcare, to government and education. As we discussed in the last chapter, IoT devices, social media platforms, and cloud storage spaces are vulnerable to cyber-attacks, but thankfully, much of this risk can be averted through Blockchain technology. The fundamental structure of blockchain technology—which includes a decentralized system that stores information in repositories scattered across the internet, immutable transactions, a digital signature of participants, and encryption—makes it a highly secure platform. In other words, blockchain protects endpoints, user identities, transactions, and critical infrastructures.

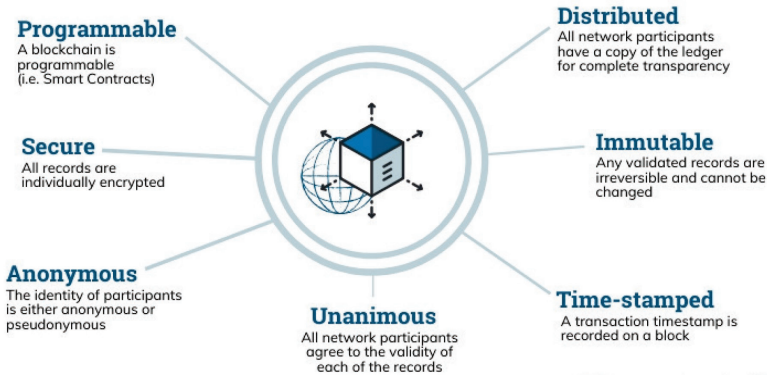
Blockchain technology came to the limelight with the introduction and successful deployment of the world's first cryptocurrency, bitcoin. While many people are aware of bitcoins and the new digital monies, only a few grasps the intricacies of the technology behind it. Technically,

blockchain is a type of distributed ledger technology (DLT) in which transactions are recorded with an immutable cryptographic signature, duplicated, and distributed across the entire network of computer systems. This means that information held on a blockchain is protected by a code and exists as a shared and continually reconciled database stored in multiple locations. By being hosted on millions of computers simultaneously, its data is accessible to anyone on the internet and easily verifiable. Put in straightforward terms, blockchain refers to digital information (the "block") stored in a public database (the "chain").

Each block on the chain comprises various digital pieces of data. They include data on transactions like date, time, the dollar amount of a recent purchase, and information about who is participating in transactions, all recorded using digital signatures instead of actual names (i.e., a hash, or a unique identification code that distinguishes one block from another). A blockchain platform operates by adding blocks to the chain. For a block to be appended, a transaction must occur. The transaction details will then be verified by a network of computers stored in a block and given a hash.

Data stored on a blockchain is designed to be impossible to change. Any attempt to change a single transaction record would require altering all subsequent records across all of the distributed versions of the chain. If a hacker initiated this change, it would be immediately apparent that the system is being tampered with, thereby making the technology nearly impossible to hack. Besides immutability, transparency and decentralization are two other core properties of blockchain technology. The diagram below illustrates the essential features of any DLT.

The Properties of Distributed Ledger Technology (DLT)



© Euromoney Learning 2020

In the last decade, five major innovations have shaped the blockchain technology landscape and led to massive breakthroughs. The first was bitcoin's invention in 2009 by a man known only by the pseudonym Satoshi Nakamoto. Bitcoin was a digital currency experiment, created to be sent peer-to-peer without the need for a central bank or other authority to operate and maintain the ledger, much like physical cash. In the first year, the tender was worth \$0. Now, it has a total market capitalization of \$117.8 billion, according to a 2020 Q1 report by Statista.

Next came the separation of bitcoin from blockchain. This innovation was supported by the realization that the underlying technology that operated bitcoin had far-reaching potentials outside cryptocurrencies. Before this, blockchain and bitcoin were often thought of as the same thing, when in reality, bitcoin is an application built using blockchain's principles. Massive investment and research was poured into blockchain, and in 2014, attempts to repurpose the blockchain for use in healthcare applications, insurance, supply chains, voting, and more began in earnest. According to a report by IBM, 15% of 200 global banks surveyed in 2017 used Blockchain technology in some capacity.

The next great innovation in blockchain technology was Ethereum, a cryptocurrency introduced in 2013 which has grown to become the

second-largest market by market capitalization. This ledger was an improvement on bitcoin and included a feature known as “smart contracts” that allowed financial instruments and assets—like loans, bonds, goods, and services—to be represented instead of only the bitcoin's cash-like tokens. The Ethereum smart contract platform now has a market cap of \$25.17 billion as per the second quarter of 2020, with hundreds of projects headed toward the market.

Originally, blockchain mining was based on a system called “proof of work,” which rewarded miners with the largest computational power. Blockchain mining peer-to-peer computer process used to secure and verify bitcoin transactions. Mining involves Blockchain miners who add bitcoin transaction data to Bitcoin's global public ledger of past transactions. However, this system is cost-intensive, slow, and energy-consuming. To tackle these issues, developers like Ethereum have adopted a new mechanism called “proof of stake,” which is major innovation in the blockchain space.

The fifth major innovation is still in development and aims to solve one of the most significant limitations of the present blockchain landscape—scalability. The issue of scalability arises from the fact that every transaction made on blockchain is processed by every computer on the network, making the transaction speed slow. A scaled blockchain accelerates the process without compromising security by determining how many computers are necessary to validate each transaction and efficiently divide the work. Developers are currently working on a solution, and in fact, other cryptocurrencies like Ethereum have already partially solved this problem and offer much faster transaction speeds than bitcoin.

Thanks to these milestone achievements, blockchain is drastically transforming numerous industries and is regarded as the second most disruptive technology in recent times, after artificial intelligence and machine learning, says Gartner. As of 2018, blockchain's most prevalent use cases within organizations were in supply chain management and the Internet of Things (IoT). According to Compare Camp, the financial sector is heavily invested in blockchain technology, with a market share

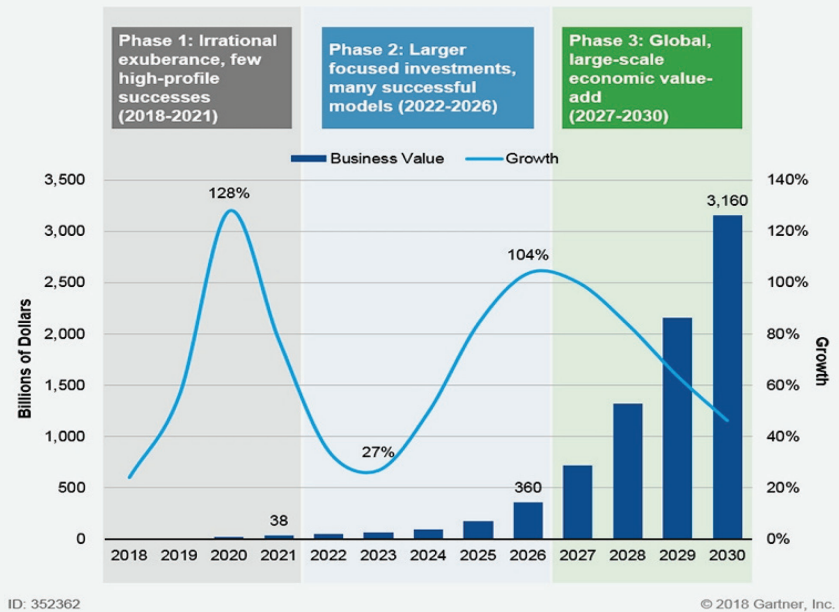
of 46%, higher than any other industry. This trend is expected to continue growing, and so is the market size. According to Statista, the global blockchain market size, which stood at \$1.2 billion in 2018, is forecasted to climb to \$39.8 billion by 2025,

Experts predict that most governments worldwide will create or adopt some form of virtual currency in the not-too-distant future as the global economy shifts from Web 2.0—based on the decades-long transition to digital business and online connections—to Web 3.0, the blockchain era. In the future blockchain era, the soon-to-be trillion-dollar firms such as Amazon, Apple, and Google will be replaced by trillion-dollar tokens—tokens that support a decentralized ecosystem of entities that together fulfill the role of the mega-corporation.

8.1 Impacts on Business

Unlike most modern technological innovations that are built to improve enterprise operations and processes, blockchain was designed to completely transform business models. Borrowing from the words of Jonathan Reichental, CEO of Human Future, “What makes [blockchain] different is that it is quite a provocative, disruptive tech compared with many other techs that have emerged in the last 10 to 15 years.” Today, many industry leaders have realized the disruptive and game-changing potential of blockchain technology and are already adopting it into their business space. According to a report from the International Data Corporation (IDC), blockchain spending is forecasted to reach approximately \$12 billion by 2022, up from an estimated \$2 billion in 2019. The diagram below illustrates the projected blockchain business value expected to reach \$3.1 trillion in 2030.

Blockchain Business Value Forecast, 2018-2030



Of all business areas, logistics and supply chain are the biggest beneficiaries of blockchain technology. Blockchain offers transparency, an invaluable asset to retail companies, particularly in supply chain management. By recording exchanges of goods on a blockchain, business owners can effectively trace who their vendor's suppliers are and where their products have been.

Every transaction stored on the platform leaves an audit trail. For this reason, Walmart uses blockchain to keep track of their pork, where it came from, where it was processed and stored, and what its expiry date is. According to Forbes, Unilever and Nestle have also adopted the innovation for similar logistical tracking. Incorporating transparency into the supply chain also helps verify things like ethical sourcing and the authenticity of parts. Besides transparency, blockchain increases the efficiency of the supply process (from warehousing to delivery to payment) and promotes effective communication among significant parties. In light of this, BHP Billiton, the world's largest mining firm, announced in 2018 that it would use blockchain to track and record data throughout the mining process with its vendors.

Another significant advantage of Blockchain is its ability to lower the cost of operations. Blockchain enables businesses to send and receive payments through a programmatic set of rules called "smart contracts," which removes expensive brokers, escrow agents, and other financial intermediaries from the equation. Since all actions related to a particular smart contract are transparent and recorded, the cost of tracking and reconciliation is also reduced. For example, by applying Blockchain in the distribution of pharmaceuticals, companies can eliminate the cost of taking excessive steps or having too many brokers along the supply chain. Blockchain is also promising for global corporations as basic administrative functions like payroll management could be executed seamlessly across different countries. Furthermore, recent studies cited in The Financial Times revealed that the asset management industry could cut costs by \$2.7 billion every year by moving to blockchain. Practical use cases of blockchain in the financial services industry include client screening and onboarding, recordkeeping, data privacy and security, and trade processing. Similarly, the insurance industry is rife with errors and costly mistakes. The FBI estimates that over \$40 billion a year is lost through fraud across all non-health insurance sectors.

In the area of marketing and advertising, executives can take advantage of blockchain's enhanced protection to ensure their marketing ROI doesn't suffer as a result of fraudulent activities. Studies by Juniper Research suggests that advertisers lose over \$50 million every day to fraudulent activities such as click fraud. This cybercrime is at the heart of the issue, costing many companies massive sums to expand their markets in the digital age. According to experts at Accenture Interactive, the principles of this technology designed to prevent banking fraud can also be applied to media buying. Additionally, utilizing the system to manage budget spending, remove intermediaries, and prevent fraud can increase efficiency and reduce the risk of overcharging and underperformance. IndaHash, an online platform that helps brands reach digital influencers, is an excellent example of how blockchain can transform marketing. It facilitated the deployment of authentically branded campaigns in a swift and scalable manner by directly connecting brands and influencers.

The reinvention of companies like Kodak One and NagriTech is a pragmatic example of how blockchain is disrupting management and optimizing operations. Since the appearance of smartphones, the legendary camera-maker, Eastman Kodak, now known Kodak One, has been struggling to stay competitive. But with the help of blockchain technology, the company found a way to revive itself. They launched the KODAKOne management platform—a Blockchain venture that allows photographers to register licenses for their work, protecting against image theft. In a similar vein, NagriTech utilizes cryptocurrency to help farmers in developing markets like India and Mexico improve crop yields by tackling the problems of high inflation and regular currency devaluation through better regulated financial transactions.

Commenting on the future of blockchain in the business space, Dr. Michael Yuan, Chief Scientist of CyberMiles, a foundational Blockchain developed for commercial apps, says, "Future applications of this technology [would include] e-commerce marketplaces and applications, peer-to-peer finance and insurance transactions, content distribution, healthcare data exchanges, B2B accounting applications, supply chain, and customer service applications." The benefits of blockchain will be limited only by the imagination and effort of the visionaries who will use it to transform their organizations.

8.2 Impacts on Workforce

Experts anticipate drastic transformations in the global job market when blockchain fully incorporates into our economic environment. And as with every technological advancement, blockchain will put certain jobs at risk and increase demand for others. Because Blockchain by its very nature eliminates intermediaries or the so-called middleman, it is a threat to agents working in different industries, including real estate, traveling, and insurance. Other jobs likely to be endangered are those connected with office paperwork, banking processes, and all kinds of verification and certification. Blockchain will not need notaries or auditors because all the transactions will be automated. Some analysts

believe that the first sector to be hit will be reconciliation activities, as we will no longer need it.

However, experts predict that some will still be in demand as excellent human interaction skills never go out of style. Thus, if you have excellent communication skills or are extremely good at selling something, you might get some good deals in the future, too. But, if you are just starting out in your career, it is best to avoid becoming a middleman in those fields—in a few years, you might face strong competition with remaining experts because most customers will prefer to buy and sell real estate through the internet, much like we buy stuff on Amazon today.

Presently, professionals and specialists in AI and web services are in high demand due to the increasing adoption of blockchain technology. In a blockchain-powered future, there will be even greater demand for web-developers, data scientists, technical writers, and specialists in machine learning, security, and encryption. To prepare for this future, it would be wise to consider becoming a blockchain-related specialist, like a blockchain engineer or a blockchain project manager who can interact with companies seeking blockchain solutions for their business to adapt the technology to their platforms and needs.

Outside the tech-sphere, jobs that require good leadership skills, creative approaches, and the ability to solve problems and analyze information are all looking promising. According to a PwC roundtable of HR professionals and blockchain scientists, blockchain technologies will also have transformational impacts on HR functions. For instance, a recent study by CareerBuilder showed that 58% of employers had found false information on CVs from job applicants. Ensuring this type of information accuracy is still one of the most time-consuming tasks for HR, and is also one of the most expensive. By providing unalterable or "traced" digital records, blockchain technology speeds up and automates how employers check information about a talent's identity, facilitating better matches between talents and positions. This process will also boost productivity and efficiency for small-and-medium-sized enterprises (SMEs) who struggle to recruit the right candidates.

Blockchain is also poised to radically transform the way salaries are paid by making payments faster and instant. There are already existing blockchain solutions that facilitate real-time payments to contingent workers, such as members of the gig economy workforce like Fiverr. No payroll aggregators, no banks, no fiat currencies needed. But that isn't the full extent of the benefits for HR or workers; these innovations potentially expand talent reach. Payments on a blockchain will occur in real-time—and if desired, through an internationally standard cryptocurrency—which will appeal to talent pools that were previously inaccessible because they were too distant or because their identity and experience couldn't be validated.

For new employees, blockchain doesn't only accelerate the salary payment process; it could also get them off to a flying start with their new job by simplifying one of the most frustrating and time-consuming aspects of taking up a new position—contracts. With smart contracts enabled by blockchain technology employees, can avoid many administrative protocols, such as identity checks, passwords, email templates, and checklists, which often considerably slow down new employees' progress during the first few weeks in their new role. It's this potential for speed, transparency, and decentralization—coupled with the massive reduction in transaction costs and operational risks—that makes this technology an attractive alternative to the way contracts are currently managed. Recently, the cloud service company Oracle disclosed its plans to adopt blockchain technology to improve its employees' workload efficiency.

8.3 Impacts on Societies

The impacts of blockchain technology and solutions on societies are numerous and far-reaching. With this technique, automated communication can become faster, safer, and more reliable. According to Matt Peterson, co-founder of Jive Communications and an early adopter and miner of bitcoin, while a lot of communication is currently automated, this type of communication is generally non-critical and asynchronous. He also said that "blockchains can shift the playing field to allow authorized, bi-directional communications and transactions

that occur more freely in an automated environment and produce an immutable record of communication."

Today, IoT devices include cars, buildings, doorbells, toys, refrigerators, and even drugs that are embedded with software, network connectivity, and sensors. However, because these devices operate from a central location that handles communications, hackers can easily gain access to the car you're driving, the home you live in, or the pills you take. Thankfully, blockchain has ability to address these critical security concerns because it decentralizes all of the information and data. This is increasingly more essential as the prevalence and capabilities of IoT devices expand.

Blockchain's security potential can also be used to foster and implement online voting. Blockchain ensures the vote is successfully posted and protects voter's anonymity, thereby addressing the biggest obstacle to carrying out a fair voting process today—security. In 2014, Denmark became the first country to employ blockchain in its voting, with the political party Liberal Alliance using it in a campaign. According to BitShares, a worldwide database, DPOS (Delegated Proof of Stake), leverages the power of stakeholder approval voting to solve consensus issues in a fair and democratic way. All network parameters, ranging from fee schedules to block intervals and transaction sizes, can be adjusted via elected delegates.

Digital identity works closely with digital security, a very significant issue in today's world. Verification of identity is essential to the integrity of the global commercial market. Blockchain technology functions in this domain to ensure security and increased efficiency in the management of digital identity, thereby decreasing fraud. This is highly valuable in the world of national security, healthcare, and digital retail. With its fool-proof technique of recording unchangeable transaction data, this technology can prevent common problems like database hacking and breaching of accounts.

Donating to a worthy cause is always a welcomed idea, but what percentage of your contributions are actually being given to those it's meant for? Blockchains can help ensure that your donations and other

charitable resources get to the desired destination. Bitcoin-based charities are already creating trust through smart contracts and online reputation systems, enabling donors to see where their donations go through a secure and transparent ledger. The United Nations' World Food Programme is currently implementing blockchain technology to track aid flow from source to destination.

Many authorities, including the ex-vice president of JP Morgan Chase, Pang Huadong, have posited that blockchain could help eradicate poverty, stabilize the world economy, or prevent economic crisis, and recent developments suggest that these assertions might be right. The ability to create savings and store value is a primary means of prosperity, but in developing countries, where access to banks can be difficult, Blockchain and other virtual currencies provide a way to store and transfer value that detaches people from traditional value stores, such as livestock or land that are susceptible to the perils of nature and other humans. For instance, if a poor farmer creates a digital wallet and trades his goods for digital currency, he develops a value store that can be saved or spent as he sees fit without fear of loss. All he needs is a mobile phone and a digital wallet to create a store of value that is better secured than his current alternatives.

According to Global Market Insights, the global Blockchain in technology healthcare market size, which was estimated at \$48 million in 2018, is expected to reach \$1.6 billion in 2025. Presently, the rising awareness of Blockchain technology's importance for the systematic collection of medical records and patient data is driving the Blockchain technology market value. Several health institutions and hospitals are already using the technology to analyze, record, and monitor patient information accurately. The increasing risks of cybersecurity attacks and data privacy, counterfeit drugs, and increasing demand for a secure and trustworthy identification system for patients are all expected to boost Blockchain technology adoption in the upcoming years. Based on this same report, cybersecurity and the internet of medical things (IoMT) will experience 62.6% CAGR between 2018 and 2025.

Conclusion

In the words of Michael Goldstein, president of the Satoshi Nakamoto Institute, “Bitcoin is not competing with Visa or MasterCard. Bitcoin is competing with the Federal Reserve and the US dollar.” So, the big question is: will the application of blockchain technology, such as cryptocurrency, be the end of fiat currency and the banking sector? While digital currency zealots like Pierre Rochard, member of the Satoshi Nakamoto Institute, believe that bitcoin will continue to cause all fiat currency from US Dollars to the Venezuelan Bolivar to fail, and will also cause the permanent closure of financial institutions. Experts like Mihail Lala, founder of Wawlet Enterprises Limited, posit that Blockchain technology will help banks, not kill them. According to her, banks are robust and reliable entities, much more than just intermediaries, and it is a utopia to assume that they will cease to exist. Rather than go extinct, they will be forced to quickly adapt, which the market will strongly demand.

CHAPTER 9

3D Printing: Digitalization of Entire Manufacturing Process

“The next episode of 3D printing will involve printing entirely new kinds of materials. Eventually we will print complete products - circuits, motors, and batteries already included. At that point, all bets are off.”

- Hod Lipson

3D printing is undoubtedly one of the most transformative elements of the digital era. Technology is poised to make our lives safer, cheaper, easier, and more convenient—and 3D printing offers all these and much more in very exciting fashions. Thanks to this revolutionary technique, you can now create your son's favorite toy, replace your door handle, or produce a customized cup or a phone case without purchasing any of these items. All you need is a 3D printer.

The impacts of these techniques also cut across various industries ranging from manufacturing and construction, architecture to healthcare, engineering to education. In the heat of the COVID-19 pandemic, many hospitals were overrun with COVID-19-stricken patients, and the global supply of personal protective equipment (PPE) and medical devices were dwindling. As a result, many healthcare facilities turned to 3D printing to supply their staff with much-needed protective equipment and the parts to fix their ventilators, empowering

hospitals on the frontlines of this deadly fight and saving many lives. With 3D printers, engineers in factories can create custom jigs and fixtures that save time and reduce injury during the manufacturing process. Communities can foster “maker spaces” that teach STEM skills and aid new startups, thereby creating new jobs and local opportunities.

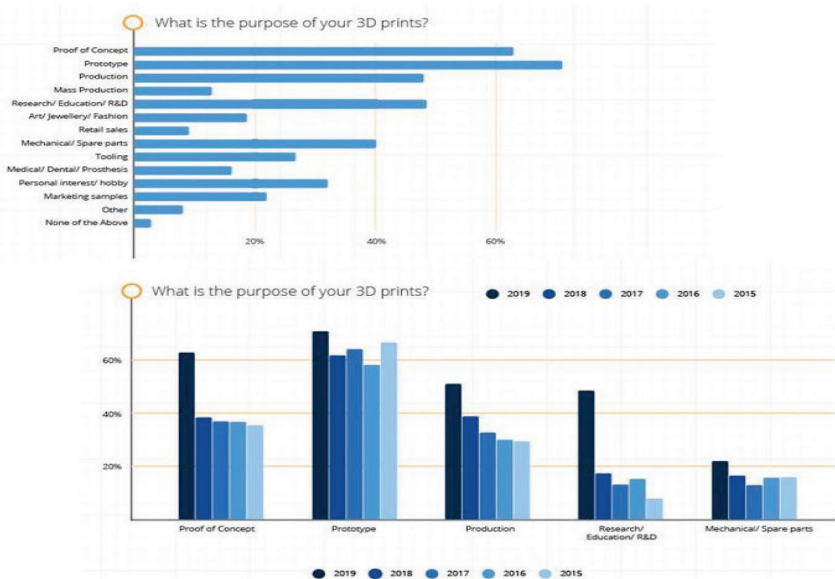
Insights from a Sculpteo study revealed that 93% of firms that employed 3D printing gained a competitive edge through reduced time-to-market and shorter production runs, as seen in the increase from 29% in 2017 to 39% in 2018. Given that 3D printing technology is already transforming many aspects of our lives, it is wise to understand the scope of this innovation, its current global state, and what the future holds.

3D printing, sometimes referred to as additive manufacturing, is a printing process that uses a computer-aided design (CAD) to create three-dimensional objects from a digital file via a layering or additive procedure. These objects have width, depth, and height, like any object in the real world, and can be fabricated in different sizes, shapes, rigidities, and colors. A typical 3D printer uses similar methods to a traditional inkjet printer but with 3D outputs. Like a document printer requires a digital document (a PDF or DOC file) for printing, a 3D printer requires digital design files of 3D objects, made possible by computer-assisted modeling. Modeling occurs on the 3D software, CAD, which allows for the creation of accurate, intricate, and delicate designs and enables printers to customize products down to the tiniest detail. This modeling software is particularly essential to an industry like dentistry, where labs use three-dimensional software to design teeth aligners that precisely fit the individual. It's also crucial to the space industry, where the software is being used to model the most vital parts of a rocket.

After modeling comes slicing. Since 3D printers cannot conceptualize three dimensions the way that humans do, engineers need to slice the model into layers for the printer to create the final product. Slicing software takes scans of each layer of a design and tells the printer how to move to recreate that layer. Slicers also give instructions to 3D printers on where to "fill" a model, which gives the 3D printed object

internal lattices and columns that help shape and strengthen the exterior of the object. Once slicing is completed, the actual printing process commences.

Before the invention of CAD and lasers, models and prototypes were laboriously carved from wood or stuck together from small pieces of cardstock or plastic. They could take days or even weeks to make and were typically cost-intensive. Making changes or alterations was difficult and time-consuming, especially if an outside model-making company was being used, which could discourage designers from making improvements. 3D printing was birthed to solve these problems. This technology creates models anywhere from minutes to a few hours, depending on the type of project. It allows for alterations and helps companies save costs on research and development for products.



As of 2019, a significant portion of global manufacturers increased their reliance on 3D printing as part of their broader manufacturing strategies, with production use up to 51% from 38.7% in 2018, according to Sculpteo's 5th edition study. The survey also revealed that 3D printing technology was predominantly used in the proof of concept and prototyping areas in manufacturing companies, as illustrated below. According to SmartTech Analysis, in the same year, the global additive

manufacturing market grew to over \$10.4 billion, crossing the pivotal double-digit billion thresholds for the first time in its nearly 40-year history.

Besides manufacturing, 3D printing is gaining rapid traction in the healthcare industry as investments skyrocket. The introduction of new materials, shorter lead times, innovative finishes, decreased prices of additive manufacturing-based machines, and growing expertise and technology advancements (such as AI and machine learning) are all contributing to the exponential adoption rates in the healthcare space.

On the other hand, many businesses reported file repairs, file preparation, machine setup, maintenance, job preparation, and quality control as some of the prevalent challenges of using their 3D printers. Despite these barriers, however, experts predict the expansion of the global 3D printing market in the future. According to the MordorIntelligence Market report, the 3D printing market's value is expected to reach \$63.46 billion by 2025, up from \$13.7 billion in 2019, rising at a CAGR of 29.48% over the forecast period. Commenting on future trends, Greg Paulsen, Director of Application Engineering at Xometry, says, "We'll see more software tools that help engineers design parts better for a given process. Besides improved and better-integrated designs, analysts forecast that 3D printing will soon become a mainstream technology for serial production.

9.1 Impacts on Business

The impacts of 3D printing in the business world are glaring and revolutionary. This technology has radically transformed manufacturing and production processes and disrupted the way manufacturers do business. A recent survey conducted by Jabil revealed that the number of companies utilizing 3D printing across a variety of applications rocketed dramatically from 27% to 52%. As mentioned in the introduction to this chapter, one of the primary advantages of 3D printing over traditional manufacturing processes is that it saves the organization a tremendous amount of time and money. A prime example

is the Volkswagen Autoeuropa. According to John Kawola, president of 3D printer maker Ultimaker, "The company turned to desktop 3D printing to create custom tools and jigs that are used daily on the assembly line, replacing an old process that required outsourcing and long lead times... Not only did 3D printing introduce a more cost-effective way to produce the tools, it gave time back to the company. The seemingly minor change saved \$160,000 in just one plant in 2016, and it's projected to save \$200,000 this year."

Besides lowering production costs, this disruptive technique helps companies to increase design flexibility. Take, for instance, the German luxury automaker Audi, which recently launched a 3D printing center in Ingolstadt and is currently partnering with the SLM Solutions Group AG, which specializes in metal additive manufacturing, to produce prototypes and spare parts. This development means that their new process not only can develop complex or rare parts at a significantly lower cost, but the 3D printing approach affords greater design freedom, even if a design component is meant to handle multiple functions in a vehicle.

According to experts, by reducing prototyping and production costs, 3D printing is driving innovation and entrepreneurship. The typical procedure for developing a custom product, such as a watchband or the sole of a shoe, requires that molds be made to cast or shape the desired design. Molds often cost thousands of dollars (with most projects requiring multiple molds), making it an expensive undertaking, especially for start-ups. Since molds need to be created before the product or market testing commences, they are sunk costs. Even if the product turns out to be a huge success, there's no way to recoup what was already spent. 3D printing eliminates this pricey step, as materials are printed directly onto a surface to create a product. Until recently, an entrepreneur might have had to spend upwards of \$100,000 to produce a prototype, but the operating terrain has changed, and that cost can now range from \$2,000 to \$4,000. Furthermore, by eliminating the need for molds and reducing the upfront cost of creating customized products, 3D printing technology gives manufacturers unprecedented freedom to tailor offerings to clients' specific requirements, which can

foster mass-customization, limited-edition collections, and enhanced customer experience.

Thanks to this technology, the Swiss fashion house AKRIS produced a special collection of architectural rings (printed in silver and polyamide) for their runway shows, while Ferrari Concept 3D-printed a short run of colorful eyewear for Paris Fashion Week. In a traditional setting, these projects would have required using conventional manufacturing processes, longer development, and production times substantially.

3D printing is also poised to change the supply chain and logistics industry. Since 3D printing technology allows for local manufacturing, it means that many parties and processes reliant on shipping in the past will no longer need it—or at least not for the same purpose. For example, a retailer that has long purchased products from outside their local area can utilize 3D printers to manufacture the products in-house, thereby bringing the products closer to consumers and relinquishing the support of logistics and shipping providers. This is particularly critical during times of geopolitical tension, like a trade war, when the cost of purchasing components globally can rapidly increase.

Experts predict that in the future, a hybrid version of manufacturing will exist. It will include large factories, larger numbers of smaller sites with 3D print farms, or printers being deployed in alternative locations, like service and support centers, distribution centers, or even people's homes. 3D printing will eventually become simple enough that most households will pull files and print a product with just a few clicks, like printing photos at home a mere ten years ago.

9.2 Impacts on Workforce

3D printing is part of a larger trend known as Industry 4.0, which comprises cloud technology, artificial intelligence, big data analysis, high-speed mobile connections, augmented reality, and other transformative digital technologies. According to a World Economic Forum report, 3D printing will be the leading enterprise technology

adopted in the coming years. Hence, its impact on the workforce is inevitable. The report reckons that in 2018, 71 percent of the production hours were made by humans and the remaining 29 percent by machines. However, it is estimated that in 2022 this hourly allocation will reach 58% and 42%, respectively. Automated processes such as 3D printing have the potential of reducing the manufacturing workforce, and it might also spell doom for retailers such as furniture sellers and other household goods peddlers who could be replaced by individuals who manufacture and sell furniture simultaneously using a portable 3D printer. Additionally, the increasing prevalence of affordable 3D printers is now driving the creation of freelance manufacturing opportunities. For example, websites like Shapeways allow anyone to open their own 3D print shop online, thereby offering a great opportunity for individuals who want to pursue modern manufacturing opportunities.

To escape being replaced by machines, up-skilling is imperative in the manufacturing space. The World Economic Forum posits that by 2022, no less than 54% of workers will require a significant increase in their skills and abilities; 39 % of workers will need additional training of six months, 9% from 6 to 12 months, while 10% will need to be trained for more than a year. In a recent PricewaterhouseCoopers report, Kent Rockwell, CEO of 3D printing firm ExOne, said, "I see manufacturing taking a profound turn with additive technologies in the next five years... We'll see elite job shops grow, and new start-ups grow. We'll also see blue-collar employees learn the technology and adapt and start wearing white shirts." Due to the reduction in upfront investment costs powered by 3D adoption, companies will be able to take on larger-scale jobs that require more complexity. In other words, even though this new technique will displace some workers, particularly in the traditional manufacturing process, it will simultaneously introduce new job opportunities for retrained employees and talents with the required skills. 3D printing designers, CAD modelers and technicians, hardware producers, software developers, and research and development professionals will be in high demand.

While today's workforce is working to adapt to a 3D printing-centric world, future generations will benefit from more educational

opportunities. Additive manufacturing is becoming a vital component of schools, and several post-secondary offerings are rapidly springing up. As of 2017, Youngstown State University became one of the only universities in the United States to possess all seven major additive manufacturing methods. New 3D printing technology facilities were opened at MSU Denver and Wichita State University. While EOS announced this year, it would expand its Academia program, promote powder-based 3D printing at universities and research institutions. Presently, the Phoenix School in Roseburg, Oregon, has incorporated 3D printing technology into its classrooms to teach students that previously struggled academically in conventional settings. Commenting on the growing trend, Dr. Adrian Keppler, CEO and Speaker of the Corporate Management at EOS GmbH, explained, "As a technology and market leader, it is essential for us to prepare the scientists and students of today for the professional requirements of tomorrow." Expect the next generation of workforce professionals to be well-versed in additive manufacturing fundamentals.

9.3 Impacts on Societies

As the world battles with the crippling effects of climate change and global warming, developers must look towards eco-friendly innovations. Thankfully, the inventors of 3D printing technology put this into consideration. 3D printing is a "greener," more energy-efficient approach that reduces waste, lowers the risk of overproduction and excess inventory, and limits the carbon footprint. Traditionally, goods are manufactured in totally different places from where they are consumed—and often on different continents. These goods have to be transported to the end consumer by plane, ship, train, or road, all of which burn fossil fuels and cause hazardous emissions to the environment. With the widespread adoption of 3D printing, however, most goods will be designed on computers and "manufactured" directly in consumers' homes, thus reducing both the costs and environmental effects of transportation. As the price of hardware and materials

continues to fall, the demand and supply of 3D printers will increase, thereby enabling a healthier environment.

3D printing technology is also employed in various medical applications to save lives and improve patient care. The use of 3D bioprinting in regenerative medicine and tissue engineering is already a growing trend—and for good reason. The shortage of organs is a major health crisis as the human population lives longer due to other medical advances. In fact, since 2013, the number of patients requiring an organ has doubled, while the actual number of available donor organs has barely moved, says HRSA. Regenerative medicine uses scaffolds, biomaterials, cells, or a combination of biomaterials and cells to attempt to create organs for transplants instead of relying on the current donor model. Presently, the creation of multilayered objects (tissues/organs) from soft biomaterials such as living cells and biomimetic synthetic polymers has been the most challenging technological advancement, and many problems need to be addressed for complex organs (such as the heart or liver) to be 3D bioprinted and subsequently transplanted into a patient. Simple organs such as the bladder, however, have been transplanted into patients since the early 2000s.

3D printing also offers an entirely new opportunity to develop and prepare personalized medicines at the pharmacy and industrial levels. Introducing 3D printers to pharmacies and hospitals would enable physicians, nurses, and pharmacists to form a dose and delivery system based on the patient's body size, age, lifestyle, and sex. This would make medicine specific to the patient and also save money and resources. Today, Aprelia Pharmaceuticals is the only company with a certified 3D printed drug, Spritam, which is used to treat epilepsy.

According to a report by GlobalData, poor, and developing countries can enjoy better access to affordable treatment as 3D printing becomes universal. By eliminating certain costs at the R&D and production stages, this technology can drive cheaper pharmaceuticals. As a result of these and other potential benefits, the global 3D printing healthcare market size was valued at \$973 million in 2018. It is projected

to reach \$3.7 billion by 2026, growing at a CAGR of 18.2% from 2019 to 2026, according to AlliedMarketResearch.

Similarly, 3D printing in education is witnessing remarkable growth. According to Technavio, the global 3D printing market in the education sector is projected to grow by USD 1.54 billion during 2020-2024, and the market's growth momentum will accelerate during the forecast period. In the education sphere, university students in Cleveland embarked on a heartwarming project powered by 3D printing technology to help disabled veterans continue with their cherished hobbies, while a university in India inaugurated a waste management initiative that will focus on teaching a 3D and 4D additive manufacturing course called Waste Management by Additive Manufacturing. This technology is being used by educators to enrich STEAM learning through 3D printing projects and curricula at lower levels.

Conclusion

From all indications, 3D printing is here to stay, and the only option is to embrace it and keep up with emerging trends. Perhaps the most disruptive attribute of this technology is its ability to transform consumers, low-skilled, and untrained workers into manufacturers that will dominate the manufacturing domain. According to Paul Heiden, SVP of Product Management for Ultimaker, “The future of additive manufacturing will not be in the hands of a select few engineers, but rather with any worker who have 3D printing experience. Software solutions enable those untrained workers to create parts and tools, closing their own personal skills gap and preparing them for a career in the future factory.” Soon, homes worldwide will be transformed into production hubs where individuals can produce and customize products as desired. To businesses, the possibilities are endless. However, all these won't be possible until the existing adoption barriers, such as quality concerns and costs, are effectively addressed.

CHAPTER 10

5G Network: Transforming Lives at High Speed

*"If you just think of speed, you don't see the magic of all it can do."
- Jefferson Wang*

Do you remember your first encounter with a high-speed internet connection? Do you remember how fast browsing, downloading, chatting, and streaming suddenly became? Well, it's about to get a lot faster with the introduction of 5G networks—in fact, up to 100 times faster than the current 4G technology, according to a report on Lifewire.com. The report posits that while existing 4G LTE networks at best can work at a speed of 12.5 MB/s (megabytes per second), 5G technology is predicted to deliver speeds of up to 2.5 GB/s (gigabytes per second), with some companies promising to push speeds even higher. According to Ericson, a major telecommunication company, 5G networks are projected to cover 40% of the globe and handle 25% of all mobile traffic data by 2024, taking mobile connectivity to a whole new level. However, the impacts of this technology will be felt very acutely in a number of industries and enterprises.

According to a World Economic Forum study, this innovation is poised to unlock massive possibilities for numerous businesses and organizations, including optimized service delivery, improved decision-

making, and enhanced consumer experience. 5G is a revolutionary technology that will enable the full realization of the positive impact of Industry 4.0 and its related emerging technologies such as AI, robotics, drones, augmented reality, virtual reality, machine learning, and wide-scale IoT. Borrowing from the words of Randal Stephenson, CEO of AT&T, "You can begin now to conceive of robotic manufacturing that is always on and always connected via 5G networks." Speaking further, he says, "Just to put this into perspective, the Internet of Things, the devices and sensors that are connected all over the place, with today's networks in a square mile, you can connect a thousand, two thousand, or possibly three thousands of those. In a 5G world, you can connect millions of those in a square mile." In light of this vast and intelligent internet connectivity, the economic impacts of 5G are expected to be massive. In fact, IHS Markit predicts that the global 5G chain will create approximately \$3.6 trillion in economic output and 22.3 million jobs by 2035, translating into a global economic value of \$13.2 trillion. The manufacturing industry will represent over a third of that output; information and communications, wholesale and retail, public services, and construction will account for another third combined.

By definition, 5G refers to fifth-generation mobile wireless network technology. It is the new global wireless standard, but 5G isn't an entirely new technology; it is well-established on the mobile networks already in place around the world. This has been the pattern for mobile networks throughout history, with incremental upgrades that gradually added more capacity and speed. This approach has yielded incredible results—as much as we might gripe about coverage or speeds today, the first real cell networks (or 1G, as it was retroactively dubbed when the next generation was introduced) could only support about a dozen calls per tower, had no data capacity, and used unencrypted analog signals that were easy to intercept.

2G gave way to a digitized future for mobile networks by introducing encrypted calls, text, and multimedia messages. With 2G, calls were significantly clearer with less static and background crackling. These features dramatically revolutionized the business landscape and led to 3G in 2001, which was a significant upgrade that standardized

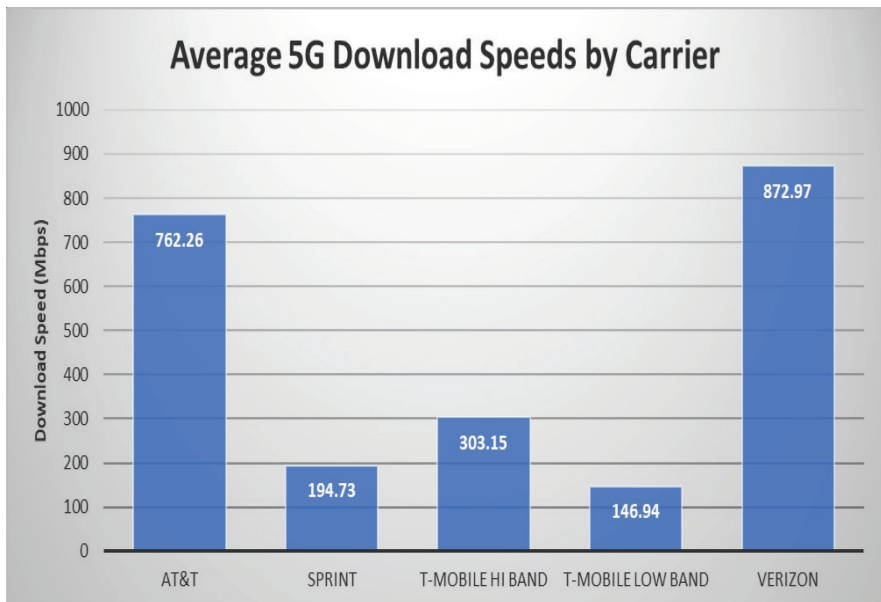
network protocol, making access to data from any location in the world possible. In this era, international roaming services and new services such as video conferencing, video streaming, and voice over IP (such as Skype) became a reality.

Network capability was stretched like never before with 4G, first deployed in 2009 as the LongTerm Evolution (LTE) 4G standard. 4G is the dominant mobile standard around the world with over 4 billion connections, accounting for 52% of total connections, according to GSMA. It offers fast mobile web access (up to 1 gigabit per second for stationary users), facilitating gaming services, high-quality video streaming, and HQ video conferencing.

Despite these incredible benefits, 4G is limited by the low-band spectrum used to transmit the signals. While this technology can broadcast quite a lot of data, each signal takes up a sizable chunk of the available airwaves, resulting in congestion. This is why the average 4G LTE smartphone typically had a full "five bars" of service when the technology first arrived, but today is more likely to see only one or two bars during peak usage times. There are simply too many devices and signals competing for the available bandwidth, and since those signals are broad, they struggle to transmit data effectively. On the other hand, 5G is designed to function using millimeter-wave (mmWave) across medium- and high-band spectrums with less congestion, and the airwaves contain more available channels. With 5G technology, more data can be transmitted over these smaller channels. Since so much of these higher-frequency ranges are currently unused, 5G technology opens up a massive range of possibilities for future Internet of Things (IoT) and edge computing devices.

According to a report by Statista, the major companies active in developing the 5G technology include the US companies Qualcomm and Intel, South Korean companies Samsung Electronics and LG, Chinese companies Huawei and ZTE, and European companies Ericsson and Nokia. Presently in the US, four major mobile carriers have begun providing some kind of 5G service experience: AT&T, Verizon, T-Mobile, and Sprint. Sprint used its existing mid-band (2.5 GHz)

spectrum to build out its 5G network until T-Mobile acquired it in 2019, and the service deactivated. T-Mobile currently has a mid-band in five cities, high-band in seven cities, and has rolled out a nationwide 5G service using a low-band spectrum that can reach 7,500 cities in addition to rural areas. Similarly, AT&T launched 5G Plus, which relies on mmWave in the 35 cities it's available in, but the carrier also has a low-band network that has grown to 395 markets covering 205 million people. T-Mobile still has a wider reach, claiming to cover over 250 million people. Since its initial 5G launch, Verizon has relied exclusively on mmWave or high-band spectrum and now boasts the best speeds by far at 872.97 Mbps, as illustrated in the chart.



Gartner predicts that \$4.2 billion will be spent on 5G wireless network infrastructure worldwide in 2020, up from \$2.2 billion in 2019. With investment rising, soon 5G will be deployed worldwide and the revolutionary potentials will be realized on a broad scale. According to Research and Markets, the global 5G market will soar to a whopping \$277 billion by 2025, growing at a compound annual growth rate of 111% between 2019 and 2025.

A 5G-powered future will include innovations with the potential to radically transform the healthcare sector, such as remote surgeries, telemedicine, and even remote vital sign monitoring. Smarter electricity grids for greatly reduced carbon emissions, more connected vehicles sharing data to prevent road collisions, faster deployment of emergency services to accidents early, and improved detection and warning of natural disasters are also some of the anticipated impacts of this technology.

10.1 Impacts on Business

According to Ericsson, 5G is the foundation for flexible, efficient, and responsible business. A recent GSMA analytical report revealed that 5G would become the first generation in mobile history to have a greater impact on enterprise than consumers. Following a recent ABI Research study, 5G tech would likely decrease production times of emerging technologies ten times more than 4G connections. Many experts agree that it is a critical component in the mass adoption of AR and VR technology. Qualcomm reports that 5G tech will improve the connection speed, website traffic, and reliability, all of which will accelerate the widespread integration of new technologies to come, thereby giving a competitive edge to businesses at the forefront of creating and using such technologies.

5G provides faster internet connection via increased bandwidth, which allows for very high download speeds that improve applications and reduce bottlenecks. 5G will deliver download speeds of up to 10Gbps, allowing for network-related tasks—such as online sales or sharing large files or presentations in the cloud—to become faster and more efficient. This will allow mobile devices to perform business processes without the need to connect to wi-fi, offering huge productivity gains and boosting staff morale.

After increased connection speed, low-latency services are arguably the most beneficial impacts of 5G networks in the business sphere. Latency means response time—the length of time it takes between something (like a data packet) being sent and received. The current 4G latency is about 50 milliseconds. 5G latency will decrease that to one millisecond, or one-

thousandth of a second—400 times faster than the blink of an eye. Low latency is essential to any device that requires real-time reactions, such as self-driving vehicles and remotely controlled robotics. According to Scott Schober, president and CEO of Berkeley Varitronics Systems, "It is estimated that latency for 5G will be lower by a factor of 100 in comparison to 4G, which is a game-changer for emerging applications such as augmented reality, virtual reality, and most peer-to-peer communications."

By leveraging lower latency, businesses can stream high-resolution video, audio, and images instantaneously—and without any lag or glitches—meaning richer communication experiences for customers and remote workers. Innovative contractors and interior designers will walk clients through virtual rooms before building the real thing, enabling easier decision-making and more accurate outcomes. Through low latency and ultrafast connectivity, 5G technology will empower smart manufacturing and autonomous factories. It will effectively revolutionize factory floors by enabling remote real-time monitoring of robots and processes, while also using 5G-powered simulations in augmented reality to better train the workforce and increase productivity.

An early example of smarter factories' benefits is the mobile phone plant controlled by Changing Precision Technology Company in Dongguan City, China. The factory replaced 90% of its human workforce with 60 robot arms working round the clock, and the results were a 250% increase in productivity and an 80% drop in defects.

5G connectivity allows for greater and far-reaching impacts, as illustrated by Bright Machines' software. Bright Machines manages a cloud-based software used to set up, reconfigure, and run any physical production lines for assembly, allowing enhanced operations and replacing the traditional assembly processes. When applied to North American factories, this software reduced defect rates parts per million (PPM) by 88% and increased unit production per hour by 33%.

5G also offers enhanced network capacity. This means that the number of devices and machines that can communicate with each other will drastically increase once 5G becomes fully active. In fact, experts anticipate that 5G will connect 500 times more devices than 4G. Companies with fleets

or machinery will be able to use IoT to maximize equipment efficiency and usage—for instance, a delivery company can use IoT with 5G to determine a truck's exact location in real-time to alert the recipient and ensure that the most efficient and effective routes are in use at all times. While some organizations currently use IoT for asset management, 5G will accelerate the process and offer even more accurate data. From a warehousing perspective, 5G will enable companies to use smart shelves, which can track when a product is running low and trigger an action, which will keep the supply chain running smoothly and efficiently.

Although the difference between 5G and 4G networks is glaring, some companies are still reluctant to upgrade. Many organizations today do not believe that 5G offers anything that 4G can't. According to the GSMA, "While a majority of enterprises recognize the benefits of speed gains brought about by 5G, other improvements (such as network slicing, edge computing, and low-latency services) are not widely appreciated, with many believing that 4G remains 'good enough.'"

Another obstacle to the global adoption of faster network connectivity is the cost of deployment. Unleashing 5G comes at a lofty cost: operators are expected to invest around \$1.1 trillion worldwide in the next five years, of which 80% will be dedicated to 5G networks. Unfortunately, most mobile operators have been either stagnating or experiencing much slower growth than before, making adoption difficult. However, despite the challenges facing 5G, the GSMA predicted that the technology would contribute \$2.2 trillion to the global economy by 2034.

10.2 Impacts on Workforce

Since 5G technology supports the increased adoption and improved efficiency of emerging technologies such as artificial intelligence and robotics, the big question is: will it lead to human labor displacement? The answer to this question is both yes and no. Experts' consensus indicates that 5G will be more of a job creator than a destroyer. According to a recent report by Accenture, 5G can generate three million

jobs in the US alone, adding \$500 billion to the US GDP. But how will this happen?

Currently, the US wireless industry, which generates \$475 billion in GDP, facilitates more than 4.7 million jobs and produces \$1 trillion in economic output. With the rollout of 5G underway, the industry expects to add 63 percent more jobs to build out network infrastructure across the US. 5G requires much denser infrastructure than 4G—with more than 300,000 small cells needed over the next four years. For reference, this is relatively equivalent to twice the number of macro towers built in the last 30 years. Since wireless providers will invest more than \$275 billion in US infrastructure in the next three years, experts agree that 5G will have a direct impact on the workforce. This investment could create more than 350,000 new construction jobs in the US (and a total of 850,000 jobs if you include suppliers and partners in the network build-out).

The report findings also indicate that the vast economic benefits of 5G will produce an additional 2.2 million jobs in local communities across the country. "5G-powered smart city solutions applied to the management of vehicle traffic and electrical grids alone could produce an estimate of \$160 billion in benefits and savings for local communities and their residents," said Tejas Rao, managing director and Mobile Offering Network lead for Accenture's North America practice. Small-to-medium-sized cities with a population of 30,000 to 100,000 could see anywhere from 300 to 1,000 jobs created, while cities with populations like Chicago could see as many as 90,000 jobs created, according to the report.

However, since 5G will foster automation, some jobs, particularly the dangerous and low-skilled ones, will be eliminated. The changes that will be ushered in by 5G will require workers with high-level skills and in-depth knowledge of the internet, what some experts like Mischa Dohler, Professor in Wireless Communications at King's College London, call "internet of skills." According to Dohler, billions of connected devices will create the need for thousands of skilled technicians to install, sustain, and maintain these networks. It will also

offer unlimited opportunities to entrepreneurs and developers. Developing IoT applications can be the next big killer app and provide for unimagined and unmet business demands.

Additionally, 5G will support remote working and collaboration across all work environments. Collaboration tools such as video conferencing and enterprise chat applications will be chief benefactors of the increased connection speed provided by 5G technology. According to the Brookings Institution, 5G's augmented speeds will increase economic opportunities through improved healthcare access, education, and employment. Indeed, 5G can connect those without access to broadband—particularly rural and underprivileged populations—to the growing remote workforce and enable them to reap its benefits. This will translate into an overall workforce that is more diverse, qualified, and hand-selected for appropriate roles over the next ten years. As 5G reaches the furthest corners of the planet and bridges the digital divide, collaboration tools will play a significant part in keeping this increasingly remote and distributed workforce connected, communicative, and productive

5G will also empower employees to work from their preferred mobile devices. Mobile connectivity with 4G is primarily confined to smartphones and tablets, but 5G will allow for a wide variety of devices to connect over a mobile network. Julie Coppernoll, VP of global marketing at Intel, recently said nothing would be labeled as "mobile" under 5G, as everything will be mobile. Workers will enjoy the flexibility of how, when, where, and on which devices to collaborate and produce. Workflows will be less rife with connectivity issues thanks to 5G's faster speeds and reliability, leading to increased creativity and productivity.

10.3 Impacts on Societies

The huge step up in internet speeds and network capacity will undoubtedly mean faster video streaming and downloading times for consumers as well as improved entertainment experiences. For instance, 5G will completely change the fan experience at live events. Music

festivals will particularly benefit from the 5G expanded spectrum, as many people could use their mobile data at the same time to message friends, download maps, upload photos to Instagram, and check what time their favorite band is playing. In 2019, Glastonbury become the UK's first 5G-connected festival thanks to a temporary trial of 5G networks from the British mobile operator, EE.

The arrival of 5G will also enhance sporting events, as new innovations will make fan experience more interactive. Immersive experiences such as VR, AR, and 360-degree video will radically boost fan engagement and improve the live experience. Also, faster internet speeds will enhance smart stadium apps, including interactive maps that will help fans find their seats and order half-time snacks from their smartphones. FC Barcelona's Nou Camp, the largest stadium in Europe, is set to be the world's first stadium with permanent 5G coverage, setting the pace for other sporting centers around the world.

Another area where consumers can benefit from 5G is shopping. A combination of 5G and edge computing will revolutionize the shopping experience by seamlessly integrating the physical and digital worlds. 5G allows for the processing of data at edge locations (i.e., closer to the data source, meaning better performance, reliability, and low latency), enabling shoppers to benefit from immersive and interactive technologies such as AR by virtually trying out products. And in-store shoppers can also enjoy hyper-personalized experiences. From intelligent shop signage to smart payment technology, smart retail innovations are set to be massive in the 5G era. In fact, the value of the smart retail market is expected to reach a staggering \$58.23 billion by 2025, according to Grand View Research.

5G holds great potential in critical areas such as health, safety, environmental sustainability, and education. According to a study by PwC and the World Economic Forum, 5G can deliver social value across eleven key areas in the context of the UN SDGs. Thus, this technology can contribute to good health and well-being, enhance infrastructure, promote sustainable industrialization, foster innovation, support responsible consumption, facilitate sustainable cities, and so on.

5G can promote societal well-being and ensure safety by facilitating autonomous vehicles (AV), according to a report cited Starsky Robotics, a manufacturing firm that is currently developing self-driving trucks with remote driving capabilities. Using teleoperation, the truck can be remotely driven between freight depots and the freeway where a highway-only automated driving system takes over. This innovation is expected to solve driver shortages by allowing human drivers to work in office environments while making trucks autonomous on the highway. This can reduce the number of driver fatalities during long-haul journeys by using well-trained, well-rested teleoperators and exit-to-exit highway automation.

Healthcare will experience countless benefits from 5G technology, and many experts believe that it is the field that might experience the most transformations. For instance, in Finland, innovators are already working on a way to facilitate stroke rehab through VR. Other researchers are developing smart bandages that track your healing and create a mechanism that allows parents to interact with babies in incubators. And 5G connectivity can ensure all these developments.

According to Anthem, 86 percent of doctors say wearables—a common type of remote monitoring device—improve patient engagement with their own health. Additionally, wearables are predicted to reduce hospital costs by 16 percent in the next five years. These numbers are likely to increase in the coming years. Although expectations regarding health sensors, wearables, and the ability of other connected to transmit data from a user to a doctor are already high, at the moment, mobile network performance does not match these expectations. That's why 5G could be a game-changer.

To make patients the point of care, accurate pocket-sized connected devices are needed that constantly monitor the patient's state and notify the physician if any values deviate from the normal range. 5G technology could enable such health IoT networks to operate in a stable and highly efficient way. Adding a high-speed 5G network to the existing health care architectures will allow for quick and reliable transfer of huge data files of medical imagery like MRIs and PET scans. At the Austin Cancer

Center, the PET scanner generates huge files—up to 1 gigabyte of information per patient per study. With low bandwidth networks, transmission can take a long time (or even abort), which means the patient would have to wait longer for treatment, and providers can see fewer patients in the same amount of time.

Conclusion

Commenting on the global impacts of 5G, Rajeev Suri, CEO of Nokia, states, “We knew from an early stage that 5G would make digitalization more accessible, allowing small businesses, public services, and even individual households to reap the benefits of smart products and services ... 5G’s speed, reliability, and scale are already unlocking huge social and economic gains.” Despite the enormous benefits of 5G, the technology poses a serious threat to businesses and consumers. Sadly, the very attributes that make 5G so valuable create new cybersecurity risks. With more devices connected to the network and more files being transferred across it, 5G opens-up vulnerabilities and widens the attack surface. As the evolving threat landscape becomes clearer as the full deployment of 5G edges closer, its important security protocols do not decrease the productivity gains businesses are looking forward to by slowing or preventing authorized access. Instead, relevant stakeholders should adopt a more effective approach, like the zero-trust security model. It is considered to be the safest way to mitigate the rising threat without hindering enterprise profits.

SUMMARY

Technology, in whatever magnitude, has always had unprecedented impacts on our lives. Think of how the invention of gas-powered vehicles completely changed the transportation of goods and people, and how mobile headsets brought a more personalized experience to watching a movie and listening to music. Throughout history, technology has created new jobs, improved productivity in the workplace, enhanced business operations, and facilitated better health care services and learning processes. Inventions such as GPS trackers, electronic tag readers, security cameras, alarm systems, and motion sensors help law enforcement wage war on crime and make the world safer. Technology improves environmental sustainability and natural disaster detection and management, while also tackling global issues such as hunger and inequality.

Like the eras before, the 21st century is witnessing massive transformations due to the emergence of certain technologies. These modern technologies are poised to change how we live, interact with people and machines, do business, go shopping, store information, learn, receive treatment, travel, and even impact our career choices in ways never seen before. All these technologies will profoundly impact the education system, skill acquisition, and career choices. As the adoption of these innovations continues to expand, there will be increasing demand for the skills associated with each emerging technology. According to the World Economic Forum, automation will produce 133 million new jobs by 2022, and most of these jobs will require data analysis and IoT management skills—both of which are currently in shortage, largely due to the outdated education curriculum. A modern and capable education curriculum must include courses on emerging technologies to produce tech-enabled graduates who are adequately equipped for the evolving workplace landscape. With jobs like data scientists, web-developers, technical writers, machine learning, security, and encryption specialists expected to be in high demand,

employees who wish to remain employed in the coming years must be self-motivated to acquire new skills.

For disruptive technologies to emerge, there is an urgent need for institutions to adopt innovative styles of teaching that will encourage students to think for themselves and apply their skills to complex real-world situations. This will reduce the current creativity deficiency in the educational institutions and build the required skills necessary to prepare for the future. Only those students who can think independently will succeed in a growing freelance economy.

The future of education will include self-paced and personalized learning by students, and technology can dramatically propel this change through various innovations. If the analysts are right, by 2030, artificial intelligence, in collaboration with other technology, will provide access to a wealth of data tailored to the needs, aspirations, and learning styles of each student. This will mean that every student can learn and specialize in a certain technology based on future demand at their own time, pace, and preferred place.

This book is a roadmap to the coming changes to the technology landscape. It will help both students and their parents understand the future of technology and how it will affect their studies, their careers, and the societies in which they live.

ABOUT THE AUTHOR



Dr. Srikanth Gaddam is an author, angel investor, and seasoned entrepreneur who has launched three successful technology companies in the last seventeen years. Dr. Gaddam's greatest accomplishment is building ERP Analysts, Inc. from a two-person organization to an eighty-five-million-dollar firm. ERP Analysts, Inc. (www.erpagroup.com) has been recognized as one of the fastest-growing companies by Inc. 5000 for ten years, and a Deloitte Fast 500 and Business First Fast 50 for several years. ERP Analysts have also been recognized as a “Best Places to Work” in Ohio for several years running. Dr. Gaddam graduated with the Doctor of Management (DM) from Case Western Reserve University, MBA from the Ohio State University, and the Owner President Management program (OPM 43) from Harvard Business School. He is the author of the book “Destination Success: Discovering the Entrepreneurial Journey” and also co-author of “Roadmap to Success”.

REFERENCES

Introduction: References

<https://www.google.com/url?q=https://www.cars.com/amp/articles/which-cars-have-self-driving-features-for-2020-418934/&usg=AFQjCNEFaFmYJeQoLubBvMWKUhDVnGqpuA>

https://www.google.com/url?q=https://www.globalfleet.com/en/autonomous/europe/features/tesla-and-audi-move-autonomy-different-levels&usg=AFQjCNG3klmg3T3n64O-WrDUGR_hRWVTAQ

<https://www.google.com/url?q=https://www.theverge.com/platform/amp/2019/10/10/20907901/waymo-driverless-cars-email-customers-arizona&usg=AFQjCNFIwKsm1fIgyzAyFgJDJT02FRyLrw>

<https://www.google.com/url?q=https://theconversation.com/amp/autonomous-cars-five-reasons-they-still-arent-on-our-roads-143316&usg=AFQjCNEOP2PtGJ9GqMDFpGq2Ivli1RPsHg>

<https://www.google.com/url?q=https://wtop.com/news/2020/04/top-7-autonomous-vehicle-stocks-to-buy-now/amp/&usg=AFQjCNEOQKK9ZnOW-aeXvjXZ7JA6VjEnw>

<https://www.google.com/url?q=https://www.forbes.com/sites/vishalmaria/2019/01/11/the-future-of-artificial-intelligence-in-the-workplace/amp/&usg=AFQjCNFDIeUHbMj4FZTGdqkwIcwB9Oq2tQ>

https://www.google.com/url?q=https://www.artificial-solutions.com/blog/impact-of-ai-in-the-workforce&usg=AFQjCNG8smluw9Ulp7_Hbs0F1cgtgflTbg

<https://www.forbes.com/sites/isabeltogoh/2020/07/09/tesla-vehicles-could-soon-become-completely-autonomous-as-self-driving-tech-very-close-elon-musk-says/amp/>

<https://jasoren.com/how-to-bring-value-to-customers-shopping-experience-and-increase-sales-with-ar/>

<https://www.idigitalhealth.com/news/new-reality-clinical-care-xr-transform-healthcare>

<https://aimseducation.edu/blog/the-impact-of-technology-on-healthcare/>

<https://www.chthealthcare.com/blog/artificial-intelligence-in-healthcare>

<https://www.google.com/url?q=https://www.nextgyn.com/extended-reality-in-education-xr/&usg=AFQjCNHX9FbVBSuV7erB385g53Uc1WLGlQ>

<https://www.thetechadvocate.org/top-9-must-personalized-learning-apps-tools-resources/>

https://en.m.wikipedia.org/wiki/Digital_Revolution

<https://www.google.com/url?q=https://www.halski.com/2018/09/04/how-technology-has-changed-our-lives-for-the-better/&usg=AFQjCNHHj4xZUXriAV8bpbqjaSMSDirRQw>

<https://www.google.com/url?q=https://amp.usatoday.com/amp/40934825&usg=AFQjCNEGKm5ab0gFVNyC2dAklTFPyWExXQ>

<https://www.google.com/url?q=https://www.explainthatstuff.com/historyofcomputers.html&usg=AFQjCNGxRMFItdSlrFji6w9prdV1qVLsvA>

<https://www.google.com/url?q=https://www.livescience.com/amp/20718-computer-history.html&usg=AFQjCNEOB8g2-reBOhNVucxXLKjmUcj4Mg>

https://www.google.com/url?q=https://www.brighthubpm.com/methods-strategies/79052-exploring-how-technology-has-changed-communication/&usg=AFQjCNEAJFwitpnHf_h9OeWngPfxXQeEgA

https://www.google.com/url?q=https://www.researchgate.net/publication/305393741_Editorial_Technology_evolution_and_its_cyclical_relation_with_us&usg=AFQjCNGamRhqqWDGMqNKkSg72xJNQpN5XA

<https://www.google.com/url?q=https://chiefexecutive.net/how-emerging-technology-is-driving-job-creation-new-industries/amp/&usg=AFQjCNE45t9ItsvEJgy6bVTiUsfgZGQ9TA>

<https://www.google.com/url?q=https://www.bbvaopenmind.com/en/articles/internet-changed-everyday-life/amp/&usg=AFQjCNFm3Rrv mavKfcLAqegKM-1pnRgJqw>

<https://www.mckinsey.com/featured-insights/employment-and-growth/technology-jobs-and-the-future-of-work>

<https://www.google.com/url?q=https://www.getsmarter.com/blog/market-trends/blockchains-effect-on-business/&usg=AFQjCNFYWyCBzMLjLDieU8DIo0DrzmaPnA>

<https://sloanreview.mit.edu/article/managing-technology-for-the-post-digital-era/amp>

Chapter 1: References

<https://www.google.com/url?q=https://www.zdnet.com/google-amp/article/what-is-cloud-computing-everything-you-need-to-know-about-the-cloud/&usg=AFQjCNGhzujguaDwctw0-SclpxEfOKorQA>

<https://www.google.com/url?q=https://blog.carbonteq.com/benefits-of-cloud-computing/&usg=AFQjCNGM5On2Vyp1TaTUUqDCCEwVE2VyAw>

https://www.google.com/url?q=https://www.sas.com/en_us/insights/data-management/cloud-computing.html&usg=AFQjCNH1E_gDvbKfiRI8ypzbsBMGgnoX2g

<https://www.google.com/url?q=https://www.wired.com/insights/2013/09/how-the-cloud-is-changing-the-role-of-technology-leaders/&usg=AFQjCNEMu0XqgS5uLe-zEQBStHzdOM-M7A>

<https://www.google.com/url?q=http://www.theijes.com/papers/v5-i6/version-2/O050602086097.pdf&usg=AFQjCNEDaGaphEJsDF8b71RdHnqpFPSgrQ>

https://www.google.com/url?q=https://www.researchgate.net/profile/D_r_Lakshmi_Devasena_C/publication/271520206_IMPACT_STUDY_OF_CLOUD_COMPUTING_ON_BUSINESS_DEVELOPMENT/links/54cb1ea50cf2c70ce524eb7b/IMPACT-STUDY-OF-CLOUD-COMPUTING-ON-BUSINESS-DEVELOPMENT.pdf&usg=AFQjCNH6BwH81Z6U6jbuPynxILcY1qPGDQ

<https://kinsta.com/blog/cloud-market-share/>

<https://hostingtribunal.com/blog/cloud-computing-statistics/>

<https://www.google.com/url?q=https://www.bmc.com/blogs/cloud-revenue-market-share-trends/&usg=AFQjCNHOiDZt7Ua1VlS5ts3AMhnI66PGBQ>

<https://sados.com/blog/aws-benefits-and-drawbacks/?amp>

<https://dzone.com/articles/how-cloud-technology-impacts-the-business-world>

<https://www.google.com/url?q=https://www.villanovau.com/resources/bi/ways-cloud-computing-affects-business/&usg=AFQjCNGKTJhvZPe6JgwGLp5vqOb7UKEvLg>

<https://www.bellwethercorp.com/cloud-computing-technology-and-its-impact-on-business-and-purchasing/#>

<https://hbr.org/amp/2018/02/how-cloud-computing-is-changing-management>

<https://www.getcloudapp.com/blog/workplace-cloud-use>

<https://www.google.com/url?q=https://ritzherald.com/the-future-of-cloud-computing-impact-on-businesses-workforces-and-societies/&usg=AFQjCNHKfOEgQEhzbA9kLxj--qHtXv6Mdg>

<https://www.google.com/url?q=https://www.gqrgm.com/pros-of-cloud-technology-in-the-workplace/&usg=AFQjCNEtL9jDDwIBiar0XV6UzHxxrQuQxg>

<https://www.google.com/url?q=https://www.ibm.com/blogs/cloud-computing/2013/04/04/how-cloud-computing-is-impacting-everyday-life/&usg=AFQjCNFMRnUxb9V1ZB-XA-3cmU4uVxIRUQ>

https://www.google.com/url?q=https://deloitte.wsj.com/cio/2018/11/14/the-societal-impact-of-cloud/&usg=AFQjCNH5c_tyJvIQysyX6RsBk6NWdKC9TQ

<https://synoptek.com/insights/it-blogs/healthcare-cloud-computing-trends-for-2019/>

Chapter 2: References

<https://www.bernardmarr.com/default.asp?contentID=766>

<https://www.cognetik.com/blog/business-impact-of-big-data-top-5-things-you-need-to-know/>

<https://bernardmarr.com/default.asp?contentID=1076>

<https://www.visualcapitalist.com/how-much-data-is-generated-each-day/>

<https://www.prnewswire.com/news-releases/the-global-hr-analytics-market-size-is-expected-to-grow-from-usd-1-9-billion-in-2019-to-usd-3-6-billion-by-2024--at-a-compound-annual-growth-rate-cagr-of-13-7-300992306.html>

<https://hostingtribunal.com/blog/big-data-stats/#gref>

<https://ritzherald.com/the-future-of-big-data-impact-on-businesses-workforce-societies/>

<https://tdan.com/ways-that-big-data-impact-hr/22576>

<https://www.itransition.com/blog/the-future-of-big-data>

<https://www.futureofeverything.io/expert-predictions-the-future-of-big-data-and-business-20-years-from-now/>

https://blog.bismart.com/en/most-interesting-big-data-projects?hs_amp=true

<https://medium.com/@syedjunaid.h47/what-is-big-data-why-is-big-data-important-in-todays-era-8dbc9314fb0a>

<https://www.itransition.com/blog/big-data-and-its-business-impacts>

Chapter 3: References

<https://www.forbes.com/sites/bernardmarr/2020/03/09/whats-the-impact-of-artificial-intelligence-and-technology-on-society/#7045d75b3098>

<https://www.sutisoft.com/blog/the-impact-of-ai-and-machine-learning-on-workforce-management/>

<https://www.forbes.com/sites/gilpress/2019/07/15/is-ai-going-to-be-a-jobs-killer-new-reports-about-the-future-of-work/#3b761c5cafb2>

<https://www.businessnewsdaily.com/9402-artificial-intelligence-business-trends.html>

<https://roboticsandautomationnews.com/2020/06/22/6-ways-autonomous-vehicles-will-impact-life-as-we-know-it/33326/>

<https://www.businesswire.com/news/home/20200226005597/en/Autonomous-Vehicles-Impact-Logistics-Industry-Experts-SpendEdge>

<https://www.trendhunter.com/protrends/retail-robotics#:~:text=Trend%20%2D%20The%20incorporation%20of%20human,experiential%20purchase%20journeys%20for%20customers.>

<https://chatbotsmagazine.com/ai-and-robotics-in-retail-drivers-impact-and-challenges-68a51dbf74cb>

<https://yourstory.com/mystory/how-ai-is-transforming-business-growth/amp>

<https://towardsdatascience.com/how-artificial-intelligence-is-transforming-business-in-2020-1e68d4c1dd53>

<https://www.forbes.com/sites/cognitiveworld/2019/07/10/how-artificial-intelligence-is-transforming-business-models/amp/>

<https://blog.zoominfo.com/statistics-about-artificial-intelligence/>

<https://www.oreilly.com/radar/ai-adoption-in-the-enterprise-2020/>

<https://www.forbes.com/sites/cognitiveworld/2019/10/17/the-ai-enabled-future/#3b66c3cf3339>

<https://www.technologyreview.com/2019/12/18/102365/the-future-of-ais-impact-on-society/amp/>

<https://builtin.com/artificial-intelligence>

<https://www.bbc.com/news/amp/business-48760799>

<https://techjury.net/blog/ai-statistics/#gref>

<https://home.bt.com/tech-gadgets/future-tech/9-jobs-overtaken-by-robots-11364003046052>

<https://www.iotforall.com/impact-of-artificial-intelligence-job-losses/>

<https://www.computerhope.com/issues/ch001799.htm>

https://www.ey.com/en_gl/innovation/how-ai-is-transforming-business-right-now

Chapter 4: References

<https://www.fool.com/investing/what-does-the-future-hold-for-self-driving-cars.aspx>

<https://onlinemasters.ohio.edu/blog/5-effects-of-the-adoption-of-autonomous-vehicles/>

<https://emerj.com/ai-adoption-timelines/self-driving-car-timeline-themselves-top-11-automakers/>

https://www.mes-insights.com/5-top-autonomous-vehicle-companies-to-watch-in-2020-a-910825/?cmp=go-aw-art-trf-MES_DSA-20200217&gclid=Cj0KCQjw-O35BRDVARIsAJU5mQXCjoVsYXTQu6yRKgx4wywTT1ke80sDwVZBUXz1PSs8oRE-yDqi33YaAuA4EALw_wcB

<https://www.orange-business.com/en/blogs/driving-forward-whats-state-autonomous-vehicles-today>

<https://www.wired.com/story/intersection-self-driving-cars-electric/>

<https://www.google.com/amp/s/www.constructionweekonline.com/products-services/169830-autonomous-trucks-vehicles-and-machines-show-benefits-for-worlds-largest-mining-companies%3famp>

<https://www.ucsusa.org/resources/self-driving-cars-101>

<https://www.vox.com/platform/amp/future-perfect/2020/2/14/21063487/self-driving-cars-autonomous-vehicles-waymo-cruise-uber>

https://rudermanfoundation.org/white_papers/self-driving-cars-the-impact-on-people-with-disabilities/

<https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety>

<https://innovationatwork.ieee.org/autonomous-vehicles-for-today-and-for-the-future/>

<https://www.govtech.com/fs/automation/Autonomous-Vehicles-to-Have-Huge-Impact-on-Economy-Tech-Sector.html?AMP>

<http://www.mining.com/rio-tinto-autonomous-trucks-now-hauling-quarter-pilbara-material/#:~:text=They%20use%20pre-defined%20GPS,driverless%20trains%20in%20Western%20Australia.>

<https://www.google.com/amp/s/amp.cnn.com/cnn/2019/08/22/us/traffic-commute-gridlock-transportation-study-trnd/index.html>

https://www.spendedge.com/blogs/autonomous-vehicles-logistics-industry/?utm_source=B1.0&utm_medium=BWSQ1w09&utm_campaign=BusinesswireB1Q1w09&utm_term=Autonomous%20Vehicle&utm_content=Impact%20of%20Autonomous%20Vehicles%20in%20the%20Logistics%20Industry

<https://www.statista.com/topics/3573/autonomous-vehicle-technology/>

<https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/ten-ways-autonomous-driving-could-redefine-the-automotive-world>

<https://www.google.com/amp/s/www.forbes.com/sites/danielaraya/2019/01/10/top-10-industries-transformed-by-self-driving-cars/amp/>

<https://techwireasia.com/2019/05/here-are-all-the-business-opportunities-that-self-driving-cars-will-create/>

<https://www.retail-insight-network.com/comment/autonomous-vehicles-retail/>

<https://www.google.com/amp/s/arstechnica.com/tech-policy/2018/08/self-driving-cars-will-destroy-a-lot-of-jobs-theyll-also-create-a-lot/%3famp=1>

<https://www.minntran.org/autonomous-vehicle-technologies-and-the-impact-on-workforce-training-and-education/>

<https://www.socialtables.com/blog/hospitality/self-driving-cars/>

<https://techcrunch.com/2017/08/25/business-models-will-drive-the-future-of-autonomous-vehicles/>

Chapter 5: References

<https://techbeacon.com/security/7-ways-secure-iot-your-enterprise>

<https://www.iotevolutionworld.com/smart-factories/articles/433239-iot-creating-destroying-more-jobs.htm>

<https://www.brookings.edu/blog/techtank/2018/04/18/will-robots-and-ai-take-your-job-the-economic-and-political-consequences-of-automation/amp/>

<https://medium.com/@billsoftnet/iot-and-job-loss-what-does-the-future-hold-d15bc405b139>

<https://internetofbusiness.com/iot-result-94000-job-losses/amp/>

<https://techcrunch.com/2016/06/10/the-future-of-the-iot-job-market/amp/>

<https://adtmag.com/articles/2019/06/14/iot-spending-trends.aspx?m=1>

<https://www.forbes.com/sites/gilpress/2019/07/15/is-ai-going-to-be-a-jobs-killer-new-reports-about-the-future-of-work/#2b562a76afb2>

<https://www.google.com/amp/s/www.newgenapps.com/blog/8-uses-applications-and-benefits-of-industrial-iot-in-manufacturing/%3famp>

<https://www.machinedesign.com/automation-iiot/article/21836897/how-iot-will-impact-different-industries>

<https://www.cmswire.com/digital-workplace/how-iot-impacts-the-digital-workplace/amp/>

<https://magneticcreative.com/iot-impact-business-start-ups/>

<https://www.vxchnge.com/blog/impact-of-iot-on-business>

<https://www.comparitech.com/internet-providers/iot-statistics/>

<https://www.zdnet.com/article/uk-hospitals-embrace-rfid/#ftag=CAD-00-10aag7e>

<https://www.statista.com/topics/2430/smart-homes/>

<https://www.zdnet.com/google-amp/article/what-is-the-internet-of-things-everything-you-need-to-know-about-the-iot-right-now/>

<https://www.analyticsvidhya.com/blog/2016/08/10-youtube-videos-explaining-the-real-world-applications-of-internet-of-things-iot/>

<https://disruptive.asia/iot-statistics-and-facts-infographic/>

<https://www.stoodnt.com/blog/iot-statistics-for-2020/>

<https://www.statista.com/statistics/791575/us-smart-speaker-household-ownership/>

<https://www.politico.com/agenda/story/2015/06/internet-of-things-growth-challenges-000098/>

https://www.vxchnge.com/blog/iot-statistics?hs_amp=true

<https://www.statista.com/topics/2637/internet-of-things/#:~:text=The%20installed%20base%20of%20active,21.5%20billion%20units%20by%202025.&text=The%20smart%20home%2Fhome%20automation,billion%20US%20dollars%20by%202023.>

<https://www.marketsandmarkets.com/Market-Reports/iot-in-agriculture-market-199564903.html#:~:text=%5B204%20Pages%20Report%5D%20The%20agriculture,10.4%25%20from%202019%20to%202024.>

[https://www.avsystem.com/blog/iot-technology/#:~:text=The%20Internet%20of%20Things%20\(IoT,human%2Dto%2Dcomputer%20interaction.](https://www.avsystem.com/blog/iot-technology/#:~:text=The%20Internet%20of%20Things%20(IoT,human%2Dto%2Dcomputer%20interaction.)

Chapter 6: References

<https://www.mcafee.com/enterprise/en-us/security-awareness/cybersecurity.html#:~:text=Share%3A,number%20of%20other%20malicious%20actions.>

<https://www.cyber-observer.com/cyber-news-29-statistics-for-2020-cyber-observer/#:~:text=The%20damage%20related%20to%20cybercrime,2021%2C%20according%20to%20Cybersecurity%20Ventures.>

<https://www.fintechnews.org/the-2020-cybersecurity-stats-you-need-to-know/>

<https://www.varonis.com/blog/cybersecurity-statistics/>

<https://securityboulevard.com/2020/05/the-definitive-cyber-security-statistics-guide-for-2020/amp/>

<https://www.csoonline.com/article/3153707/top-cybersecurity-facts-figures-and-statistics.html>

<https://www.websitehostingrating.com/cybersecurity-statistics-facts/>

<https://www.uscybersecurity.net/history/>

<https://one.comodo.com/blog/cyber-security/what-is-cyber-security.php>

<https://www.cisco.com/c/en/us/products/security/what-is-cybersecurity.html#~how-cybersecurity-works>

<https://cybersecurityventures.com/cybersecurity-ceo-the-history-of-cybercrime-from-1834-to-present/>

<https://cyberexperts.com/history-of-cybersecurity/>

<https://www.smartbrief.com/original/2020/01/glimpse-future-cybersecurity>

<https://sectigostore.com/blog/42-cyber-attack-statistics-by-year-a-look-at-the-last-decade/>

<https://blog.netwrix.com/2018/05/15/top-10-most-common-types-of-cyber-attacks/>

<https://www.innefu.com/blog/how-cyber-security-impacts-businesses-globally/>

<https://www.anetworks.com/effects-of-cyber-attacks-on-business/>

<https://www.nibusinessinfo.co.uk/content/impact-cyber-attack-your-business>

<http://www.bbc.com/storyworks/chubb-future-proof/the-importance-of-cybersecurity-in-business>

<https://www.investopedia.com/financial-edge/0112/3-ways-cyber-crime-impacts-business.aspx>

<https://www.google.com/amp/s/www.alva-group.com/blog/the-reputational-risk-of-cyber-attacks-talktalk-case-study/amp/>

<https://www.google.com/amp/s/www.smartdatacollective.com/3-legal-repercussions-of-cyber-attacks/amp/>

<https://www.nec.edu/cybersecurity-jobs-essential-world-contentends-with-covid-19/>

<https://www.sungardas.com/blog/educating-employees-on-cyber-security/>

<https://workingnation.com/covid-19-cybersecurity-and-it-workers-are-essential-in-demand-employees/>

<https://www.infosecurity-magazine.com/news/us-facing-catastrophic-cyberattack/>

<https://www.weforum.org/agenda/2020/06/covid-19-pandemic-teaches-us-about-cybersecurity-cyberattack-cyber-pandemic-risk-virus>

<https://www.asu.edu/about>

<https://www.healthcareitnews.com/node/537411>

Chapter 7: References

<https://online.maryville.edu/blog/the-multifaceted-future-of-augmented-reality/>

<https://www.nextgyn.com/societal-impact-virtual-reality/>

<https://www.flatworldsolutions.com/IT-services/articles/virtual-reality-impact-on-business.php>

<https://www.businessnewsdaily.com/9344-virtual-reality-business-predictions.html>

<https://www.bbc.com/news/technology-37576755>

<https://www.fdmgroup.com/5-exciting-uses-for-virtual-reality/>

<https://www.businesswire.com/news/home/20171129005097/en/Worldwide-Spending-Augmented-Virtual-Reality-Forecast-Reach#:~:text=Worldwide%20spending%20on%20augmented%20reality%20and%20virtual%20reality%20is%20forecast,over%202016%2C%20according%20to%20IDC.>

<https://thinkmobiles.com/blog/what-is-vr/>

<https://www.google.com/amp/s/www.techrepublic.com/google-amp/article/infographic-the-history-of-ar-and-vr-and-what-the-future-holds/>

https://www.vxchnge.com/blog/augmented-reality-statistics?hs_amp=true

<https://www.threkit.com/20-augmented-reality-statistics-you-should-know-in-2020#:~:text=According%20to%20IDC%2C%20global%20spending,%2C%20up%2078.5%25%20from%202019.&text=From%202019%2D2023%2C%20the%20global,77%25%20compound%20annual%20growth%20rate.>

<https://www.emarketer.com/content/us-virtual-and-augmented-reality-users-2020>

<https://kommandotech.com/statistics/virtual-reality-statistics/>

<https://www.forbes.com/sites/cognitiveworld/2019/10/01/retailers-have-a-lot-to-gain-from-ar-and-vr/amp/>

<https://kallesgroup.com/how-will-virtual-reality-impact-the-business-world/>

<https://perfectial.com/blog/augmented-reality-for-business/>

<https://www.forbes.com/sites/deep Patel/2017/11/14/6-ways-vr-will-change-the-workplace/#2410a37f27cd>

<https://www.pgcareers.com/virtual-reality-impact#:~:text=Changing%20our%20workplace%20to%20our%20taste.&text=By%20using%20virtual%20reality%2C%20employees,under%20construction%2C%20or%20a%20theatre.>

<https://www.vrdirect.com/blog/use-case/five-companies-that-are-using-vr-for-training/>

<https://www.google.com/amp/s/www.cnbc.com/amp/2020/06/03/remote-work-will-be-legacy-of-pandemic-conference-board-survey-finds.html>

<https://towardsdatascience.com/augmented-reality-ar-trends-the-past-present-future-predictions-for-2019-8e1148345304>

<https://www.letsnurture.com/blog/how-virtual-augmented-reality-will-evolve-and-impact-society-in-10-15-years.html>

<https://blog.marketresearch.com/virtual-reality-and-augmented-reality-in-healthcare-a-market-overview>

<https://www.grandviewresearch.com/industry-analysis/virtual-reality-in-gaming-market>

Chapter 8: References

<https://bitnewstoday.com/opinion/will-blockchain-kill-banks-or-financial-sector-can-use-this-technology-to-improve-its-efficiency/>

<https://www.google.com/amp/s/reason.com/podcast/pierre-rochard-goldstein-bitcoin/%3famp>

<https://jaxenter.com/blockchain-education-161738.html#:~:text=Student%20records%20and%20credentialing&text=Blockchain%20diplomas%20will%20allow%20learners.get%20information%20about%20students'%20accomplishments.>

<https://www.google.com/amp/s/www.gminsights.com/industry-analysis/blockchain-technology-in-healthcare-market/amp>

<https://www.google.com/amp/s/www.gminsights.com/industry-analysis/blockchain-technology-in-healthcare-market/amp>

<https://cointelegraph.com/news/will-blockchain-protect-the-world-economy-from-financial-crises>

<https://www.itproportal.com/features/blockchains-implications-for-society/>

<https://www.digitalistmag.com/future-of-work/2018/05/02/how-blockchain-technologies-impact-human-resources-06143011/amp/>

<https://www.welcometothejungle.com/en/articles/blockchain-and-employment-how-hiring-and-paying-salaries-could-be-set-to-change>

<https://www.gartner.com/smarterwithgartner/5-ways-blockchain-will-affect-hr/#:~:text=Blockchain%20solutions%20already%20exist%20to,potentially%20expand%20access%20to%20talent.>

<https://medium.com/@tkeycoin/blockchain-technology-how-it-will-affect-the-job-market-72b2950f7635>

<https://www.juniperresearch.com/press/press-releases/ad-fraud-to-cost-advertisers-19-billion-in-2018>

<https://digitalmarketinginstitute.com/blog/how-will-blockchain-change-the-way-organizations-work>

<https://www.getsmarter.com/blog/market-trends/blockchains-effect-on-business/#:~:text=Blockchain%20allows%20businesses%20to%20send,called%20%E2%80%9Csmart%20contracts%27%27.&text=As%20a%20ll%20actions%20related%20to,cost%20of%20tracking%20and%20reconciliation.>

[https://www.idc.com/getdoc.jsp?containerId=prUS44898819#:~:text=FRAMINGHAM%2C%20Mass.%2C%20March%204,International%20Data%20Corporation%20\(IDC\).](https://www.idc.com/getdoc.jsp?containerId=prUS44898819#:~:text=FRAMINGHAM%2C%20Mass.%2C%20March%204,International%20Data%20Corporation%20(IDC).)

<https://medium.com/mvp-workshop/five-ways-blockchain-can-transform-traditional-business-and-impact-the-market-in-the-future-6310a9554214>

<https://www.statista.com/statistics/807195/ethereum-market-capitalization-quarterly/>

<https://www.statista.com/statistics/647231/worldwide-blockchain-technology-market-size/>

<https://www.blockchain-expo.com/2018/10/blockchain/future-of-blockchain-technology/>

<https://cointelegraph.com/news/talking-digital-future-blockchain-technology/amp>

<https://www.ft.com/content/b6171016-171f-11e8-9e9c-25c814761640>

<https://www.visualcapitalist.com/exploring-the-practical-applications-of-blockchain-technology/>

<https://techjury.net/blog/blockchain-statistics/#gref>

<https://hbr.org/amp/2017/02/a-brief-history-of-blockchain>

<https://www.tradefinanceglobal.com/blockchain/history-of-blockchain/#:~:text=Blockchain%20began%20with%20a%20man,as%20a%20medium%20of%20exchange.>

<https://www.statista.com/statistics/377382/bitcoin-market-capitalization/#:~:text=The%20market%20capitalization%20of%20Bitcoin,circulation%20by%20the%20Bitcoin%20price.>

<https://www.statista.com/topics/5122/blockchain/#:~:text=Worldwide%20spending%20on%20blockchain%20solutions,estimated%2015.9%20billion%20by%202023.&text=The%20financial%20sector%20accounts%20for,industry%20from%20healthcare%20to%20agriculture.>

<https://www.statista.com/statistics/194246/cyber-crime-incidents-victim-industry-size/#:~:text=Cyber%20crime%20incidents%20worldwide%202019%202C%20by%20victim%20industry%20and%20size&text=In%202019%202C%20the%20global%20accommodation,and%206%2C843%20reported%20incidents%20respectively.>

<https://thenextscoop.com/blockchain-technology-impact-cyber-security/amp/>

<https://dzone.com/articles/how-can-we-benefit-from-using-blockchain-technolog>

<https://www.forbes.com/sites/ilkerkoksas/2019/10/23/the-benefits-of-applying-blockchain-technology-in-any-industry/amp/>

<https://www.ibm.com/blogs/blockchain/2018/02/top-five-blockchain-benefits-transforming-your-industry/>

<https://www.investopedia.com/terms/b/blockchain.asp>

<https://blockgeeks.com/guides/what-is-blockchain-technology/>

<https://opensource.com/article/19/12/blockchain-evolution>

<https://opensource.com/article/19/12/blockchain-evolution>

Chapter 9: References

<https://ultimaker.com/learn/what-is-3d-printing>

<https://m.all3dp.com/1/what-is-3d-printing/>

<https://www.explainthatstuff.com/how-3d-printers-work.html>

<https://www.zdnet.com/google-amp/article/everything-you-need-to-know-about-3d-printing-and-its-impact-on-your-business/>

<https://www.zdnet.com/article/vroom-how-3d-printing-is-revving-up-to-save-the-auto-industry-big-bucks/#ftag=CAD-00-10aag7e>

<https://3dinsider.com/3d-printing-statistics/?amp>

https://amfg.ai/2020/01/14/40-3d-printing-industry-stats-you-should-know-2020/amp/#3D_printing_statistics_A_tale_of_the_burgeoning_industry

<https://www.mordorintelligence.com/industry-reports/3d-printing-market>

<https://www.alliedmarketresearch.com/3d-printing-healthcare-market/amp>

<https://www.google.com/amp/s/www.forbes.com/sites/louiscolumnbus/2018/05/30/the-state-of-3d-printing-2018/amp/>

<https://3dprinting.com/what-is-3d-printing/>

<https://amfg.ai/2019/08/21/10-predictions-on-the-future-of-3d-printing-expert-roundup/amp/>

<https://www.forbes.com/sites/louiscolumbus/2019/05/27/the-state-of-3d-printing-2019/#251527be46c2>

<https://hpmegatrends.com/how-3d-technology-is-transforming-the-auto-industry-a3b6cd857d>

<https://hpmegatrends.com/how-3d-technology-is-transforming-the-auto-industry-a3b6cd857d>

<https://www.forbes.com/sites/lizlong/2018/03/01/how-3d-printing-can-benefit-your-business/amp/>

<https://view.ingwb.com/will-3d-printing-transform-business#:~:text=Companies%20will%20benefit%20from%203D,for%20storage%20of%20final%20products.>

<https://bmilab.com/blog/2017/9/27/what-is-the-influence-of-3d-printing-on-business-models?format=amp>

https://www.maineporte.com/practical-insights/five-ways-3d-printing-will-impact-the-global-supply-chain?hs_amp=true

<https://www.businessnewsdaily.com/9297-3d-printing-for-business.html>

<https://www.google.com/amp/s/3dprint.com/256528/3d-printings-impact-on-the-shipping-industry-too-early-to-tell/amp/>

<https://www.jabil.com/blog/future-of-3d-printing-additive-manufacturing-looks-bright.html>

<https://www.3dprintingmedia.network/the-future-of-jobs-report-2018/>

<https://www.businessnewsdaily.com/5125-3d-printing-jobs.html>

<https://re3d.org/phoenix-school/>

<https://www.machinedesign.com/3d-printing-cad/article/21837540/the-positive-effects-of-3d-printing-accessibility-on-society>

<https://www.google.com/amp/s/3dprint.com/198898/3d-printing-education-2017/amp/>

<https://www.technavio.com/report/3d-printing-market-in-education-sector-industry-analysis>

Chapter 10: References

<https://www.techradar.com/amp/news/5g-how-will-businesses-benefit>

[https://www.qualcomm.com/invention/5g/what-is-5g#:~:text=Early%201990s%3A%20G%20introduced%20digital,%20Code%20Division%20Multiple%20Access\).&text=Early%202000s%3A%203G%20brought%20mobile%20data%20\(e.g.%20CDMA%202000\).&text=2010s%3A%204G%20LTE%20ushered%20in,than%20was%20ever%20available%20before.](https://www.qualcomm.com/invention/5g/what-is-5g#:~:text=Early%201990s%3A%20G%20introduced%20digital,%20Code%20Division%20Multiple%20Access).&text=Early%202000s%3A%203G%20brought%20mobile%20data%20(e.g.%20CDMA%202000).&text=2010s%3A%204G%20LTE%20ushered%20in,than%20was%20ever%20available%20before.)

<https://www.wired.com/story/wired-guide-5g/amp>

<https://www.brainbridge.be/news/from-1g-to-5g-a-brief-history-of-the-evolution-of-mobile-standards>

<https://www.engadget.com/amp/2020-03-16-1g-to-4g-history-upscaled.html>

<https://www.ericsson.com/en/5g/what-is-5g>

<https://www.pcmag.com/news/what-is-5g?amp=true>

<https://www.rogers.com/business/blog/en/how-will-5g-impact-business>

<https://www.zdnet.com/google-amp/article/as-5g-arrives-the-biggest-impact-will-be-on-business/>

<https://www.vxchnge.com/blog/5g-statistics>

<https://www.webpronews.com/5g-world-att/>

<https://www.statista.com/topics/3447/5g/>

<https://enterprisersproject.com/article/2020/1/5g-12-statistics-see>

<https://www.tomsguide.com/amp/us/5g-release-date,review-5063.html>

<https://www.5gtechnologyworld.com/5gs-current-state-what-you-need-to-know/>

https://techcrunch.com/2020/03/05/5g-is-now-live-in-24-markets-gsma-predicts-itll-be-20-of-global-connections-by-2025-and-eyes-a-big-tech-break-up/amp/?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAC84v6RXEFMka2AGN0TXtNzIokRfm0yMakpQCnDwwkR82pNWnkpSJCZXTN7zRu8BK8PJlnnJRaAJ3xV6I1JfN0jWX0-XjH-s2G5AzonUrJKfKhwpLCNhTi57Hz80w8dj-jKjuAE0OGxNDC9KO1kt1VcGs-pohcLUKeeZhAhv4P5w

<https://www.vxchnge.com/blog/iot-statistics>

<https://www.tomsguide.com/news/t-mobile-raises-the-5g-stakes-by-launching-a-nationwide-network>

<https://www.mondo.com/blog-5g-tech/>

<https://connectedremag.com/das-in-building-wireless/5g-rollout-to-create-3-million-new-jobs-adding-500-billion-to-the-us-economy/>

<https://connectedworld.com/june-5g-in-the-workplace/#:~:text=5G%20will%20enable%20new%20ways,a%20workplace%20enabled%20by%205G.>

[https://techerati.com/features-hub/opinions/5g-society-smart-city-change-world-](https://techerati.com/features-hub/opinions/5g-society-smart-city-change-world-2019/#:~:text=With%20its%20faster%20speeds%2C%20greater,to%20be%20a%20game%20changer.&text=By%20expanding%20the%20scope%20of,to%20have%20significant%20societal%20impact.)

[2019/#:~:text=With%20its%20faster%20speeds%2C%20greater,to%20be%20a%20game%20changer.&text=By%20expanding%20the%20scope%20of,to%20have%20significant%20societal%20impact.](https://techerati.com/features-hub/opinions/5g-society-smart-city-change-world-2019/#:~:text=With%20its%20faster%20speeds%2C%20greater,to%20be%20a%20game%20changer.&text=By%20expanding%20the%20scope%20of,to%20have%20significant%20societal%20impact.)

<https://medicalfuturist.com/5g-in-healthcare-boosting-telehealth-vr-connected-health/>

<https://www.zdnet.com/google-amp/article/how-5g-will-make-smart-cities-a-reality/>

http://www3.weforum.org/docs/WEF_The_Impact_of_5G_Report.pdf