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Convergence of AI, IoT, Big Data and Blockchain: *A Review*

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Abstract

Data is the lifeblood of any business. Today, big data has applications in just about every industry – retail, healthcare, financial services, government, agriculture, customer service among others. Any organization that can assimilate data to answer nagging questions about their operations can benefit from big data. In overall, the demand for big data transcend across all sectors and business. Those who work to understand their customers' business and their problems will be able to proactively identify big data solutions appropriate to their needs, and thus gain competitive advantage over their competitors. Job demand for people with big data skill-set is also in the rise especially professional, scientific and technical services; information technology; manufacturing; and finance and insurance; and retail. DevOps is baseless without the cloud. IoT needs cloud to operate efficiently, for computing is required by the cloud operate efficiently. AI remained only as model up until the advent of big data. Blockchain and related distributed ledger technologies are disrupting the technology sector as we know it. The confluence of technologies is just inevitable and often they are beneficial especially today when usher in the 4th industrial revolution (Rabah, 2017a) and the forth coming machine economy (Rabah, 2018). More-so, data is a key ingredient of approaches to developing AI and machine learning, which are now being applied to a wide variety of uses, from stock trading to chatbots to self-driving cars. There is barely a business or human activity today that is not considered as a target for AI in future years and decades.

Keywords: Big data, Agriculture; Data infrastructure; Governance; Business modelling, Healthcare, Manufacturing industries, Education, Urban planning, analytics, Hadoop, Blockchain. IoT, AI, fog computing

1. INTRODUCTION

The way the world conducts businesses is changing at a fast pace, the world has leaped from an era of traditional advertising, marketing and sales to an era where almost every digital data that today is powered by big data. The most important ingredient today is data and while the contest of who controls most of the world's data seems to have been won by the GAFAs (Google, Amazon, Facebook, and Apple) and their likes, which combined is pushing out at an alarming rate. Over the coming years, the competitive nature of the business will heavily depend on the real-time data analysis and capability to predict future outcomes and trend even by a fraction of minutes might just be the differentiating factor that enables them to gain competitive advantage. Currently, big data technology is the new phenomena associated with most corporations having limitless data sets and information

Big data analytics is the process of examining large data sets containing a variety of data types – i.e., big data – to uncover hidden patterns, unknown correlations, market trends, customer preferences and other useful business information. The analytical findings can lead to more effective marketing, new revenue opportunities, better customer service, improved operational efficiency, competitive advantages over rival organizations and other business benefits (Vaidyanathan, 2017). Currently, there is a growing research in the field of big data. It involves extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations, decision support especially relating to human behavior and interactions. Major IT investment is today going towards managing and maintaining big data.

Over the last couple of decades, and more-so today, we are constantly bombarded with the deluge of data. From its humble beginning in the early 1960s (Kahn, 1997; Leiner et. al., 2009), today Internet is the source of huge data, emanating from a broad range of applications areas with data being collected at unprecedented scale and speed. Notably, decision that were previously based on guesswork, or on complex and painstakingly constructed models of reality, can now be made based on the data itself. Today, such Big Data analysis now are the main drivers behind every, if not, most of our modern society economic and social activities, including mobile service (data, video and financial), retail, engineering and manufacturing, financial, life sciences, and physical sciences (CCC, 2011; Jagadish et al., 2014; Paradiso, 2014). In the area of life sciences, there now exist well-established tradition of depositing scientific data into public repository, and also of creating databases for user by other researchers. Mores-so as technological advances, especially with the advent of Next Generation Sequencing (NGS), the size and number of experimental datasets available is increasingly exponential (Jagadish et al., 2014). Furthermore, there now exists an entire discipline of bioinformatics, which is largely devoted to the curation and analysis of such life sciences related data.

Other scientific research that has also been revolutionized by the Big Data includes the Digital Sky Survey (Eisenstein, 2011), which has today become a central resource for astronomers the world over. The field of astronomy, which couple of years ago, mainly involved taking pictures of the sky by the astronomers, has been suddenly transformed to where pictures are all in a database already and the astronomer's task now involves finding interesting objects and phenomena in the database.

Today, the promise of data-driven decision making support using big data is just now being recognized broadly as a major contributing factor to a countries economy. For example, Google is an engine of economic growth – Google's 2015 Economic Impact report finds the company contributing $165 billion of economic activity for 1.5 million businesses and non-profits nationwide, up from $131 billion in 2014. Using Google's big data – Ads and search lead to clicks, and some clicks lead to business. The incremental revenue gained has a not insignificant impact on job creation as well.

However, there is still a wide-gap between big data potential and its realization. Some of the major impediments are heterogeneity, scale, timeliness, complexity, and privacy problem – thus making progress difficult at all phases of the pipeline that can create value from data. The key to this starts right from data acquisition – i.e., at the point when data deluge requires us to make decisions, which currently happens in ad hoc manner, deciding what data to keep and what to discard, and how to store what we require reliably with right metadata. Today much of the data is not natively stored in structured format, e.g., blogs and tweets are weakly structured pieces of text, which images and video are structured for storage and display – but not for semantic content and search – thus, posing tremendous challenge in transforming such content into a structured format for analysis.

Most importantly, the value of data is known to explode when it can be linked with other data – thus data integration is a major creator of value. Since most data today is directly generated in digital format – it presents us both an opportunity and the challenge to influence the creation to facilitate later linkage, and to automatically link previously created data. However, data analysis, organization, retrieval, and modeling are the other foundational challenges. Among these, data analysis is considered a major bottleneck in many applications, both due to the lack of scalability of the underlying algorithms and due to the complexity of the data that needs be analyzed. Finally, the presentation of the results and its interpretation by non-technical domain experts is crucial to extracting actionable knowledge.

It's important to note that over the last four decades, data management principles such as physical and logical independence, declarative querying and cost-based optimization have created a multi-billion dollar industry. More importantly, today these technical advances have successfully enabled implementation of business intelligence applications, and laid the foundation for managing and analyzing Big Data. More-so the many novel challenges and opportunities associated with Big Data necessitate rethinking of many aspects of these data management platforms, while retaining other desirable aspects. It's highly believed that appropriate investment in Big Data should lead to a new wave of fundamental technological advances, which will be embodied in the next generations of Big Data management and analysis platforms, products and systems.

Furthermore, it's our believe that these research problems are not only timely, but have the potential to create huge economic value in the US and across the global economy for many years to come. But they are also hard and complex, thus prompting us to rethink data analysis systems in fundamental ways. However, a well-directed major investment in Big Data, can led not only in major scientific advances, but also lay the foundation for the next generation of advance in science, medicine and business.

Edwards Deming once said that "without data you are another person with an opinion." But Deming couldn't have imagined the size and speed of data systems we have today. Automation that relies on continuously gathered data is now changing our daily lives. Drivers today don't need to know how to use maps anymore, when they can use smart navigators that find them the best routes; similarly, airline pilots spend more time flying on autopilot than by hand. Similar trends are happening in education systems with countless reformers trying to "disrupt" schools as they are, and as we know them today.

Today, there is a great demand not only for increased access to valuable data but also for tools to automate data collection, archiving, and analysis. More-so, industry influencers, academicians, and other prominent stakeholders certainly agree that big data has become a big game changer in most, if not all, types of modern industries, and how we do things over the last few years.

DLT

Distributed ledger technology (DLT) is expected to reduce both the costs of verification and networking, influencing then the market structure and eventually allowing the creation of new marketplaces. It is important to note that the intrinsic power of this technology, which can be looked as a *foundational technology* that aims to *change the scope of intermediation* and not as a disruptive innovation technology (Catalini & Gans, 2017). Iansiti and Lakhani (2017) have come up with a brilliant idea which looks at a parallel between blockchain and TCP/IP that shows how blockchain is slowly going through the four phases that identify previous foundational technologies such as the TCP/IP, i.e., single-use, localized, substitution, and transformation. They noted that the *novelty*" of such a technology makes it harder for people to understand the solution domain, while its "*complexity*" requires a large institutional change to foster an easy adoption.

Blockchain & AI

Blockchain is the underlying technology that powers cryptocurrencies like Bitcoin – and refers to a continuously growing list of records or ledger that are linked and secured using cryptography (Rabah, 2016a, 2016b). In recent times, it has become a frontier for cybersecurity, IoT, digital ledgers, and other data technologies respectively. Currently, tremendous research and investment is being put into the advancement of blockchain technology, because of the massive potential and countless applications it offers. Moreover, blockchain technology is proving to be the most significant technology breakthrough since the invention of the Internet (Rabah, 2016a, 2016b) – and it's expected to become an important part of many businesses over the coming years. Blockchain technology's ability to guarantee the accuracy of data makes it useful for a number of AI applications, both for feeding data into AI systems and for recording results from them.

Artificial Intelligence (AI) technology or Machine Learning, which has been with us for couple of decades, once again is in vogue, as can be seen on how bots are taking over the web space in a viral manner. Today, AI is gaining practical use and is becoming inseparable from daily life activities, gaining relevance across almost all sector of the economy, ranging from financial and banking services, healthcare, transportation, defense among others. Moreover, with a wide and an almost endless variety of AI applications, we're definitely in the dawn of an automated world powered by machine-2-machine interconnection or machine economy.

Moreover, it's undeniable that AI and blockchain are two of the major technologies that are catalyzing the pace of innovation and introducing radical shift in every sector of industry. More-so, each technology has its own degree of technical complexity as well as business implication but the joint use of the two may be able to redesign the entire technological (and human) paradigm from scratch.

Some of the organization working on leveraging these technologies includes CognativeScale, an AI startup that's backed by IBM, Intel, Microsoft and USAA, among others that seek to use blockchain technology to securely store the results of an AI application that it built for regulatory compliance in the financial markets world. An industry that's bogged down with a lot of regulatory, thus being able to store AI-derived decision securely should help market participants stay on top of onerous reporting requirements. IBM is also currently toying with the idea of marrying both its blockchain offering – based on open-source Hyperledger Fabric – and its Watson AI platform for a range of industries. One such project involves Everledger, which applies blockchain technology to track provenance of luxury items, including diamond trade. For example, IBM is leveraging Everledger's data store of individual diamond characteristics (more than a million of them, secured by IBM blockchain). Similarly, Watson is applying knowledge of thousands of regulation to ensure that diamond comply with UN edicts preventing the sale of conflict minerals.

Leveraging Fog Computing, AI, Blockchain & IoT

Indeed we're living in a very exciting time, globalization is no longer a buzz-word – we now toy with ushering in the 4th industrial revolution, which will soon give way to machine economy (machine-to-machine) world. Technology such as Internet of Things (IoTs) have quietly but steadily evolved over the past few years, going from a mere buzzword to business game-changer – and in the process, reshaping the Internet as we know it. Thanks to deluge of data streaming out of IoT devices, and which today has enabled the internet to evolve into a real-time conduit of copious amounts of data that enterprises can analyze to improve decision making, enhance performance and increase profits. Moreover, IoT with its many diverse markets, has shifted the paradigm to operational technology and lines of business as key buying centers, seeking solutions and services that drive business outcomes – thus, IoT is finally ready for primetime.

The year 2018 is expected to usher-in the blockchain technology into the IoT equation, thus helping enterprises overcome data trust challenges that previously hindered its adoption. Since blockchain offers a secure exchange of value between entities in a distributed network, a new class of IoT applications will arise. For example, automakers may use blockchain to authenticate the interactions between connected vehicles and roadside infrastructure (Rabah, 2017), or supply chain can trace and authenticate the source of goods with technology's tamper-proof transaction records (Rabah, 2017a).

The next big thing in the IoT world, is fog computing. Fog computing is a term created by Cisco that refers to extending cloud computing to the edge of an enterprise's network. Also known as Edge Computing or fogging, fog computing facilitates the operation of compute, storage and networking services between end devices and cloud computing data centers. In relation to IoT, fog computing, which has quickly become a mainstream concept describing a distributed cloud environment – for instance, many bandwidth-intensive IoT applications requiring real-time data processing – traditional cloud computing focused on batch processing is no longer sufficient. Fortunately, fog computing breaks down this adoption obstacle, for example, today the best example of fog computing in use involves an offshore oil rig that generates terabytes of data daily. Thus, rather than spending days waiting for the that data stream to be transmitted to the cloud – fog computing brings the power of the cloud closer to earth – real-time information can be locally processed and analyzed based on centralized policies from the cloud, only exceptions and alerts are sent through the satellite.

The ultimate technology breakthrough can be realized when we leverage the integration of IoT, AI, blockchain and fog computing. For instance, consider an autonomous car. Traditional data analysis, compute, security and networking solutions aren't powerful or intelligent enough to drive a highly autonomous vehicle. However, distributed and increasingly cost-effective AI engines connected via high-speed deterministic networks inside and outside the vehicle can make decisions based on the massive amounts of high integrity data made immutable by blockchain and processed by fog nodes. As a result, the vehicle can quickly, dynamically and safely navigate the roads with little to no human intervention.

AI is better able to crunch data successfully to enable us garner valuable insights from it, and therefore, it is playing a good role in IoT. Machine Learning is a sub branch of AI, and has huge potential to detect the patterns and anomalies in the data that smart sensors generate. Currently, machine learning based analytics is now being provided by major IoT and cloud vendors who offer a host of AI capabilities. Furthermore, the Machine Learning is 20 times faster when compared to other monitoring systems, and on top of it, the accuracy is also greater. More-so, if the data operations such as these have to be secure then Blockchain technology can play a vital role. Today, Machine Learning enabled analysis is employed in best of fraud detection systems.

Today, blockchain is redefining how trusted transactions ought to be carried out. Notwithstanding that the internet today is itself highly vulnerable – the blockchain is out with the solution to address it. The blockchain is able to solve the security fault lines that are common with AI and IoT. Most IoT devices are connected to each via public networks, which from common knowledge, are highly vulnerable. Blockchain solves this problem by linear and permanent indexed records, which can be created, which then can be referenced globally by the general public without censorship. They can also help enhance the commerce process by providing a payment mechanism as well as communication channel. There are no controls from any centralized entity as is the case with banks – and therefore, the public is the authority. Hence Blockchain can be used to provide a secure, scalable and verifiable platform that has invincible security implementations (Rabah, 2016b; Rabah, 2017c).

Currently, Ethereum blockchain, for example, has made smart contracts very popular owing to the efficiency (Rabah, 2017d). For instance, the data from the IoT devices can be made to trigger some tasks e.g., in the case of auto insurance. For example, assume there are IoT sensors installed in a car and in some parts defects appear. In this case, the AI will aid the sensor to detect the defects. If this scenario is coupled to Blockchain implementation – then as soon as the sensor detects a defect – then it will automatically trigger the insurance money to be credited to the claimant's account.

Today, machine learning is becoming part of our daily life – they're capable of detecting the most savvy and intelligent fraud activities at very high speeds, with greater efficiency and with huge scale. They're able to detect data from sensor, for example, to assess whether or not the defect in the vehicle is genuine or not. More importantly, false positives will greatly be reduced in this case. Likewise the trio could massively disrupt the auto insurance industry.

Another example is to consider a host of self-driving trucks (AI) that have to deliver goods to distribution centers using AI technology. But a self-driving truck is useless if it doesn't bill & charge automatically at a charging station – and for this to happen, one needs to put in place a mechanism for authentication, authorization and smart contract framework, which works around the scenario. Finally, a ledger that cannot be tampered with is employed to record the transactions in this smart contract that use Etherium (Blockchain). Once the goods reach the distribution center, they are then deployed to the customers through drones (IoT) employed by retail company.

IoT and Personal Data in the Era of Machine Economy

As we venture into the machine economy where data derived from variant of smart device, majorly consumer data collected by the service providers for one reason or the other – this has pitted the consumers against the service providers regarding the gathering and use of personal data. On the one hand, consumers expect to get personalized choices from a custom site search and other tools that rely on data gathering and processing. However, when things go wrong e.g., when a data breach occurs – then attention quickly shifts from usefulness of allowing data gathering to its potential perils.

Today, one of the most prevalent smart devices found almost in almost all consumer related gadgets is IoT smart device from wearable etc. But Internet of Things (IoTs) is an industry with heavy focus on data collection. Most IoT use cases involves data gathering. Data monetization is set to be one of the hottest IoT trends in 2018. But IoT is also an industry that's had plenty of security issues. Security is one of the reasons for the relatively slow adoption of IoT. While we're looking forward to see whether the governments will step in with tighter regulations on IoT, we're about to witness Europe's legislative response to the evolving digital landscape with the GDPR enforcement – and it's bound to affect IoT implementation and usage.

GDPR is short for General Data Protection Regulation – is an EU regulation. GDPR is concerned with personal data, or data that can be used to identify a person. GDPR has a pretty broad take on a person's identity; such personal data include data that describe the person's economic, mental, or physical status. Sensitive personal data include data on ethnicity, political opinion, religious beliefs, health, and genetic and biometric data. Location data and online identifiers are also considered personal data. That is, GDPR aims to protect and expand EU citizen's right to have their data processed safely and only when needed, however, it doesn't affect only EU companies. Basically, it affects any business that wants to offer services or products to EU citizens and that plans to process or order processing of EU citizens' data s subject to the GDPR.

Under the GDPR, manufacturers or service providers who want to process data need to have legal grounds for data processing. Consent is one of the possible legal grounds, but only if it meets strict criteria: it needs to be informed, given freely, specific, and given in an affirmative action. Manufacturers or service providers who fail to meet the criteria of legal grounds for processing are expected to face penalties of up to 4% of global income or €20 million, whichever is higher.

In overall, the success of implementation to leverage the convergence of these technologies i.e., IoT, AI and Blockchain, will not depend on the capability of the technology but rather on the security provided to data. Therefore, security should be considered to be the main criteria to be fulfilled if these technologies can hopped to take-off in a big way. It's envisaged that each of these technologies can leverage the strong points of each other and pave way for a vision where devices are securely transacting with each other making use of Blockchain technology and the data is processed through AI and Machine learning technology for decision making (Rabah, 2017c).

Big Data and Its Application in Education

Other sector that Big Data is bound to revolutionized is in the area of education. The data gold rush in education began in earnest around eight years ago, with the emergence of the field of learning analytics, which are today commonly found in most of the major Learning Management Systems (LMS). Learning analytics focuses on the measurement and analysis of student data to improve learning and learning environments. Big Data is making education more interesting, affordable and available.

According to a recent detailed study undertaken by Dobbie and Fryer Jr, (2013) that involved quantitative comparison of different approaches taken by 35 charter schools in NYC, they observed that one of the top five policies correlated with measurable academic effectiveness involve the use of data to guide instruction. For example, let's imagine a world in which we have access to a huge educational database, where we collect detailed measure of every student's academic performance. The collected data could be used to design the most effective approaches to education; starting from reading, writing, teaching STEM (science, technology, engineering & mathematics) to advanced college-level courses. We can say, it's just a matter of time, before we can have access to such data, however, there is a powerful trend in this direction, for example, there is a strong trend for massive Web deployment of educational activities, and this is expected to generate an increasingly large amount of detailed data about student's performance, thus quickly allowing the school administration to proactively manage students' wellbeing.

In the higher education sector, the big data revolution has delivered universities deep goldmines of information on how to track, with every click they make logged, and analyzed through online learning systems. However, the educational sector needs to stay focused on what it's all for – actually helping students learn and their performance outcome (Corin et al., 2017).

Today, Big Data is assisting educational institutions and related companies to understand things they could not have previously. For student enrollments, Big Data and predictive analytics have the ability to prepare analytical databases, which can cater to college administrators with fast, actionable information. This information helps them to take smart enrollment decisions, and allocate both staff time and financial resources to raise enrollment from current markets, while constructing new ones. From a student's viewpoint, Big Data and predictive analytics can assist the candidate to shortlist colleges that best fit for their profile.

Moreover, in the advent of online learning system, the sheer volume of online learning data now available is mind boggling and very seductive – however, it's pretty hard and complex to mine the data and know where in the landscape of big data we need to be digging to find the meaningful insights. Thus, we need to first and foremost know more about what we are looking for, which means better understanding on how we can improve student learning outcome. That is, if big data is the answer for education, then what is the question?

In most cases, majority of the institutions, seek to address the issues that include, for example, student retention; provide students with feedback on their learning; or attempt to identify as early as possible those students 'at risk' of falling behind or dropping out, so that proactive intervention can be taken to help these students stay on track. In general, clear student key performance indicators, is the key to realizing the usefulness of the big data. More importantly, these institutions want to align the outcomes of the analysis of big data with broader institutional priorities. In the overall, the crucial challenge is on how to use big data to improve learning.

Big Data and Its Application in Healthcare

A big-data revolution is under way in healthcare. Big data could transform the health-care sector through accelerating value and innovation, but the industry must undergo fundamental changes before stakeholders can capture its full value. Start with the vastly increased supply of information capture by Web-enabled healthcare information systems that are now common place in most modern hospitals across the globe. Over the last decade, pharmaceutical companies have been aggregating years of research and development data into medical databases, while payors and providers have digitized their patient records for ease of patient healthcare management and transferability. Thus, it's now widely believed that over the coming years, the use of information technology is expected to reduce the cost of healthcare, while improving its quality and delivery (CCCa, 2011) – by making healthcare more preventive and personalized that can easily be customized to suit more extensive (home-based) continuous patient monitoring. A study by McKinsey (Manyika, *et al*., 2011) – estimates that a saving of 300 billion dollars in the US alone, which today's standard could be higher, is clear way to show how leveraging big data for healthcare is good for the economy of a country.

For example, the US federal government and other public stakeholders have and continuous to open their vast stores of healthcare knowledge, including data from the clinical trials and information on patients covered under the public insurance programs (Kayyali, 2013). At the same time, current technological advances have made it easier to collect, store and analyze information from multiple sources – thus a major benefit in the healthcare offering, since data for a single patient can easily be ported from various payors, hospitals, laboratories, and physician offices/clinics.

Although, healthcare costs may seem paramount in the big data's rise, clinical trends have also played a role. Couple of years ago, physician traditionally used their judgment when making treatment decisions, however, today in recent times there have been a move towards evidence-based medicine, which involves systematically reviewing clinical data and making informed treatment decisions based on the best available information. More-so, the possibility to aggregate individual data sets into big-data algorithms often provides the most robust evidence, since nuances in subpopulations – such as the presence of patients with gluten allergies – may be so rare that they are not readily apparent in small samples.

Artificial intelligence powered machine learning is continuing to gain foothold in healthcare sector – for example, scientists from Google and its health-tech subsidiary Verily have discovered a new way to assess a person's risk of heart disease using machine learning. By analyzing scans of the back of a patient's eye, the company's software is able to accurately deduce data, including an individual's age, blood pressure, and whether or not they smoke. This is then used to predict their risk of suffering a major cardiac event, e.g., heart attack, with roughly the same accuracy as the current leading methods – this shows how AI can help improve existing diagnostic tools – they are taking data that's been captured for one clinical reason and getting more out of it than we currently do. Thus, the algorithm potentially makes it quick and easier for doctors to analyze a patient's cardiovascular risk, as it doesn't require a blood test. Although, the idea of looking at your eyes to judge the health of your heart sounds unusual, it draws from a body of established research. Google acknowledges that the work represents more than just a new method of judging cardiovascular risk – it points the way towards a new AI-powered paradigm for scientific discovery.

Today and over the coming years, some of the key and vital ground breaking work is being leveraged through partnerships between medical and data professionals, with potential possibilities to peer into the future and identify medical related problems before they happen. One such partnership, for example, Pittsburg Health Data Alliance in US, looks at the possibility of taking data from various sources e.g., medical and insurance records, wearable sensors, genetic data and even social media use, to draw a comprehensive picture of the patient as an individual, in order to offer a tailored healthcare package (Marr, 2015).

Another key aspect of big data for healthcare, for example, is using the example of a hospital or healthcare provider, poorly managed patient data increases the risk that a patient will be misdiagnosed, treated incorrectly, or that test results become lost or corrupted. There's also a concern that two touchpoints on a patients' treatment journey (e.g. a GP and specialist) might have different datasets for the same person. Thus, placing healthcare databases on the blockchain would create a single, unchangeable resource for practitioners to use when treating a patient (Smyth, 2016). The most significant benefit the blockchain could offer healthcare is security. For example, in the United States, insurers such as Anthem, UCLA Health, and several others lost more than 100m patient records to hackers in 2015, a breach that left patients at risk of identity theft. Under blockchain, even a doctor would require multiple authorized "signatures" or permissions from other parts of a network to access patient records.

A blockchain-based healthcare system would also allow providers to share records with justice departments, insurers, employers and any other sector with an interest in people's health without the exponential increase in risk factors that comes with stretching a network thin; after all, a multi-department system is only as secure as the defenses at its weakest point. Unfortunately, blockchain integration in healthcare is still a long way off. On the technology and application front, there is need to rebuild database infrastructure, train and hire new staff, and to persuade directors that blockchain is worth the financial outlay means that the system's growth will be confined to health-based start-ups for the foreseeable future (Smyth, 2016).

The report predicts that the convergence of blockchain with AI, IoT and machine learning will provide new opportunities for digital health economies. Blockchain would offer the potential of a shared platform that decentralizes healthcare interactions, which would ensure integrity, security, access control and authenticity. It could also present new value-based care and reimbursement models.

More-so, burgeoning connected health devices and the need to protect against data breaches make blockchain, with its ubiquitous security infrastructure, the obvious foundation for emerging digital health workflows and advanced healthcare interoperability. However, it's important to note that Blockchain technology may not be the panacea for healthcare industry challenges needs but it holds the potential to save billions of dollars by optimizing current workflows and disintermediating some high-cost gatekeepers pricing out would be genuine patients from accessing critical healthcare needs. Thus, the healthcare industry needs to establish blockchain consortia to facilitate partnerships and create standards for future implementation on a large scale across healthcare use case (Walsh, 2017). Key factors to be looked into are data interoperability, insurance fraud management, drug supply chain provenance, and identity management applications which offer growth opportunities or the healthcare industry (Rabah, 2017b). It's projected that over the next five to 10 years, we should see a blockchain ecosystem with healthcare-focused use cases involving health data exchanges, smart drugs and asset management, insurance settlement and payment solutions.

Big Data and its Application in Urban Planning

Today, the rising complexity of modern cities and some extend smart cities; have rendered the traditional urban planning, urban design and urban management methods, which currently have reached their limits. Life in a city and major urban areas have become increasingly dynamic, whereas the old thinking urban planning often relies on static and sectorial approaches, involving a very limited number of citizens and stakeholders in relevant decisions. The emergence of "big data" has allowed social scientists to gather massive and detailed amounts of information about cities and their residents. Currently, Big Data is becoming an exponentially growing source for evidence-based high-quality decisions by analyzing existing or past situations. Big Data-Informed Urban Design transcends the retrospective view by integrating advanced data analytics into the urban design and planning process.

In recent times, there have a persuasive cases made for the value of big data for urban planning – through fusion of high-quality geographical data – intelligent transportation, through analysis and visualization of the live and detailed road network data capture – environmental modeling, through sensor network ubiquitously collecting data (Rabah et al., 2017, CCCb, 2011); energy saving – through unveiling of patterns; smart materials – through the new materials genome initiative (Ward, 2012); computational social science – through a new methodology fast growing in popularity, because of the dramatically lowered cost of obtaining data (Lazer, 2009); homeland security – through analysis of logged information and other events, known as Security Information and Event Management (SIEM) and others. It is expected that Big Data-Informed Urban Design will develop a framework to support urban planning, urban design, and urban management with five work streams: urban governance, cognitive design computing, urban complexity, citizen design science and evidence informed urban design.

Furthermore, it's expected that information derived from Big Data will make urban planners and designers more informed and aware; it will also strengthen the role of design as an activity that sets goals beyond past evidence, in the future. Big Data-Informed Urban Design will fundamentally improve the understanding and utilization of urban data; it will support the formalization of expert knowledge for the design process. On the applied research level, it will integrate the methods developed by the team into an interactive planning support system, which, by visualizing planning effects differently, provides a tool for designers, politicians, citizens, and other stakeholders. By making their operations more data-driven, cities can fine-tune regulations, improve the allocation of scarce resources, and forecast future needs, the possibility to tame the flooding menace encountered low laying cities during rainy seasons. In fact, big data is the new engine powering the future urban planning and economy of cities.

Big Data and its Role in Agricultural Sector

In the agricultural sector our main interest is geared towards looking what are the challenges facing farmers today. That is, the need to understand what farm data is and how they can harness it to improve their operations in terms of food production, plant health etc. Also the learning curve of technologies and tools that help farmers collect, transfer and make sense of their data. Many farmers are already harnessing the power of their data. Many are just starting down the path. The farmer wants to protect himself, and get the most out of his data. He needs to understand what farm data is, and how his data is managed and who can see it.

The big data revolution in farming is here – now it's time to get on board, and start realizing how beneficial data can be leveraged in managing individual or organization's operation. It can be a confusing space, but informed farmer can adapt and use it to gain efficiency, productivity, yields and profits. Over the last couple of years, we have seen tremendous digital revolution in farming activities, majorly in the area of big data application in agri-food sector, where there exist several collection and analytics tools that may be leveraged by players in the food systems – i.e., between farmers and large corporation. For example, who should own or retain ownership of data generated by applications like Monsanto Corporation's *Weed I.D.* "app"? More-so, are privacy implications with data gathered by John Deer's precision agricultural equipment? In this respect, there is a need for researchers to systematically trace the digital revolution in agriculture, with a view to charting the affordances as well as the limitations of big data applied to food and agriculture – covering a broad research goal for big data scholarship. This should be expected to bring data scholarship into conversation with food studies in relation to importance of big data in our society.

The advantage of leveraging big data for agriculture is the need to identify key challenges that are faced by big data analyst trying to solve problems for agriculture communities, discuss potential solutions, and identify the opportunities emerging from cross-domain interactions among agriculture experts, hydrologists, dairy experts, aquaculture experts, and big data analytics experts. Some of the key areas and challenges are as follows (Wolfert, Ge, Verdouw & Bogaardt, 2017):

- Big Data is expected to have a large impact on Smart Farming and involves the whole supply chain.
- Smart sensors and devices produce big amounts of data that provide unprecedented decision-making capabilities.
- Big Data is expected to cause major shifts in roles and power relations among traditional and non-traditional players.
- Governance (incl. data ownership, privacy, security) and business models are key issues to be addressed in future research.

Farming is undergoing a digital revolution. Big data are being used to provide predictive insights in farming operations, drive real-time operational decisions, and redesign business processes for game-changing business models. It's envisaged that big data is expected to cause a major shifts in roles and power relation among different players in current and future food supply chain networks. In recent times, the landscape of stakeholders exhibits an interesting game between powerful tech companies, venture capitalists and often small start-ups and new entrants.

There's nothing more important than our food supply. America is a country synonymous with wheat farms and orange trees. But according to McKinsey & Company, about a third of food produced is lost or wasted every year. Globally, that's a $940 billion economic hit (Sparapani, 2017). Big data is moving into agriculture in a big way. Sensors on fields and crops are starting to provide literally granular data points on soil conditions, as well as detailed info on wind, fertilizer requirements, water availability and pest infestations.

More-so, drones powered by IoTs and RFID sensors are helping on-farm pest controls that have today already boosted crop yields significantly across the globe. A Bulgarian startup company is currently working on developing a web-based solution that help farmers process drone captured images and detect, in real-time, zone with potential crop health issues. The platform is powered by a cloud infrastructure and does not require any specific hardware to be present on the farmer's local machine (or a fast internet connection) (Mihail_agrohelper, 2018; Rabah, 2017a)

Big Data and its Application for Industry

Data is the lifeblood of any business, and those that will competitively leverage its use, will definitely have a competitive advantage over its competitors. In the last couple of years, disruptive new technologies and transformative innovations have hit some industries harder than others. Some sectors adopt earlier or follow faster than others. For big data, financial services, retail and communications are among the trailblazers. And there is much these leaders from other sectors can learn from these standard setters as we have seen earlier.

In manufacturing industry, for example, the ability to effectively analyze big data use cases can help to reduce processing flaws, enhanced customer service, improve production quality, increase efficiency, enhance value chain processes, and save time and money. For example, Tata Consultancy Services in one of its research had asked manufacturers to rate the following big data benefits on scale of one to five, and obtained the following results, shown in Table 1:

Table 1: Rating of big data benefits within the manufacturing industry

Item	Rating of benefits of Big data
Product quality and defects tracking	3.37
Supply planning	3.34
Manufacturing process defect tracking	3.32
Supplier, components, and parts defect tracking	3.11
Supplier performance data to inform contract negotiations	3.08
Output forecasting	3.03
Increasing energy efficiency	2.97
Testing and simulation of new manufacturing processes	2.88
Support for mass-customization of manufacturing	2.75

From Table 1, it can be observed that the range of big data use cases in manufacturing industry is limited only by available data and imagination. Thus, it's important to note that a big data use case can provide a focus for analytics, by providing the parameters for the types of data that can be of value, and determining how to model that data using, for example, Hadoop analytics. This can aid in answering complex questions, like "where is the next big market for my product", which is harder to answer than "who is likely to buy more product in the United States".

Further, in the area of supply chain management, using big data analytics, can allow a company to predict potential delays on a map, analyzing weather statistics or tornadoes, earthquakes, hurricanes, etc. Furthermore, use of predictive analytics allows a company to calculate the probabilities of delays. Thus, the use of analytics findings can enable the company to identify backup supply and develop contingency plans to make sure production isn't interrupted by natural disaster.

Big Data and Public Services Delivery

Governments have an opportunity to harness big data solutions to improve productivity, performance and innovation in service delivery and policymaking processes, For example, the key question here is why is big data important for government? It's envisaged that joining up public sector data sources can make government more efficient service delivery, save money, identify fraud and help public bodies better serve their citizens. That's data can enable government to do existing things more cheaply, do existing things better and do new things it doesn't currently do.

Moreover, when contrasting the traditional forms of sources, such as user surveys commonly undertaken by governments, regarding citizens' needs, views, attitude and behavior is today augmented by modern information technologies, which provide us with much better possibilities to collect, store, process and combine large data based on actual behavior, exact localities, and often based on modern sensors devices monitoring daily activities around us ranging from human activities, road use etc. For example, the Dutch tax authorities at one point discovered that when cross-matching their data sets that individuals, who were in the process of getting divorced, were much more likely to make mistakes in their tax self-assessments. Similarly, a few years ago, there is a classic example of how the search engine Google was able to predict both outbreaks and movement of flu, based on what search terms citizen entered, but at that point precision was, however, questioned.

For some, this trajectory is not only a revolution for delivering services to the public, but also entails a real knowledge-based asset for the public sector, which can be shared, or even sold to commercial interests, contributing to innovation and economic growth in the country. Thus, in future the role of policy advisor will be expected to diminish, and simply be that of a harvester of known or accessible facts, that some kind of algorithm will then be applied and that the policy answer – and there can only be the one policy answer

– will emerge. Indeed, taken to its extreme, policy analysis will be replaced with information systems management – thus, we're expecting to do away with the traditional analog of doing things and ushering in the new digital powered future, which holds out real possibilities in public administration and public service to new digital realities and new possibilities for governance. Thus, the administrative vocation as such will become an historical relic (Lofgren, 2016).

In this respect, the data analytics, in this alterative view, becomes part of the toolkit that the public service adviser can draw on from the knowledge-based perspective. Now, the remaining challenge will be how to get the public sector leaders to understand, not only the possibilities, but also the limitations of the data analytics. It's expected that in so doing governance may become all the richer, the role of public servants all more important in a range of authorizing environments, and citizens made active participants in co-production, not the passive recipients of policymaking by some kind of enhanced Wikipedia-like (Lofgren, 2016).

Finally, it's imperative to note that to realize the potential of Big Data, there is an important balance to be found between the rights of individuals to privacy and confidentiality and the benefits from sharing information. With these concerns addressed to tackle public cynicism, Big Data has the potential to redefine both public and private services for the better.

Big Data Challenges

Big data today is a technology that is maturing up, but as with any other emerging technology, it comes with some teetering issues and challenges that must solved before it becomes widely accepted by the end-users – some of the key challenges encountered with big data, include control, data authenticity and monetization (McConaghy, 2016).

Big Data Controls

The first and foremost challenge to big data, is who controls the infrastructure when there are multiple actors involved? For example:

- If you're a multinational enterprise, how do you share data around the planet? If you have multiple copies, how do you know, which one is the most up-to-date? How do you reconcile a different system administrator role at each regional office?
- If you're an industry consortium, how do you share control of the ecosystem infrastructure among the companies in your consortium? This is especially hard if those companies are competitors!
- Why can't there be data just "out there" as a single shared source of truth that no one on the planet owns or controls, parse? Rather, data would be a public utility like electricity or the internet itself.

Big Data Trust

The second, and most important issue touches on the trust, how well can you trust the data? For example:

- If you generate the data yourself, how do you prove you were the originator? If you get data from others, how do you know it was truly them?
- What about crashes and malicious behavior? Machines crash, glitches happen, bits flip. Zombie IoT toasters might be inputting garbage. So after all your fancy Spark calculations, is it still just garbage out?

Big Data Monetization

Finally, how do you monetize the data? For example:

- How do you transfer the rights of the data, or buy rights from others?
- There's a long standing dream of a universal data marketplace; how?

Integrating AI, Big Data & Blockchain Technology

Integrating big data with Blockchain technology is a sure way of answering and managing some or most of the key issues and challenges involving big data. Blockchain technology came to popular notice with the rise of bitcoin and other cryptocurrencies (Rabah, 2016a; Rabah, 2016b). The block chain is essentially a ledger that every single Bitcoin transaction must pass through in order to be verified by the millions of other peer to peer users. This means that every transaction is public, and that every Bitcoin user's activities are visible to the millions of other people on the block chain. The technology allows for highly secure digital transactions and recordkeeping. Even though blockchain found its first use in cryptocurrencies, the concept can be applied to all sorts of transactions, including agricultural ones.

Moreover, the recent surge in blockchain was sparked by Bitcoin. Technically, all blockchain are simply databases, but databases with "blue ocean" benefits: decentralized / shared control, immutability / audit trails, and native assets / exchanges (Rabah, 2016a). Blockchains is expected to give greater confidence in the integrity of the data. Immutable entries, consensus-driven timestamping, audit trails, and certainty about the origin of data (e.g. a sensor or a kiosk) are all areas where you will see improvement as blockchain technology becomes more mainstream.

Beyond data integrity (which is a huge component), the shared data layer that blockchains will introduce creates an entirely new set of possibilities for AI capabilities and insights. Trent McConaghy, CTO of BigChainDB does a great job in explaining the benefits of decentralized/shared control, particularly as a foundation for AI. In this world, he says, you get (Epstein, 2017):

- More data, thus improved modelling capabilities
- Qualitatively new data leading to entirely new models.

The inherent immutability leads to more confidence in training and testing data and the models they produce.

In this respect, the future looks good, as we expect to see an expansion of the concept of big data, as we move away from proprietary data silos to blockchain-enabled shared data layers. In the first epoch of big data, power resided with those who owned the data. In the blockchain epoch of big data, power will reside with those who can access the most data (where public blockchains will ultimately defeat private blockchains) and who can gain the most insights most rapidly. This brings about two significant implications; these are (Epstein, 2017):

- Customer data will not belong to organizations, locked away in corporate databases. It will belong to each individual, represented as tokens or coins on an identity blockchain. The customer of the future will grant access to others as necessary.
- Transaction data will be viewable by anyone. Anyone can access the data about the transactions that occur on a given blockchain.

When data moves out of proprietary systems onto open blockchains, having the data itself is no longer a competitive advantage. Interpreting the data becomes the advantage. In a blockchain world, all competitors are looking at the same ledger (imagine you and your competitors all have the Google Sheet or Excel file).

Data Security Requirements for Big Data

In the era of big data, the ever expanding data volumes and longer compliance data retention requirements are putting enormous and previously unforeseen stresses on organizations' data security and compliance environment. Thus, when looking at solutions that provide the power and capacity of a big data platform, it's crucial that it also meet the data security requirement. Currently, IBM is putting forward a solution, IBM Security Guardian Big Data Intelligence, for this purpose. It enables organizations to become more agile, quickly creating an optimized, secure data lake that retains large quantities of historical data over long time periods to deliver new, enriched analytical insights and nearly real-time reporting while reducing operational and performance costs.

Big data, AI and Quantum Computing

In the advent of quantum computing, which is raring to come of-age – quantum computer promises to run calculations far beyond the reach of any conventional supercomputers found today. They might revolutionize the discovery of new materials by making possible to simulate the behavior o matter down to the atomic level. Or they upend cryptography and security by cracking otherwise invincible codes e.g., via inter factorization (Rabah, 2006). More-so, there is even hope they will supercharge artificial intelligence (AI) by crunching through the big data more efficiently.

Big Data Skills Demand

According to Forbes, over the last one year and moving forward, the top industries hiring people with big data skills were professional, scientific and technical services; information technology; manufacturing; and finance and insurance; and retail. From the report findings, most companies most likely to have big data scientists are in research, defense and space, market research, education and computer software. Some of the key skill-set, besides Hadoop, include languages like Python and R, plus experience with SQL and NoSQL databases.

SUMMARY & CONCLUSION

Data is the lifeblood of any business. Today, big data has applications in just about every industry – retail, healthcare, financial services, and government. Any organization that can assimilate data to answer nagging questions about their operations can benefit from big data. In overall, the demand for big data transcend across all sectors and business. Those who work to understand their customers' business and their problems will be able to proactively identify big data solutions appropriate to their needs, and thus gain competitive advantage over their competitors.

Big Data and the use of data analytics now provide exciting new ways of working – harvesting better business intelligence and insights and enabling more targeted and earlier interventions. Finally, it's imperative to note that to realize the potential of Big Data, there is an important balance to be found between the rights of individuals to privacy and confidentiality and the benefits from sharing information. With these concerns addressed to tackle public cynicism, Big Data has the potential to redefine both public and private services for the better.

Finally, it's important to note that it doesn't matter if its blockchain, big data, predictive analytics, AI or machine learning, these technologies share so much in common because they all depend upon the other for an effective solution. What matters most, is the transformative power of this technology in enhancing business competitiveness, say in marketing, sales, customer service, growth hacking among others. More-so, with clear benefits of AI to humanity, it's imperative to think AI to any solution. Furthermore, judging from current global trends, it's easy to understand why human interact more with business that adopt AI solution due to convenience.

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