Blockchain Technology, Cognitive Computing, and Healthcare Innovations

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***Abstract*— Exponential growth of the impact of information technology innovation is an indispensable part of today's industry. Blockchain technology has identified itself as an efficiency booster and service optimization for financial industries. Yet non-financial venues have gained little benefit from this new major horizon, Blockchain technology. It offers a secure way to exchange any kind of good, service, or transaction. Industrial growth increasingly depends on trusted partnerships; but increasing regulation, cybercrime and fraud are inhibiting expansion. Blockchain enables more agile value chains, faster product innovations, closer customer relationships, and faster integration with the Internet of Things (IoT) and cloud technology. Now with Cloud and Blockchain technologies providing high computing power and network capabilities, cognitive systems are available tools to deepen the relationship between humans and the world. Many problems that have been with our society for a long time can be solved. Cognitive systems are the tools to accomplish that ambitious goal. This study is continuing our effort on surveying the applicability of Blockchain technology innovation in non-finance (non-bitcoin). The study concluded with discussing opportunities and challenges of the application of two intra-horizons of Blockchain technology, Cognitive Computing and Healthcare.**

***Index Terms*—blockchain technology, cognitive computing, healthcare innovation, scalability, trust**

I. Introduction

Blockchain was firstly introduced as the computational infrastructure of Bitcoin, a digital currency, but has tremendously found much interest in a variety of industrial application domains. Blockchain technology owes major of this trend to its underlying trust system without the requirement of central authority. Creation of Smart contracts where each transaction is verifiable and transparent, made the Blockchain technology to be named as one of the emerging horizons of 2017 [1]. In 2008, Satoshi Nakamoto introduced the world to Bitcoin by releasing the paper, "Bitcoin: A Peer-to-Peer Electronic Cash System."[2] The proposal was to distribute electronic transactions rather than maintain dependency on centralized institutions for the exchange. When looking at Bitcoin the new concept is the Blockchain framework based on research for time stamping packages and protecting the chain of custody. Blockchain is essentially a simplified payment verification system.

Blockchain keeps evolving in a number of industrial domains as the body of research grows[3]. Researchers are working to apply a number of use cases included smart contracts, such as supply chain, and healthcare. The scalability feature and distributed implementation of Blockchain technology makes it a powerful tool to improve the supply chain process where Ecopreneurs were given the option to make informed decisions toward improving global economy and sustainability of the project where supply chain is implemented [4]. The flow initiated from raw material to the final product until they are handed to the end consumer could gain benefit from this distributed implementation of scalable ledger platform, Blockchain technology, to track the supply chain elements, ranging from raw materials to the transportation equipment to the human resources. Authors predict the utility of Blockchain technology in the novel supply chain managements could place companies in a higher level of competition for enhanced socio-economic, socio-environmental and eco-efficiency[4].

Released statistics by Centers for Disease Control (CDC) prevention [5], [6] and the estimated projection of chronic diseases prevalence in the next decade [7], are evidences for the inefficiencies in current healthcare networks. Reports revealed the existence of exponential correlation between poor care coordination and unnecessary cases of hospitalizations. These are all on a side of extensive financial burden of unsatisfactory treatments, according to Gallup organization survey via patients. Current trend in healthcare services are more inclined toward remote patient care, real-time long-term health surveying plus sustained health monitoring with multi-stages personalized treatment[8], [9]. Evolvement of mobile technology in healthcare has shown to be a two-edged sword. Increasing the number of applications

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and their potential to provide healthcare network customers a quicker service along with facilitating the communication line between healthcare provider and healthcare payee (customer) were among the benefits of mobile technology incorporation in healthcare network. However, Following HIPAA (Health Insurance Portability and Accountability Act of 1996) privacy rule, individually identifiable health information including demographic and genetic information, that is transmitted or maintained in any form or medium, is categorized as Protected Health Information (PHI)[10][11]. HIPAA privacy rule created a set of standards on keeping the privacy of the individuals' PHI under security and gives patient's rights over those protected health information. Although the rapid growth of cloud utilization for creation of HIPAA-compliant database boosted the physical safeguarding of information and reduced HIPAA violations, however this mitigation to distributed databases on the cloud would not alone solve the health care payee and provider's dilemma of privacy breaches. This ultimate concern yields to applicability of novel cryptographic technologies, such as the one enlisted for Blockchain technology into the HIPPAA compliant healthcare networks. Prior work of authors have introduced an implementation of Blockchain powered infrastructure, HealthChain, for the storing and retrieval of protected health information in a secured, scalable and cloud-friendly yet HIPPAA compliant fashion [9][8]. The current study is an effort to systematically surveys the non-finance applications of BlockChain technology, and specifically two very specific landmarks of Blockchain technology, Blockchain and Cognitive Computing; Blockchain and Healthcare, that have been recently highlighted by industry pioneers.

II. Blockchain Roadmap

The focus of the current survey has been placed on 2015 and 2016 to cover the timeline when previous surveys did not include and we limited our search to IEEE Xplore search engine with the keyword of "Blockchain". A total of 65 IEEE indexed publications were hit. Twenty-five percent of the results were ranked as publications toward non-bitcoin applications of Blockchain technology. Majority of Blockchain applications were devoted to configuration, build and implementation and control of Internet of Things (IoT) devices [12]. Advancing the communication protocols to the era of Internet of Things (IoT) has shown promising improvements in smart cities and autonomous transportation [13]. Decentralized trust creation and scalability of Blockchain is being adjusted for the connection of sensors and actuators in the IoT using hybrid cloud platform by defining new business models with improved security and access privileges based on mapping the subscription request to the IoT as digital currency exchanges among users of IoT [14][15][16][17]. An interesting application domain proposed by [18] introduced Blockchain as an infrastructure for tracking and identifying illegal digital footprints on Wi-Fi hotspots. A similar scheme was proposed by [19] to detect insurance fraud. [20] combined the logistics of Blockchain with Radio Frequency Identification (RFID) in the food network supply chain. The next two sections discuss two landmarks where authors concluded them as the intra-horizons of the Blockchain technology for the next decade, Cognitive Computing and Healthcare.

III. Blockchain and Cognitive Computing

Data has become the new currency transforming to information, creating knowledge, and interpreted for action through the lens of mathematical models and embedded technologies. As a utility we have recognized the importance of data analytics and potential of cognitive computing, which is a revolutionary step forward in the understanding of human machine interaction. Data science competences are developed in all areas, including customer retail sales, power plant operation and maintenance as well as trading. The business case is always a little different, however the data science competences are similar in all these areas.

Data analytics development is in tremendous demand, using experiments, POCs and pilots in multiple areas. Based on these experimental activities we develop our vision and direct all the activities towards this common goal. At this point of time the experiments are running. Many platforms and processes are tested. One of the IoT platforms for the pilots is IBM's Bluemix. We have already run some pilots using Bluemix utilizing machine learning and cognitive capabilities. The competitive edge utilizing Bluemix with Watson cognitive computing capabilities is the possibility to use unstructured data to look for insight or patterns that may not be transparent. Component failures can be predicted and the model can be developed using supervised machine learning or unsupervised machine learning. Cognitive computing is not meant to replace human decision-making, but compliment the process.

In 1946 IBM joined forces with Columbia University to create the first academic program called "computer science." The event changed the world forever and continues to influence us every day of our lives. We are undergoing another major shift in how voice recognition, tablets, smart phones, artificial intelligence, data analytics, autonomous vehicles, robotics, cyber- security, social media, cloud technology, etc. are coming together in a new Cognitive Era, which will change the citizens' quality of life, energy development, public service, customer service, and enhance research capabilities. Cognitive computing is a revolutionary step forward in the understanding of human machine interaction. Cognitive computing can be defined using two key principles:

1. Computers facilitate or perform the process or patterns humans define as thinking,
2. Enable the cooperation between computers and humans to solve or accomplish a complex task, without the existence of a predefined answer or program.

The idea of Cognitive computing didn't emerge recently, and has been part of our culture for a long time. For decades (maybe more) humans have dreamed of

computers, which can simulate complex human reasoning patterns. As technology evolved, we reached the point where we are on the brink of computers being able to accomplish complex tasks left in the past only for humans. In February 2011 IBM introduced Watson, the first widely seen demonstration of a cognitive system. IBM Watson defeated Ken Jennings and Brad Rutter in Jeopardy! a game largely believed to require human cognition.

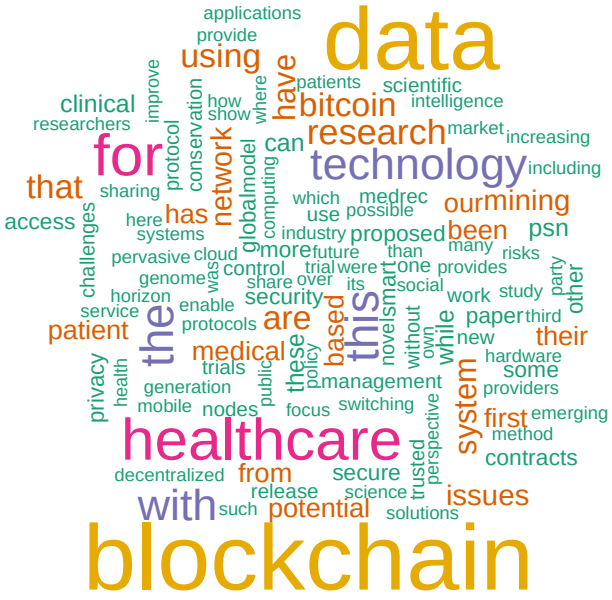

Figure 1. A graphical summary of text analytics on the survey results.

When Watson played Jeopardy! it focused primarily on one NLP task: Question answering. Since then, IBM has developed an ecosystem of cognitive capabilities available in Bluemix that can enable companies to create truly cognitive solutions. Cognitive computing is not a single discipline of Computer Science - it is a combination of multiple fields, including Natural Language Processing and Artificial Intelligence, and more importantly, using industry expertise in the creation of solutions where humans and computers collaborate constantly to obtain the best outcome. There are five core capabilities of Cognitive systems:

1. They create a deeper human engagement, as they try to understand the human qualities of the user that interacts with them, delivering an overall greater value

2. They scale and elevate the expertise, as they can automatically ingest huge volumes of documents in context, and help the experts and professionals navigate vast amounts of information available to them

3. They infuse products and services with cognition, allowing products and services to sense and to improve themselves using adaptation

4. They enable cognitive processes and operations, which allow businesses to heightened awareness of workflows, context and environment

5. They enhance exploration and discovery, as they allow increasingly uncovering complex patterns and opportunities.

Our understanding of Cognitive computing today is heavily influenced for the societal and business need in our communities. All technology revolutions are propelled by our need for better technologies. Cars that drive themselves, cities that take into account your emotions and interact with their citizens accordingly, systems that guide emergency respondents and give them accurate summaries of all information crossing across multiple agencies, and products that continually improve their performance through sensing and monitoring use IoT (Internet of Things). For a long time, creating truly cognitive systems was beyond the reach of our technology. Today, we are in the brink of the generalization of Cognitive systems in all markets, and the general availability of intelligent machines that work side by side with humans in all tasks.

We believe Cognitive systems are tools to deepen the relationship between humans and the world. Many problems that have been with our society for a long time can be solved, and Cognitive systems are the tools to accomplish that ambitious goal.

IV. Blockchain and Healthcare Innovation

Following a survey of two peer-reviewed scientific indexing websites, PubMed (www.ncbi.nlm.nih.gov) and IEEEXplore (www.ieeexplore.ieee.org). “Blockchain” and “Blockchain Healthcare” were the search terms for PubMed and IEEEXplore, respectively. A total of 10 publications (2 conference and 8 journal publications) were relevantly found to the subject. Fig. 1 shows a summary of word analytics on these search results.

As the figure presents, Blockchain technology is an umbrella for a network of decentralized nodes where objective has been to enhance privacy, security, trustworthy and transparency. [21] discusses a few avenues where the Blockchain technology applicability could be assessed for healthcare sector. Three application domains were discussed in [22][23], [24] where modularity feature of Blockchain infrastructure joins mobile computing implemented on Pervasive Social Network (PSN)-based network could enhance the wireless transfer and organizations of medical records. [25] shed light into a very important issue of clinical trail data. According to [25], more than half of the clinical trials lack the availability of all corresponding methods and results. Suggested protocol in the hands of Blockchain smart contract with its attached trust and transparency could be where the level of medical service can be significantly improved. [26] surveyed Blockchain to a broader range of application and theory for the time range of 2013-15 where they reported more than 80% of the efforts in Blockchain have been allocated to the Bitcoin. A modified Blockchain protocol using time-stamping was empirically shown [27] to be a low cost and secured replacement for the existing audit process of clinical studies.

Although the survey agreed with our initial hypothesis of underestimating the applicability of Blockchain technology in healthcare compared with other industrial sectors, However, implementation of Blockchain

technology in healthcare may not be as straightforward solution as is for other industrial applications for the very clear reason of Protected Health Information (PHI) being traded as a digital currency. Following HIPAA (Health Insurance Portability and Accountability Act of 1996) [10] privacy rule, individually identifiable health information including demographic and genetic information, that is transmitted or maintained in any form or medium, is categorized as Protected Health Information (PHI) [11]. Authors have pioneered in suggesting a framework, HealthChain [9], for how Blockchain powered technology could improve the healthcare while increasing the level of security embedded inside the healthcare network.

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