

CSU34031: Integration of AI, IoT and Blockchain

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Abstract—In recent years, Artificial Intelligence (AI) has become a major analytic tool, delivering scalable and highly accurate analysis of big data in real time through use of advanced algorithms. Internet of Things (IoT) is being used in modern computing and telecommunications by companies who wish to strengthen their existing networks with use cases like asset management and remote system monitoring. Blockchain technology is taking the world by storm. In the telecommunications industry in particular, Blockchain technology is already being used in the automation of many internal operations like supply chain management and billing systems. In this paper, we will discuss the integration of AI, IoT and blockchain technology in today's world, and how they can be used to tackle modern day problems in computing and the telecommunications industry.

I. INTRODUCTION

A. Artificial Intelligence (AI)

Artificial intelligence (AI) is a branch of computer science where smart machines and algorithms are developed that are capable of performing tasks that would typically require the intelligence of a human being. AI has a wide range of approaches across multiple scientific disciplines, but advancements in machine and deep learning are particularly revolutionizing the computing industry. AI applications are generally one of two types, Expert Systems (ES) and Machine Learning (ML). - Expert Systems use rules and facts that are represented in a knowledge base, but they lack the ability to learn autonomously from external data. The rules are applied to the known facts which then generates new facts. Typical applications of Expert Systems include classifications - Machine Learning has the ability to learn by itself, making observations on its own and creating its own rules. Examples of Machine Learning techniques are neural networks and genetic algorithms.

B. Internet of Things (IoT)

The Internet of Things (IoT) is a vast extended system network that is based on the Internet. The overall goal of IoT is to achieve real-time interaction among things, machines and humans. [1] This can be achieved through various technological means. The basic concept of IoT is achieving smart connections between various people, machines, tasks and knowledge through use of the Internet and sensors. [2] IoT basically refers to the countless physical devices around the world that are simultaneously connected to the internet. All of these devices are collecting and sharing data. Connecting all of these devices and adding sensors to them creates a highly intelligent network that is capable of transmitting real-time data without the involvement of a human being. Examples of IoT in today's world would be smart home security systems, autonomous farming equipment or wearable health monitors.

C. Blockchain

Blockchain technology is solely based on the blockchain. A blockchain is essentially a digital ledger of transactions that is duplicated and distributed across the entire network of computer systems on the blockchain. A blockchain records data in a way that makes it impossible to alter the system and change data that is on the blockchain. Every block that is in the chain contains a number of transactions. Every time a new transaction takes place, every participant's ledger is updated to include this latest transaction. This decentralised database that is managed by multiple participants is known as Distributed Ledger Technology (DLT). The most notable example of blockchain technology today would be the cryptocurrency known as Bitcoin. Bitcoin is a decentralised cryptocurrency that makes use of blockchain technology. It was invented in hope of solving issues that arise in relations to trust when creating a digital currency. Many have tried to create digital money in the past but failed due to transparency issues. Bitcoin aims to solve this problem with its decentralised blockchain where every transaction can be viewed at any time and can never be removed or altered. Bitcoin, along with many other cryptocurrencies, has notably risen in value and gained a lot of popularity and funding in recent years as many of the world's largest companies began accepting it as a form of payment. This is a fine example of how blockchain technology can be used in today's world.

II. AI IN THE TELECOMMUNICATIONS INDUSTRY

Artificial Intelligence applications in network industries have limitless potential. They can be used to reduce network roll-out and operating costs, improve performance, enhance customer service and support the development and introduction of new services. A challenge that many telecommunications networks face is the resource allocation in the backbone and network configuration. Artificial Intelligence can be used to support the dynamic dimensioning of the backbone. A neural network can be used to perform reconfigurations based on the traffic volume and reconfigurations. Another application of Artificial Intelligence can be seen when AI is used to support the establishment of connections and routing in IP networks. Although there are certain requirements that must be met for business cases such as the setup of transmission network or the installation of sensors, more often than not telecommunications operators will already have these readily available in their existing network. By finding the most energy efficient route to traverse an IP network, an operator can greatly reduce their energy footprint. This is also the case in the smart grid approach in electricity networks. Choosing the optimal network path can be achieved through various AI methods such as swarm intelligence, neural networks and

genetic algorithms. AI can also be used to optimize parameters of optical transmission in telecommunications networks. Examples of this are laser amplitude or phase noise. [3] Finally, in the networking industry it is vital to be able to quickly and efficiently identify network failures and to predict or foresee maintenance needs. Zhang, Hou, Guo, Wang, Sun and Yang (2016) and Wedde and Farooq (2006), [4] for example, propose AI techniques for fault diagnosis and maintenance prediction in optical access networks. One potential AI-based feature of such networks could be an automatic restart of a server when a fatal problem is encountered. For features like this to be implemented it is apparent that modern, flexible and programmable software defined networks (SDN) would be required. Networks like this allow for central and directly programmable control of the network. In the future, telecommunications operators could certainly benefit from using AI-based systems that actively work to detect, predict and localize anomalies that occur throughout the network and also directly take steps to mitigate them. For instance, they could identify a distributed denial of service (DDOS) attack on the network, analyze and identify certain package characteristics and drop all packages with these malicious characteristics in order to protect the network from the attack.

III. IOT IN THE TELECOMMUNICATIONS INDUSTRY

Telecommunications companies can use the internet of things (IoT) in various different ways, such as using it to enhance business analytics, make remote sites safer, or reduce operational costs. Many different business sectors are implementing IoT solutions to improve efficiency and safety in the workplace, and the network and telecommunications industry is no different. Telecommunications companies can use IoT to gather extremely large volumes of critical data. They can then use this data to develop information pools. This data and information can be used to generate business insights that are crucial in the telecommunications industry. This data can be used to predict upcoming trends in the industry, something that can be vital for telecommunications operators. Through use of IoT, telecommunications companies can communicate from machine-to-machine in a rapid and energy efficient manner. This is crucial in this industry. Companies typically use WiFi and GSM for this communication, which have high bandwidth and power requirements. Less power consuming, radio based wide area networks can be used in IoT devices to lower energy requirements and overall costs. Installing sensors across various services such as public transport would allow smart phones to communicate with them and transmit real-time data in relation to location services. Such sensors could be installed anywhere such as bus stops or train stations in order to improve location services. This would be of great benefit to telecommunications companies who wish to broaden and improve their location services and its accuracy. Other use cases of IoT in telecommunications are autonomous vehicles or equipment monitoring through use of remote cell towers.

IV. BLOCKCHAIN IN THE TELECOMMUNICATIONS INDUSTRY

Although blockchain technology was introduced to the tech market as a way of managing and protecting cryptocurrencies like Bitcoin, it now has multiple applications across various different industries, including the network and telecommunications industry such as billing systems, roaming and supply chain management. Blockchain technology is already used in multiple applications across the telecommunications industry. A decentralised blockchain allows historical records of users to be stored in a manner that ensures that they can never be altered or tampered with. This makes it possible to manage different aspects of a user's account in a safe and transparent manner. One major aspect of blockchain technology that has the potential to revolutionize the telecommunications industry is smart contracts. A smart contract is a transaction protocol which is intended to automatically execute, control or document legally relevant events and actions according to the terms of a contract or agreement. [5] Companies can use smart contracts to automate billing systems, saving them huge amounts of time, money, and can also help prevent the possibility of any fraud occurring. This would open up the possibility of completely autonomous accounting and auditing due to the transparent and completely decentralised nature of the blockchain. The low cost of implementing blockchain for cheap payments would allow companies to provide micro-payments that could be used to purchase any type of product. No sensitive data such as credit card details would be required to be provided to third party devices of networks as it would all be stored on the blockchain. The security of the blockchain would essentially provide an even higher level of security for telecommunications companies. Since blockchain offers an extremely reliable and safe aspect of security, one of its most valuable applications will be digital ID verification. Today, identity verification methods and applications cost companies billions every year, but this price will surely plummet as the industry begins to deploy blockchain technology which can be used for digital ID verification in a much cheaper and cost-effective manner. One example of this is Civic who offer an extremely reliable security identification system that is based off of blockchain technology.

V. CONVERGENCE OF AI, IOT AND BLOCKCHAIN

One of the main use cases for IoT in the network and telecommunications industry is the role it can play in gathering extremely large pools of data. Various frameworks and architecture exists already that support the analysis of this data, for example, cloud analysis, fog analysis, edge analysis and device analysis. There are many issues that arise among these methods such as low accuracy, low speed, low latency, less computational storage and single point of failure due to the fact that IoT applications generate such vast volumes of data. Centralization is also a massive issue that arises in relation to the large amounts of data gathered by IoT. The data that is gathered by companies using an IoT is generally not standardized in a single data format. Blockchain technology can be used to solve this problem by

standardizing the data. Due to the use of hash functions, data on blockchain is generally stored in one format. Due to its high level security and decentralization, it holds the solution for various fields across IoT such as finance, agriculture and more importantly the network and telecommunications industry. Another beneficial feature of blockchain technology is the high degree of data privacy that can be implemented with the underlying cryptography. On blockchains, transactions are conducted using pseudonyms, and can also be conducted entirely anonymously such as transactions conducted by cryptocurrencies like Monero. Blockchain systems allow for full encryption of data that is both stored and transmitted. The convergence of AI, IoT and blockchain technology provide various solutions that mitigate issues that arise when IoT devices gather large amounts of data. Decentralization, digital signatures, smart contracts and secure shared data are just some of the countless applications that are provided. Using a decentralized blockchain allows for large amounts of data to be shared with other members or devices in the IoT, making the transaction immutable, secure, explainable, digitally signed and also validated. The secure transmission of large amounts of data across an IoT like this is crucial in the telecommunications industry. Artificial Intelligence algorithms can also be used to solve accuracy, centralization, security or privacy issues that arise. Today, AI is used in various areas of advanced technologies such as blockchain thinking, decentralized AI, and intelligent machines. Decentralized AI is a combination of Blockchain technology and Artificial Intelligence. It is used to share data and information in a cryptographically signed, secured, and trusted manner without the use of a third party. As mentioned earlier, the main use case for the IoT is to gather large pools of data. Once this data has been gathered and stored securely, for example on a blockchain, it can then be analysed by the company who gathered it. Artificial Intelligence algorithms provide the perfect solution for analysing, traversing and dissecting the data that has been gathered. These intelligent algorithms use this data to build a store of knowledge and teach themselves, in turn making accurate predictions based off of the mass amounts of available data that the IoT has gathered and deployed it upon. Another use case of AI in relation of convergence with IoT and Blockchain is cybersecurity. With the large amounts of data that can be gathered by an IoT and stored on a blockchain come major security concerns that can't all be solved by the security of a blockchain. An extra layer of security can be added by using Artificial Intelligence to develop complex algorithms that protect networks and systems such as an Internet of Things. These intelligent complex algorithms detect unusual behaviour that may indicate an attack is occurring on the IoT. AI technologies such as decision trees, linear regression, machine learning, support vector machines, and neural networks have been used in IoT cybersecurity applications to identify and eliminate threats and potential attacks.

VI. USE CASE

To really get an idea of how these three technologies can be integrated we can look at a use case. We can look at one of

the largest companies in the world, Amazon. How could these three technologies be used by a company like Amazon? Firstly we can establish the Internet of Things as their entire company, ranging across all of the devices, vehicles, headquarters, offices, warehouses that the company owns. All of these devices are constantly gathering large amounts of data that in relation to customers, sales, trends in the market, and all of this is priceless information to Amazon. How could they store all of this data in a single format in a way that ensures a high level of security and also fast transmission of data across a large network? Blockchain technology could most certainly be used. We highlighted earlier the advantages of using blockchain technology to store the large amounts of data gathered by an IoT like this. Finally, how could Amazon analyse this data that they have gathered on customers, sales and the market? Without a doubt Artificial Intelligence algorithms would be the perfect solution for this. Complex intelligent algorithms hold the ability to efficiently analyse the data, identifying trends in customer purchases that could be used to improve sales numbers and maximise marketing techniques by studying customer interests. The convergence of all three technologies in a huge company like this is very possible, and that shows how much this technology has come on in recent years, and how close it is to revolutionizing the tech industry as a whole.

VII. CONCLUSIONS

In this paper, we discussed the three technologies Artificial Intelligence (AI), Internet of Things (IoT), and Blockchain technology in the network and telecommunications sector and how they can be integrated to solve modern day problems in this industry. An Internet of Things can be used to gather vast amounts of data. The data that is gathered by this IoT could be stored on a decentralized blockchain, that we have shown to be extremely secure and efficient. Artificial Intelligence could be used to protect this data from malicious attacks, but also the intelligent complex algorithms could be used to analyse the data and identify trends in it. Data is the lifeblood of any business. Today, big data has applications in just about every industry you can think of. Most particular is the network and telecommunications industry. Any company that can assimilate data to provide the answers for nagging questions about their operations can benefit from big data. The demand for big data transcends across all sectors and businesses. Those who work to understand their customers' business and their problems have the ability to proactively identify big data solutions that are tailored to their needs, therefore gaining a competitive advantage over the rest of the field. Big data and the use of data analytics now provide new ways of working, harvesting business, intelligence and insights and enabling more targeted and early interventions. It is 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. It is clear that the three technologies Artificial Intelligence, Internet of Things and Blockchain Technology

have the potential to revolutionize the way that big data is gathered, stored and analysed, but we can't be sure if this potential will be fulfilled. Although I highlighted the countless positives and benefits of using these technologies, that does not mean that they are flawless. Many downsides exist, and they could be the reasons that these technologies are never adapted, but we cannot say for sure. In recent years the technology industry has progressed at an exponential rate, and it is safe to say that it is impossible to ever predict for sure what the next leading technology will be. One thing that is for sure is that the three technologies studied in this paper hold the potential to become the leading technologies in the network and telecommunications industry if they are integrated correctly together.

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