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Emergence and Convergence of AI, Blockchain and IoT

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Abstract

Technology has been growing at a fast pace since the last three decades and blockchain, artificial intelligence and the internet of things (IOT) are a result of this. Apart from making significant contributions individually, the amalgam of these technologies has led to a variety of high-level applications in several domains. Blockchain, AI, and IOT are revolutions providing remarkable benefits for pellucidity, stability, safety, confidentiality, and the automatisation of business procedures. Not one individual, nor all three is a silver bullet for exploiting data or data-driven parsimoniousness, but all are themes of thrilling hype and potential. This golden triad has a lot to serve if they are intertwined and interlinked together. They can be converged together for better future insinuations. . In this paper, we have highlighted how blockchain, IoT and AI work individually, in a pair and synchronously with each other in the healthcare and smart city domain.

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Keywords: *Artificial Intelligence, Blockchain, IOT, Smart City, Healthcare.*

1 INTRODUCTION

Alvin Toffler rightly said that technology is the great growling engine of change. Over the last 3 decades, we have seen a larger number of innovations in the field of information management and automation. This has not only given birth to a variety of fields but their convergence has also proven to be a boon to several existing domains. Three such trending technologies are -: Blockchain, Artificial Intelligence and Internet of Things. We know blockchain as the most secure way to buy, trade or manage leading cryptocurrencies like Bitcoin and Ethereum. Artificial Intelligence refers to the simulation of human intelligence and cognitive thinking in machines with efficient use of data and predictive algorithms.

The Internet of Things quite literally means the network of things around us; it is a platform on which embedded devices are connected to be able to interact with each other. The convergence of these three leading technologies leads to a broad spectrum of applications which has the potential to change how our system functions today and even though it may seem like a tale of the future, many of these applications are already being implemented today.

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2 BRIEF OVERVIEW

AI, Blockchain and IoT are ground-breaking technologies which will pave the path for digital revolution and will disrupt different industries.

2.1 Artificial Intelligence

AI is the study of the technology via which computers are equipped to perform responsibilities that humans label as difficult by creating intelligent representatives.

The learning of AI began in the 1950s, and it has enhanced dramatically over a brief period of time with improved statistical methods and superior computing power.

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The different types of AI are: The theory of mind, limited memory, reactive machines, and self-awareness [2]. The basic approaches include analytical methods, conventional coding AI and computational ability. High Computational power cost, large scale availability of data and advances in

algorithms have proved to be the motivation behind the growth and progress of AI.

A paradigm shift has been generated in the business domain due to this cognitive capability to perform all the jobs on their own making everyone attracted to the investment in the AI world a necessity.

Key Characteristics of Artificial Intelligence are:

1. Efficient Management of Data
2. Data Mining
3. Personalization
4. Future Estimation
5. Real-Time Support
6. Deduction of Errors

The significant applications of AI are Strategic gaming, Natural Language Processing, Speech recognition, Vision Systems, Expert systems, and intelligent robots. AI has faced various challenges and the influence is clearly noted in situations where there exists collaboration between businesses and standalone.

Challenges faced by AI:

1. One-Track Cognizance
2. Deficiency of well-equipped Labour
3. Difficulty in developing trust
4. Lack of computing power

These challenges expose the business in collaboration with standalone AI, to a greater amount of risks and threats. Artificial intelligence (AI) makes it imaginable for machines to learn from experience, adjust to new inputs, and perform human-like tasks [32]. By means of these technologies, computers can be trained to achieve precise tasks by processing large amounts of data and recognizing patterns in the data. Our society will flourish as long as we win the race between the growing power of technology and the wisdom with which we manage it [31].

2.2 Blockchain

Blockchain are tamper-proof digital archives implemented in a distributed manner (lacking a central repository) and mostly without a central authoritarian institution like a government or a bank. At its root, it allows the users to document transactions in a common shared registry within that community. This is done so that under customary operation of the blockchain network once a transaction is published it cannot be altered [4].

A blockchain ledger is quite literally a chain of blocks consisting of a block header and block data. The block header contains the metadata while the block data has the transaction information as well as other pertinent data information. All block headers, barring the primary block of the blockchain, contain a cryptographic link to the antecedent block's header. Every individual transaction entails one or more participants in the blockchain network along with a log of the proceedings that is digitally signed by the participant who proffered the transaction [4].

To implement blockchain technology one needs to understand the core fundamentals, like if we were to implement a blockchain at an organizational level and needed to update the data we have stored within the existing blockchain network. To go about this, we realise that while modifying the existing network is a hassle, we can work around this by treating the newer blocks and transactions that we add to the existing

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chain as updates or modifications to the previous entries [4]. This sort of software abstraction allows for alterations while providing a full log history.

Another crucial aspect of blockchain technology is the manner in which users decide if a particular transaction is valid or invalid, known as "reaching consensus". Since blockchain fundamentally is just one part of an entire solution for a particular business case we see a range of positives and negatives for the existing models that help users to reach a consensus.

Blockchains are almost always implemented with a specific objective in mind, whether it be smart contracts, cryptocurrencies or digital ledgers between organisations. Blockchain approaches mainly fall into two main subcategories, permissionless and permissioned.

A permissionless blockchain network, as the name suggests requires no user authorization for making any change to the transaction be it a read or write operation. Permissioned blockchain networks on the other hand limits the contribution to a select bunch of individuals or a group thus making it a far more controlled approach.

Blockchain technology takes tried and tested concepts to give a homogeneous solution. But even though there are so many variations of blockchain networks along with the rapid growth of blockchain related technologies, most blockchain networks still use the same core fundamentals [4].

Blockchain technology is still a fairly new technology which we must probe into further with the perspective of leveraging it to its full potential rather than trying to make the blockchain technology paradigm fit our problem statement, making sure that we use it only where it's pertinent.

2.3 Internet of Things (IoT)

The Internet of Things (IOT) is a concept where the physical devices are interconnected through a network to identify themselves to other devices through an IP address, RFID, sensor technologies, wireless technologies, and QR codes. The key features that distinguish IOT from other emerging technologies are automation and control, tracking, cost effective and time saving [5]. Via the Internet, the sensors and software of IOT devices collect and exchange the data. All this data can be integrated and analysed on an IOT platform to address specific needs. Evaluation of what information is useful and what can be ignored is done with the help of these powerful platforms. The information retrieved through this process can be used to detect patterns, detect possible problems before they occur and make recommendations. For example, a company can collect the data and use it to target individuals with special offers by tracking phone's location and learning a person's shopping habits.

Today, with the help of IOT it is possible for a smart fridge to order the products automatically based on the past consumption without any human interaction.

Though IOT is a fast and emerging technology, it gives rise to some challenges. The continuous exponential growth of IOT devices distributed widely in remote places enables performance issues and processing delays. Privacy, security and regulatory related number of concerns are highlighted by IOT, out of which many existed prior to the growth of IOT.

For example, through the device's application, the cloud or the device itself, the smart devices can collect personal information endangering the privacy of a user. Also, the majority of IOT devices use encrypted network services which ultimately means that there is insufficient authentication and authorisation. During download, many of the software updates are not encrypted. Also, a lot of information can be disclosed to the third parties and can be used to regenerate the data for other new purposes. IOT devices that are close to data subjects limit the status of being anonymous because it becomes easy to identify the source.

Thus, there have been many challenges that IOT is facing and it can be possibly eliminated by the convergence [6]. It could not only resolve these major prohibiting issues but also drive the development of autonomous business models and transform industrial corporations digitally [7].

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3 THE INTERSECTION OF TECHNOLOGIES

IOT, Blockchain and AI as standalone technologies have proved to be remarkable for the upcoming future but they have some crucial flaws which hinder their progress in the path to discovery of continuously changing efficient technology. These cons can be substantially overcome by the combination of these innovative technologies.

3.1 Blockchain and AI

Artificial intelligence emphasizes the simulation of human intelligence either by expanding the accuracy of production or by performing autonomous tasks. Blockchain is a secured distributed immutable database shared by all parties in a distributed network and allows unknown people to trust a shared record of events. In spite of being an extremely powerful technology blockchain has its limitations as well which is why artificial intelligence incorporated in the block chain systems makes it a perfect ally [8].

AI serves as the perfect companion for Blockchain in several domains. The first application of this integration would be energy consumption. We know that mining is an incredibly difficult task and requires a huge amount of resources in terms of energy and money to be completed [8]. Artificial intelligence plays the role of optimizing energy consumption and results in lower investments for mining hardware. Block chain technology is growing at a steady rate of 1 megabyte per 10 minutes and with the help of artificial intelligence new decentralized learning systems like federated learning can be introduced to make the system more efficient.

Block chain on its own is a fairly secure application and almost impossible to hack but it's the deeper layers are not so secure. This is where machine learning comes into picture to guarantee a secure application deployment. The running cost for validating and sharing transactions on Blockchain are as high as $600 million a year, with the help of artificial intelligence systems the total computational cost can be lowered and further decreases energy consumption and increases the efficiency. This in turn also reduces the network latency which can facilitate faster transactions on blockchain. Mining the block chain by companies as well as individuals requires investment on a huge amount of money for buying specialized hardware components.

With the integration of artificial intelligence the system becomes more efficient and some hardware components can be converted into neural networks that can be used for mining. Artificial intelligence can also be used to create virtual agents to automate transactions.

Now that we have discussed the effect that AI has on the block chain let us now understand the impact that the block chain can have on the development of intelligence systems. Blockchain allows to increase the effectiveness of the artificially intelligent system by providing it with secure data sharing means and more data leads to the building of better models and in turn gives better results. Integrating AI with block chain systems lowers the market barrier for entry and shrinks the competitive advantage that the tech Giants have. It enables easy data sharing and a new market place jointly with Blockchain data verification by providing more fluid integration.

This method also helps solve two other problems of providing data access and also enables a more efficient data monetizing mechanism. This proves that the two technologies, blockchain and AI may have certain limitations individually but complement each other to work together as the perfect allies [8].

3.2 AI and IOT

With a confluence of AI and IOT, we have managed to enhance the capacity of these individual technologies to almost twofold. In recent times we have seen an increase in use cases such as in autonomous vehicles, flexible energy systems and even intelligent healthcare solutions. IOT in recent

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years has been synonymous with consumer goods and bringing interconnectivity within homes through various intelligent systems such as smart speakers or intelligent energy meters. Since a majority of the focus has been on bringing connectivity, we're faced with a challenge of generating actionable cognizance of the real-time data generated by the sensory devices. This is where AI based solutions come in, since AI is nothing without useful data to analyse and IOT applications generate a humongous amount of data. It has been estimated that data generated will reach approximately 847 zettabytes by any IOT device by 2021.

Some of the notable advantages of leveraging AI especially within Industrial IOT applications has been the rise of operational efficiency and improved risk management. Organizations have stood to benefit

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from the predictive capabilities of AI enforced IOT systems that have identified and tweaked certain variables at runtime helping to maintain ideal outcomes. This greatly reduces machine downtime and helps companies to avoid unforeseen costs.

As with everything else, the key to leverage this is identifying key areas where it would maximise the differentiation capabilities of the system.

An important aspect to note is that this isn't an automatic configuration-based solution and requires a fair bit of expertise to make the solution work in your model. Another challenge is maintaining the quality of data, for a sensor to utilise the full potential of predictive maintenance is to have a good flow of data allowing it to analyse which variables are the weak point in its system.

A myriad of applications stands to gain with this interconnected system, such as retail, financial services and manufacturing. A notable example of this sort of system has been seen at the London City Airport which leveraged this cross-technology networking to track every element of travel from passenger whereabouts to boarding queue traffic etc, this accelerated the business delivery process effectively and provided better customer service engagement by providing customers with informed data. As we can see the real challenge for this comprehensive system to work is in setting up the right network for people with data for optimal results.

3.3 Blockchain and IOT

We will need to find some common way to interoperate a large number of devices, manufacturers and platforms. One way to handle this is to have one centralised system that handles data and communications. Thus, it is a typical client-server-based approach. Though this model has worked up for now but it gives rise to some limitations and threatens to overcome a number of difficult challenges.

A centralised system has a drawback that it has a single point of failure that means if the system goes down, then millions of devices connected will also be shut down and critical infrastructure could be threatened. Basically, in centralised systems, there is an intermediation where the devices send data to a cloud-based platform that analyses it and then the instructions are sent back. Managing centralised systems with limited scalability and flexibility to meet the increasingly complex demands of IOT environment seems to be a difficult challenge for a single entity to meet.

In order to tackle this problem, blockchain comes into the picture. We can employ blockchain with IOT to potentially alleviate some of these issues. We can replace a centralised system by a single vendor with decentralised IOT platform which is developed and run by group of interested stakeholders. In this situation, an individual IOT device on the network would follow following steps: -

1. Package the data together with metadata.
2. Hash the data.
3. Electronically sign with its own private key.
4. Send to the blockchain.

In this way, the data will be sealed and secured with the help of hash and will be made uniquely identifiable and findable with the help of public key in the database.

Blockchain can help provide a common and trusted communication layer in between different types of devices connected together and can harden the network by providing decentralised device logs which are easier to analyse, audit and way harder to hack than centralised logs.

For example, IOT devices like fingerprint scanners, face recognition devices and iris scanners are often used to identify information about a person. Just like that, QR Codes, GPS trackers, sensors, etc are used to identify information about an object. After completing the identification process, blockchains can secure the link between them and their source that cannot be tampered.

Another use-case is an apartment-sharing platform which is decentralised and based on blockchain. Renters and dwellers both can directly deal with each other without any miscommunication and mediator. This way it becomes easier to negotiate in a trusted way and allows smart contracts to handle payments,

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deposits and registration. Smart locks can be used to open the property by identifying the guests by themselves using IOT scanners.
Thus, convergence of Blockchain and IOT facilitates secure data storage, feasible data sharing and distributed networks.

4 THE CONVERGENCE OF AI, BLOCKCHAIN AND IOT

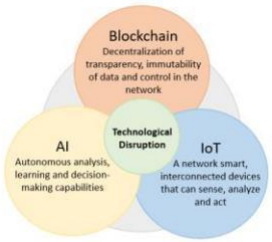

Figure 1 Convergence of AI, Blockchain and IOT [6]

'Synergy' is a term that commits to a collaboration of entities which will lead to the creation of a greater impact than possible by the individual actualities on their own.

The inexplicable convergence of IOT, Blockchain and AI can customize an impactful amalgamation of interconnection, safety, and autonomy to revolutionise the technique of doing tasks.

Blockchain, AI, and IOT are revolutions providing remarkable benefits for pellucidity, stability, safety, confidentiality, and the automatisation of business procedures. Not one individual, or all three is a silver bullet for exploiting data or data-driven parsimoniousness, but all are themes of thrilling hype and potential.

This golden triad has a lot to serve if they are intertwined and interlinked together. They can be converged together for better future insinuations as follows:

Artificial Intelligence or AI can be defined as intelligence that countenances machines the ability to learn and reason in human ways [6]. Merging this with the radiating influences of IoT, and we have a gradient scheme that is variably more fascinating than standalone technologies [6]. The massifs of data points apprehended and registered by IoT can be percolated and studied by AI resulting in the discovery of significant and conclusive patterns that would be extremely tedious and scrutinizing for humans to realize and alter. In addition to this, the algorithms should progress with time to improvise on the contemporary trends in technology [6].

On the other hand, Blockchain technology can be the driving force behind the creation of permanent, tenacious, and easy-to-search records, contracts or transactions, and official documents.

A probable connection between these technologies could be that IoT amasses and delivers data, blockchain proposes the infrastructure, and sets up the rubrics of engagement alongside AI augments procedures and rules [7].

As IoT networks encompass a myriad of associated devices, there are abundant vulnerabilities in the system, making it prone to fraud, hacker attacks, and data larceny. To avert security concerns, AI-driven by machine learning can proactively guard against malware and other attacks. The safety of the network system and the data can be further improved by blockchain, which can bound illegal access and alteration of the data on the system. AI can also augment the functional competence of the IoT network by converting it to a smarter and m it smarter and more autonomous system.

The amalgamation of these technologies can lead to the emergence of new future trends where: The data fathered by multiple systems is analysed by AI to undertake intelligent decisions which are then logged and timestamp on blockchain as a part of the permanent record system of decisions which can be further communicated and worked up for better insights [6].

Significant examples of the convergence of IoT, Blockchain, and AI can be demonstrated as:

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Table 1 Examples of convergence of Blockchain, IoT and AI

System	Blockchain	IOT	AI
Car	Providing reliable and secure database enabling the tokenization capability	Collection of rich quality data from the various cars	Optimising the consumption of fuel
Machine	Providing a stable and secure database featuring privacy, enabling the tokenization capability	Collection of rich quality data from various machines	Optimization of production, maintenance, and working of machine processes

By design, IoT, AI, and blockchain are complements and are used up to their full potential only if they are converged. Blockchain technology converged with AI and IoT will overlay the path to a new phase of digitization [7].

5 USE CASES

5.1 Applications of convergence

5.1.1 Auto Insurance

The sensors (IoT) are installed in a car and in unlikely scenarios, some parts faults appear. The sensor powered by AI will detect the defects in the car and as soon this trigger is activated, the insurance money is transferred to the claimant's account via the implementation of Blockchain technology.

5.1.2 Self-driving trucks

Consider a host of self-driving trucks (AI) who has to distribute possessions to delivery centers using AI technology. The action of charging itself at the respective charging station is an important action that will render the purpose of a self-driving truck useful if it's not present. It will require authentication, approval, and smart contract which is implied via Blockchain and the goods will be delivered via IoT drones to the customers as soon as they reach the centers.

5.1.3 Fujitsu heat stress algorithm

The algorithm to analyze the heat stress of workers is another application of this convergence developed by Fujitsu in July 2017. This algorithm in its virtual presence equips IoT to fun the safety of the workers. Unlike the previous algorithms that could only detect the heat stress, this algorithm

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calculates and analyses the cumulative stress as well. This scheme would be comprehensive if they are insured as well by the Blockchain technology. If in unfortunate situations, the worker's health depreciates, the sensor logs this situation and activates the transfer of insurance money to the worker's account via the smart contract of Blockchain.

5.2 Healthcare

It is said that the collision of blockchain, artificial intelligence and the Internet of things could be one of the best things to happen to the healthcare domain. It is believed that by 2025 the three will converge to develop a healthcare-focused ecosystem. Over the next few years, healthcare organizations will have access to integrated IT platforms by converging technologies like blockchain, IoT and Artificial Intelligence to control the drug supply chain, data interoperability, identity management and insurance fraud management.

This convergence will offer an area of new opportunities in the digital health economics domain. Blockchain ensures security authenticity access control and integrity by offering a decentralized shared platform for healthcare interactions. This would also promote value-based healthcare and efficient reimbursement models.

With its unparalleled security infrastructure, blockchain protects the information against data breaches. It leverages a distributed decentralized data system and provides a secure way to ensure authorized access and edits to the data.

Blockchain not only ensures data integrity and trust but it also enables a better way of controlling how the information is used and by whom by creating a trust layer over the distributed network to minimize the cyber threats. The industry that benefits the most from the collaboration of blockchain with IoT and AI would be the pharmaceutical industry, which can potentially save about $200 billion dollars. Blockchain provides a secure way of overlooking the pharmaceutical supply chain management by keeping a record of every pill or vial that has been manufactured, right from production to the point that it reaches the stakeholder that is the patient [9]. The use of blockchain collaboration will promote the execution of large healthcare concepts like population health management and precision medicine.

IoT enables remote monitoring of the patients using smart sensors with medical device integration which helps monitor real-time patient data and flag the critical points, if any. The sensors on the devices collect the data and gain insights from it to report and analyze the data so that a health practitioner can gain a deeper understanding of the patient’s health and make an accurate diagnosis. Real-time monitoring will save lives for the time-critical ailments like a heart attack or stroke and this will proactively prevent untimely mortality and improve the patient’s quality of life.

With an ongoing increase in population, healthcare professionals have to manage the increasing amount of healthcare data on a daily basis. As this continues to happen, it becomes harder for healthcare institutions to manage and store the patient data in a secure way. This is how the distributed nature of blockchain data management proves as an advantage to the healthcare domain. With blockchain, the transparency, integrity and immutability of data can be ensured and the correctness of the data can be rechecked across multiple admins. This allows the sharing of patient data at a faster rate across multiple organizations, helping patients and healthcare providers access the data securely anytime from any place.

Artificial intelligence ensures delivery of personalized healthcare services by creating healthcare chatbots and applications to gain automated feedback from the patient inputs. The bots improve patient experience and pave a path for faster online consultations.

The universal adoption of these technologies has a high potential of improving the quality of patient care, increasing the efficiency of treatment and reducing the treatment cost. In the future, we can see multiple revolutions in the healthcare field using these technologies.

There is a potential to save billions of dollars in the healthcare industry by optimizing the current workflows and giving autonomous access to the highly-priced gatekeepers. The combination of analytics using machine learning and the Internet of things along with the effective and innovative approach of blockchain can boost healthcare information management to new levels.

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5.3 Smart City

Smart cities have long been seen as an evolutionary measure to respond to the rapidly growing technological advances. They've been seen as an innovative ideation to improve citizen engagement, liability, and synergism.

IoT-enabled AI applications may be instrumental for public services across many facets of the government. The myriad of data collected by IoT can be shared with the people with the intent to further government transparency, improve cognizance among the public, and vivify active participation of citizens in public administration. However, the potential of IoT and AI is not without challenges in sectors such as technical, organizational, and policy making [10].

Present day cities are vast, complex interdependent systems that are a delicate amalgamation of dynamic and critical infrastructure like energy, commute, waste and economic systems. So, administration of these complexities keeping the risk and costs in mind is an arduous task, this is where blockchain can work with IoT and AI by utilising automation and data-management proficiency through decentralisation.

The implementation of this cohesive convergence can be done by having the blockchain act as an arbitrator between IoT devices and AI-assisted administration systems through automated control and smart contract layers. They can also act as a security layer for data storage for interconnection between varied sources cross-validating the data and ingress to external chain repositories. AI can then use the structured data collected by the blockchain and assist in decision making processes regarding the coordination of city events or handling unforeseen hiccups and emergencies all in real time.

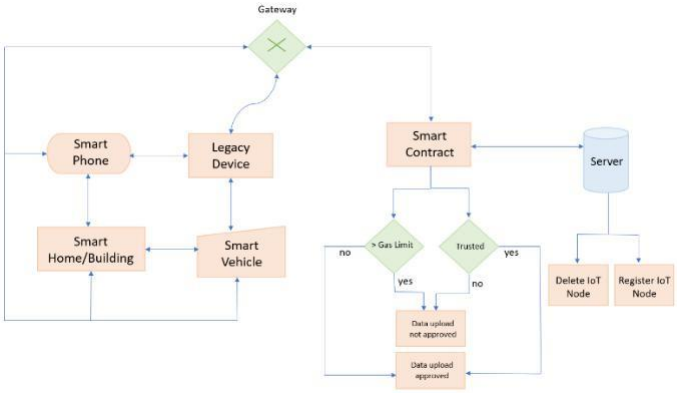

Figure 2 Proposed Architecture for Smart City

At an infrastructure level, the different sectors can see the following advantages:

5.3.1 Advanced air traffic control systems

Autonomous vehicles equipped with IOT services can help establish guidelines for reducing traffic on highways and within the city by deploying diverse data collection and analytical systems to avoid traffic jams.

Smart parking devices systems can make use of the advancement of sensor technologies to tag parking slots using RFID technology allowing for improved mobility by monitoring the parking spaces and providing accurate information to drivers in busy city areas.

5.3.2 Environment Monitoring

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Crucial environment variables such as temperature, humidity, soil conditions and pollution level can be closely observed by health and safety agencies as well as law enforcement services in case of any accidents [11].

We can also monitor water supply resources and use various sensor technologies to efficiently notify the right people in case of emergency such as leakages. This reduces any wastage of resources.

5.3.3 Security and surveillance

With the advancement of behavioral monitoring AI recognition systems, we can effectively track suspicious activities in public spaces and even homes.

Automated surveillance controls for doors that are cross platform can help us even govern our homes using our cell phones, this can also enable other functionalities for home improvement such as temperature, light monitoring. This can help extricate unnecessary energy consumption and time spent.

Thus, with the help of the city residents blockchain, AI and IOT could help improve the quality of life along with a well envisioned, well balanced and much safer urban ecosystem.

6 Proposed healthcare system and methodology

Understanding the perspective of how each of these technologies, blockchain, internet of things and artificial intelligence, can contribute to the healthcare domain individually, a comprehensive healthcare system that integrates these three technologies to give maximum possible assistance to society. The confluence will not only improve the quality of life but also make it easy for the healthcare professionals to track, monitor and analyse the real-time statistics to generate important insights.

The system is divided into 4 components:

1. Health Data Management
2. Patient monitoring
3. Doctor-patient portal
4. Intelligent software

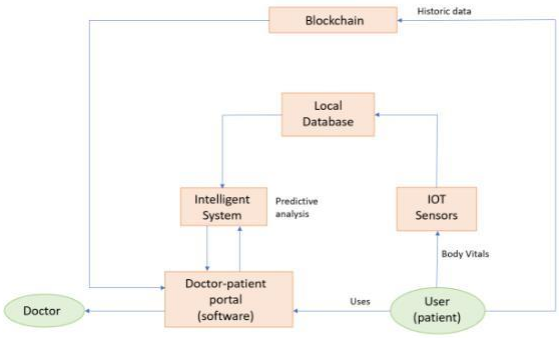

Figure 3 Architecture of proposed Healthcare management system

6.1 Health data management

Almost everyone in the developed world has a medical record. Medical records amass valuable and sensitive figures about the health of an individual like their medical conditions along with the treatments prescribed. The requirement to retain health records for a particular time period makes their management complex. The digitalization of medical records is known as Health Data Management (HDM). HDM proceeds the user with the functionality of analysing medical data to increase the efficiency of patient

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care, extraction of important insights that will revolutionize medicine, at the same time taking into consideration the significance of security and privacy.

In the current scenario, the medical files of the patients are stored as physical copies of paper and managing the records becomes quite tedious in this format. A localised database system can empower the doctors to view and access the patient records in a systematic format but looking beyond the horizons, a centralized data handling system would be an optimal solution regarding the problem of scattered data. Every time a patient bill is generated, it is stored in the respective blockchain created or the same along with the history of the patient. Following this methodology, next time the patient visits the doctor, his/her entire medical history is available with corresponding updates and treatments. The system thus ensures that all the privacy protocols are followed, hence baring the infiltrators from accessing any sort of details about the treatment plan or about the patient's history. Hence, each modification that has been made to the patient's record can be reflected as a transaction under their database [36].

6.2 Patient monitoring

Patient Monitoring is the continuous measurement of patient considerations such as heart rate and rhythm, blood pressure, respiratory facts, blood-oxygen saturation, and others which are needed to be monitored with respect to the care of critically ill patients.The main motive of patient monitoring is warning the patients about early or hazardous deterioration. Patient monitoring plays a vital role in heathcare and the benefits can be listed as:

1. Saving tremendous amount of time
2. Staff Relief
3. Enhanced efficiency in terms of treatment
4. Cost Optimization
5. Better control of the treatment

Every day, a doctor has to treat a tremendous number of patients and it can take away the characteristic regarding personalization of progress tracking. Also, there are certain limitations to the human ability to monitor the admitted patient.

Currently, we have hospital nurses as a substitute to monitor the patient in the absence of the consulting doctor. The nurses record the patient vitals, twice or thrice a day, and apprise it on the respective charts so that when the doctor visits the patient for rounds, he/she can inspect the charts and monitor the patient. By means of the technology of the Internet of Things, sensors can be installed in each of the admission rooms [33]. These sensors periodically record the vitals of the patients with the help of the sensors and synchronise it with the patient database established using blockchain [35]. This system permits the doctor to remotely monitor the patient's progress on a case-by-case foundation and enables personalization of treatment [34].

6.3 Doctor-Patient portal

Efficient Doctor-patient portal is a management system that aids doctors as well as the patients by providing choices to further analyse the patient vitals and treatments as per the convenience of both doctor and patients.

With technology, access to information and connectivity comes easy. This fact drives the need of the incorporation of a software system to bridge the gap between the doctor and the patient. The system will converge the patient's medical markers with the doctor's insights to establish two-way communication between them post the visiting hours [38].

In the current system, there is a gap between the patient's latest data and the doctor's insights. A delay in patient tracking at critical times can lead to unforeseen consequences, which can be avoided by regularly updating the doctor with the latest vitals of the patient by the means of a portal [40].

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The portal can have a unit wherein the patient can chat with a bot about their medical status and if need be, the bot can connect the patient with the doctor to address their concerns. The other segment of the bot would be a progress tracker which will periodically update the vitals of the patients on the portal so that the doctor can monitor them remotely [37].

6.3 Intelligent software

In the current conditions, people are facing numerous diseases due to the pandemic, environmental conditionsand the living conduct. Hence, prediction of the respective disease at an earlier phase becomes an important and crucial task. But accurate prediction on the basis of symptoms becomes tough for doctors. The precise prediction of disease is the most challenging assignment. To overcome this problem, the system will play an important role to predict the disease.

The data of the symptoms and the corresponding ailments can aid the future diagnosis in a huge way. With each set of common and unique symptoms, there are innumerable plausible diseases that can be detected. To make a precise diagnosis, certain tests have to be made which can consume a lot of time. This poses a threat to the life of time-critical patients.

The intelligent software will permit the patient to lodge their symptoms and with the support of predictive analysis tools, the software can give the most probable outcomes for the symptoms and accordingly, then the doctors can make a call. The proposed system will narrow down the extensive possible diseases to a few and support the doctors make an informed decision. Using this tool as the amalgamation of AI technology with the doctor's insights will save a lot of time and optimise costs for the tests along with enabling faster diagnosis which in turn can save a lot of lives [39].

7 BENEFITS AND CHALLENGES

The pros and cons of the amalgamation of Artificial Intelligence, Blockchain and IOT can be weighed, analyzed and discussed as given.

7.1 Benefits of the convergence

The main benefit of converging blockchain, IOT and AI is that it maximizes the benefits of each of these technologies and minimize the limitations and risk associated with them. These technologies can be amalgamated in multiple dimensions indicating of creating a wave of new innovations and business opportunities [7]. It is also opening up numerous possibilities for entering the culture and lifestyles of individual customers in infinite ways.

With digital services becoming more dominating than traditional products and markets, we will continue to see the development of new business models that combine these three technologies to provide value to the customers, industries, supply and distribution chains, etc.

Also, such business models could be widely applied to any autonomous devices and objects such as sensors, cars, machines, cameras, and other IoT devices and could help in reduction of costs too [7].

7.2 Challenges and risks

The convergence of all these innovative technologies encompassing IoT, Blockchain, and AI is faced with numerous challenges and risks.

We will delve deeper into the challenges by looking at them through three lenses:

7.2.1 Technological

The first challenge in the construction of convergent systems will be to safeguard the required infrastructure. Distinct technologies need to be performant. Blockchain, as it is young, is facing scaling,

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and interoperability issues which in turn is a particular example of this performant problem. The fundamental infrastructure, like Speed Connectivity, Computing technology improvements, etc. needs to be performant too.

Large-scale use cases, for instance, smart cities or global supply chains, will rest on the suitable infrastructure being accessible to all stakeholders. This is possible if in turn is provided with sufficient funding and research and development opportunities along with timely futuristic planning.

A key challenge will be attaining interoperability between various technologies. Large-scale convergent platforms will face numerous serious security trials and risks too. Designers will need to guarantee ample data privacy along with the allowance for legitimate data use of the common goal. In these systems, mistakes will be costly and will cause a disturbance in people's lives and rights.

Engineers will have to emphasize intensely on preventing unsolicited or unsafe outcomes, especially where there is a high level of automation. They may also have to face firsthand risks specific to the combination of blockchain with AI and IoT.

7.2.2 Legal and regulatory

Moving to the legal and regulatory perspective, a number of challenges and risks can be identified as well. The open, distributed, often transparent, non-authorized nature of blockchains can raise a huge amount of tricky legal and regulatory queries.

These range from the reconciliation of mutually controlled, an undisputable ledger with the personal data security requirements of a system like Europe's GDPR, to queries about legal obligations of data and businesses carried out on blockchains, the applicability of law in case if large-scale, cross juridical stages and the legitimacy along with the liability of activities undertaken by the blockchain-based autonomous proxies.

Most of these are carried over to convergent platforms, where superior autonomous systems which may constitute blockchain take in data, assess it, and take respective actions along with making transactions at their personal discretion.

Liability is likely to verify a specific challenge. There are also interrogations of liability in the AI-based decision construction process. The probability of being faced with such challenges and problematic queries depends on the size of convergent systems and the extent of autonomy.

7.2.3 Governance, privacy and data ethics

The large-scale convergent system which combines the Blockchain, IoT and AI technologies raise crucial questions in terms of privacy, governance, and data ethics.

Considering smart cities as an example, smart city-wide mobility arrangement using a convergence of blockchain, IoT, and AI to regulate public transportation accessibility to demand, the proposition of alternative routes to drivers in real-time and alter traffic lights for optimum traffic flow.

While contributing momentously to life quality, such as system advances, substantial data ethics and privacy concerns as the movement of every single citizen can theoretically be recorded.

Such apprehensions have already been raised pertaining to some primary projects, for instance with Google's plans to advance smart city infrastructure for Toronto. For such public use cases, the use of blockchain to substitute a central, profit-based provider with a distributed, communal, or consortium-built policy is a plausible option. While this scheme might alleviate some types of trepidations, prevailing decentralized platforms arrive with its own flock of hurdles.

Despite these challenges and risks, the convergence of blockchain, IoT, and AI can empower organizations to maximize the benefits of these technologies individually, while minimizing the risks, challenges, and limitations associated with them.

8 CONCLUSION

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Even individually, the fields of artificial intelligence, blockchain and internet of things are empowering enough to bring about a revolution in automation and information systems. The convergence of these technologies will drive digitalization by increasing the standards for data management, promoting connectivity and automation in the industry. With IoT, billions of smart devices are already connected with each other which, enables the businesses to gain insight from the data collected from these devices. Blockchain brings about a level of trust in the data obtained from the devices connected over the IoT network. Adding a layer of automation with the help of artificial intelligence enables the organization to learn from the patterns generated by the data and make smart data driven decisions. Thus, adopting a convergence of blockchain with IoT and artificial intelligence will enable business organizations to deliver smart solutions without the fear of compromise, hence ushering in a new age of applications to change our daily lives to a great extent.

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