The Synthesis of Blockchain, Artificial Intelligence and Internet of Things

Brian Parker and Christian Bach

***Abstract*—This paper is an exploration of several theories on the synthesis of the Blockchain(BC), the Internet of Things (IoT), and Artificial Intelligence(AI) through a literature review. Blockchain technology is a decentralized peer-to-peer network that stores records and transactions in immutable blocks secured by cryptography. The decentralization aspect of blockchain eliminates the need for trusted third party interceder. Internet of Things(IoT) is an interrelated computer system that makes a connection between computers and humans to communicate in several areas; smart devices like homes, cars, radio are just a few examples. IoT challenges are security, connectivity, issues with the analysis of big data, centralization, and vulnerability to attacks. Artificial Intelligence(AI) machine learning technology is the advanced decision-making process that influences daily routines such as banking, healthcare, gaming, transportation, and space exploration, among others. AI's challenges are; security, centralized architecture, and resource limitations. The methodology will be a comprehensive quantitative analysis of the existing research and how these technologies can be a transformative impact on how information is accessed through enterprise and society. The convergence of BC, AI, and IoT will provide scalable, secure high-level intellectual functioning that will be the new paradigm of digital information.**

***Index Terms*—Artificial Intelligence, Blockchain, Internet of Things.**

I. Introduction

The Internet of Things (IoT) is industrializing in several real-world applications such as smart transportation, smart cities, smart energy, and communication [1]. The deployment of IoT services is contingent upon whether it is an IoT architecture, ecosystem, or use for enterprise settings [2]. To analyze big data, Artificial Intelligence (AI) plays a significant role as a robust analytic tool, and it delivers a scalable and accurate analysis of data for decision making in real-time [3]. However, the design and development of a useful big data analysis tool using AI have some challenges, such as centralized architecture, security, and privacy, resource constraints, and lack of enough training data [4-7]. Conversely, as an emerging technology, Blockchain (BC) supports a decentralized architecture [8]. It provides a secure sharing of data and resources to the various nodes of the IoT network functioning to remove centralized control and can overcome the existing challenges in AI [9, 10].

The successful synthesis of Blockchain, AI, and IoT will eventually transform how information is processed, analyzed, and shared. There have been numerous theories developed to find efficient methods to converge these technologies, which is investigated in this paper through a literary review. Now the convergence of these technologies is just beginning to strike interest in academia and business worlds [1, 11-13].

According to Jeffery Voas, communication, computing, sensing, and actuation are the substructures of the science of IoT [14]. BC presents new opportunities to introduce practical methods to decentralize the Internet of Things(IoT) into a much more efficient structure [15].

The advancements in AI combined with blockchain platforms will develop a framework to collect big data, create possible profits for contributors, and have a shared public model for machine learning [11]. The applications that make these works are; machine learning model, the data handler, and the incentive mechanism [11].

The need to challenge how information is processed, delivered, and interpreted is what motivates continued advancements in digital transformation. IoT connects people and devices; AI moves IoT to intelligence, and Blockchain has the potential to create secure and robust processing. Blockchain synthesis will address how it can make existing processes within an enterprise more efficient and effective by improving large scale data transformation and resolving the weaknesses of each component working independently. There have been many theories and trials that attempt to converge AI, IoT, and Blockchain; however, further research will be necessary to find a digital method that could successfully bring the three together for a functional and reliable digital component. This paper highlights and direct research toward that goal with a detailed analysis as well as to summarize and tabulate new platforms and challenges connecting these technologies. There is still a large gap between big data capabilities and its realization.

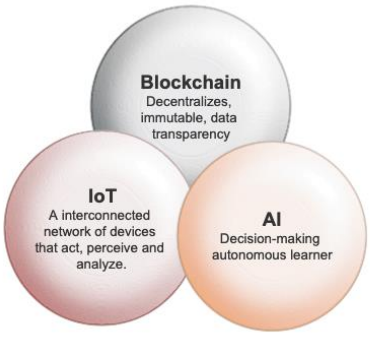

Fig. 1. The Synthesis of Blockchain, Internet of Things and Artificial Intelligence [12].

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II. Research Method

The methodology incorporated in this study is a comprehensive quantitative analysis of the existing research on Blockchain Technology(BC), the Internet of Things(IoT) and Artificial Intelligence(AI), and how these technologies can converge to be a transformative impact on the way information is analyzed and interpreted through a lens of exact structure, security, and accessibility. With new research advancing these technologies, we will have new avenues created to develop and strengthen this synthesis.

III. Discussion

A. Blockchain

BC is a public ledger that is decentralized digital network sharing data. Although BC is mostly known for cryptocurrency use, it has advanced to further application from supply chains, industry, and any other form of a public or private need for shared information [13]. The architecture of BC has decentralized ledgers with public and private keys combined with hash algorithms, which makes BC a powerful internet alternative [14]. BC provides an immutable, distributed ledger that enables secure storage of data. Moreover, BC is a tool to prevent the occurrence of malicious IoT devices into the network. Besides the economic impact of BC on companies in terms of operational cost, it can potentially help to mitigate legal fees arising from disputes [15]. In order for a BC transaction to flow without corruption, a consensus mechanism is in place to safeguard transactions. A consensus mechanism will guarantee tracking and immutability as well as supporting a stable BC when confronted with errors or adversarial conditions [16]. When converging BC with smart contracts, a level of reliability and security becomes developed due to decentralization and mobile infrastructure in attribute-based access control models securing radio-frequency identification [11].

B. Internet of Things and Blockchain

IoT is an application that is everywhere, a system that works with numerous devices, like phones, smart homes, cars, and many other devices capable of a connection [17]. Global Standards Initiative defined **IoT** as at least two linking objects or people on a network that can also link small cities' infrastructure [18].

There have been numerous research and innovations in the advancement of IoT and how it could converge with BC, AI, or other technologies for further applications.

Deepak Puthal developed a consensus algorithm that will resolve several weaknesses in the IoT. This algorithm is a resource-constrained lightweight BC decentralized, secure distributed system. Proof-of-Authentication is a new development that uses a lightweight and sustainable BC for a distributed resource-constrained system that incorporates IoT and edge computing. This algorithm uses decentralized solutions for security [19]. Haiping Si incorporates a double-chain model to improve dependability issues by using data and transaction BC for storage distribution and data reliability. However, there are privacy vulnerability risks when applying this method to specific industries [20].

Inputs: nodes follow Secure Hash Algorithm(SHA- 256) hash
Nodes have private(PrK) and public keys(PuK)
Outputs: Blocks verified when added to blockchain.

1 (Trx+) blocks: /* Blocks formed when numerous transactions combine with nodes */
2 (SprK) - broadcast /* blocks sign by nodes with PrK and are broadcast network wide
3 (VpuK)(block) media access control; /* signature only verified with trusted node on PuK
If authorized **then**
block||PoAH(D) - broadcast /* verified blocks are broadcasted by trusted nodes */
H(block)- blocks are added into chain /* nodes contact trusted nodes blocks are added to chain
Else
release the block /* not verified release the block */
GOTO (1) succeeding block;
Fig. 2 Propose Algorithm for PoAH [13]

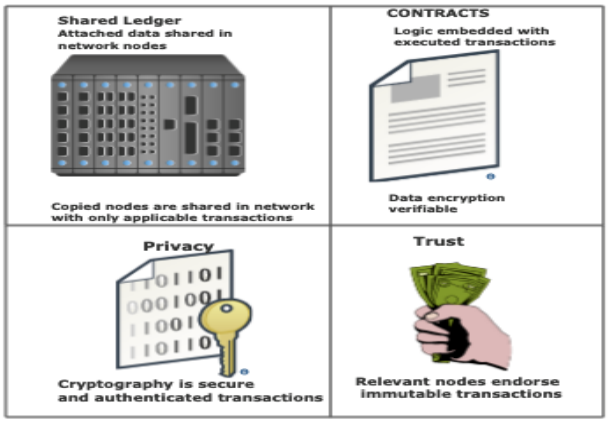

Fig. 3. Blockchain Technology has four building blocks1- shared ledger, 2 – Privacy, 3 - Trust, and Smart Contracts [14]

C. Artificial Intelligence

AI is a coded computer design that responds to set parameters in a physical or digital environment, analyzes unstructured or structured data, and decides a logical action in response to that data to accomplish a specific goal [15]. Because **AI** can find informational patterns that solve complex problems, industries can save time with laboring on

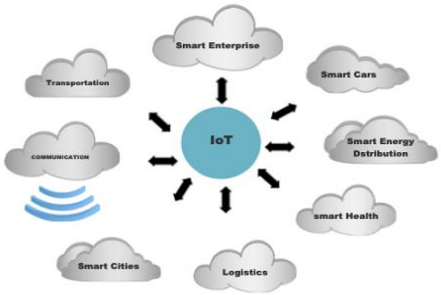

Fig. 4. IoT connects people and things daily in numerous ways; creating a smart world by just touching a button can transform and idea into actions [16]

the same work by automating, monitor, and efficient resolution [17]. For example, cloud storage enables **AI** to support Big Data with faster processing speed and more secure storage [18]. With the versatility of AI functioning, it works well with BC technology. BC can reliably track every step of the decision-making and data processing chain in AI-based systems. BC can also make the justification of the machine decision process more precise in its observation. Furthermore, BC can give insight and understanding into

tuning the AI-based systems to visible and predictable performances [19]. AI not only can be integrated but can also be a hybrid learning model connected to multiple machines to make a decision-agnostic in real-time [20].

D. Architecture

- The architecture of the convergence of Blockchain, AI and IoT will have the following benefits;
- Blockchain will ensure data accuracy transferring through IoT,
- Blockchain will monitor AI by Consensus, and AI will strengthen through coding
- AI and IoT will protect from fraud and error detection, and finally, the convergence will develop a trusted and secure digital system [21].

We will first briefly look at BC and how it integrates with IoT for an improved Fog-Cloud intelligence computing combination that is a new innovative technique. Then we will look at how BC connects with AL and finally look at how BC, IoT, and AI converge into a potential future application.

IoT enables the exchange of data from recognized external ambiance via the internet from devices and machines with various sensors that are recognized and functions that can verify essential trigger steps through actuators. Therefore, IoT takes part in developing systems that are cyber-physical in various applications domains such as agriculture, infrastructure, healthcare, transportation, air traffic control with little human involvement that supports [22]. We see that smart environments will need IoT enabled real-time processing to meet the needs of our advancing society. For example, prevention and disaster detection need an IoT application to respond in real-time for life-saving decisions. By 2025, the current trend is over 1 trillion IoT implementation that will have an over 50% increase in applications that needs immediate results [23]. Cloud data-centers can assist with big data from various smart systems that are in different geographically located IoT devices [24]. Distance becomes a challenge in communication with IoT devices, which could cause lag time in the delivery of smart service [25]. The server network will get overwhelmed when IoT devices transfer big data through the internet. This issue has spurred a new idea, that is, to employ resources from edge computing for decision making and implementing real-time functions through IoT [26]. The Fog computing environment functional layer between Cloud data and IoT devices supports numerous IoT applications with different features that are either network concentrated or computer focused. Fog computing occurrence is called Fog nodes, which are distributed locally across the edge network Fog nodes limited regarding computing capabilities and levels of communication from peer-to-peer applications. To both integrate and strengthen IoT systems with the infrastructures of both Fog and Cloud, it is necessary to utilize resources that are remote edge computing requirements [33]. The complexity of enforcing applications on an integrated environment such as the above create blocks on both internal and external functions. These blocks are due to the coexistence of different computer instances, as well as numerous decision-making systems. This integration overcomes management issues with current frameworks using techniques that are centralized and, in time, reduce the Quality of Service(QoS) [34]. A new paradigm uses the edge network resources to combine Fog-Cloud with an IoT environment called FogBus. Its function is to aid with the implementation of various coexisting models of programming applications and management of both resources and organizing policies for initiating these types of applications in the Fog-Cloud unified computing domain. FogBus implements BC for privacy and protection, data integrity, as well as secure verification and encryption methods [34]. Because IoT-enabled systems are time-sensitive for monitoring for health, air traffic control, to name a few, FogBus uses BC to verify data integrity and security and to employ encryption techniques in all FogBus implementations.

E. AI and Blockchain

Deep learning enhanced with the immutability of BC for secure, quality big data for personalized medicine, smart home, smart cities, the supply chain for food, and other needs that can deliver with assurance and decentralized privacy [27]. One of the most significant obstacles to gathering information today is accuracy in datasets. Due to the vast amount of data passed through the internet, accuracy becomes a significant problem, especially dealing with the shift in “fake news” eruption recently. This false data disseminates much faster than verified information [28]. Another problem could be incorrect data processed to get and false results and hostile interference. This example is evident by testing at Tencent Keen Security Lab with Tesla’s autopilot showing exposure to attacks in the form of privilege escalation. BC can prevent these problems through security, privacy, encryption, and data integrity [37]. AIA is when an object with sensors perceives its environment and responding to that environment through actuators.

Artificial Intelligence Agents(AIA) advances the neural network to understand as it works [29]. BC can save the programmer time by storing code that AIA has encoded on BC to simplify the search for common patterns as well as unifying rules, recording code, and the creation of algorithms. BC and AI will combine to present secure, disruptive, and reliable technology [9]. Sgantos believe that the Church-Turing-Deutsch principle can execute if implementing a multitude of AIA on the BC, which can advance humanity to such high levels [9]. For example, brainwave patterns decoded and new innovative knowledge in scientific fields. By incorporating BC and deep machine learning, algorithmic entities could reach unprecedented possibilities by exploiting all the advances of BC, that is, smart contracts, encryptions, decentralization security, and innovation is inevitable [9].

F. The Synthesis

Today, unlike any other time, Cloud computing plays a very significant role and allows people to connect from the internet. This computing system deals with an enormous amount of data and highlights the need for automated systems that have (QoS) requirements. In order to satisfy this demand, key technologies need identification, and it appears now, Blockchain, AI, and IoT are these converging systems [29]. Blockchain, AI, and IoT will eventually shift

how we look at data, and future software engineering is key to the innovative aspects of this Synthesis. Software engineering will play a pivotal role in the convergence of BC, AI, and IoT primarily due to big data and other technologies, like 5G and cloud computing. Currently, Cisco is developing an abstraction layer called Blockchain-as-a-Service [30].

Gill developed a conceptual model called Triumvirate, which is a convergence of BC, AI, and IoT to move cloud computing to a new stage of advancement [29]. With this model, AI can decrease carbon footprint, and the consumption of energy, can improve Fault tolerance and proactive problem detection and can Ensure coding of software within standards. IoT mechanisms can inspire creative applications, can improve the design with serverless computing, and can improve new ideas for systems of the future. BC will create efficient energy flow, data decentralization will help with Software Defined Network, and finally, BC will need a data structure implementation for storage efficiency [29]. Upul Jayasinghe's conceptual design integrates ROOF (real-time onsite operation facilitation), Cloud, Fog, AI, IoT, and BC to develop a secure, reliable, efficient IoT application. These services create a vastly improved IoT, combine in a self-contained, independent function. BC does data structured decentralization that supports privacy and accountability within the environment as data distributed [31]. This model attempts to resolve cloud data issues by not transmitting data on operation and resources from IoT; instead, the decision process will remain where it is needed. Integrated ROOF-Fog-Cloud architecture distributed, so that AI transformed into small independently functioning on a distributed microservices [31]. These functions will allow intelligence to provided fluidly through a hierarchical step from ROOF to Cloud layers and based on available and necessary resources executed by microservice of AI [31]. With this, combining BC will create a new path for negotiating, secure, selecting, monitoring, smart coordination, composing a dynamic, private, and efficient approach.

The Synthesis of these three emerging technologies will change how the information will have an immediate outcome for decision making in business, industry, and society as a whole. In the field of medicine, for example, safer, faster, and trusted access to critical information is available to diagnose medical issues quickly, know when a product supply line altered, and many other enterprises and everyday functionality.

Blockchain ecosystem will change healthcare in the next five to ten years as BC enhances insurance fraud management, management of drug supply chain, and secure private identity information which will satisfy privacy laws. These regulations and laws can be inserted directly into BC to enforce the protection of sensitive data [32].

Healthcare will have a shared platform that will decentralize the health care business functions through the strength of BC, AI, and IoT [33].

One of the most significant advantages of BC converging with AI and IoT in healthcare is security and enhanced interoperability globally, which will remove geographical boundaries [34]. BC delivers trust, transparency to view shared and transpicuous history that is decentralized and immutable. For example, medical and personal information is secured by BC and protected through auditing functions that offset hacker attacks, malware infusion, and spoofing [35].

The main challenge in implementing BC into healthcare is developing a system that the public will feel confident in protecting the privacy and security of patient medical records to comply with confidentiality laws [34]. The system must be able to consistently deliver sensitive medical data to providers without the concern of malicious attacks [36].

The lifeblood of most businesses today is global connections that are big data-driven. The analysis of big data helps businesses find hidden correlations, trends, patterns that could affect the market and develop new revenue streams. The Synthesis of blockchain, AI, and IoT will create a new efficient and safe analysis of big data.

IV. Conclusion

"To understand IoT, AI, and blockchain, it helps to think of them as interconnected organic processes. IoT is like the human nervous system. It senses, with billions of connected devices around the world now recording a universe of new data. AI is like the reasoning part of your brain. It thinks by analyzing data and making decisions previously reserved for humans. And blockchain is like your memory— creating a secure, indelible record of transactions and data exchanges [30]".

BC resolves the vulnerability of the infrastructures of IoT and AI applications with BCs sequential registers that are indexed. BC's answer to the centralization weakness of IoT is by verification of nodes that are within the network instead of a central server [31]. Authentication through cryptography will identify participating node transactions to the BC registry. With the decentralization of BC, IoT will upgrade its data collection to advance connecting AI systems [31].

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Appendix

When analyzing the architectural descriptions, technological dimensions, and future trends, the Synthesis has one thing in common with all the different proposed research architectures; that is, together, they strengthen each other, whereas they are much weaker independently. Together they have safety and trust with blockchain, interconnectivity, and enhanced global monitoring with IoT and decision making and deep learning automation with AI.

TABLE I: ARCHITECTURAL DESCRIPTION, TECHNOLOGICAL DIRECTION, AND FUTURE TRENDS OF SIX DIFFERENT CONVERGING ARCHITECTURES OF BLOCKCHAIN, IOT, AND AI AND HOW THEY COMPARE AND CONTRAST IN THEIR SYNERGETIC FUNCTIONS

Architectural Description	Technological Dimensions	Future Trends
BlockIoTIntelligence [1]	Scalable IoT secured with Device, Fog, Edge, and Cloud Intelligence.	Support smart applications that lend themselves to further advancement.
Artificial Intelligence Implementations on the Blockchain [9]	Artificial Intelligence agents on the Blockchain Technology.	Church-Turing-Deutsch Principle
Blockchain and Artificial Intelligence [37].	The alliance of Blockchain and AI to create and strengthen the issue of security. Sustainability, scalability, privacy, efficiency, and hardware.	To unite blockchain and AI may change the structure of human-machine interaction and therefore affect economic systems.
Blockchain meets IoT: An architecture for scalable access management in IoT [38].	BC-based distributed access control system that implements proof of concept(POC) prototype in IoT.	A fully decentralized system that is scalable for future iterations with other technologies to advance IoT.
Cybersecurity Challenges and Opportunities in the New "Edge Computing + IoT" World[39].	A zero-trust framework to strengthen IoT applications based on BC for security in Edge Computing and IoT.	A Technological synergy between BC, IoT, and Edge Computing has excellent potential to create unlimited applications for big data.
Hybrid Blockchain and Pseudonymous Authentication for Secure and Trusted IoT Networks [40].	Allow trusted transactions with multiple organizations through the public BC.	The consensus in BC technology can guarantee transactions that trusted in a p2p network, which can assist with big data.

REFERENCES

[1] S. K. Singh, S. Rathore, and J. H. Park, "BlockIoTIntelligence: A Blockchain-enabled Intelligent IoT Architecture with Artificial Intelligence," *Future Generation Computer Systems*, 2019, doi: 10.1016/j.future.2019.09.002.

[2] I. Lee, "The Internet of Things for enterprises: An ecosystem, architecture, and IoT service business model," *Internet of Things*, vol. 7, 2019, doi: 10.1016/j.iot.2019.100078.

[3] Y. Duan, J. S. Edwards, and Y. K. Dwivedi, "Artificial intelligence for decision making in the era of Big Data – evolution, challenges and research agenda," *International Journal of Information Management*, vol. 48, pp. 63-71, 2019, doi: 10.1016/j.ijinfomgt.2019.01.021.

[4] O. O. Abiona *et al.*, "Architectural Model for Wireless Peer-to-Peer (WP2P) File Sharing for Ubiquitous Mobile Devices," 2009.

[5] M. U. Scherer, "Regulating Artificial Intelligence Systems: Risk, Challenges, Competencies, and Strategies," 2016.

[6] P. Gandotra, R. Kumar Jha, and S. Jain, "A survey on device-to-device (D2D) communication: Architecture and security issues," *Journal of Network and Computer Applications*, vol. 78, pp. 9-29, 2017, doi: 10.1016/j.jnca.2016.11.002.

[7] K. Salah, M. H. U. Rehman, N. Nizamuddin, and A. Al-Fuqaha, "Blockchain for AI: Review and Open Research Challenges," *IEEE Access*, vol. 7, pp. 10127-10149, 2019, doi: 10.1109/access.2018.2890507.

[8] D. Yaga, P. Mell, N. Roby, and K. Scarfone, "Blockchain Technology Overview," 2018, doi: 10.6028/nist.Ir.8202.

[9] K. Sgantzos and I. Grigg, "Artificial Intelligence Implementations on the Blockchain. Use Cases and Future Applications," *Future Internet*, vol. 11, no. 8, 2019, doi: 10.3390/fi11080170.

[10] A. Reyna, C. Martín, J. Chen, E. Soler, and M. Díaz, "On blockchain and its integration with IoT. Challenges and opportunities," *Future Generation Computer Systems*, vol. 88, pp. 173-190, 2018, doi: 10.1016/j.future.2018.05.046.

[11] Figueroa, Añorga, and Arrizabalaga, "An Attribute-Based Access Control Model in RFID Systems Based on Blockchain Decentralized Applications for Healthcare Environments," *Computers*, vol. 8, no. 3, 2019, doi: 10.3390/computers8030057.

[12] N. Joshi, "What happens when blockchain, IoT, and AI converge! ," *Allerin*, 2018, doi: https://www.allerin.com/blog/what-happens-when-blockchain-iot-and-ai-converge.

[13] D. Puthal, S. P. Mohanty, V. P. Yanambaka, and E. Kougianos, "PoAh: A Novel Consensus Algorithm for Fast Scalable Private Blockchain for Large-scale IoT Frameworks," 2020.

[14] N. O. Nawari and S. Ravindran, "Blockchain Technology and BIM process: Review and Potential Applications " *Journal of Information Technology in Construction*, 2019.

[15] C. Vocke, C. Constantinescu, and D. Popescu, "Application potential of artificial intelligence for the design of innovation processes," 2019.

[16] E. F. Jesus, V. R. L. Chicarino, C. V. N. de Albuquerque, and A. A. d. A. Rocha, "A Survey of How to Use Blockchain to Secure Internet of Things and the Stalker Attack," *Security and Communication Networks*, vol. 2018, pp. 1-27, 2018, doi: 10.1155/2018/9675050.

[17] R. Mahanty and P. K. Mahanti, "Unleashing Artificial Intelligence onto Big Data: A Review," in *Handbook of Research on Computational Intelligence Applications in Bioinformatics*, (Advances in Bioinformatics and Biomedical Engineering, 2016, ch. chapter 1, pp. 1-16.

[18] P. N. Ramkumar *et al.*, "Artificial Intelligence and Arthroplasty at a Single Institution: Real-World Applications of Machine Learning to Big Data, Value-Based Care, Mobile Health, and Remote Patient Monitoring," *J Arthroplasty*, vol. 34, no. 10, pp. 2204-2209, Oct 2019, doi: 10.1016/j.arth.2019.06.018.

[19] T. N. Dinh and M. T. Thai, " AI and Blockchain: A Disruptive Integration," 2018.

[20] Y. Xing, C. Lu, Y. Liu, H. Guo, H. Gao, and D. Cao, "Hybrid-Learning-Based Classification and Quantitative Inference of Driver Braking Intensity of an Electrified Vehicle," 2018.

[21] S. S. Gill *et al.*, "Transformative effects of IoT, Blockchain and Artificial Intelligence on cloud computing: Evolution, vision, trends and open challenges," *Internet of Things*, vol. 8, 2019, doi: 10.1016/j.iot.2019.100118.

[22] J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions," *Future generation computer systems*, vol. 29, no. 7, pp. 1645-1660, 2013.

[23] M. Company, "The Internet of Things: How to capture the value of IoT.," 2018, doi: https://www.mckinsey.com/featured-insights/internet-of-things/our-insights/the-internet-of-things-how-to-capture-the-value-of-iot.

[24] S. M. M. R. G. Muhammad, A. Alelaiwi and A. Alamri, "Smart Health Solution Integrating IoT and Cloud: A Case Study of Voice Pathology Monitoring," *IEEE Communications Magazine*, vol. vol. 55, no. no. 1, pp. pp. 69-73, January 2017, doi: https://ieeexplore.ieee.org/document/7823340.

[25] M. R. M. a. M. A. R. M. Afrin, "Real time detection of speed breakers and warning system for on-road drivers," *015 IEEE International WIE Conference on Electrical and Computer Engineering*, pp. pp. 495-498, 2015, doi: https://ieeexplore.ieee.org/document/7443976.

[26] R. M. Flavio Bonomi, Jiang Zhu, and Sateesh Addepalli, "Fog computing and its role in the internet of things," *MCC workshop on Mobile cloud computing* 2012, doi: DOI:https://doi.org/10.1145/2342509.2342513.

[27] H. P. Institute, "HSCBB17-Booklet," 2017.

[28] J. Donath, "Why fake news stories thrive online," 2016, doi: https://edition.cnn.com/2016/11/20/opinions/fake-news-stories-thrive-donath/.

[29] Github.inc., "The World's Leading Software Development Platform. ," 2019, doi: https://github.com/.

[30] Oracle, "Transformational Technologies: Today," p. 4, 2018.

[31] M. Verdú, "Data Security Essential for the Convergence of IoT, AI & Blockchain," 2020, doi: https://www.iotsworldcongress.com/data-security-essential-for-the-convergence-of-iot-ai-and-blockchain/. IOT Solutions World Congress.

[32] G. Zyskind, O. Nathan, and A. S. Pentland, "Decentralizing Privacy: Using Blockchain to Protect Personal Data," presented at the 2015 IEEE Security and Privacy Workshops, 2015.

[33] S. Walsh, "Blockchain, IoT, AI Will Converge in Healthcare," *RTInsights.com*, 2017, doi: https://www.rtinsights.com/blockchain-iot-ai-will-converge-in-healthcare/.

[34] M. N. O. Sadiku, K. G. Eze, and S. M. Musa, "Blockchain Technology in Healthcare," 2018, doi: 10.7324/IJASRE.2018.32723.

[35] C. Phil Laplante, PE, PHD, "AI/IoT/Blockchain: Enabling High Integrity Solutions in the Real World," 2018.

[36] M. Orcutt, "“Who will build the health-care blockchain”?," 2017, doi: https://www.technologyreview.com/s/608821/who-will-build-the-health-care-blockchain/.
[37] T. Marwala and B. Xing, "Blockchain and Artificial Intelligence," 2018.
[38] O. Novo, "Blockchain meets IoT: An architecture for scalable access management in IoT," *IEEE Internet of Things Journal*, vol. 5, no. 2, pp. 1184-1195, 2018.
[39] J. Pan and Z. Yang, "Cybersecurity Challenges and Opportunities in the New "Edge Computing + IoT" World," presented at the Proceedings of the 2018 ACM International Workshop on Security in Software Defined Networks & Network Function Virtualization - SDN-NFV Sec'18, 2018.
[40] J. Chen, "Hybrid Blockchain and Pseudonymous Authentication for Secure and Trusted IoT Networks," 2018.

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