

IoT and Cloud Computing for a Bright Future

Dr. Ranjan Kumar Mondal

Assistant Professor, Department of CSE, Swami
Vivekananda University, Kolkata, WB

ranjankm@svu.ac.in

ABSTRACT: The vast potential for revolutionary advancement that the convergence and integration of the Internet of Things (IoT), Cloud Computing (CC), and Big Data (BD) offer will enable the vast industrial revolution that is so common in today's digital world. This raises the question of how these three disciplines may work together to provide new prospects for a better future and explore these synergies. Through this integration, billions of IoT devices are connected easily, CC's potential is fully utilized, and massive information produced by these devices is effectively managed.

Organizations may get important insights, promote data-driven decision-making, and stimulate innovation in various sectors by combining BD analytics with IoT and CC. However, implementing these systems also brings several noteworthy challenges, including data security, privacy concerns, scalability, and data management. Through a thorough analysis of the possible advantages, problems, and mitigation measures, the article dives into these issues, investigates solutions, and looks at obstacles and best practices for dealing with them. Furthermore, this article provides insights into how combining CC, BD, and IoT might open up new possibilities for technology and society in the future.

Keywords: Internet of Things, Cloud computing, Big data.

Introduction

We have witnessed incredible technological advancements in the past few years that have the power to alter many aspects of our lives drastically. The Internet of Things

(IoT), sophisticated robotics, virtual and augmented reality, artificial intelligence, and other cutting-edge technologies are all integrated into these fascinating new technological developments. Among these developments, the convergence of big data, cloud computing, and the Internet of Things has attracted a lot of interest as it is seen to be a potent combination that can influence a better future. This integration combines the enormous computational power and scalability provided by cloud computing, the vast network of connected devices in the Internet of Things, and the potential insights gained from analyzing massive amounts of data through big data analytics.

Cloud computing, big data analytics, and the Internet of Things are incredibly valuable. However, the true strength comes from forming an integrated ecosystem that handles data processing, analysis, storage, and gathering. An enormous quantity of dynamic, varied data is produced by a network of interconnected sensors and gadgets known as the Internet of Things. This unstructured data has previously overtaken organizations. Cloud computing gives them the means and infrastructure to effectively store and manage such data. Last but not least, big data analytics helps businesses find hidden trends and get valuable insights from this previously overwhelming IoT data.

Combining these technologies allows data to move quickly through a networked environment. This establishes a beneficial cycle of data collecting, storing, processing, and analysis that produces the valuable insights businesses need to boost innovation, streamline operations, and gain a competitive edge.

Real-time processing must be done on the cloud to fully use the potential of sensor data. This type of data processing makes creating proactive and intelligent apps and services possible. IoT and big data provide several advantages, such as proactive and predictive knowledge, real-time actionable insights, performance optimization, and a thorough comprehension of the environment and circumstances. Cloud technology allows decentralized and scalable information processing, analytics, and data management. In this work, we provide

a cloud-based platform and the related requirements for IoT and big data applications. Numerous sensors and devices, big data analytics, cloud-based data management, edge-intensive computing, capabilities, and virtualization support are only a few of the essential parts of this platform.

However, combining these three fields presents many difficulties. To fully realize the promise of this integration, measures must be taken to address challenges related to data security and privacy, scalability, and effective data administration. Companies must overcome these challenges skillfully and implement robust plans that ensure data privacy, accuracy, and availability while maximizing their potential for revolutionary results.

This paper explores the complex interplay between IoT and cloud computing. It looks at how various technologies may work together and how merging them could change things. It also assesses the interplay between these elements and clarifies the advantages and disadvantages they could bring. Additionally, this article aims to thoroughly analyze how businesses may set the stage for effectively utilizing the combined power of big data, cloud computing, and IoT. We empower stakeholders to realize the enormous promise of these technologies while managing the risks by demonstrating best practices to overcome significant roadblocks. By carefully examining the advantages and obstacles, we can strive toward a future where we fully utilize IoT, cloud computing, and big data analytics in a safe, scalable, and responsible manner.

Related Work

Nazari Jahantigh et al.'s research [11] first gives background information on each technology separately to thoroughly analyze the confluence of cloud computing and the Internet of Things. The 38 chosen papers showcase features like real-time analytics and scalability and are divided into applications, platforms, and interactions with other technologies. However, it recognizes enduring difficulties with standards, security, privacy, and effective resource management. Despite its value, the review does not thoroughly examine the advantages and disadvantages of the strategies covered in the

sample articles. Moreover, the paper selection process is still not entirely apparent, and the scope seems limited to recent years, ignoring significant earlier contributions. Though general, the results don't provide any concrete suggestions. In conclusion, this study discusses IoT-cloud integration; nevertheless, it might benefit from a deeper investigation and a broader focus that incorporates a more thorough assessment of earlier research. In their comprehensive study, Chegini et al. [12] concentrated on automation methods used in IoT-Fog-Cloud ecosystems. The exponential rise in linked IoT devices and the associated big data and heterogeneity concerns are well noted. The authors put forward six categories of automation features, from workflow management to data filtering, to help alleviate these difficulties. These automation techniques are intended to improve Fog offloading, handle diverse components, and quickly process large amounts of data. While the study classifies pertinent material based on these kinds of automation, it does not critically evaluate the merits and demerits of the strategies mentioned. The scope mainly covers research at the proposal level; studies assessing practical implementations and performance trade-offs are excluded, which might improve the analysis. The review by Selvaraj and Sundaravaradhan [13] examined the issues and patterns in research about IoT-enabled healthcare systems. With an emphasis on healthcare applications, such as patient monitoring and helping older patients, it thoroughly reviews IoT architecture, cloud integration, big data, and security measures. The advantages are listed, including early illness diagnosis and remote healthcare access, but drawbacks are also mentioned, including excessive energy consumption, data security flaws, and scaling problems. The analysis covers a wide range of technology and applications but doesn't critically evaluate the effectiveness and relative merits of the methods it cites. The scope mainly covers proposal-level work without providing significant insights into performance trade-offs and real-world installations. Furthermore, a detailed discussion of possible solutions to the difficulties presented is lacking [13]. A comprehensive analysis of IoT technological improvements was provided by Amin et al. [14], focusing on how these technologies integrate with big data,

data science, and network science. The study looks at how cutting-edge methods like federated learning, blockchain, and machine learning might improve the next generation of IoT, especially in areas like edge/cloud computing, data provenance, and architecture. It points out shortcomings, most notably the need for a comprehensive assessment of federated learning and deep learning in Internet of Things scenarios. It recommends that the research community prioritize these cutting-edge techniques to overcome the drawbacks mentioned in earlier studies. Together with a systematic examination of state-of-the-art IoT advancements, this evaluation also identified possibilities and unresolved challenges consistent with the results of earlier surveys [14]. Ali et al. [15] covered the standards and enabling technologies for Internet of Things systems in their thorough analysis. As previous studies have pointed out, the heterogeneity of devices, the variety of underlying technologies, and the absence of standards provide significant problems for IoT. This evaluation used a layered architectural approach, focusing on the role of middleware platforms in enabling IoT application development and integration while also analyzing the state-of-the-art and unresolved challenges at each tier of the IoT stack. Nevertheless, the study is deficient in providing a thorough critical examination of practical applications and a comparative assessment of the technologies mentioned. The solutions that have been explored are still at an abstract level and do not include specific technological details. Although it provides a comprehensive overview of middleware platforms and the IoT technology stack, a more thorough evaluation of their usefulness might improve the study even more.

Developments and technologies without delving into analyses of viability. However, the paper critically reviews the potential synergies between cloud computing, IoT, and big data analytics. A crucial component absent from previous surveys is a comparative assessment of various integration strategies and their effectiveness in addressing significant challenges. This work stands out more since it offers doable solutions based on best practices to overcome scalability, security, interoperability, and governance challenges. This research provides a more comprehensive approach to realizing

the full potential of the IoT, cloud, and significant data nexus than earlier literature studies because it incorporates conceptual frameworks, rigorously technologically based critical analysis, and practical implementation guidance.

3. The Internet of Things

The Internet of Things (IoT) has recently become a major technical trend with many energy, healthcare, and agriculture applications. The Internet of Things connects and facilitates communication among network-enabled devices. Allowing distant equipment to interact and exchange real-time data via the Internet wirelessly is proving to be a potent tool for control and automation in the industrial industry. A network of linked devices that can gather and share real-time data inside itself is referred to as the Internet of Things. The Internet of Things (IoT), which can link everything from industrial machinery to wearable technology, enables remote monitoring, automation, and coordination, revolutionizing conventional production processes. The Internet of Things (IoT) has the potential to completely transform the industrial industry by streamlining operations, cutting expenses, and improving quality control as this cutting-edge technology advances. IoT offers an exciting new avenue for industrial innovation, and its potential in manufacturing is just now beginning to be explored. This opens up many opportunities for integrating computer systems into the real world by allowing devices to collect and exchange data without human involvement via network infrastructure. IoT devices carry out a variety of tasks, including gathering and sending data to and from other devices connected to the network. The Internet of Things (IoT) includes many Internet-connected intelligent gadgets, including TVs, smartphones, watches, eyewear, and alarm monitoring systems. Health monitoring, smart cities, waste management, security, intelligent traffic, emergency services, retail, industry, and healthcare are just a few of the many applications for which it provides solutions.

4. Computing In The Cloud

Cloud computing describes the ability to quickly and easily access resources without directly maintaining the underlying

hardware infrastructure. It includes various computer services provided over the Internet, such as servers, vital software, networking, data analytics, and databases. This method makes faster deployment, cost-effective scaling, and the availability of flexible resources possible.

6. Hybrid Iot And Cloud Computing Integration

Acknowledging the unique benefits and limitations of big data, cloud computing, and the Internet of Things, there is a growing agreement on combining these technologies to maximize their combined potential. Several integration scenarios have emerged, highlighting the benefits that result from their joint use. These integration scenarios cover many different areas, such as:

Integration of Cloud Computing with IoT: The Internet of Things generates vast real-time data from connected devices and sensors. Businesses can handle this data deluge with the scalable infrastructure provided by cloud computing and IoT systems integration. The cloud provides flexible, on-demand computing power for ingesting, processing, analyzing, and storing IoT data as it is created. This real-time data flow enables advanced monitoring, automation, and predictive capabilities enabled by cloud-based analytics and machine learning technology. Combining IoT with cloud computing makes it easier for businesses to fully use the disruptive potential of big data produced by IoT.

7.1 Models Of Iaas, Paas, And Saas

A cloud-based IoT platform is a resource-sharing platform that provides flexible and dynamic IoT services. This concept of cloud computing is consistent with what NIST defines as an architecture that offers easy access to a shared pool of reconfigurable computing resources. With the least amount of administration work or communication with service providers, this paradigm allows businesses to supply and release resources quickly. Three service models power the cloud-based Internet of Things platform: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Its main goal is to simplify IoT data use by offering scalable resources and effective service management.

The platform ensures the resources needed to handle and analyze enormous volumes of IoT data are easily accessible. It also enables resource scaling as necessary, improving resource efficiency and allocation.

Usually, the cloud-based IoT platform has to choose one of three service models: SaaS, PaaS, or IaaS. IaaS uses resource virtualization to outsource computer infrastructure to support business activities. Cloud technology's ability to run old programs on virtual machines (VMs) under external management was originally the driving force behind its popularity. As a result, application owners were freed from handling the physical infrastructure.

However, PaaS eliminates the difficulties of developing and maintaining infrastructure by providing a platform for users to create, execute, and manage applications. PaaS frameworks assembled applications from their source code and launched them into lightweight virtual machines or containers. Task scheduling and application scalability are other features offered by PaaS platforms.

Conversely, Software as a Service (SaaS) is a software distribution and licensing model that uses subscriptions to pay for centrally hosted software. It is accessible using a web browser and is usually called "on-demand software." Cloud-based IoT systems often use the Software as a Service (SaaS) model, providing web-based pay-per-use IoT services. However, SaaS IoT solutions do have limitations in terms of sophisticated customization and application development. While some have methods for user-provided callback extension, the resultant applications could not be consistent and might be challenging to update.

The massive volumes of data created nowadays must be organized due to the enormous quantity of data generated by IoT. Big data is increasing significantly, and so is the need for data analytics systems like Hadoop. As a result, this movement has created new opportunities in the IoT and cloud computing space. As a result, well-known service providers such as Google, Microsoft, and Amazon Web Services (AWS) have introduced their big data solutions at competitive prices

that are easily expandable to suit the requirements of many types of businesses. This progress has led to a new service model called Analytics as a Service (PaaS). PaaS offers a fast and scalable method for integrating various structured, semi-structured, and unstructured data forms. Through real-time analysis, transformation, and visualization, it provides companies with efficient means of realizing the potential of data. The figure illustrates the basic models of cloud computing, 4. as well as variations that use the Internet of Things and big data.

7.2 Iot Bigdata Analytics Platform Requirements

Some essential considerations must be made when building an IoT big data analytics platform. First and foremost, it must show that it can handle the Internet of Things data dynamically, resolving interoperability problems and the inherent communication difficulties among varied and heterogeneous devices. The platform's ability to extract essential insights and information from the enormous IoT data repositories is crucial.

In addition, the platform should show universality in terms of accessibility and connection for people, services, and things, focusing on mobile contexts. It must also provide the adaptability required for seamless orchestration and user management, effectively handling the wide range of connected devices and the massive volumes of data they generate. Finally, it has to be centered on customizing the user experience and the service, prepared to provide tailored solutions that closely align with user preferences and real-world situations.

The following is a summary of what an IoT big data analytics platform needs to have:

- **Intelligent and Dynamic Capabilities:** The platform should have intelligent and autonomic characteristics to dynamically manage Internet of Things functions, components, and applications. It should also be able to act proactively, dynamically allocate resources, and make wise judgments based on knowledge of the application requirements, user requirements, and environmental

context. This entails the dynamic transfer of resources and services and the dumping of burden from clients and hosts to the cloud.

- **Distributed Architecture:** The platform needs a distributed architecture with several crucial parts. These comprise distributed data management functions, storage, intelligence, information processing, and computing capabilities. These critical operations must be dispersed over a network, including gateway/server systems, cloud environments, and smart devices. Relocating computing power closer to end users is a critical component of this design to reduce bandwidth consumption. The platform's speed is maximized, and this distributed configuration improves its efficiency in handling and processing data across several nodes and environments.

- **Scalability:** The platform must snowball, supporting different quantities of users, services, and devices. Data management, storage, and processing services must be constantly adjusted to satisfy changing needs.

- **Real-Time Processing:** The platform must process data in real-time to provide prompt analysis and replies, especially in emergencies. Effective real-time data processing requires prioritizing time-sensitive jobs over non-urgent ones.

- **Programmability:** The platform must strongly support programming features, enabling the customization of data warehousing strategies, service models, and IoT business and service logic. Customization and adaptation to particular needs must be flexible.

- **Interoperability:** Interoperability is necessary for smooth connectivity across diverse IoT services and infrastructures. This implies that APIs must comply with recognized standards and that components must be released and maintained as open-source software. Admittedly, the ultimate objective is developing a standard data model using structured and unstructured data. These are critical steps in facilitating the creation of flexible, cross-domain intelligent applications, the transition from

unlinked to linked data, and the use of explicit, concise representations of pertinent data.

- **Security:** The platform must prioritize privacy and security by design. This includes data integrity, localization, confidentiality, and service level agreements (SLAs). Across value chains, holistic methods are required to address privacy and security problems.

7. OPPOSING IOT ARCHITECTURES: TRADITIONAL IOT VS. CLOUD AND BIG DATA

Cloud and big data-based IoT is distinct from conventional, non-cloud, and big data-based IoT in several important ways:

- **Scalability:** Cloud-based IoT with big data offers almost infinite scalability compared to typical IoT solutions. Cloud infrastructure's ability to dynamically assign resources in response to demand makes it possible to manage vast IoT device data sets and large-scale installations.
- **Storage Capacity:** Cloud-based IoT with big data uses scalable and distributed storage solutions, including distributed file systems or data lakes, to handle enormous volumes of data. Due to their low storage capacity, conventional Internet of Things systems may need manual data management or archiving.
- **computing Power:** Big data and cloud-based IoT may use cloud infrastructure's computing power for applications like data processing, analysis, and machine learning. Conventional IoT systems sometimes depend on less potent edge devices for basic data processing due to their low computing capacity.
- **Real-time Analytics:** Cloud-based IoT with big data makes real-time or almost real-time analytics on incoming data streams possible. Quick, actionable insights may be obtained using big data processing technologies such as Apache Spark or stream processing frameworks. Batch processing or delayed analysis are likely the only analytics capabilities available to traditional Internet of Things devices.

- **Adaptability and Flexibility:** Big data and cloud-based IoT provide adaptability regarding device integration, protocols, and data formats. Numerous tools and APIs are often available on cloud platforms to enable smooth integration with IoT devices and protocols. The compatibility and interoperability of traditional IoT systems with various devices and data sources may be restricted.

- **Cost-Efficiency:** Pay-as-you-go pricing options for cloud-based IoT with big data lead to cost benefits. Businesses may avoid the initial expenditures associated with setting up and maintaining an on-premises infrastructure by scaling capacity as required. Conventional Internet of Things solutions need large initial hardware, upkeep, and infrastructure setup costs.

- **Data Security and Privacy:** Strong security protocols, encryption, access control, and data anonymization are prioritized in cloud-based IoT with big data. Cloud service providers usually follow compliance standards and industry best practices. Because traditional IoT systems have fewer security safeguards, they may be more vulnerable to attacks or need more work to protect user privacy.

- **Analytics Ecosystem Integration:** Big data and cloud-based IoT readily connect with current analytics tools and ecosystems. Companies may link with third-party analytics services or use advanced analytics and machine learning features of cloud platforms. Advanced analytics technologies may not integrate well with traditional IoT systems, necessitating more analysis and insight extraction work.

- **Updating and Maintenance:** Big data and cloud-based IoT lessen the strain of updating and maintaining systems. Cloud service providers manage the underlying infrastructure and supply software upgrades, security patches, and availability. Conventional IoT systems need specialized personnel for upkeep, upgrades, and guaranteeing system availability.

Compared to traditional/non-cloud and non-big data-based IoT systems, cloud—and extensive data-based IoT systems provide improved scalability, storage capacity, processing power, real-time analytics, flexibility, cost-effectiveness, security, integration, and easier maintenance. Table 2 summarizes the distinctions and does not include all potential variants in IoT deployments.

8. Cloud-based IOT components

According to our investigation, the following crucial elements are often included in an IoT system that is based on cloud computing and big data:

- **Internet of Things gadgets:** These are the hardware items that gather and send data, such as sensors, actuators, and smart gadgets. They are in charge of gathering and transmitting data to the cloud.
- **Cloud Infrastructure:** This component, consisting of cloud computing resources and services from major cloud service providers such as AWS, Microsoft Azure, or Google Cloud Platform (GCP), serves as the system's fundamental framework. It consists of virtualization, networking, storage, and server technologies.
- **Data Storage Layer:** This layer provides a range of storage technologies, including distributed file systems, data lakes, relational and NoSQL databases, and warehouses, and is essential to storing gathered data. The selection of storage technology is contingent upon an IoT application's particular requirements and data processing demands.
- **Data Processing Layer:** This tier uses acquired data to carry out various data processing operations, such as processing, transformation, aggregation, and analysis, to extract insightful information. This tier often uses technologies like cloud-based data processing services, Apache Spark, and Apache Hadoop.
- **Analytics and Machine Learning:** Utilizes cutting-edge analytics methods and machine learning algorithms to derive conclusions, spot trends, and forecast outcomes

from processed data. Tools for data visualization, dashboards, anomaly detection, predictive modeling, and recommendation systems could be included in this component.

- **Security and Privacy:** This component guarantees the security and privacy of IoT data and the system by implementing safeguards, including authentication, access control, encryption, data anonymization, and adherence to data protection laws.
- **Integration and APIs:** This part allows integration with other services and systems, facilitating data interchange and application compatibility. APIs, or application programming interfaces, allow data exchange and communication between various components or external systems.
- **Monitoring and Management:** This part entails constantly monitoring the system's availability, health, and performance. It includes capabilities for managing errors, logging, alerting, and real-time monitoring. Furthermore, management tools allow system component setup, scalability, and maintenance.

Together, these interconnected parts provide a scalable, adaptable, and effective cloud-based IoT extensive data system that can handle the massive amounts of data produced by IoT devices and extract insightful information. Figure 5 shows the composition of IoT based on cloud and significant data components.

9. Troubles And Unresolved Issues

Big data, cloud computing, and the Internet of Things combine to provide innovative applications and ground-breaking solutions. However, this convergence presents a distinct set of challenges and open issues that need attention to ensure smooth implementation. Although complexities and obstacles are associated with the convergence of potential technologies, Table 3 offers a concise overview of the critical issues in each coupling.

In this talk, we explore the following persistent major problems and unresolved concerns with IoT systems that are connected to cloud and big data:

1. **Scalability and Resource Management:** Managing the skyrocketing data volumes, device connections, and processing resources while accommodating the growing scope of IoT installations is still tricky. Effective resource management and dynamic adjustment to changing demands are essential.

2. **Data Security and Privacy:** Preserving the privacy, confidentiality, and integrity of data created by the Internet of Things is a constant concern. This means using strong encryption to secure data during transmission, storage, and access. Mitigating developing threats and vulnerabilities is equally essential.

3. **Interoperability:** Smooth interoperability and harmonic communication between these components are still challenging in the vast IoT ecosystem, which comprises various devices, protocols, and standards.

4. **Real-Time Processing:** Many Internet of Things applications rely on real-time data processing to make timely decisions. The main concerns are latency mitigation and responsive data processing pipelines.

5. **Data Completeness and Quality:** Many IoT data come in noisy formats. Maintaining data consistency, quality, and dependability is a continuous struggle for accurate analytics and decision support.

6. **Edge Computing:** It's still unclear where data should be processed—in the cloud or at the edge. Finding the ideal edge and cloud computing mix for specific use cases is still challenging.

7. **Energy Efficiency:** Improving energy efficiency without sacrificing functionality is a persistent issue for battery-powered Internet of Things (IoT) devices, often used in energy-constrained contexts [7].

8. **Standardization:** The lack of globally recognized standards hinders the smooth integration and scalability of big data, cloud, and IoT systems—continuous attempts to harmonize encounter significant obstacles.

9. **Regulatory Compliance:** Implementing IoT technologies while adhering to various data protection and privacy rules, including GDPR, is complex and expensive.

10. **Data Governance:** Creating solid frameworks for data ownership, access, and lifecycle management that apply to the Internet of Things (IoT)- generated data is challenging.

11. **Cost management:** As IoT installations grow, the cost of using cloud resources for data processing and storage might become unaffordable. Therefore, developing cost-effective techniques for managing and allocating resources is crucial.

12. **Ethical Considerations:** Gathering and using IoT data presents ethical challenges. Addressing problems with data ownership, collection, use, and transparency is becoming more complex.

13. **Analytics Complexity:** Applying machine learning and advanced analytics to large-scale IoT datasets may be computationally demanding. One constant problem is optimizing analytics pipelines for scalability, efficiency, and real-time processing.

14. **Edge AI and Machine Learning:** Using AI and machine learning algorithms at the edge to make decisions instantly is a developing field. However, updating models and inferring conclusions efficiently is challenging.

15. **Data Integration and Fusion:** It is difficult to combine disparate data sources—both structured and unstructured—from many areas to enable thorough analysis.

16. **Data Lifecycles:** Complying with strict data security standards while managing the whole lifespan of IoT data, including retention, archiving, and safe disposal,

poses complex logistical issues. The advent of quantum computing presents possible challenges to conventional encryption techniques, hence requiring the creation of security mechanisms resistant to quantum mechanics.

In conclusion, integrating IoT and cloud computing has many advantages but presents many difficulties and unresolved problems. Researchers, industry stakeholders, and policymakers are working to address these nuances and promote innovation in this dynamic and quickly changing field.

Conclusion

The convergence of big data, cloud computing, and the Internet of Things has the potential to significantly change a wide range of industries. As this study explains, IoT continually creates enormous amounts of real-time data from linked devices and sensors. This flood of IoT data may be handled effectively using the cloud's infinite processing and storage capacity. Then, using methods like data visualization, predictive modeling, and machine learning, big data analytics provides priceless insights.

However, this convergence also raises significant issues related to scalability, security, privacy, real-time processing, and other areas, as discussed in Sections 7 and 8. Strong encryption, access control, data anonymization, resource optimization, edge computing, and standards development can overcome these obstacles. This article sheds light on how the synergistic integration of IoT, cloud, and big data might lead to revolutionary advancement across sectors. This includes the comparative evaluation in Sections 5 and 6. By utilizing real-time data and analytics, this connection, for example, can support preventative care, individualized treatment, and remote patient monitoring in the healthcare industry. It can improve public safety, ease traffic patterns, and use less energy in smart cities.

The influence of change also reaches industries such as manufacturing, Agriculture as well as transportation.

Corporations, politicians, researchers, and other stakeholders must work together to realize the full promise of this confluence of technologies. The synergistic integration of IoT, cloud computing, and big data may unlock a better future across industrial and social sectors, with vigilant attention to security, privacy, interoperability, scalability, and other critical challenges.

References

- S. Khare and M. Totaro, "Big data in IoT," in 2019 10th International Conference on Computing, Communication and Networking Technologies (ICT), IEEE, Jul.2019,pp.1-7 [Online]. Doi:10.1109/ICCCNT45670.2019.8944495.
- H. Cai, B. Xu, L. Jiang, and A. V. Vasilakos, "IoT-based big data storage systems in cloud computing: Perspectives and challenges," IEEE Internet Things J., vol.4, no.1,pp. 75-87, Feb.2017. doi:10.1109/JIOT.2016.2619369.
- Y. Chen, "IoT, cloud, big data and AI in interdisciplinary domains," Simul. Model. Pract. Theory, vol. 102, p.102070, Jul.2020. doi:10.1016/j.simpat.2020.102070.
- A. Hadjadj and K. HALIMI, "COVID-19 patients' health monitoring system using fuzzy ontology and internet of things," Iraqi J. Comput. Sci.Math., vol.4,no. 1,pp.191-203, Jan.2023. doi:10.52866/ijcsm.2023.01.01.0016.
- A. Malik and H. Om, "Cloud computing and Internet of things integration: Architecture, applications, issues, and challenges," in Sustainable Cloud and Energy Services, Cham: Springer International Publishing, 2018, pp. 1-24.[Online]. Available:doi:10.1007/978-3-319-62238-5_1.
- H. Kumar, P. J. Soh, and M. A. Ismail, "Big data streaming platforms: A review," Iraqi J. Comput. Sci. Math., vol.3,no.2, pp.95-100, Apr.2022. doi:10.52866/ijcsm.2022.02.01.010.
- M. Talebkah, A. Sali, M. Marjani, M. Gordan, S. J. Hashim, and F. Z. Rokhani, "IoT and big data applications in smart cities: Recent advances, challenges, and critical issues," IEEE Access, vol. 9, pp. 55465-55484, 2021. doi:10.1109/ACCESS.2021.3070905.

M. Azeem, A. Haleem, S. Bahl, M. Javaid, R. Suman, and D. Nandan, "Big data applications to take up major challenges across manufacturing industries: A brief review," *Mater. Today Proc.*, vol. 49, pp. 339–348, 2022. doi:10.1016/j.matpr.2021.02.147.

A.H.Ali, M.Z. Abdullah, S.N. Abdul-Wahab, and M. Alsajri, "A brief review of big data analytics based on machine learning," *Iraqi J. Comput. Sci. Math.*, vol. 1, no. 2, pp. 13–15, Jul. 2020. doi:10.52866/ijcsm.2020.01.01.002.

Z. S. Al-Talib and Saad Fawzi Al-Azzawi, "A new simple 6D hyperchaotic system with hyperbolic equilibrium and its electronic circuit," *Iraqi J. Comput. Sci. Math.*, vol. 4, no. 1, pp. 155–166, Jan. 2023. doi:10.52866/ijcsm.2023.01.01.0013.

M. Nazari Jahantigh, A. Masoud Rahmani, N. Jafari Navimirour, and A. Rezaee, "Integration of internet of things and cloud computing: A systematic survey," *IET Commun.*, vol. 14, no. 2, pp. 165–176, Jan. 2020. doi: 10.1049/iet-com.2019.0537.

H. Chegini, R. K. Naha, A. Mahanti, and P. Thulasiraman, "Process automation in an IoT-Fog-Cloud ecosystem: A survey and taxonomy," *IoT*, vol. 2, no. 1, pp. 92–118, Feb. 2021. doi:10.3390/iot2010006.

S. Selvaraj and S. Sundara varadhan, "Challenges and opportunities in IoT healthcare systems: A systematic review," *SNAppl. Sci.*, vol. 2, no. 1, p. 139, Jan. 2020. Doi:10.1007/s42452-019-1925-y.

F. Amin, R. Abbasi, A. Mateen, M. Ali Abid, and S. Khan, "A step toward next-generation advancements in the Internet of things technologies," *Sensors*, vol. 22, no. 20, p. 8072, Oct. 2022. doi:10.3390/s22208072.

O. Ali, M. K. Ishak, M. K. L. Bhatti, I. Khan, and K.-I. Kim, "A comprehensive review of internet of things: Technology stack, middle wares, and fog/edge computing interface," *Sensors*, vol. 22, no. 3, p. 995, Jan. 2022. doi:10.3390/s22030995.

D. Serpanos and M. Wolf, *Internet-of-Things (IoT) Systems*. Cham: Springer International Publishing, 2018. [Online]. Available: doi:10.1007/978-3-319-69715-4.

I. Abrar, S. N. Pottoo, F. S. Masoodi, and A. Bamhdi, "On IoT and its integration with cloud computing: