Integration of IoT Enabled Cloud Computing : A Comprehensive Survey

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Abstract

Cloud and IoT—these two innovations are getting to be progressively intertwined in our everyday lives. With the rapid advancement of technology, the utilize of IoT gadgets is developing, driving to the era of endless sum of information. This surge in information requires the integration of cloud computing with IoT, cultivating critical headways in different spaces such as agriculture (e.g., crop recommendation), smart homes, security, and smart transportation, in this manner settling numerous real-world issues. This paper aims to discuss how Cloud-IoT integration is being implemented over diverse areas, the different models utilized in this integration, the challenges confronted, and the future scope of Cloud-IoT integration. Basically, this paper gives a comprehensive overview of the integration of Cloud-IoT.

Keywords: Cloud Computing, IoT, SDN, WSN, PSP

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1. Introduction

In this world of many technologies IoT and Cloud computing emerges as new cutting edge technology which as created a transformative paradigm, enhancing a wide range of applications from precision agriculture to smart cities and healthcare. IoT technology, by integrating information-sensing equipment, facilitates intelligent identification, positioning, and monitoring of entities across various domains, such as agriculture, healthcare, and smart infrastructure .

The evolution of CC is currently related to the increasing popularity of big data. In fact, CC provides the necessary computation, storage, applications, and networking, which can support big data applications. These applications empowered by CC solutions can extract very useful information to guide better decisions in many usage areas as in healthcare applications **(cited by Ashraf Darwish)**.In the present day, the proper integration of IoT sensors, mobile devices, and cloud and data analysis is essential in the field of precision agriculture. Additionally, the technologies must fit with the farmers' knowledge and experience so as to contribute toward increasing sustainability in agriculture. So, the real-time data will give better accuracy in predictions for the specific fields compared to the offline dataset as per geographical locations **(cited by Murali Krishna Senapaty**).

In order to overcome the disadvantages of traditional networks like measurability problems, inflexibility, etc. different cloud information centres have started accepting the software-defined networking (SDN) thought in their DCNs . With the help of SDN, provisioning of incorporated centralized management logic with a perspective of the full system at the centralized controller will form dynamic changes on the conduct of the system. The network will likewise be modified by the controller, which is well suited to the more dynamic nature of the service provided by the cloud . Large suppliers of clouds, Google for example, formally received the SDN plan in their information centres. There is a tremendous rise in the rate of IoT devices and to accommodate the growth of this rate, the cloud data centre has to expand its functionality in order to provide the best services to every user. So, there is a need to implement the new architecture of cloud networking to enable innovation and continue the functionality and services of cloud **(cited by Tsu-Yang Wu)**.

In the current era, safeguarding data is vital for organizations. As technology progresses, vulnerabilities are on the rise. IoT-enabled cloud computing is particularly prone to security threats like cyberattacks through public channels. Strengthening security protocols can help reduce these risks. SGX is divided into a trusted execution environment and an untrusted execution environment. Because a malicious attacker cannot access the trusted execution environment, storing data in this environment ensures data integrity, privacy, and confidentiality **(cited by Tsu-Yang Wu)**.

The purpose of this study aims to provide a thorough overview of the state of research on IoT-enabled cloud computing across several domains. The survey highlights the major contributions, field of research, optimization approaches, challenges, and future advancements in this field of study.

2. Architecture and Model used

The swift expansion of IoT is profoundly influencing various facets of our lives, largely due to the advancement of wireless networks. These networks enable the formation of smart environments and support a diverse range of applications, including smart traffic systems, healthcare, homes, and agriculture. IoT frameworks are widely used in multiple sectors, as shown in Figure 2, which highlights important areas such as smart environments, healthcare, homes, agriculture, offices, and supply chain logistics. The IoT architecture is fundamentally dependent on wireless sensor networks that facilitate rapid data transfer to the destination gateway in real time. Technologies like RFID and Wi-Fi play a pivotal role in evolving the Internet into a fully integrated "Future Internet," where interconnected objects create intelligent environments. The following fig depicted overview architecture of IoT application.

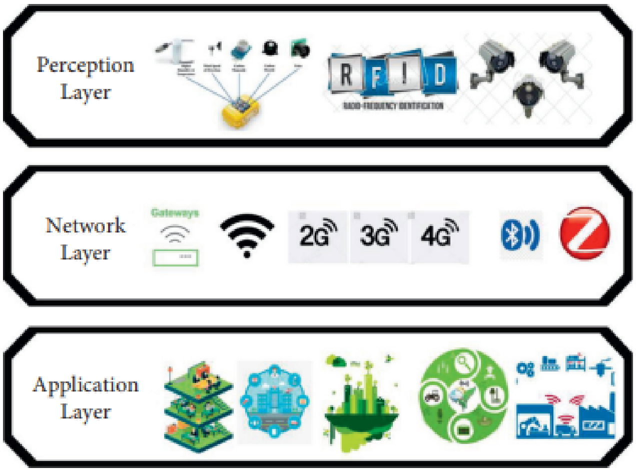

FIGURE 1: Architecture of an IoT application [3–6].

Cloud computing innovation is quickly expanding since it diminishes infrastructural costs and diminishes the need for physical capacity. This innovation permits clients to get to their information from anyplace at any time utilizing equipment and computer program over the web. Cloud computing employments central inaccessible servers to oversee information and applications through the Web, empowering clients to run applications without introducing them or straightforwardly getting to their records from any internet-connected device.

The models that come beneath the cloud deployment category are:

1. Public Cloud: This show is handled on a pay-per-user premise and is basically claimed by Cloud Service Provider (CSP). It is available through a subscription.

2. Private Cloud: This show gives a adaptable environment for neighborhood clients, coming about in more effective and helpful cloud services.

3. Hybrid Cloud: This demonstrate combines both private and open clouds. It is essentially utilized for huge information operations, where non-sensitive information is kept in the open cloud, and delicate information is put away in a private cloud environment.

4. Community Cloud: This is a later variety of the private cloud demonstrate outlined for commerce communities. Benefit suppliers share business-related data and improvement apparatuses required to meet community needs.

Cloud computing innovation gives on-demand administrations such as:

1. Infrastructure as a Service (IaaS): Gives virtualized computing assets over the internet.

2. Platform as a Service (PaaS): Offers equipment and computer program instruments over the web, more often than not for application development.

3. Software as a Service (SaaS): Conveys program applications over the web on a membership premise.

With IoT enabled sensors in WSN and cloud computing, the process of integrating IoT smart devices with set of cloud technologies it is considered to be Claudio (or) Cloud of Things. It is also known as IoT Cloud computing for the purpose of computing in this environment. Access upon the various business resources over cloud environment for better accessing is possible in this hybrid environment **(cited by R. Geetha)**. The following figure depicted the architecture of integration of IoT and cloud computing in different areas:

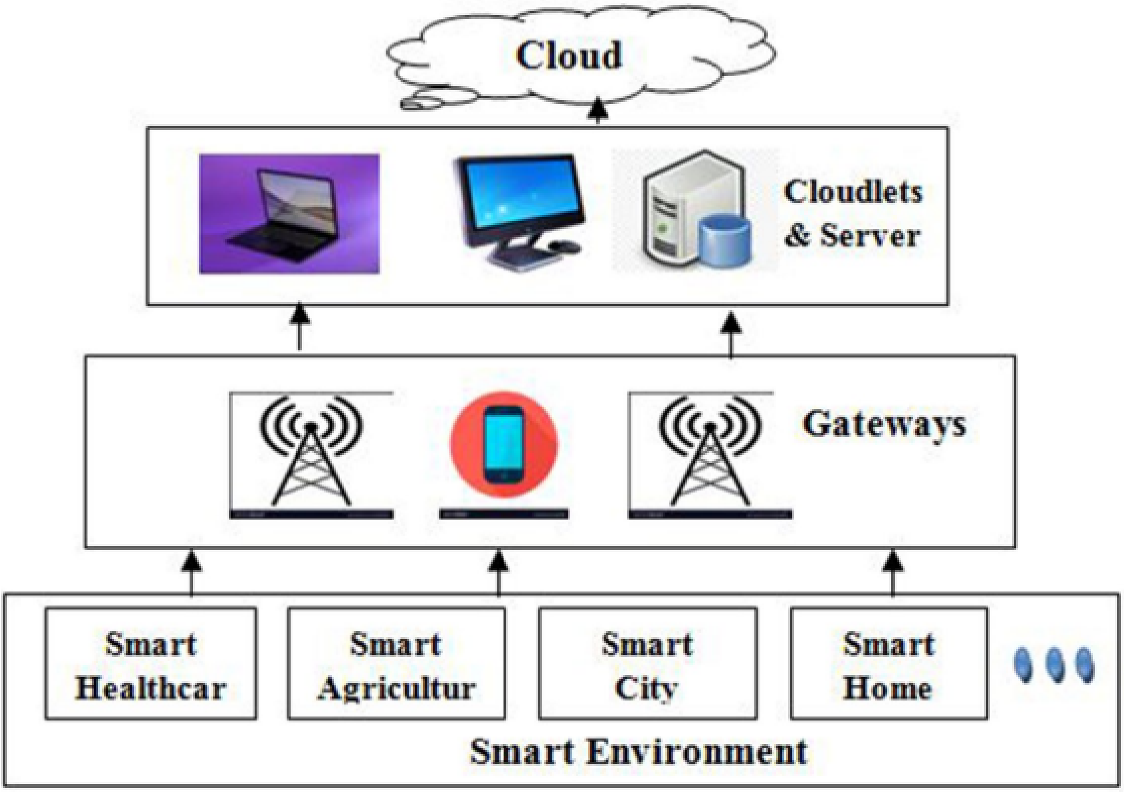

Fig: Applications based on cloud integrated IoT enabled sensors

3. Applications in different areas

The two worlds of Cloud and IoT have seen a rapid and independent evolution. These worlds are very different from each other and, even better, their characteristics are often complementary, as following Tab. 1 shows. Such complementarity is the main reason why many researchers have proposed and are proposing their integration, generally to obtain benefits in specific application scenarios (**cited by Alessio Botta).**

Table 1: Complementary aspects of Cloud and IoT.

	IoT	Cloud
Displacement	pervasive	centralized
Reachability	limited	ubiquitous
Components	real world things	virtual resources
Computational capabilities	limited	virtually unlimited
Storage	limited or none	virtually unlimited
Role of the Internet	point of convergence	means for delivering services
Big data	source	means to manage

The integration of IoT and cloud computing has driven to the creation of different applications that altogether ease our ordinary lives in various ways. In this segment, we will talk about the affect of IoT-cloud integration and how headways in machine learning and fake insights have encourage upgraded these advances. This paper highlights the advancement and advancement of IoT through its collaboration with cloud computing. We will look at a few applications of this integration and investigate their executions.

3.1 Healthcare

CloudIoT explored in this paper can simplify healthcare processes and allows enhancing the quality of the medical services by enabling the cooperation among the different entities involved. Ambient assisted living, in particular, aims at easing the daily lives of people with disabilities and chronic medical conditions. Through the application of CloudIoT in this field, it is possible to supply many innovative services such as collection of the vital data of patients via a sensor network, delivering the data to a medical centers Cloud for storage, and processing, properly managing information provided by sensors (Gachet et al. 2012; Löhr et al. 2010). An important feature of the integration of CloudIoT-Health is that it provides high-quality with low cost and ubiquitous of medical services. Pervasive healthcare systems generate a huge amount of data of sensor network that need to be managed for further data processing (Doukas and Maglogiannis 2012). CC represents a solution for managing healthcare data collected via sensor network effectively and allows to abstract technical details, eliminating the need for expertise in the technology infrastructure (Alagoz et al. 2010). Moreover, it leads to the easy automation of the process of collecting and delivering data at a reduced cost **(cited by Ashraf Darwish).**
By leveraging cloud infrastructure, the system ensures scalability, real-time data analysis, and secure storage of patient data. The integration of AI models helps in creating personalized treatment plans and improving the accuracy of CHD predictions. Healthcare applications of IoT-enabled cloud-computing point to make strides understanding checking, information administration, and therapeutic diagnostics. Inquire about highlights incorporate inaccessible wellbeing observing frameworks, shrewd restorative gadgets, and wellbeing information analytics. In healthcare applications , one of the most important applications is healthcare monitoring system where Figure 2 illustrates the proposed system's architecture. This architecture gives good data with the data science technology with IoT assistance for healthcare monitoring system (HM-DST). Multiple sensors are utilized for monitoring variations in the human body such as heaviness in blood and hotness. (is data would be stored utilizing a local method of dispensation, which is regarded as the needed medical data. (is is an effective system in the prediction of cancer in patients, such that it could be utilized for creating

a mammogram or blood test result after detection of variations in temperature and blood cell. As the blood test features are the features of the cancer patient or a normal person, the features of the results of blood test are classified. On the perception of benefits caused to the users or specific users, this is essential **(cited by Rasha M Abd El-Aziz)**.

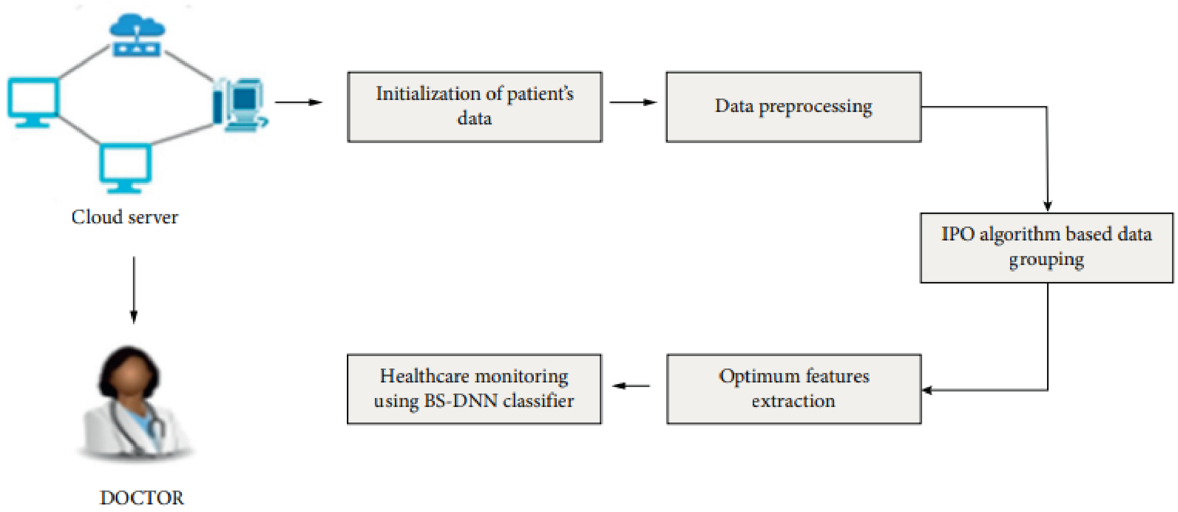

Figure 2: Working process of the proposed HM-DST mechanism.

There are various challenges that still require to be tended to to improve the proficiency and optimization of healthcare applications coordinates with cloud computing frameworks. A few of the common challenges incorporate guaranteeing information security for clients, overseeing execution unusualness, and exploring lawful issues, all of which stay zones of progressing examination

3.2 Agriculture.

In the present day, a timely decision is the prime goal in the field of agriculture, as it can save time and resources and give us an accurate decision. So, a support system for pre-processing the cloud data and then analysing it for predictions is required. The different classification and regression tools are used for data analysis so that the prediction is more accurate. The major contributions of this paper are:

- Proposing an IoTSNA-CR model.
- Sensors to collect data on soil properties.
- Proposing an MSVM-DAG-FFO algorithm.

This paper proposes an IoT-enabled soil nutrient analysis and crop recommendation (IoTSNA-CR) model for precision agriculture. For precision agriculture and monitoring irrigation, a decision support system along with WSN and IoT was proposed. It has been observed that fully sensor-based agriculture will have certain limitations, such as the cost of installation and maintenance and common farmers' lack of knowledge. So, undated information was provided to farmers so that an appropriate decision could be made . A model has been proposed by an author for feature extraction using naive Bayes, random forest, SVM, decision tree, logistic regression, and XGBoost. have the highest accuracy of 99% in prediction **(cited by Murali Krishna Senapaty)**. The integration of IoT and cloud innovation has essentially streamlined trim checking, sparing ranchers a impressive sum of time. It too empowers early forecast of trim wellbeing, permitting agriculturists to take opportune safeguards. Also, edit proposal frameworks help agriculturists in making educated choices almost the most appropriate crops to develop.

3.3 Security

The integration of IoT with cloud innovation includes the exchange of endless sums of information, particularly when utilizing open clouds over the web. This increment in information exchange has driven to increased vulnerabilities to cyber-attacks, raising concerns almost client information security. To address this, analysts have proposed different plans to guarantee secure communication between IoT gadgets and cloud servers. Be that as it may, indeed among these plans, security vulnerabilities still exist. Thus, analysts have moreover presented certain confirmation conventions to safely exchange information and empower machine-to-machine communication, in this manner securing against cyber-attacks.

One of the researcher investigate, analyze, discuss, and explain the scheme against all potential attacks using ProVerif, the ROR model, and informal security discussions.

ProVerif Code:ProVerif is a simulation toolkit that is used to simulate cryptographic algorithms. ProVerif checks the key secrecy, reachability, and confdentiality. According to the ProVerif simulation result, our proposed scheme is secure.

ROR Model: In this section, author evaluate the proposed scheme SK by using the ROR model. Tree participants are involved in this scheme such as user PT1 u , public cloud server PT2 ps , and IoT-enabled device PT3 . The author demonstrate each query used in ROR model such as Execute, CorruptSC, Reveal, Send, and Test.

Shared Session Key Correctness: In this section, author prove that the shared session key for communicating participants is the same. During in login and authentication phase the shared session key is calculated by IoT device.

The comparison results show that the proposed scenario is suitable for practical implantation in the IoT using a public cloud server. In the future, we have planned to design a transitional authentication for end-users when using IoT. At the same time, its security will be conducted using AVISPA (**cited by Naveed Khan).**

In 2020, Kang et al. designed a lightweight authentication and key agreement (AKA) protocol based on the IoT-enabled cloud computing environment. Huang et al. proposed an AKA protocol that combines IoT and cloud computing and implemented it in a smart city environment in 2021. Iqbal et al. proposed an AKA protocol for an IoT and cloud computing architecture in 2022. The architecture of IoT-enabled cloud computing and the communication entities include the user, cloud server, and control server. The cloud service provider deploys cloud servers in the region where the cloud service is provided and configures a control server to manage the cloud servers and users. Intel software guard extensions (SGX) can be introduced to improve the security of AKA protocols designed for IoT-enabled cloud computing environments. SGX is an extension of the Intel instruction set, which protects the security of programs in the running state. In this paper, we first described the necessity of combining the IoT with cloud computing. Simultaneously, we reviewed some AKA protocols designed in the IoT-enabled cloud computing environments and found that there are still some security problems. To address those problems, we proposed an SGX-based lightweight AKA protocol for IoT-enabled cloud computing. Our goal was to ensure data privacy and sustainable communication between the entities. In addition, the security of the proposed protocol was examined using the ROR model, the ProVerif tool, and informal security analysis (**cited by Tsu-Yang Wu**).

3.4 Networking

IoT-enabled cloud computing has revolutionized the field of organizing by encouraging consistent integration and administration of endless systems of interconnected devices. This collaboration permits for real-time information collection, preparing, and examination, which essentially upgrades the effectiveness and adequacy of organize operations. By leveraging the versatility and adaptability of cloud stages, IoT devices can communicate and collaborate more successfully, driving to made strides execution in different applications such as shrewd lattices, brilliantly transportation frameworks, and computerized mechanical forms. The capacity to remotely screen and control organized gadgets through cloud administrations moreover empowers proactive support, quick investigating, and energetic asset assignment, in this manner optimizing arrange usefulness and diminishing downtime. As a result, IoT-enabled cloud computing plays a significant part in progressing the capabilities and unwavering quality of present day organize frameworks.

For example, a smart watch is not only smart because it is connected to the Internet but because it is making use of some cloud where the data is stored, and analysing that cumulative data and making a smart decision. Cloud computing has emerged in such a simple way that its acceptance is universal. The computing that has been facilitated by cloud computing has eliminated several problems while providing services to the shoppers like direct investment, minimizing operational expenses, the handiness of on-request computing resources, protractible scaling, and creating pay-peruse . As the utility of this computing model is expanding, it should be matched with a supplier of cloud with a similar brokering system that is dynamic for hosting its application. The application supplier can lease resources used for computing from the cloud supplier by just clicking on a mouse at regular intervals and using their application without direct payment. With a dynamic adjustment (either increasing or decreasing) of the amount of virtualized infrastructure resources such as virtual machines (VMs), the extensibility and flexibility in the cloud atmosphere is achieved. These virtual machines connect to the customer through varied system switches and switches. So as to transfer the traffic among varied VMs effectively and with information efficiency, network centres are established. Because the Data Centre Network (DCN) interfaces a huge range of servers, the system can have better quality, which makes it exhausting to administrate and scale within the standard systems administration view. In customary systems, every system switch has its own specific management explanation that solely chooses its conduct based on the info obtained from its neighbours . The traditional system approach is wasteful with regards to the information centre of the cloud, where a better thickness provided by varied virtual machine servers that increasingly change over time . In order to overcome the disadvantages of traditional networks like measurability problems, inflexibility, etc. different cloud information centres have started accepting the software-defined networking (SDN) thought in their DCNs. With the help of SDN, provisioning of incorporated centralized management logic with a perspective of the full system at the centralized controller will form dynamic changes on the conduct of the system. The network will likewise be modified by the controller, which is well suited to the more dynamic nature of the service provided by the cloud. The SDN controller controls the system related capacities, which are associated with the director of the cloud through APIs that are north-bound. SDN highlights such as arranging topology disclosure, virtual system administration; organizing checks and dynamic system designs are empowered through the controller of SDN. Cloud computing is a field for creating big storage statistics and analysis. IoT is attractive on its own, but the enormous amount of data coming from IoT devices, its storage, big data statistics, and analysis must be performed by cloud computing Therefore, it can be concluded that as the data from IoT devices is coming in a huge manner, we need a cloud infrastructure in such a way that it has the capability to handle the rate of growth of the network. SDN has the capability to achieve this. Therefore, if SDN is implemented in the cloud it can increase the capability, efficiency of cloud storage and hence this cloud is called an SDN based IoT cloud **(cited by Sumit Badotra)**.

3.5 Transportation:

In the present time, smart transportation has emerged as a progressive solution in the transportation industry. The integration of IoT with cloud computing has effectively tended to different challenges, extending from smart parking to traffic management. Here, we will discuss how this integration has streamlined and progressed transportation frameworks.
Smart parking: The Internet of Things (IoT) permeates with the world of parking to streamline processes that deliver intelligent parking solutions, which extend and manage parking inventories. In this context, IoT uses embedded wireless sensor networks to connect physical parking space infrastructures with information and communication technologies, where cloud-based smart management services are provided. This interconnectivity shift is also driving socio-economical changes, where data unleashed from physical infrastructures is leading to productivity gains through new applications

and new business models. The proposed solution in this work-in-progress turns unused parking spaces into revenues, allowing virtually all parking space owners, ranging from individuals to business entities, to market their assets with a Parking Service Provider (PSP). Motorists are empowered with this service to reach on-street and off-street parking through a better utilization of parking spaces. Both consumers and providers of parking spaces maximize their mutual benefits in this business model. The process is automated through meaningful data that calibrate demand and supply along dynamic pricing models, and plan parking based on real-time information that include special events, holidays and traffic considerations. Smart cities need smarter parking information and guidance systems that interoperate services in the interconnected continuum of parking spaces and vehicles.

The economy is increasingly using cloud services to design new business models. For example, Amazon has created a platform where sellers and buyers can perform secure business transactions. The proposed work-in progress described in this paper reveals a research agenda that aims at lifting the parking space management from a purely physical business to a business that transforms parking into a computational service. Parking space owners profit from the new services by a more economic use of their parking space, which is represented as an economic resource in the parking management system.(**cited by Yacine Atif)**

Traffic Monitoring: Traffic monitoring is an application of IoT technology that involves the use of sensors to detect traffic flow and provide real-time information to drivers. These sensors are typically installed on roads and highways, and they collect data about traffic volume, speed, and congestion. This data is then transmitted to a central system that can provide drivers with real-time information about traffic conditions. Traffic monitoring can also help to improve safety on the roads. By detecting traffic flow and congestion, traffic monitoring systems can provide early warning of potential hazards, such as accidents or road closures. This can help drivers to avoid these hazards and reduce the risk of accidents on the roads
Cloud computing can enable Mobility-as-a-Service (MaaS) platforms, where transportation services are provided on-demand and integrated with other modes of transportation. MaaS platforms offer a convenient and cost-effective alternative to traditional modes of transportation, such as private car ownership, and can help reduce traffic congestion, air pollution, and carbon emissions. Cloud-based data analytics tools can help transportation systems to optimize their operations by providing insights into areas such as traffic congestion, capacity utilization, and demand forecasting. For example, data analytics can help transportation systems to identify the root causes of traffic congestion and develop strategies to mitigate it, such as optimizing traffic signals or rerouting traffic **(cited by Maxim Mnyakin)**.

4. Limitations:

IoT-based cloud computing encounters various obstacles in different sectors, primarily stemming from security issues, power usage, and resource constraints. Traditional security methods often prove inadequate for cloud-connected IoT systems, leaving them susceptible to risks like account breaches, phishing, malware, man-in-the-middle attacks, and service denial. The abundance of connected devices with limited capabilities exacerbates these security challenges, along with the presence of insecure APIs and internal threats. The shared responsibility model in cloud computing necessitates cooperation between users and providers on security matters, though this can be challenging to execute effectively. Machine learning methods, particularly supervised learning algorithms, are being utilised to bolster security by identifying malware and addressing privacy concerns, yet these solutions are not universally successful.

In the healthcare sector, IoT-based cloud computing must contend with issues such as data interference, high costs of signal analysis, energy usage, and real-time communication challenges. These problems are especially crucial in applications for monitoring elderly individuals and expectant mothers, where precision and dependability are essential. Power consumption and resource limitations also affect the efficiency of IoT healthcare applications. While technologies like deep learning offer potential solutions, continuous research and development are necessary to enhance security, decrease energy consumption, and boost performance. Within the energy industry, IoT-based cloud computing must handle substantial data volumes with minimal latency, particularly crucial for smart power plants. Security concerns persist as significant issues, necessitating advanced strategies like deep learning to tackle these challenges. Furthermore, energy conservation in virtualized cloud computing systems is a major focus, demanding efficient task scheduling to strike a balance between energy usage and performance. Overcoming obstacles like data transfer delays, high bandwidth demands, and data security remains imperative.

Overall, IoT-based cloud computing offers enhanced resource utilisation and storage but faces substantial challenges in terms of security, power management, and data privacy. Addressing these issues requires innovative solutions and collaborative efforts to ensure the secure and efficient deployment of IoT systems across various industries.

5. Future Aspects:

The future aspects of IoT-driven cloud computing are promising across various sectors, offering a versatile structure for accessing resources across different industrial settings. By merging IoT with cloud technology, sectors can achieve improved security, scalability, and performance. New approaches to cloud computing are tackling traditional challenges, positively influencing the IoT landscape. IoT cloud providers are offering specialised services for applications, highlighting the potential of IoT clouds in the market.

IoT-driven cloud computing is set to transform healthcare by managing the extensive data produced by various technologies. The combination of IoT and cloud computing boosts scalability, storage, security, and processing capabilities. This enables the monitoring of patients remotely, the collection of personalised healthcare data, and the use of advanced analytics for enhanced patient care. AI algorithms on cloud platforms like Amazon and IBM assist in diagnosing diseases, classifying them, and predicting outcomes. Wearable sensors linked to cloud storage enable the real-time collection, analysis, and sharing of data with healthcare providers, supporting prompt interventions and tailored treatment plans. In summary, IoT-driven cloud computing is poised to revolutionise the delivery of patient care and optimise healthcare processes.

The integration of IoT and cloud computing in the energy sector is looking bright, especially in renewable energy systems. Middleware platforms facilitate communication between devices and applications, integrating network assets into a distributed system. This leads to better energy efficiency, increased generation of renewable energy, and lower maintenance expenses. IoT technologies are ready to transform the energy sector by reducing energy losses in transmission, improving the reliability of power supply, and optimising the flow of energy. The use of real-time data collection, analysis, and cloud-based solutions like Particle Swarm Optimization promises energy-efficient and reliable operations, modernization of power grids, and enhancement of security and reliability.

IoT-driven cloud computing is expected to significantly improve efficiency and safety in transportation. Intelligent Transportation Systems (ITS) have the potential to revolutionise public transport, vehicle monitoring, and traffic management. These systems allow for the real-time monitoring of vehicle metrics, tracking, and analysis of driver behaviour, contributing to safer transportation experiences. Cloud-assisted IoT-ITS can optimise traffic flow by collecting and analysing data, and automating the control of traffic signals based on traffic conditions, enhancing traffic management in smart cities. This technology is poised to streamline operations, enhance safety measures, and transform urban mobility for a sustainable and efficient future.

IoT-driven cloud computing is set to bring advancements in production efficiency and security in manufacturing. The integration of cloud computing enables real-time monitoring, data analysis, and decision-making processes. IoT devices connected through cloud, fog, and edge computing ensure strong protection against cyber threats and efficient allocation of resources. The Cloud-Fog Continuum Computing Architecture overcomes the limitations of low-latency services and real-time data analysis, offering agile and scalable solutions for manufacturing. Cloud-based intelligent machine monitoring and control systems improve the efficiency of modelling and data stability, supporting the transition to intelligent factories with operational capabilities anytime, anywhere. These advancements signify a move towards more adaptive, secure, and interconnected manufacturing operations, paving the way for the evolution of Industry 4.0.

Overall, the future of IoT-based cloud computing is poised for growth and innovation across various sectors, offering enhanced accessibility, cost reduction, and improved performance while addressing security concerns through advancements in deep learning and artificial intelligence.

6. Conclusion:

The integration of IoT and cloud computing is reshaping various divisions by giving imaginative arrangements to conventional challenges. In the transportation industry, shrewd frameworks encouraged by IoT and cloud innovations offer critical changes in ranges such as shrewd stopping and activity administration. These progressions not as it were improve operational proficiency but too contribute to financial and natural benefits. In healthcare, IoT-enabled cloud computing frameworks bolster superior persistent checking, information administration, and therapeutic diagnostics, hence making strides the quality of restorative administrations at diminished costs. Exactness horticulture benefits from IoT-cloud integration through productive trim checking and early wellbeing forecast, making a difference ranchers make educated choices and optimize resources.Security remains a pivotal concern, as the endless information exchange included in IoT-cloud integration presents vulnerabilities. Analysts proceed to create conventions and confirmation strategies to defend against cyber-attacks and guarantee information judgment. In organizing, the combination of IoT and cloud computing improves the administration and execution of interconnected gadgets, advancing real-time information investigation and proactive maintenance.Overall, the consolidating of IoT and cloud computing advances cultivates critical headways over different applications, driving advancement, making strides effectiveness, and tending to basic challenges in advanced frameworks. As these advances proceed to advance, their integration will likely surrender indeed more transformative impacts in the future.

References:

1. Mnyakin, Maxim. "Applications of ai, iot, and cloud computing in smart transportation: A review." *Artificial Intelligence in Society* 3.1 (2023): 9-27.
2. Khan, N., Zhang, J., Ali, J., Pathan, M. S., & Chaudhry, S. A. (2022). [Retracted] A Provable Secure Cross-Verification Scheme for IoT Using Public Cloud Computing. *Security and Communication Networks*, *2022*(1), 7836461.
3. Darwish, A., Hassanien, A. E., Elhoseny, M., Sangaiah, A. K., & Muhammad, K. (2019). The impact of the hybrid platform of internet of things and cloud computing on healthcare systems: opportunities, challenges, and open problems. *Journal of Ambient Intelligence and Humanized Computing*, *10*, 4151-4166.
4. Li, H., Wang, X., Feng, Y., Qi, Y., & Tian, J. (2024). Driving Intelligent IoT Monitoring and Control through Cloud Computing and Machine Learning. *arXiv preprint arXiv:2403.18100.*
5. Ahmad, W., Rasool, A., Javed, A. R., Baker, T., & Jalil, Z. (2021). Cyber security in iot-based cloud computing: A comprehensive survey. *Electronics*, *11*(1), 16.
6. Sharma, B., & Obaidat, M. S. (2020). Comparative analysis of IoT based products, technology and integration of IoT with cloud computing. *IET Networks*, *9*(2), 43-47.
7. Wu, T. Y., Meng, Q., Kumari, S., & Zhang, P. (2022). Rotating behind security: A lightweight authentication protocol based on iot-enabled cloud computing environments. *Sensors*, *22*(10), 3858.

8. Mistry, J., Ganesh, A., Ramakrishnan, R., & Logeshwaran, J. (2023). IoT based congenital heart disease prediction system to amplify the authentication and data security using cloud computing. *European Chemical Bulletin*, *12*, 7201-7213.

9. Bazgir, E., Haque, E., Sharif, N. B., & Ahmed, M. F. (2023). Security aspects in IoT based cloud computing. *World Journal of Advanced Research and Reviews*, *20*(3), 540-551.

10. Mnyakin, M. (2023). Applications of ai, iot, and cloud computing in smart transportation: A review. *Artificial Intelligence in Society*, *3*(1), 9-27.

11. Saleem, M. U., Shakir, M., Usman, M. R., Bajwa, M. H. T., Shabbir, N., Shams Ghahfarokhi, P., & Daniel, K. (2023). Integrating smart energy management system with internet of things and cloud computing for efficient demand side management in smart grids. *Energies*, *16*(12), 4835.

12. Maurya, M., Panigrahi, I., Dash, D., & Malla, C. (2024). Intelligent fault diagnostic system for rotating machinery based on IoT with cloud computing and artificial intelligence techniques: a review. *Soft Computing*, *28*(1), 477-494.

13. Hamdan, S., Ayyash, M., & Almajali, S. (2020). Edge-computing architectures for internet of things applications: A survey. *Sensors*, *20*(22), 6441.

14. Darwish, A., Hassanien, A. E., Elhoseny, M., Sangaiah, A. K., & Muhammad, K. (2019). The impact of the hybrid platform of internet of things and cloud computing on healthcare systems: opportunities, challenges, and open problems. *Journal of Ambient Intelligence and Humanized Computing*, *10*, 4151-4166.

15. Milovanovic, D., & Bojkovic, Z. (2017). Cloud-based IoT healthcare applications: Requirements and recommendations. *International Journal of Internet of Things and Web Services*, *2*, 60-65.

16. Qaisar, F., Shahab, H., Iqbal, M., Sargana, H. M., Aqeel, M., & Qayyum, M. A. (2023). Recent trends in cloud computing and IoT platforms for it management and development: a review. *Pakistan Journal of Engineering and Technology*, *6*(1), 98-105.

17. Ansari, M., Ali, S. A., & Alam, M. (2022). Internet of things (IoT) fusion with cloud computing: current research and future direction. *International Journal of Advanced Technology and Engineering Exploration*, *9*(97), 1812.

18. Atlam, H. F., Alenezi, A., Alharthi, A., Walters, R. J., & Wills, G. B. (2017, June). Integration of cloud computing with internet of things: challenges and open issues. In *2017 IEEE international conference on internet of things (iThings) and IEEE green computing and communications (GreenCom) and IEEE cyber, physical and social computing (CPSCom) and IEEE smart data (SmartData)* (pp. 670-675). IEEE.

19. Badotra, S., & Panda, S. N. (2019). A review on software-defined networking enabled iot cloud computing. *IIUM Engineering Journal*, *20*(2), 105-126.

20. Nancy, A. A., Ravindran, D., Raj Vincent, P. D., Srinivasan, K., & Gutierrez Reina, D. (2022). Iot-cloud-based smart healthcare monitoring system for heart disease prediction via deep learning. *Electronics*, *11*(15), 2292.

21. Liu, Y., Dong, B., Guo, B., Yang, J., & Peng, W. (2015). Combination of cloud computing and internet of things (IOT) in medical monitoring systems. *International Journal of Hybrid Information Technology*, *8*(12), 367-376.

22. Al-Abiad, M. S., Hassan, M. Z., & Hossain, M. J. (2021). Energy efficient federated learning in integrated fog-cloud computing enabled internet-of-things networks. *arXiv preprint arXiv:2107.03520.*

23. Ortiz, G., Zouai, M., Kazar, O., Garcia-de-Prado, A., & Boubeta-Puig, J. (2022). Atmosphere:

Context and situational-aware collaborative IoT architecture for edge-fog-cloud computing. *Computer Standards & Interfaces*, *79*, 103550.

24. Hennebelle, A., Materwala, H., & Ismail, L. (2023). HealthEdge: a machine learning-based smart healthcare framework for prediction of type 2 diabetes in an integrated IoT, edge, and cloud computing system. *Procedia Computer Science*, *220*, 331-338.
25. Gaire, R., Sriharsha, C., Puthal, D., Wijaya, H., Kim, J., Keshari, P., ... & Nepal, S. (2020). Internet of Things (IoT) and cloud computing enabled disaster management. *Handbook of Integration of Cloud Computing, Cyber Physical Systems and Internet of Things*, 273-298.
26. Deng, Q., Goudarzi, M., & Buyya, R. (2021, June). Fogbus2: a lightweight and distributed container-based framework for integration of iot-enabled systems with edge and cloud computing. In *Proceedings of the international workshop on big data in emergent distributed environments* (pp. 1-8).
27. Kang, B., Han, Y., Qian, K., & Du, J. (2020). Analysis and Improvement on an Authentication Protocol for IoT-Enabled Devices in Distributed Cloud Computing Environment. *Mathematical Problems in Engineering*, *2020*(1), 1970798.
28. Yakubu, I. Z., & Murali, M. (2023). An efficient meta-heuristic resource allocation with load balancing in IoT-Fog-cloud computing environment. *Journal of Ambient Intelligence and Humanized Computing*, *14*(3), 2981-2992.
29. Mahmud, R., Koch, F. L., & Buyya, R. (2018, January). Cloud-fog interoperability in IoT-enabled healthcare solutions. In *Proceedings of the 19th international conference on distributed computing and networking* (pp. 1-10).
30. Senapaty, M. K., Ray, A., & Padhy, N. (2023). IoT-enabled soil nutrient analysis and crop recommendation model for precision agriculture. *Computers*, *12*(3), 61.
31. Yang, C., Lan, S., Shen, W., Huang, G. Q., Wang, X., & Lin, T. (2017). Towards product customization and personalization in IoT-enabled cloud manufacturing. *Cluster Computing*, *20*, 1717-1730.
32. Abdalzaher, M. S., Krichen, M., Yiltas-Kaplan, D., Ben Dhaou, I., & Adoni, W. Y. H. (2023). Early detection of earthquakes using iot and cloud infrastructure: A survey. *Sustainability*, *15*(15), 11713.
33. Huang, H., Lu, S., Wu, Z., & Wei, Q. (2021). An efficient authentication and key agreement protocol for IoT-enabled devices in distributed cloud computing architecture. *EURASIP Journal on Wireless Communications and Networking*, *2021*(1), 150.
34. Quy, V. K., Hau, N. V., Anh, D. V., Quy, N. M., Ban, N. T., Lanza, S., ... & Muzirafuti, A. (2022). IoT-enabled smart agriculture: architecture, applications, and challenges. *Applied Sciences*, *12*(7), 3396.
35. Lakhan, A., Mohammed, M. A., Abdulkareem, K. H., Jaber, M. M., Nedoma, J., Martinek, R., & Zmij, P. (2022). Delay optimal schemes for Internet of Things applications in heterogeneous edge cloud computing networks. *Sensors*, *22*(16), 5937.
36. Hu, J. X., Chen, C. L., Fan, C. L., & Wang, K. H. (2017). An intelligent and secure health monitoring scheme using IoT sensor based on cloud computing. *Journal of Sensors*, *2017*(1), 3734764.
37. Rajak, A. A. (2022). Emerging technological methods for effective farming by cloud computing and IoT. *Emerging Science Journal*, *6*(5), 1017-1031.
38. Raju, K. B., Dara, S., Vidyarthi, A., Gupta, V. M., & Khan, B. (2022). [Retracted] Smart Heart Disease Prediction System with IoT and Fog Computing Sectors Enabled by Cascaded Deep Learning Model. *Computational Intelligence and Neuroscience*, *2022*(1), 1070697.

39. Khan, H. U., Ali, F., Alshehri, Y., & Nazir, S. (2022). Towards enhancing the capability of IoT applications by utilizing cloud computing concept. *Wireless Communications and Mobile Computing*, *2022*(1), 2335313.

40. Uppal, M., Gupta, D., Juneja, S., Dhiman, G., & Kautish, S. (2021). Cloud-based fault prediction using IoT in office automation for improvisation of health of employees. *Journal of Healthcare Engineering*, *2021*(1), 8106467.

41. Khan, H. U., Ali, F., Alshehri, Y., & Nazir, S. (2022). Towards enhancing the capability of IoT applications by utilizing cloud computing concept. *Wireless Communications and Mobile Computing*, *2022*(1), 2335313.

42. Khan, N., Zhang, J., Ali, J., Pathan, M. S., & Chaudhry, S. A. (2022). [Retracted] A Provable Secure Cross-Verification Scheme for IoT Using Public Cloud Computing. *Security and Communication Networks*, *2022*(1), 7836461.

43. Butpheng, C., Yeh, K. H., & Hou, J. L. (2022). A Secure IoT and Cloud Computing-Enabled e-Health Management System. *Security and Communication Networks*, *2022*(1), 5300253.

44. Chen, J., Wu, H., Zhou, X., Wu, M., Zhao, C., & Xu, S. (2021). Optimization of Internet of Things E-Commerce Logistics Cloud Service Platform Based on Mobile Communication. *Complexity*, *2021*(1), 5542914.

45. Safdar Malik, T., Siddiqui, M. N., Mateen, M., Malik, K. R., Sun, S., & Wen, J. (2022). Comparison of blackhole and wormhole attacks in cloud manet enabled iot for agricultural field monitoring. *Security and Communication Networks*, *2022*(1), 4943218.

46. Song, L. (2022). [Retracted] Construction of Accounting Internal Control Management Platform Based on IoT Cloud Computing. *Wireless Communications and Mobile Computing*, *2022*(1), 9552118.

47. Mir, M. H., Jamwal, S., Mehbodniya, A., Garg, T., Iqbal, U., & Samori, I. A. (2022). [Retracted] IoT-Enabled Framework for Early Detection and Prediction of COVID-19 Suspects by Leveraging Machine Learning in Cloud. *Journal of healthcare engineering*, *2022*(1), 7713939.

48. Wang, P., Li, B., Shi, H., Shen, Y., & Wang, D. (2019). Revisiting Anonymous Two-Factor Authentication Schemes for IoT-Enabled Devices in Cloud Computing Environments. *Security and Communication Networks*, *2019*(1), 2516963.

49. Shah, S., Khan, M., Almogren, A., Ali, I., Deng, L., Luo, H., & Khan, M. A. (2020). Security measurement in industrial IoT with cloud computing perspective: taxonomy, issues, and future directions. *Scientific Programming*, *2020*(1), 8871315.

50. M Abd El-Aziz, R., Alanazi, R., R Shahin, O., Elhadad, A., Abozeid, A., I Taloba, A., & Alshalabi, R. (2022). An Effective Data Science Technique for IoT-Assisted Healthcare Monitoring System with a Rapid Adoption of Cloud Computing. *Computational Intelligence and Neuroscience*, *2022*(1), 7425846.

51. Siam, A. I., Almaiah, M. A., Al-Zahrani, A., Elazm, A. A., El Banby, G. M., El-Shafai, W., ... & El-Bahnasawy, N. A. (2021). Secure health monitoring communication systems based on IoT and cloud computing for medical emergency applications. *Computational Intelligence and Neuroscience*, *2021*(1), 8016525.

52. Butpheng, C., Yeh, K. H., & Hou, J. L. (2022). A Secure IoT and Cloud Computing-Enabled e-Health Management System. *Security and Communication Networks*, *2022*(1), 5300253.

53. Saini, D. K., Kumar, K., & Gupta, P. (2022). [Retracted] Security Issues in IoT and Cloud Computing Service Models with Suggested Solutions. *Security and Communication Networks*, *2022*(1), 4943225.

54. Rahmani, M. K. I., Shuaib, M., Alam, S., Siddiqui, S. T., Ahmad, S., Bhatia, S., & Mashat, A. (2022). [Retracted] Blockchain-Based Trust Management Framework for Cloud Computing-Based Internet of Medical Things (IoMT): A Systematic Review. *Computational Intelligence and Neuroscience*, *2022*(1), 9766844.

55. Daoud, W. B., Mchergui, A., Moulahi, T., & Alabdulatif, A. (2022). [Retracted] Cloud-IoT Resource Management Based on Artificial Intelligence for Energy Reduction. *Wireless Communications and Mobile Computing*, *2022*(1), 2248962.

56. Jia, D., & Wu, Z. (2022). Enterprise collaborative integrated management system based on IoT cloud technology. *Mobile Information Systems*, *2022*(1), 6098201.

57. Dong, M., Yu, H., Sun, Z., Wu, M., Zhang, L., Sui, Y., ... & Zhao, R. (2022). [Retracted] Design of IoT Gateway for Crop Growth Environmental Monitoring Based on Edge-Computing Technology. *Computational Intelligence and Neuroscience*, *2022*(1), 8327006.

58. Zhao, G., Wang, Y., & Wang, J. (2023). Lightweight Intrusion Detection Model of the Internet of Things with Hybrid Cloud-Fog Computing. *Security and Communication Networks*, *2023*(1), 7107663.

59. Deepika, J., Rajan, C., & Senthil, T. (2021). Security and privacy of cloud-and IoT-based medical image diagnosis using fuzzy convolutional neural network. *Computational Intelligence and Neuroscience*, *2021*(1), 6615411.

60. Pirozmand, P., Ghafary, M. A., Siadat, S., & Ren, J. (2020). Intrusion Detection into Cloud-Fog-Based IoT Networks Using Game Theory. *Wireless Communications and Mobile Computing*, *2020*(1), 8819545.

61. Zhang, Z., Zhang, W., & Qin, Z. (2021). Fully Constant-Size CP-ABE with Privacy-Preserving Outsourced Decryption for Lightweight Devices in Cloud-Assisted IoT. *Security and Communication Networks*, *2021*(1), 6676862.

62. Abel, E. E., Abd Latiff, M. S., & Chan, W. H. (2023). IoT data analytic algorithms on edge-cloud infrastructure: A review. *Digital Communications and Networks*.

63. Feng, H., Qiao, L., & Lv, Z. (2023). Innovative soft computing-enabled cloud optimization for next-generation IoT in digital twins. *Applied Soft Computing*, *136*, 110082.

64. Rajagopalan, A., Swaminathan, D., Bajaj, M., Damaj, I., Rathore, R. S., Singh, A. R., ... & Prokop, L. (2024). Empowering power distribution: Unleashing the synergy of IoT and cloud computing for sustainable and efficient energy systems. *Results in Engineering*, 101949.

65. Li, Q., Liu, G., Zhang, Q., Han, L., Chen, W., Li, R., & Xiong, J. (2024). Efficient and fine-grained access control with fully-hidden policies for cloud-enabled IoT. *Digital Communications and Networks*.

66. Loconte, D., Ieva, S., Pinto, A., Loseto, G., Scioscia, F., & Ruta, M. (2024). Expanding the cloud-to-edge continuum to the IoT in serverless federated learning. *Future Generation Computer Systems*, *155*, 447-462.

67. Khezri, E., Yahya, R. O., Hassanzadeh, H., Mohaidat, M., Ahmadi, S., & Trik, M. (2024). DLJSF: Data-Locality Aware Job Scheduling IoT tasks in fog-cloud computing environments. *Results in Engineering*, *21*, 101780.

68. Alsharif, M. H., Kelechi, A. H., Jahid, A., Kannadasan, R., Singla, M. K., Gupta, J., & Geem, Z. W. (2024). A comprehensive survey of energy-efficient computing to enable sustainable massive IoT networks. *Alexandria Engineering Journal*, *91*, 12-29.

69. Moparthi, N. R., Balakrishna, G., Chithaluru, P., Kolla, M., & Kumar, M. (2023). An improved energy-efficient cloud-optimized load-balancing for IoT frameworks. *Heliyon*, *9*(11).

70. Rajagopal, S. M., Supriya, M., & Buyya, R. (2023). FedSDM: Federated learning based smart decision making module for ECG data in IoT integrated Edge–Fog–Cloud computing environments. *Internet of Things*, *22*, 100784.

71. Et-taibi, B., Abid, M. R., Boufounas, E. M., Morchid, A., Bourhnane, S., Hamed, T. A., & Benhaddou, D. (2024). Enhancing water management in smart agriculture: A cloud and IoT-Based smart irrigation system. *Results in Engineering*, *22*, 102283.

72. Rahman, A., Islam, M. J., Band, S. S., Muhammad, G., Hasan, K., & Tiwari, P. (2023). Towards a blockchain-SDN-based secure architecture for cloud computing in smart industrial IoT. *Digital Communications and Networks*, *9*(2), 411-421.

73. Wazwaz, A. A., Amin, K. M., Semari, N. A., & Ghanem, T. F. (2023). Enhancing human activity recognition using features reduction in iot edge and azure cloud. *Decision Analytics Journal*, *8*, 100282.

74. Bebortta, S., Tripathy, S. S., Modibbo, U. M., & Ali, I. (2023). An optimal fog-cloud offloading framework for big data optimization in heterogeneous IoT networks. *Decision Analytics Journal*, *8*, 100295.

75. Lohitha, N. S., & Pounambal, M. (2023). Integrated publish/subscribe and push-pull method for cloud based IoT framework for real time data processing. *Measurement: Sensors*, *27*, 100699.

76. Gaglianese, M., Forti, S., Paganelli, F., & Brogi, A. (2023). Assessing and enhancing a Cloud-IoT monitoring service over federated testbeds. *Future Generation Computer Systems*, *147*, 77-92.

77. Raghavendar, K., Batra, I., & Malik, A. (2023). A robust resource allocation model for optimizing data skew and consumption rate in cloud-based IoT environments. *Decision Analytics Journal*, *7*, 100200.

78. Priyatharsini, G. S., Babu, A. J., Kiran, M. G., Kumar, P. S., Babu, C. N. K., & Ali, A. (2022). Self secured model for cloud based IOT systems. *Measurement: Sensors*, *24*, 100490.

79. Kuldeep, G., & Zhang, Q. (2022). Multi-class privacy-preserving cloud computing based on compressive sensing for IoT. *Journal of Information Security and Applications*, *66*, 103139.

80. Parks, D. F., Voitiuk, K., Geng, J., Elliott, M. A., Keefe, M. G., Jung, E. A., ... & Haussler, D. (2022). IoT cloud laboratory: Internet of Things architecture for cellular biology. *Internet of Things*, *20*, 100618.

81. Romero, D. A. V., Laureano, E. V., Betancourt, R. O. J., & Álvarez, E. N. (2024). An open source IoT edge-computing system for monitoring energy consumption in buildings. *Results in Engineering*, *21*, 101875.

82. Mekid, S., & Chenaoua, K. (2023). IoT-enabled smart mask for monitoring body parameters and location through cloud. *Internet of Things*, *22*, 100794.

83. Morchid, A., Alblushi, I. G. M., Khalid, H. M., El Alami, R., Sitaramanan, S. R., & Muyeen, S. M. (2024). High-technology agriculture system to enhance food security: A concept of smart irrigation system using Internet of Things and cloud computing. *Journal of the Saudi Society of Agricultural Sciences*.

84. Martinez-Rendon, C., González-Compeán, J. L., Sánchez-Gallegos, D. D., & Carretero, J. (2023). CD/CV: Blockchain-based schemes for continuous verifiability and traceability of IoT data for edge–fog–cloud. *Information Processing & Management*, *60*(1), 103155.

.

85. Mekid, S., & Chenaoua, K. (2023). IoT-enabled smart mask for monitoring body parameters and location through cloud. *Internet of Things*, *22*, 100794.

86. Balan, R. S., Gouri, M. S., Senthilnathan, T., Gondkar, S. R., Gondar, R. R., Zeema, J. L., & Jothikumar, R. (2023). Development of smart energy monitoring using NB-IOT and cloud. *Measurement: Sensors*, *29*, 100884.

87. Bose, R., Mondal, H., Sarkar, I., & Roy, S. (2022). Design of smart inventory management system for construction sector based on IoT and cloud computing. *e-Prime-Advances in Electrical Engineering, Electronics and Energy*, *2*, 100051.

88. Golightly, L., Modesti, P., Garcia, R., & Chang, V. (2023). Securing distributed systems: A survey on access control techniques for cloud, blockchain, IoT and SDN. *Cyber Security and Applications*, *1*, 100015.

89. Hao, T., Gao, W., Lan, C., Tang, F., Jiang, Z., & Zhan, J. (2022). Edge AIBench 2.0: A scalable autonomous vehicle benchmark for IoT–Edge–Cloud systems. *BenchCouncil Transactions on Benchmarks, Standards and Evaluations*, *2*(4), 100086.

90. Morchid, A., Alblushi, I. G. M., Khalid, H. M., El Alami, R., Sitaramanan, S. R., & Muyeen, S. M. (2024). High-technology agriculture system to enhance food security: A concept of smart irrigation system using Internet of Things and cloud computing. *Journal of the Saudi Society of Agricultural Sciences*.

91. Gaiova, K., Prauzek, M., Konecny, J., & Borova, M. (2022). A concept for a cloud-driven controller for wireless sensors in IoT devices. *IFAC-PapersOnLine*, *55*(4), 254-259.

92. Gupta, B. B., & Quamara, M. (2018). An identity based access control and mutual authentication framework for distributed cloud computing services in IoT environment using smart cards. *Procedia computer science*, *132*, 189-197.

93. Junior, A. A., da Silva, T. J. A., & Andrade, S. P. (2023). Smart IoT lysimetry system by weighing with automatic cloud data storage. *Smart Agricultural Technology*, *4*, 100177.

94. Mohapatra, S., Sahoo, A., Mohanty, S., & Singh, D. (2023). IoT Enabled Ubiquitous Healthcare System using Predictive Analytics. *Procedia Computer Science*, *218*, 1581-1590.

95. Güçyetmez, M., & Farhan, H. S. (2023). Enhancing smart grids with a new IOT and cloud-based smart meter to predict the energy consumption with time series. *Alexandria Engineering Journal*, *79*, 44-55.

96. Sonkoly, B., Haja, D., Németh, B., Szalay, M., Czentye, J., Szabó, R., ... & Toka, L. (2020). Scalable edge cloud platforms for IoT services. *Journal of Network and Computer Applications*, *170*, 102785.

97. Lin, H., Xue, Q., Feng, J., & Bai, D. (2023). Internet of things intrusion detection model and algorithm based on cloud computing and multi-feature extraction extreme learning machine. *Digital Communications and Networks*, *9*(1), 111-124.

98. Goyal, A., Kaushik, S., & Khan, R. (2021). IoT based cloud network for smart health care using optimization algorithm. *Informatics in Medicine Unlocked*, *27*, 100792.

99. Mrozek, D., Koczur, A., & Małysiak-Mrozek, B. (2020). Fall detection in older adults with mobile IoT devices and machine learning in the cloud and on the edge. *Information Sciences*, *537*, 132-147.

100. Orsini, G., Posdorfer, W., & Lamersdorf, W. (2019). Efficient mobile clouds: Forecasting the future connectivity of mobile and iot devices to save energy and bandwidth. *Procedia Computer Science*, *155*, 121-128.

101. Hofmann, W., & Branding, F. (2019). Implementation of an IoT-and cloud-based digital twin for real-time decision support in port operations. *IFAC-PapersOnLine*, *52*(13), 2104-2109.

102. Ayub, M. F., Mahmood, K., Kumari, S., & Sangaiah, A. K. (2021). Lightweight authentication protocol for e-health clouds in IoT-based applications through 5G technology. *Digital Communications and Networks*, *7*(2), 235-244.

103. Mohammed, M. A., Lakhan, A., Abdulkareem, K. H., Abd Ghani, M. K., Marhoon, H. A., Nedoma, J., & Martinek, R. (2023). Multi-objectives reinforcement federated learning blockchain enabled Internet of things and Fog-Cloud infrastructure for transport data. *Heliyon*, *9*(11).

104. Huaranga-Junco, E., González-Gerpe, S., Castillo-Cara, M., Cimmino, A., & García-Castro, R. (2024). From cloud and fog computing to federated-fog computing: A comparative analysis of computational resources in real-time IoT applications based on semantic interoperability. *Future Generation Computer Systems*, *159*, 134-150.

105. Et-taibi, B., Abid, M. R., Boufounas, E. M., Morchid, A., Bourhnane, S., Hamed, T. A., & Benhaddou, D. (2024). Enhancing water management in smart agriculture: A cloud and IoT-Based smart irrigation system. *Results in Engineering*, *22*, 102283.

106. Merlino, G., Tricomi, G., D'agati, L., Benomar, Z., Longo, F., & Puliafito, A. (2024). FaaS for IoT: Evolving Serverless towards Deviceless in I/Oclouds. *Future Generation Computer Systems*, *154*, 189-205.

107. Turukmane, A. V., Pradeepa, M., Reddy, K. S. S., Suganthi, R., Riyazuddin, Y. M., & Tallapragada, V. S. (2023). Smart farming using cloud-based Iot data analytics. *Measurement: Sensors*, *27*, 100806.

108. Karumanchi, M. D., Sheeba, J. I., & Devaneyan, S. P. (2022). Integrated Internet of Things with cloud developed for data integrity problems on supply chain management. *Measurement: Sensors*, *24*, 100445.

109. Arzovs, A., Judvaitis, J., Nesenbergs, K., & Selavo, L. (2024). Distributed Learning in the IoT–Edge–Cloud Continuum. *Machine Learning and Knowledge Extraction*, *6*(1), 283-315.

110. Raharja, U., Sanjaya, Y. P., Ramadhan, T., Nabila, E. A., & Nasution, A. Z. (2024). Revolutionizing tourism in smart cities: Harnessing the power of cloud-based iot applications. *CORIS-INTA*, *1*(1), 41-52.

111. Damola, O., Adebayo, T. E., & Olayinka, O. (2023). Examining the potential of IoT-based cloud-integrated smart classroom for efficient learning and institutional sustainability. *Int. Res. J. Modern. Eng. Technol. Sci*, *5*(5), 2436-2444.

112. Humayun, M. (2020). Role of emerging IoT big data and cloud computing for real time application. *International Journal of Advanced Computer Science and Applications*, *11*(4).

113. Petrolo, R., Loscri, V., & Mitton, N. (2017). Towards a smart city based on cloud of things, a survey on the smart city vision and paradigms. *Transactions on emerging telecommunications technologies*, *28*(1), e2931.

114. Tatineni, S. (2023). Cloud-Based Data Analytics for Smart Cities: Enhancing Urban Infrastructure and Services. *International Research Journal of Modernization in Engineering, Technology, and Science*, *5*(11), 904-912.

115. Kumar, W., & Da Chen, Y. (2023). Integrating AI and Machine Learning in Cloud Services: Boosting IoT Innovation and Data Processing with Edge-to-Cloud Intelligence.

116. Taneja, M., Jalodia, N., Byabazaire, J., Davy, A., & Olariu, C. (2019). SmartHerd management: A microservices-based fog computing–assisted IoT platform towards data-driven smart dairy farming. *Software: practice and experience*, *49*(7), 1055-1078.

117. Sicari, C., Balouek, D., Parashar, M., & Villari, M. (2023, December). Event-Driven FaaS Workflows for Enabling IoT Data Processing at the Cloud Edge Continuum. In *Proceedings of the IEEE/ACM 16th International Conference on Utility and Cloud Computing* (pp. 1-10).

118. Atif, Y., Ding, J., & Jeusfeld, M. A. (2016). Internet of things approach to cloud-based smart car parking. *Procedia Computer Science*, *98*, 193-198.

119. Arulkumar, V., Kavin, F., & Nagu, B. (2024). IoT Sensor Data Retrieval and Analysis in Cloud Environments for Enhanced Power Management. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *38*(1), 77-88.

120. Yadav, S., Kalaskar, K. D., & Dhumane, P. (2022). A Comprehensive Survey of IoT-Based Cloud Computing Cyber Security. *Oriental Journal of Computer Science and Technology*, *15*(1, 2, 3), 27-52.

121. Pradeepa, M. A. M., & Gomathi, B. (2017). Towards fog computing based cloud sensor integration for internet of things. *International Journal of Computer Science and Engineering Communications*, *5*(6), 1761-1773.

122. Milovanovic, D., & Bojkovic, Z. (2017). Cloud-based IoT healthcare applications: Requirements and recommendations. *International Journal of Internet of Things and Web Services*, *2*, 60-65.

123. Joshua Samuel Raj, R., Varalatchoumy, M., Helen Josephine, V. L., Jegatheesan, A., Kadry, S., Meqdad, M. N., & Nam, Y. (2022). Evolutionary Algorithm Based Task Scheduling in IoT Enabled Cloud Environment. *Computers, Materials & Continua*, *71*(1).

124. Almolhis, N., Haney, M., & Alqhtani, F. (2019). Discovering and understanding the security issues in IoT cloud. *International journal of computer science and security*, *13*(6), 255-265.

125. Catruc, I., & Iosifescu, D. (2020). IoT Integration with Mobile and Cloud Solutions. *Informatica Economica*, *24*(2).

126. Janjua, K., Shah, M. A., Almogren, A., Khattak, H. A., Maple, C., & Din, I. U. (2020). Proactive forensics in IoT: Privacy-aware log-preservation architecture in fog-enabled-cloud using holochain and containerization technologies. *Electronics*, *9*(7), 1172.

127. Tatineni, S. (2023). Cloud-Based Data Analytics for Smart Cities: Enhancing Urban Infrastructure and Services. *International Research Journal of Modernization in Engineering, Technology, and Science*, *5*(11), 904-912.

128. Manate, B., Fortis, T. F., & Negru, V. (2014). Optimizing cloud resources allocation for an Internet of Things architecture. *Scalable Computing: Practice and Experience*, *15*(4), 345-355.

129. Tariq, N., Asim, M., Al-Obeidat, F., Zubair Farooqi, M., Baker, T., Hammoudeh, M., & Ghafir, I. (2019). The security of big data in fog-enabled IoT applications including blockchain: A survey. *Sensors*, *19*(8), 1788.

130. Dhinakaran, D., Sankar, S. M., Selvaraj, D., & Raja, S. E. (2024). Privacy-Preserving Data in IoT-based Cloud Systems: A Comprehensive Survey with AI Integration. *arXiv preprint arXiv:2401.00794*.

131. Khrais, L. T., Zorgui, M., & Aboalsamh, H. M. (2023). Harvesting the digital green: A deeper look at the sustainable revolution brought by next-generation IoT in E-Commerce. *Periodicals of Engineering and Natural Sciences*, *11*(6), 5-13.

132. Stergiou, C. L., Bompoli, E., & Psannis, K. E. (2023). Security and privacy issues in IoT-based big data cloud systems in a digital twin scenario. *Applied Sciences*, *13*(2), 758.

133. Kavitha, S., Bora, A., Naved, M., Raj, K. B., & Singh, B. R. N. (2021). An internet of things for data security in cloud using artificial intelligence. *International Journal of Grid and Distributed Computing*, *14*(1), 1257-1275.

134. Pokric, B., Krco, S., Drajic, D., Pokric, M., Rajs, V., Mihajlovic, Z., ... & Jovanovic, D. (2015). Augmented Reality Enabled IoT Services for Environmental Monitoring Utilising Serious Gaming Concept. *J. Wirel. Mob. Networks Ubiquitous Comput. Dependable Appl.*, *6*(1), 37-55.

135. Kavitha, S., Bora, A., Naved, M., Raj, K. B., & Singh, B. R. N. (2021). An internet of things for data security in cloud using artificial intelligence. *International Journal of Grid and Distributed Computing*, *14*(1), 1257-1275.

136. Alkurdi, A. A., & Zeebaree, S. R. (2024). Navigating the Landscape of IoT, Distributed Cloud Computing: A Comprehensive Review. *Academic Journal of Nawroz University*, *13*(1), 360-392.

137. Gupta, D., Bhatt, S., Gupta, M., & Tosun, A. S. (2021). Future smart connected communities to fight covid-19 outbreak. *Internet of Things*, *13*, 100342.

138. Aldowah, H., Rehman, S. U., Ghazal, S., & Umar, I. N. (2017, September). Internet of Things in higher education: a study on future learning. In *Journal of Physics: Conference Series* (Vol. 892, No. 1, p. 012017). IOP Publishing.

139. Ganesh, E. N. (2017). Implementable Approach of Addressing the Challenges of Cloud Based Smart City Using IoT. *Review of Energy Technologies and Policy Research*, *3*(2), 40-50.

140. Chinthamu, L. B., & Kumar, P. K. IMPROVED NETWORK FRAMEWORK FOR CLOUD MANUFACTURING THROUGH BLOCKCHAIN TECHNOLOGY.

141. Alenezi, M., Almustafa, K., & Meerja, K. A. (2019). Cloud based SDN and NFV architectures for IoT infrastructure. *Egyptian Informatics Journal*, *20*(1), 1-10.

142. Quy, V. K., Hau, N. V., Anh, D. V., Quy, N. M., Ban, N. T., Lanza, S., ... & Muzirafuti, A. (2022). IoT-enabled smart agriculture: architecture, applications, and challenges. *Applied Sciences*, *12*(7), 3396.

143. Hao, Y., Miao, Y., Hu, L., Hossain, M. S., Muhammad, G., & Amin, S. U. (2019). Smart-Edge-CoCaCo: AI-enabled smart edge with joint computation, caching, and communication in heterogeneous IoT. *IEEE Network*, *33*(2), 58-64.

144. Hassan, M. M., Albakr, H. S., & Al-Dossari, H. (2014, November). A cloud-assisted internet of things framework for pervasive healthcare in smart city environment. In *Proceedings of the 1st International Workshop on Emerging Multimedia Applications and Services for Smart Cities* (pp. 9-13).

145. Babar, M., Jan, M. A., He, X., Tariq, M. U., Mastorakis, S., & Alturki, R. (2022). An optimized IoT-enabled big data analytics architecture for edge–cloud computing. *IEEE Internet of Things Journal*, *10*(5), 3995-4005.

146. Barcelo, M., Correa, A., Llorca, J., Tulino, A. M., Vicario, J. L., & Morell, A. (2016). IoT-cloud service optimization in next generation smart environments. *IEEE Journal on Selected Areas in Communications*, *34*(12), 4077-4090.

147. Wu, Y. (2020). Cloud-edge orchestration for the Internet of Things: Architecture and AI-powered data processing. *IEEE Internet of Things Journal*, *8*(16), 12792-12805.

148. Wang, T., Zhang, G., Liu, A., Bhuiyan, M. Z. A., & Jin, Q. (2018). A secure IoT service architecture with an efficient balance dynamics based on cloud and edge computing. *IEEE Internet of Things Journal*, *6*(3), 4831-4843.

149. Sowiński, P., Lacalle, I., Vaño, R., & Palau, C. E. (2023, November). Autonomous Choreography of WebAssembly Workloads in the Federated Cloud-Edge-IoT Continuum. In *2023 IEEE 12th International Conference on Cloud Networking (CloudNet)* (pp. 454-459). IEEE.

150. Bhawiyuga, A., Kartikasari, D. P., Amron, K., Pratama, O. B., & Habibi, M. W. (2019). Architectural design of IoT-cloud computing integration platform. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, *17*(3), 1399-1408.

151. Botta, A., De Donato, W., Persico, V., & Pescapé, A. (2016). Integration of cloud computing and internet of things: a survey. *Future generation computer systems*, *56*, 684-700.