# OVERVIEW OF INTERNET OF THINGS (IoT) NETWORK ARCHITECTURE FOR DIGITAL LEARNING AND DISTANCE EDUCATION

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**ABSTRACT**
*The Internet of Things is a rapidly expanding network of interconnected systems and devices that connect and share data or resources over the Internet. It is a complex architecture network involving technologies from a wide range such as cloud computing, sensors and gateways. The main aim of this study is to evaluate the Internet of Things network architecture for distance learning and digital education* ***(****IoTNADLDE****).*** *The specific objectives included assessing the: IoT network architecture layers, scalability and security of the Internet of Things network standards and protocols of the Internet of Things network and Challenges presented by large-scale IoT network deployments. The method adopted in this study was the incremental descriptive model (IDM). The Internet of Things network architecture comprises multiple layers, which consist of the application layer, physical layer, data layer and network layer. Each layer within the Internet of Things (IoT) network architecture is vital for effectively implementing and functioning distance learning applications, facilitating secure and reliable data communication and sharing. The physical layer encompasses all hardware components and sensors responsible for data collection, whereas the network layer oversees the interactions between devices and gateways. The application layer is tasked with data analysis and processing, while the data layer is responsible for the storage and management of the gathered information. In summary, the IoT network architecture serves as an essential element in the operational success of the Internet of Things, allowing interconnected devices to communicate and share resources or information seamlessly. In conclusion, this study discussed the overview of the Internet of Things network architecture for distance learning.*

**KEYWORDS**
*Internet of Things, Network, Architecture, Learning, Digital, Education and Distance*

**INTRODUCTION**

An Internet of Things network architecture for digital, distance education is a review that defines the components and protocols of an IoT network structure. This architecture plays an important or significant role in data exchange and communication which involve different Internet of Things operations, applications and devices (Dickson & Okechukwu, 2024). Layers involved include the network layer, application layer and physical layer, every layer serves specific and important objectives in the functionality of the network. The physical layer consists of actuators, nodes and sensors that collect and analyses data from the physical globe. The network world is in charge of transmitting these resources or data to the devices or cloud. A layer of application performs actions based on the data. Overall, the IoT network architecture enables efficient communication between the different Internet of Things devices and systems, which leads to the implementation of various Internet of Things operations and applications successful. (Ovidiu & Peter, 2014).

The physical layer of the Internet of Things (IoT) is the important part that enables the communication, and transmission of resources or data between connected systems and devices. This layer encompasses various communication channels utilized by distinct hardware components, such as nodes, actuators, and sensors, to enable data transmission across these channels. Furthermore, the physical layer is crucial in addressing the heterogeneity present in Internet of Things (IoT) systems, accommodating devices that employ diverse communication protocols for data exchange. Techniques such as multiplexing, coding, and modulation are implemented to ensure interoperability and compatibility among different devices and channels. The network layer is a vital element within the IoT landscape, functioning as the foundational framework for device communication. As the prevalence of connected devices and intelligent technologies increases, the demand for efficient and effective network layer protocols has become more pronounced. The application layer serves as a significant component of the IoT, facilitating the control and management of communication among various devices, operations, and applications. It acts as an intermediary between the application layer and the physical layer, converting data from devices into a format that applications can interpret and process (Dickson & Amannah, 2020).

The data layer serves as a crucial interface between data management systems and Internet of Things (IoT) devices, facilitating digital and distance education. It enables the secure and efficient transfer, processing, storage, and retrieval of data from IoT devices and channels (Keyur & Sunil, 2018). The field of the Internet of Things is emerging as a transformative area of study, with the potential to alter perceptions and practices regarding device connectivity and interaction on a global scale. As the demand for IoT networks continues to escalate, this paper provides a comprehensive overview of the network architecture pertinent to digital and distance education,

focusing on the essential aspects of security and scalability in the development of these intricate and distributed systems. To ensure the security, privacy, and reliability of these networks, various standards and protocols, including Transport Layer Security (TLS), Message Queue Telemetry Transport (MQTT), and Hypertext Transfer Protocol (HTTP), are employed. Additionally, the paper addresses the challenges associated with large-scale IoT implementations, such as scalability, availability, and reliability, while exploring diverse strategies to mitigate these issues.

Digital learning encompasses the realm of online education, leveraging Internet of Things (IoT) devices and technologies to enhance the educational experience in both digital and distance learning contexts. This modality includes a variety of formats such as online courses, virtual classrooms, and interactive educational tools. It empowers learners to engage with educational content at their convenience, irrespective of time or location, thereby dismantling conventional educational barriers. Research indicates that digital learning significantly boosts student retention and engagement levels. Its efficacy has gained widespread acknowledgement, prompting numerous educational institutions to integrate it into their curricula. As technology continues to advance, digital learning is perpetually evolving, offering new avenues for education. This paradigm shift has created a plethora of opportunities, establishing digital learning as a fundamental component of contemporary education. With the growing integration of technology in academic settings, digital learning is increasingly recognized as essential within modern educational frameworks. Through online courses and virtual classrooms, students are liberated from geographical and temporal limitations, facilitating access to education from virtually any location worldwide, thus promoting inclusivity. Moreover, digital learning and distance education can be tailored to accommodate individual learning preferences and requirements, fostering success in professional endeavours. Personalized learning platforms, applications, and software utilize data and algorithms to customize the educational experience according to each student's unique abilities and progress, resulting in a more effective and efficient learning journey (Dickson & Okechukwu, 2024).

The advent of digital learning, often referred to as distance education, has the potential to transform the methodologies employed by researchers in this field. By offering a more adaptable, interactive, and personalized educational experience, digital learning can enhance the outcomes for learners and increase the flexibility of distance education for a diverse range of students. The integration of the Internet of Things into digital education, facilitated by various digital devices, has created numerous opportunities for both learners and educators. Digital tools enable students to access an extensive array of resources and educational materials, thereby fostering a more engaging and interactive learning environment. Furthermore, digital learning supports individualized education, allowing students to advance at their own pace and tailor

their learning experiences to align with their specific needs and interests. Additionally, this mode of education promotes inclusivity by dismantling geographical barriers, thus making learning accessible to individuals regardless of their location or economic status. This inclusivity plays a crucial role in advancing equal educational opportunities and reaching marginalized communities. Moreover, digital learning encourages collaboration and communication among students and educators. Through online platforms, learners can engage with peers and instructors from various regions, enriching their educational experience with diverse perspectives.

Distance Learning represents an educational model in which instructors and students are not co-located in a shared physical environment at the same time. Instead, this mode of education leverages e-learning platforms to facilitate the dissemination of materials and resources. It empowers individuals to access educational content from virtually any location with Internet connectivity, thereby offering a flexible and convenient solution for those in the workforce. The increasing prevalence of Distance Learning in academia can be attributed to technological advancements and the growing demand for remote educational alternatives. This approach enables learners to engage with their studies at their own pace and in their preferred settings, utilizing a variety of technological tools and online resources. The rise of Distance Learning has been particularly pronounced with the proliferation of the Internet of Things and innovations such as online learning platforms, video conferencing, and virtual classrooms. This educational format enhances flexibility and accessibility, allowing students to study at any time and from any place. Furthermore, Distance Learning serves as a cost-effective alternative for individuals who may find the expenses associated with traditional educational institutions prohibitive. It also fosters a more diverse and global learning environment, as students from various backgrounds and geographical locations can interact within virtual classrooms. Nonetheless, challenges persist, including the absence of direct interpersonal interaction and the necessity for self-discipline and motivation. In summary, Distance Learning has transformed the educational landscape, creating opportunities for individuals to pursue their academic goals and broaden their knowledge despite physical and geographical constraints.

The acquisition of knowledge and skills through remote educational methodologies, including online courses, video presentations, and interactive exercises, occurs without the necessity of attending a conventional classroom environment. Distance education enables learners to engage with educational content from any location with internet access, thereby offering a convenient and adaptable alternative for both students and professionals. Its popularity has surged in recent years, demonstrating effectiveness in helping individuals advance their education and achieve their academic aspirations. By removing geographical and temporal barriers, distance education ensures equitable access to high-quality learning opportunities, irrespective

of one's location. Furthermore, it fosters self-directed learning and cultivates critical thinking abilities, as learners are encouraged to take responsibility for their educational journey. This mode of learning is particularly advantageous for those with demanding schedules, such as working professionals seeking to enhance their qualifications. Distance education has transformed the educational landscape and continues to progress alongside technological advancements, resulting in a more varied and inclusive learning environment. A significant advantage of distance education is the flexibility it offers students to learn at their own pace. Through online platforms, learners can revisit materials as often as necessary and complete assignments according to their timelines, facilitating a more tailored educational experience that can be especially beneficial for those who may find traditional classroom settings challenging. Despite its numerous benefits, distance education is not without its difficulties. A primary concern is the diminished face-to-face interaction with instructors and fellow students. Nevertheless, many online programs integrate virtual classrooms and discussion forums to promote communication and collaboration among participants.

## LITERATURE REVIEW

This section highlights with critical evaluation scientifically connected to the research problem. Bertalanffy (2006) argued that the essence of science is defined by its principles of reduction, repeatability, and retaliation. The effective implementation of scientific methods within physical systems can be attributed to their inherent proximity. The theory of Internet of Things (IoT) systems posits that an organization functions as a social system composed of interconnected components. Furthermore, it emphasizes that the IoT framework encompasses the integration of various elements and the relationships among them, resulting in a cohesive, functionally related entity. The hierarchical and lateral configurations within any system, along with their corresponding integrations, are designed to facilitate the achievement of specific objectives. It is well understood that any disruption within a system's components can compromise its operational efficiency. This study is grounded in system theory, highlighting that the IoT represents a collective where numerous individuals assume distinct roles at various levels to fulfil a shared objective: the interconnection of sensors for information exchange. Dickson and Amaka (2023) carried out a study on the Overview of Internet of Things Structure and Implementation. The Internet of Things (IoT) is being increasingly viewed as a pillar of modern development, having a wide range of potential applications in a variety of fields, including the education sector. Nigeria is an important case study for the effect of IoT implementation in higher education as it faces challenges, such as a lack of resources and infrastructure, which impede the effective utilization of the latest technologies. This study aims to conduct a comprehensive review of the current IoT structure and the implementation issues for higher education in Nigeria.

The research conducted by Dickson and Ukegbu (2024) focuses on IoT-Enabled Smart Agriculture as a strategic avenue for Nigeria's economic recovery and sustainability. The burgeoning development of the Internet of Things (IoT) alongside the advent of Smart Agriculture offers Nigeria a significant opportunity to foster substantial economic growth and enhance the quality of life for its citizens. This study seeks to explore the capacity of IoT-enabled Smart Agriculture to serve as a catalyst for economic revitalization and sustainable development within the country. The specific aims include a comprehensive review of the current state of Nigeria's agricultural sector and the myriad challenges it encounters, such as security concerns, privacy issues, financial constraints, data management difficulties, energy shortages, limited access to advanced agricultural techniques, and inadequate land use oversight. The research methodology employed is the incremental descriptive model (IDM). The study subsequently outlines potential solutions that IoT-enabled Smart Agriculture can offer to mitigate these challenges, equipping Nigeria's agricultural sector with the necessary resources to enhance productivity and promote environmental sustainability. In conclusion, with the implementation of appropriate policies and strategies, this system has the potential to pave the way for economic advancement and ecological sustainability. Furthermore, the system's ability to alleviate poverty and generate employment opportunities for rural communities presents a vital chance for Nigeria to maintain its competitiveness in the global market while concurrently achieving its environmental objectives.

## RESEARCH OBJECTIVES

1. Internet of Things network architecture layers
2. Security and scalability of Internet of Things Network
3. Standards and protocols of the Internet of Things network
4. Challenges presented by large-scale Internet of Things network deployments

## RESEARCH METHODOLOGY

The method adopted in this study was the incremental descriptive model (IDM).

## DATA ANALYSIS AND DISCUSSION

Physical layer, network layer, application layer, and data layer, each serving a specific purpose in the overall network functioning.

1. Physical Layer
2. Network Layer
3. Application Layer
4. Data Layer

### The physical layer

This is the channel used for data collection for the physical world which consists of nodes, actuators and sensors of the Internet of Things for digital, distance education. The physical layer of the Internet of Things is a fundamental building block that enables the successful functioning of the entire Internet of Things ecosystem. It is responsible for transforming digital signals into physical signals and can ensure data transmission, is efficient and reliable between connected devices. Without a well-designed and optimized physical layer, the complete import of the Internet of Things cannot be realized.

**The network layer**

This is used to transfer resources or data to the cloud through Internet of Things devices. The network layer is a very important part or component of the Internet of Things as it enables the transfer and communication of data between connected Internet of Things devices for distance education and digital learning.

**The application layer**

It performs actions, processes and transmits data based on the Internet of Things devices or channels. The Internet of Things is an important aspect of the application layer which serves as a bridge between the cloud and the physical devices for data communication and transmission. It also permits monitory and remote control.

**The data layer**

**S**tores retrieved and managed the collected data**.** The data layer has become a useful component in managing and organizing this data for the Internet of Things devices.

**Security and scalability of IoT Network**

The increase of Internet of Things connected devices in the world has brought wonderful potential to various industries in the world today. This improvement comes as the result of the security and scalability of Internet of Things networks for digital, distance learning. The framework not only provides a robust defence against malicious attacks but also ensures scalability for the growing number of IoT devices. The evaluation of the framework through simulation experiments and practical deployment demonstrates its effectiveness in protecting IoT networks
(Dawson, 2011).

**Security**

This network architecture is mainly concerned with the security of sensitive or important communication that can easily be used by unauthorized persons. The Internet of Things environment for various devices or sensors makes it an efficient and practical remedy to the lack of security in Internet of Things network architecture (Leloglu, 2017).

**Scalability**

The scalability of the network architecture of Internet of Things devices and sensors are major concern and brought about a significant number of data being generated and transmitted to the cloud for distance learning. Current data communication methods used in IoT systems lack scalability, which results in a bottleneck in data transmission. This hinders the performance of the system and limits its ability to handle a large number of devices ((Taye, 2023).

**Standards and protocols of Internet of Things network**

The Internet of Things (IoT) has become a widely adopted technology in recent years, allowing for the connection and communication of various devices and systems. The increasing prevalence of the Internet of Things (IoT) has underscored the necessity for a standardized protocol to facilitate interoperability and secure communication within these networks. Professionals engaged in the IoT sector play a crucial role in fostering the comprehension and application of standardized IoT frameworks. This situation emphasizes the critical need for a uniform approach in the swiftly evolving domain of IoT (Zuo et al., 2013).

**Challenges presented by large-scale IoT network deployments**

The deployment of large-scale IoT networks presents a series of significant challenges. The recent technological advancements have catalyzed the swift expansion of IoT networks, leading to numerous obstacles associated with their extensive implementation. According to Ploumidis et al. (2015), these challenges encompass the management and security of a vast array of interconnected devices, the processing of the enormous volumes of data produced by these devices, and the maintenance of reliable connectivity to ensure effective communication. Additionally, the integration of diverse systems and protocols within IoT networks introduces further complications. Addressing these complexities in IoT network deployment necessitates the development of innovative solutions (Dickson & Amannah, 2023).

This research examined the architecture of Internet of Things (IoT) networks in the context of distance and digital education. It represents a notable advancement in securing IoT network frameworks and infrastructure, facilitating the widespread adoption and integration of IoT devices across various operations and applications in the realm of distance and digital education. However, this expansion raises important issues regarding the security and scalability of IoT network architectures. Digital and distance learning have emerged as vital components in the educational landscape, offering significant advantages such as enhanced accessibility, flexibility, and tailored learning experiences, which appeal to both students and educators. As

technological innovations progress, the capacity for digital learning to further enrich educational experiences is expected to increase.

## RECOMMENDATIONS

Public and private higher institutions should the adoption of Internet of Things network architecture for digital and distance learning.

Government should ensure that information and communication technology policy statements are translated into reality.

An information and communication policy implementation commission should be created, funded and given the power to provide information and communication facilities in the schools and their use should be monitored.

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