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A systematic Literature Review of Internet of Things for Higher Education: Architecture and Implementation

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ABSTRACT

The objectives of this paper are to analyze the implementation and architecture of the Internet of Things (IoT) from previous studies, specifically in the world of higher education; offer recommendations for future research, as well as strengthen the theory of IoT architecture that already exists in higher education. This study employed a systematic literature review (SLR) with data collection utilizing Funnel Diagrams to select articles based on their relevance to the research question. The three publisher databases (Scopus, Emerald, and EBSCO) and index journals were utilized in the search for articles. A total of 1,200 articles were gathered from these three sources, with distributions of up to 800 in Scopus, 150 in Emerald, and 250 in EBSCO. The findings demonstrate that the existing IoT architecture has a more sophisticated model than the fundamental idea, which has three layers, implying that using IoT in education may have a significant influence on user convenience. This is due to the increasingly complicated requirements of higher education's many business procedures. This study serves as an inspiration and reference for future research for higher education institutions that include the Internet of Things in their implementation to build an efficient teaching and learning environment.

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1. INTRODUCTION

The Internet of Things (IoT), commonly known as the Internet of Everything, is a network concept between software and machines in a global scope that aims to interact with each other. The main idea of IoT is to integrate the Internet, mobile devices, machines, electronic equipment, and others so that they are connected in real-time and can be shared by users (Talari *et al*., 2017; Saad, 2018; Thapwiroch *et al*., 2021; Anh, 2022; Pantjawati *et al*., 2020;). IoT connects people, devices, processes, and data that will enable stakeholders to find more efficient ways of turning data into valuable information (Shinrath *et al*., 2017; Mircea *et al*., 2021). Teixeira *et al*. illustrate that IoT is the integration of real-world objects into the internet to transform high-level interactions from the physical world to a simple one, as in the virtual world. In addition, the IoT creates an interconnection between the physical world and the virtual world of information (Teixeira *et al*., 2021). Ultimately, the goal of the IoT is to connect anything to any object, at any time, and over any network/service. The manifestation of this vision will result in the latest research resources, rooted types of IoT applications and other new technologies (Udoh & Kotoya, 2018).

IoT applications have been built and implemented in several fields such as transportation, logistics, sales, health, industry, and the environment. Despite its wide applicability, building IoT applications requires a relatively large amount of time and resources. This is due to the need for extensive data identification and the lack of an appropriate framework to handle large-scale IoT systems (Patel *et al*., 2016; Miorandi, *et al*., 2012; Patel & Cassou, 2015). A study in 2014 estimated that by 2020 IoT will reach 26 billion units, up from 0.9 billion in 2009, and that will have an impact on the information available to be accessed anytime and anywhere. This idea led to significant technological advances that enabled the creation of devices capable of efficiently connecting to the internet. This new prospect of a network allows each device to be connected and share information, which can then be processed for decision-making and later become the nickname "Smart". IoT provides great automation for industry, but it also provides insecurity, which is a problem that requires improvement in existing systems. Higher education also faces the same problem. Data transactions are a very big concern in the world of higher education. IoT provides convenience with the help of blockchain technology innovations that must be inserted to overcome security problems (Soni, 2019).

The rapid development of IoT has penetrated various sectors. For example, in agriculture, IoT is used in the nutrition monitoring process to maintain the stability of plant growth. In the process, each sensor that has been installed will send data from one node to another, where it will be processed to make decisions and can move other devices automatically according to system decisions (Rafdhi, 2021; Khanna, 2019). In the field of education, IoT tries to provide a different experience with more interesting learning concepts that can be done through e-learning. In its implementation, students and lecturers can interact efficiently. Concrete examples such as animation, online tutorials, learning materials through virtual classrooms, video lectures, and many more can be e-learning procedures. So, in the end, the media that is included with IoT becomes significantly more efficient (Soni, 2019).

Learning methods have shifted from traditional to digital as a result of advances in information and communication technology (Al-Emran *et al*., 2020). One of the paradigms supporting the initiative is the IoT. The IoT is expected to have a significant impact on higher education. The education sector is regarded as a strong candidate for IoT system implementation. In the past few years, IoT technology has also led to the consolidation

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of education (Ramlowat & Pattanayak, 2019). According to Bagheri, the implementation of the IoT in higher education, which enables Internet-based communication between physical objects, controllers, and sensors, has significantly altered educational institutions. Various parameters of the educational environment can be measured and analyzed to provide useful information by embedding sensors in objects and integrating augmented reality (Albar *et al.*, 2021; Bangkerd & Sangsawang, 2021). Other are combining with cloud computing, big data, and wearable technology on this platform. It has also resulted in novel interactions between humans and the environment in educational settings (Bagheri & Movahed, 2016).

Education has evolved from a knowledge transfer model to an independent, collaborative model influenced by the technology used in higher educational institutions (Abance *et al.*, 2021; Agarry, 2022; Ahsan *et al.*, 2022; Hardiyanti *et al.*, 2023; Abd Mokmin *et al.*, 2023). This has compelled many institutions to reconsider their teaching and learning processes (Shah, 2022; Jadhav *et al.*, 2022; Tiong & Bakar, 2022). Technology's impact can be seen in various aspects of education, from student participation in learning and content creation to assisting lecturers in providing personalized content and improving student outcomes. There are currently seven categories of technologies, tools, and strategies that drive educational innovation: "Consumer Technologies, Digital Strategies, Enabling Technologies, Internet Technologies, Learning Technologies, Social Media Technologies, and Visualization Technologies. IoT is a subsection of Internet technology that helps education in a variety of ways. IoT solutions allow educational institutions to easily gather more information from sensors and wearables and to take meaningful actions based on this data. Using embedded sensors, QR codes, and other technologies, students can explore the environment. They can access learning materials and other information from any location at any time. Lecturers can also use wearable technology and smartphones in the classroom to improve teaching and learning. An intelligent classroom is an intelligent environment outfitted with various types of hardware and software modules. Camera systems, video projectors, facial recognition algorithms, and sensors are examples of modules that monitor various physical environmental parameters or student characteristics such as performance, concentration, and achievement (Mendell & Heath, 2005).

Changes as an output from the IoT require appropriate learning strategies. IoT requires students to learn independently because essentially all course material is in big data. The IoT has an impact on education. Some problems related to education can be solved with the IoT (Bocken *et al.*, 2014). In addition, IoT has changed the knowledge transfer model in education into an independent, active, collaborative model (Kristianti, 2019). Therefore, the IoT supports key changes in the method of learning knowledge for students. The IoT infrastructure allows students to use data from sensors for learning purposes. With the innovation of the IoT in education, it helps the teaching and learning process be carried out remotely. For example, using IoT and cloud systems, special networks or extranets can be created, such as the Indonesia Research and Education Network (IdRen) (Lestari, 2018). Idren is a special network infrastructure that connects research and education institutions and communities in Indonesia.

By integrating competency-based education and employing the IoT, Virtual or Augmented Reality, and Artificial Intelligence, universities can generate excellent graduates (AI). Higher education services must be extensively based on Big Data, the IoT, and artificial intelligence technology in terms of learning, services, and management systems. Education and

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technology must be blended (Oktradiksa *et al.*, 2021).

IoT is utilized at universities since it makes it easier to interact with the internet and advanced computerized systems with machines that reduce human interference to boost effectiveness and efficiency (Rahmanto *et al.*, 2021). Students can access VR (Virtual Reality) concept films or digital labs to get a more solid knowledge base; b). Universities provide fast and free internet access, all digital-based services, and the use of robots to make it simpler not to replace professors since the lecturers still program the course content on the robot.

The existence of IoT technology has made a significant contribution to the development of various fields such as the smart environment, smart governance, smart city, smart life, and smart education (Kristianti, 2019). The use of IoT can be built on complex architectures, varied devices, and integrated communications (Zanella, 2014). In the field of education, IoT has an important role in helping organizations monitor and control educational activities, such as monitoring library access, health checks, internet cloud for web lessons, and direct monitoring of student and employee attendance (Al-Emran *et al.*, 2020). The development of the IoT will indirectly change the knowledge transfer model in education into an independent, active, collaborative model. The impact of technology on the world of education has made many institutions reorganize the existing teaching and learning processes. The IoT supports key changes in students' learning methods of knowledge (O'Reilly, 2015). The impact of technology on education can be seen from the involvement of students in many aspects of education, namely involvement in the learning process with educational personnel (Johnson *et al.*, 2016).

Along with its development, IoT technology has begun to be applied at various universities in Indonesia. The most widely used IoT application is the use of fingerprints, which is a technology used to control the attendance of students and employees. Based on the IoT architecture and the goal of turning the campus into a smart campus by implementing fingerprint as a facility to control student and employee attendance, one of which has been implemented at Atma Jaya University Yogyakarta (UAJY) (Kristianti, 2019). This technology integrates network technology with human resource management in the university environment, which by its application helps reduce the budget for the provision and use of paper and makes it easier for the campus to record attendance and recapitulation of student attendance, as well as employee payroll management (Singh *et al.*, 2017; Ayatullah *et al.*, 2019; Novita & Septian, 2022; Musdlifa *et al.*, 2020). Another IoT technology is the use of e-learning, which provides access to the need for electronic learning applications by being integrated into cloud computing. Thus, lecturers and students can easily access teaching materials. The application of IoT technology that is still being tried by universities in Indonesia is the smart classroom. Smart classrooms are created to help lecturers and students use IoT systems, cameras, sensors, and other computing devices to manage the learning process (Kwet & Prinsloo, 2020). The Smart Classroom includes both offline and online classes. An example of a university in Indonesia that has started to develop smart classrooms is Sekolah Tinggi Teknologi Kreatif (STTK) Binus Bandung. STTK Binus Bandung is currently developing a smart classroom that has several features, including smart presence, automatic room temperature regulation, and automatic lighting. In its development, various sensors and integrated networks are used.

Understanding the enormity of the advantages of IoT in assisting every learning process, as well as its function in establishing a smart campus (Zhamanov *et al.*, 2017). In university higher education, the impact of IoT can change classroom lessons and student

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discussions to be livelier. IoT technologies such as e-learning can help lecturers and students explore more diverse learning methods (Soni, 2019). IoT is useful as a support for digital transformation in the world of education, where IoT innovations have been widely developed, such as the use of smart attendance, digital libraries, e-learning systems, and smart classrooms (Petkovics, 2018). From these developments, it can become a more effective learning medium without time constraints and be more energy efficient. This condition is ideal for use during the post-COVID-19 recovery period in Indonesia at this time. This study aims to provide an overview of the IoT in terms of concepts and features in the world of higher education and its implementation in supporting applications.

2. METHODS

This research is a systematic literature review using the Funnel Paradigm method, which is carried out systematically through structured research stages or procedures. A systematic review is a research method that consists of three main stages, namely identifying, analyzing, and evaluating previous research that is relevant to a particular topic of concern. The findings studied are comprehensive because they aim to synthesize related research results. A Systematic Literature Review consists of several steps, including (i) Formulating Research Questions, (ii) Searching for Literature Reviews, (iii) Selecting and screening appropriate articles, (iv) Analysing and synthesizing qualitative findings, (v) Conducting Quality Control, and (vi) Reporting Late (Perry, & Hammond, 2002). A qualitative approach is used to analyze and provide solutions in the form of models for higher education in implementing IoT for business processes. After an in-depth study of the literature obtained, several articles were obtained, which were the main literature (Berkah, & Sawarjuwono, 2019). The initial stage of a systematic review is to formulate research questions to be material in the discussion of systematic review research. In this study, two main questions form the basis of research, including 1) how is IoT in the world of higher education defined? and 2) Is there a standardized architecture for IoT implementation in higher education?

The next stage is the literature search, carried out on three main indexing databases and journal publishers, including Scopus, EBSCO, and Emerald. The keywords used in the search are "Internet of Things," and "Higher Education," which produce as many as 1200 articles. After getting the study literature as a whole, filtering is carried out with the criteria of duplication of articles from various database sources, because these sources are in the form of publishers or journal indexers. Thus, there may be duplication. The results of the duplication filtering select 500 articles and leave 700 articles to be processed in the next stage. The next process is the title and abstract screening, which involves adjusting the research topic being studied with the criteria for relevance to the topic, objectives, findings, and research results that contain links to keywords. From the title and abstract screening process, 500 articles were selected, leaving 200 articles for full-text screening. This stage is the final stage for an in-depth review with the criteria of research focus, a unit of analysis, context, and quality assessment. From the full-text screening stage, 60 final articles were obtained to be used as references in the Systematic Literature Review of this study. **Figure 1** shows the stage funnel diagram.

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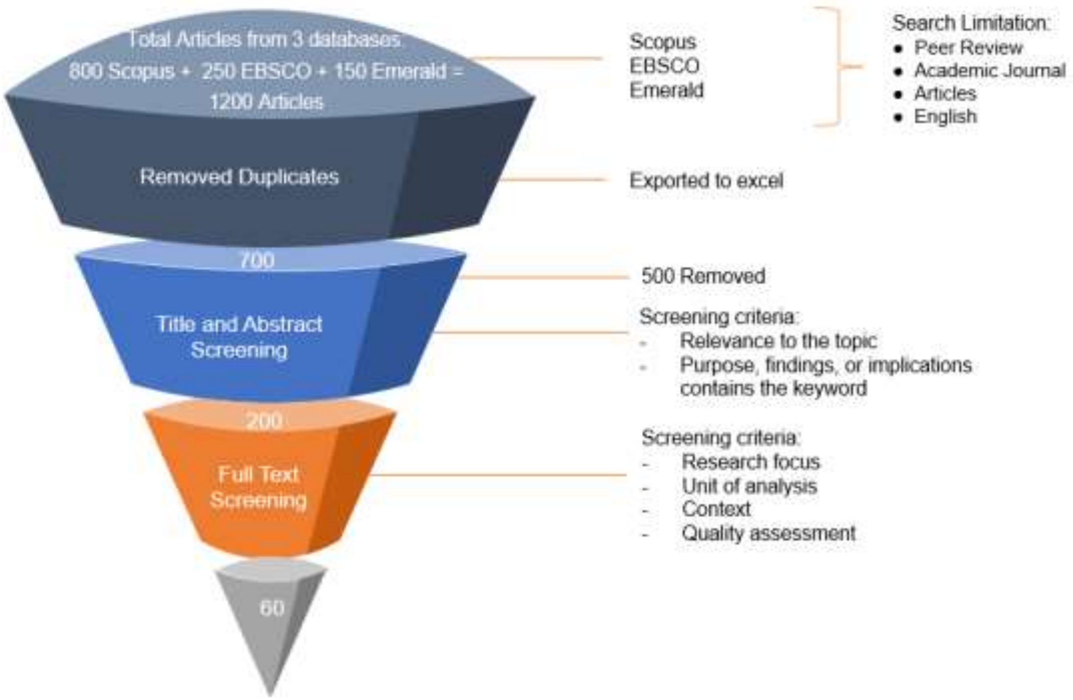

Figure 1. Funnel diagram.

3. RESULTS AND DISCUSSION

3.1. Internet of Things for Higher Education

The term "IoT " for the first time was in 1999. IoT was to sketch out a system in which ubiquitous sensors connect the physical world to the Internet. Many experts believe that the term "IoT" represents the next step in digital society (Han, 2011; Uzelac *et al.*, 2015). IoT improves employability and increases the competitiveness of both educational and commercial institutions (Emran *et al*, 2020). The phrase IoT has lately gained popularity to stress the idea of a worldwide infrastructure that links actual items and things using the same Internet Protocol, enabling them to interact and exchange information (Sula *et al.*, 2014). According to research company, 8.4 billion "things" were linked to the Internet, excluding laptops, PCs, tablets, and mobile phones. By 2020, this figure is expected to rise to 20.4 billion installed IoT devices (http://www.gartner.com/technology/research/ internet-of-things/). Because of its ever-increasing popularity, it is worthwhile to examine a purpose-built system inside the IoT, known as a "network of things".

IoT is rapidly evolving and is becoming an increasingly popular issue that generates both excitement and fear throughout the globe (Ning & Hu, 2012). There are several signs that the IoT will transform various industries, including higher education institutions, particularly universities. Universities now have the chance to lead the technological development and innovation models for the IoT, as well as to create future IoT leaders, as well as to address the TIPPSS dangers, which stand for Trust, Identity, Privacy, Protection, Safety, and Security in the IoT. In addition, the development of IoT has three potential applications in higher education: students' progressive assessment, integration of existing teaching platforms, and the creation of educational middleware (Zhiqiang & Junming, 2011). This modification improves student convenience while also making the teaching process more successful for both instructors and professors. Because of the proliferation of linked devices and technology, instructors and professors may concentrate on genuine learning that is more beneficial to students than doing repetitive tasks.

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Higher education is one of the sectors that has begun to use IoT to improve learning, training, management, experimentation, and so on (Tianbo, 2012). Many higher education institutions across the globe have used IoT to produce significant improvements in their performance (teaching, learning, management, training, buildings, etc.). IoT encompasses a wide range of fields, including computer and information science, engineering, and social and mathematical sciences. The IoT should properly represent the institutions of higher learning between the many logical aspects, as well as the goal and function of higher education. Higher education is the people-oriented purpose of students' moral, intellectual, physical, and artistic education. The link between the IoT's hierarchy and its higher education system is presented in **Figure 1**.

Figure 2 shows that, in the context of the IoT, higher education institutions should better represent the goal of being people-oriented. That is, instructors should like teaching, students should come to enjoy learning, and students, or the educated, should be at the core of education and teaching.

The student learning service includes school teaching and administration. The IoT overlaps with the local area network and services for a people-oriented education system. IoT should have the base layer and the feedback layer in addition to the perception layer, network layer, and application layer, for a total of five layers of composition. The process of digitizing actual or virtual entities is referred to as the "base layer." This is the essential key, and it marks the beginning of the IoT. There would be no IoT if this connection did not exist. The feedback layer is the meaning of assessment, which includes evaluation of command and management as well as evaluation status feedback to the IoT system to make modifications and revisions. The Professor Committee (managers) may regulate the "feedback level" (command and control layer). That is the amount of command unity required to comprehend all of their "knowledge school" material and dominate them.

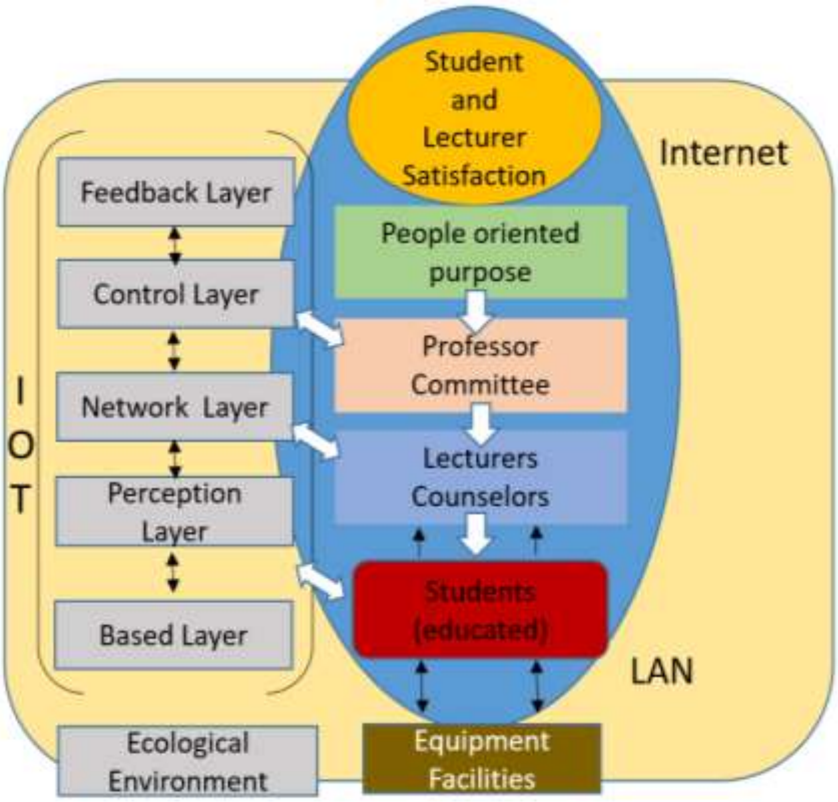

Figure 2. IoT on higher education and logic relationship diagram (Tainbo, 2012).

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3.2. IoT Architecture for Higher Education

The basic IoT architecture has many versions with different needs, but a well-known and referenced architectural model is the three-layer architecture (Chandrayan & Kumar, 2020). This architectural model presents the basic design of IoT functionality in three layers, namely the perception, network, and processing layers. Further research developments refine this basic model to include the application layer at the top level as a medium that interacts directly with its users (Burhan *et al*. 2018; Vasco Lopes, 2020). As IoT technology develops rapidly, the basic architectural model cannot support IoT needs more effectively. The basic model cannot meet the standard requirements of the current IoT and can only be implemented in the early stages of IoT development. On that basis, other architectural models are proposed with additional layers. One of them is a five-layer architecture with a more comprehensive layer that involves not only a technical perspective but also a business and operational perspective (Wu *et al*. 2010). This five-layer architecture contains layers of perception, network, monitoring, preparation, storage, and security of IoT data (Sethi & Sarangi, 2017).

The proposed IoT architecture is designed with a multi-layer architecture to facilitate the smooth integration of IoT into the educational environment. It also aims to optimize the IoT system so that it can be integrated with complete security support, more responsive processing, and IoT connectivity as needed (Altwoyan & Alsukayti, 2022). The idea behind this architecture is that it should be simple, modular, and able to grow to meet the needs of IoT implementations that use a lot of data and application requests. The proposed IoT architecture consists of six main layers and one vertical layer. A two-way connection flow is created between adjacent layers because adjacent layers will interact with each other in implementation. The layers consist of application, cloud, infrastructure, edge-computing, access, and IoT-Object (see **Figure 3**).

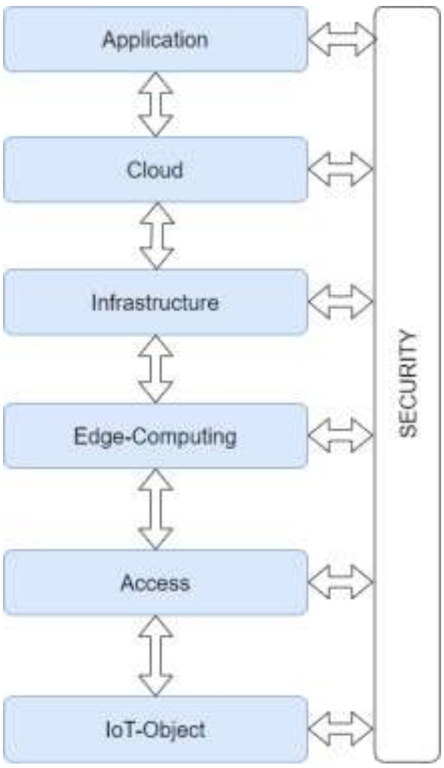

Figure 3. Representation of Architecture in the proposed educational environment (Altwoyan, W., & Alsukayti, I. S. 2022).

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The focus of this architecture is to close the gap between IoT and legacy systems that exist in the educational environment. It includes most of the functions that are implemented in the inheritance system into the sedan main layer while another layer connects the integration of typical IoT functions. Each layer has a horizontal connection that is connected to the overall security of the system between layers.

To realize the proposed architecture, new IoT elements need to be effectively incorporated into the integrated IoT system. **Figure 4** shows the architectural design that has been included based on system requirements that generally exist in an educational environment. **Figure 4** is a derivative of the architectural design previously made in **Figure 3**. The combination of elements in this layer is important to build a university system that is enhanced with IoT technology. Each new element is added to support certain layer functionality.

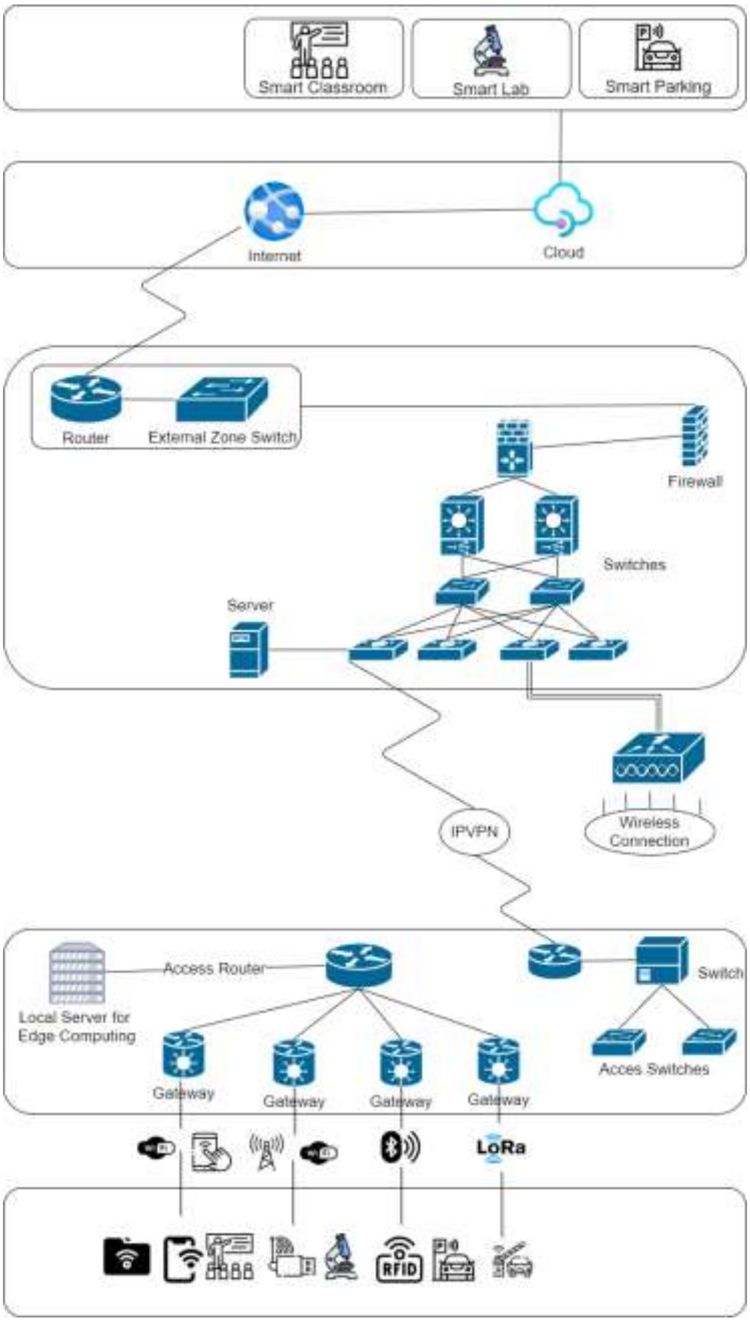

Figure 4. A systematic overview of the IoT integrated university system (Altwoyan, W., & Alsukayti, 2022).

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The proposed IoT architecture will meet the needs of various intelligent applications in the educational environment (Mkrttchian, 2021; Chang, 2021; Altwoyan & Alsukayti, 2022). Such applications are smart classrooms, smart labs, smart libraries, and smart parking applications. This will facilitate the development of an effective IoT ecosystem and can improve the teaching and learning process, enrich the educational experience, and improve administrative activities. The proposed architecture supports the effective management of all entities at different architectural layers (Alam & Benaida, 2020; Fernández & Fraga, 2019; Songsom *et al*. 2019).

In smart classroom and lab settings, entities such as environmental and activity sensors, control actuators, and IoT-enabled objects are combined. Smart library applications will mainly rely on RFID technology to tag and manage their business processes, such as collection management, membership, collection lending, returns, and so on. For smart parking applications, infrared and ultrasonic sensors are used to monitor parking spaces. Smart cameras can also be used in this application for intelligent recognition and AI-based services. For all different applications, IoT device management is realized at the IoT object layer (Majeed & Ali, 2018).

Most IoT devices are powered mainly by electricity, especially for indoor smart applications. Therefore, the stability of the application can be connected via Ethernet or Wi-Fi for data transfer needs. This will ensure high data rate accuracy and connectivity with energy-efficient IoT. For large-scale applications of IoT in the educational environment, especially intelligent classroom applications and intelligent labs, it will lead to high volumes of data flows. Thus, it will greatly benefit from the use of edge computing to provide real-time services (Zhukovskiy *et al*., 2019).

For different applications, integration into the IoT architecture does not require much modification from the previous university system. It is just that it takes an increase in bandwidth from each previous connection to ensure the flow of data to be processed at the cloud layer. For example, the smart class application only requires an additional wireless access point to be installed and connected to the local LAN network. Even for smart parking applications, each installed gateway is linked to the core infrastructure via LAN access routers and managed at the architectural access layer (Ding *et al*., 2020).

In addition to the IoT architecture, Pompei *et al*. propose an architecture with four layers, namely the IoT Object, Networking and Data, Management, and Application layers (Pompei *et al*., 2018). This architecture ensures the digitization of the campus and offers personalized services to its users. This architecture incorporates services that were integrated into the network and infrastructure of the previous campus system (see **Figure 5**).

IoT, through its installed devices, is responsible for increasing the use of resources, for example, monitoring and controlling buildings anywhere and anytime. This allows the reduction of energy consumption through the creation of an autonomous environment, where the majority of variables are monitored and actuators take control to avoid wasting energy consumption (Popoola, 2018). A basic example is turning lights and appliances on and off. With IoT, it can be programmed to ensure energy requirements can be cut efficiently through the use of installed sensors. Other areas, such as process management, have included the use of IoT devices for their tasks. It provides value by acting as a virtual assistant responsible for improving processes and reducing human involvement (Liu & Li, 2018). Even IoT functions as a learning assistant, involving the use of devices to ensure that learning methods in the classroom are appropriate for a group of students.

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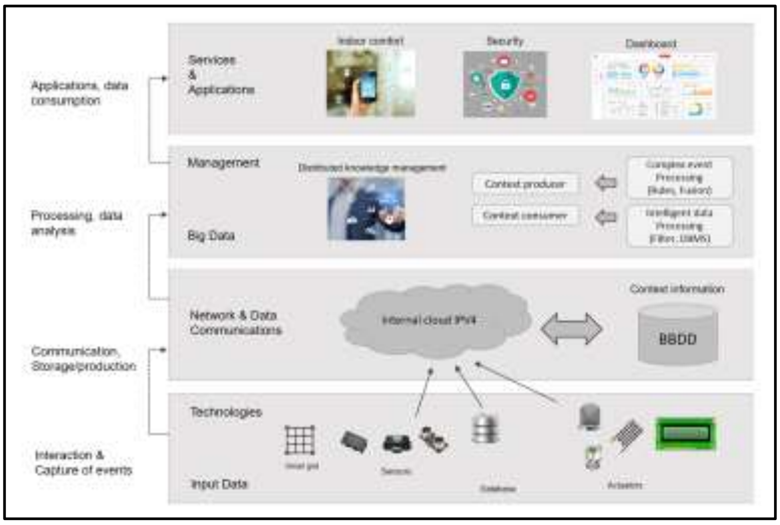

Figure 5. The architecture of a university campus with the integration of the IoT. (Pompei *et al.*, 2018).

3.2. IoT Implementation

The rapid development of IoT has led to an explosion of various IoT solutions. As a result, the current focus of the technology industry is on manufacturing and producing the right type of hardware to enable such solutions to be realized (Banafa, 2016). As the industry evolves, the need for IoT model standards such as processing, storage, and firmware updates is becoming more relevant. Creating such a model is not an easy task. There are obstacles and challenges facing the standardization and implementation of IoT solutions, and the model must overcome all of them (Rani & Gill *et al.*, 2019). Another part of this model is IoT implementation. Implementing IoT is not an easy process by any measure for a variety of reasons, including the complex nature of the various components of the IoT ecosystem. To better understand the importance of this process, the five components of IoT implementation can be seen in **Figure 6**.

The first component is the sensor. Sensors are divided into two types, namely active sensors and passive sensors. The new trend today is to use sensors in IoT, which makes sensors cheaper, smarter, and smaller (Hermawan, 2020). The challenges facing IoT sensors are power consumption, security, and interoperability. The second component of IoT is to transmit the signals collected by sensors over the network. Networks can be connected to sensors with various technologies including Wi-Fi, Bluetooth, Ethernet, Long Term Evolution (LTE), and Li-Fi (Kocakulak & Butun, 2017). The third component of IoT implementation is a standard that involves the summation of all data processing and storage activities that have been collected by sensors. There are two types of standards relevant to the aggregation process, namely technology standards (network protocols, communication protocols, and data aggregation standards) and regulatory standards (related to data security and privacy). The next component is intelligent analysis. Intelligent analysis extracts insights from the analyzed data. IoT analysis is driven by cognitive technology and the models that facilitate it (Raatikainen *et al.*, 2016). Factors driving the adoption of intelligent analysis in IoT include artificial intelligence, growth in analytics software, and real-time data processing and analysis. The last component of IoT implementation is intelligent actions. It can be expressed as an M2M (Machine to Machine) or M2H (Machine to Human) interface (Banafa, 2017). Factors driving the adoption of intelligent actions in the IoT include lower machine prices and better machine functionality.

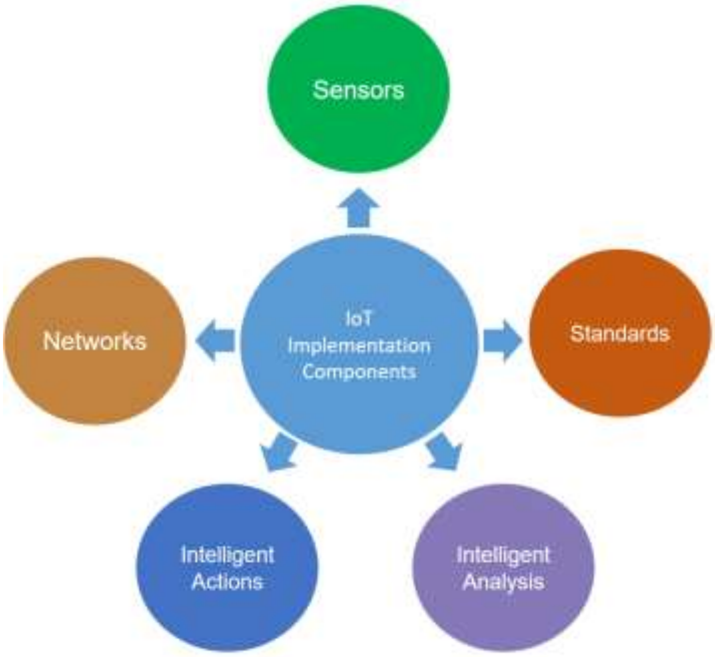

Figure 6. IoT implementation components (Banafa, 2016).

IoT has a relatively new implementation perspective in the higher education system. Generally, IoT creates a high-capacity ecosystem that provides an open infrastructure for physical and virtual objects. This potential makes it possible to develop various applications based on this ecosystem (Pande & Padwalkar, 2014). One of the most common implementations of IoT is in education, especially online education. Online education, or e-learning, provides a scalable platform for educators and students as educational objects to work together in real-time. The exclusivity of IoT characteristics in higher education system applications allows the formation of new IoT models such as the "Internet of Education Things" (IoET) (Abbasy & Quesada, 2017). The IoT promises to have a significant impact on the learning process in universities by providing access to comprehensive resources for lecturers and students.

Technically, IoT is expected to create large, high-performance virtual collaboration platforms using competent tools, sensors, and storage technologies. One example of the concept of implementing IoT in education includes integrating interactive English learning with sound and visual sensors to capture students' pronunciation skills (Bakri, 2016). In his research, Martinez developed a basic architecture to introduce internet objects into the learning space. This infrastructure uses Near Field Communication (NFC) technology to enable mobility and manage student attendance. Gómez and colleagues proposed a learning system that allows students to interact with a set of physical objects around them. In this case, objects are linked to one (or more) virtual objects that provide information to students, allowing them to manipulate objects (physically or virtually) to better understand the object under study (Gómez *et al.*, 2013). An example of a more complex IoT implementation is carried out in designing a smart parking system architecture using infrared and ultrasonic sensors (see **Figure 7**).

Figure 7 shows the architectural structure and implementation components of a smart parking system in a smart university environment. It shows how the core computing infrastructure is integrated with IoT resources and functionality (Altwoyan & Alsukayti, 2022).

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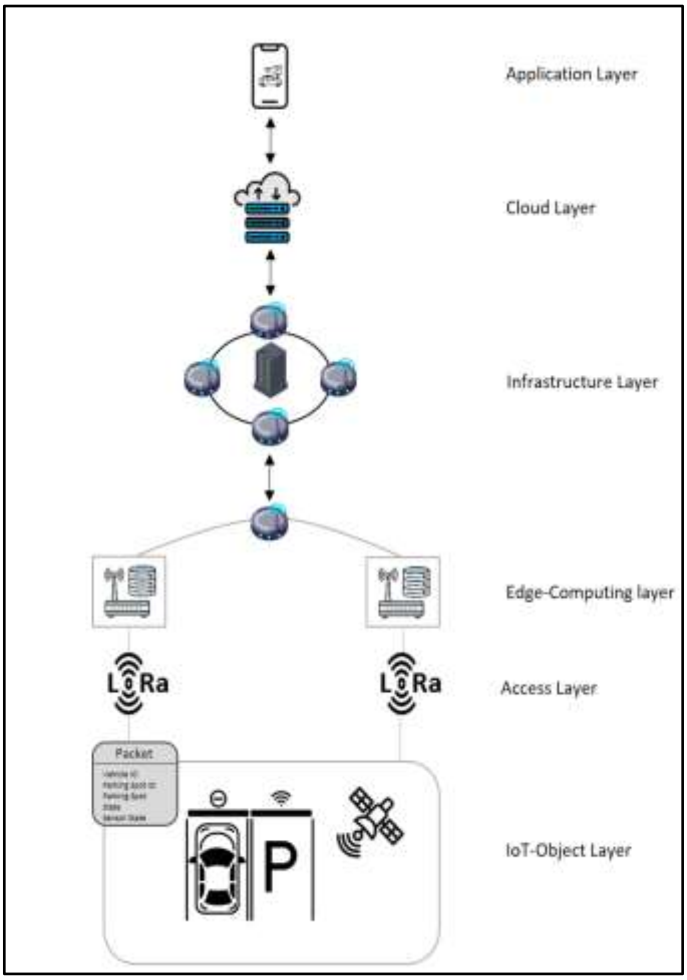

Figure 7. Overview of Simple architecture of Smart Parking (Altwoyan, W., & Alsukayti, 2022)

4. CONCLUSION

Higher Education has a high opportunity to develop IoT technology because it has 3 potential applications to be integrated with IoT, namely students' progressive assessment, integration of existing teaching platforms, and the creation of educational middleware. The integration of IoT in the higher education environment is a challenge, considering that not all previously existing systems meet the requirements to integrate with IoT. Some of the IoT architectures presented are complex enough to answer the needs of applications that make it easier for users. Each proposed architecture that is presented contains at least five main layers of the basic concepts of IoT. This means that the IoT architectural design is increasingly advanced to be able to provide value to users in a higher education environment. The education sector is considered an effective candidate for the deployment of IoT applications. The main purpose of this review study is to provide a holistic view of the use of IoT applications as well as an overview of the IoT architecture that is suitable for implementation in higher education. Many studies have been proposed and demonstrated the effectiveness of building an IoT-based learning framework. Such a step helps to create a new paradigm of learning. This innovative learning paradigm helps improve the teaching and learning process.

5. AUTHORS' NOTE

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article. The authors confirmed that the data and the paper are free of plagiarism.

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