INTERNATIONAL JOURNAL OF
Telecommunications
AIR DEFENSE COLLEGE

Interior design applications based on IoT as detection and estimation methods.

Citation:
Amin, A.; Abd El-aziem, A.; Abdelhafeez, A.; Soliman, T.
Inter. Jour. of Telecommunications, ***IJT'2023***, *Vol. 03, Issue 02, pp. 01-12, 2023.*
Editor-in-Chief: Youssef Fayed.
Received: 19/08/2023.
Accepted: date 21/09/2023.
Published: date 26/09/2023.
Publisher's Note: The International Journal of Telecommunications, IJT, stays neutral regarding jurisdictional claims in published maps and institutional affiliations.

Ahmed S.Amin [1], Ayman Abd El-aziem [2], Ahmed Abdelhafeez [3] and Tamer H.M. Soliman [4,*]

[1] Military Technical College, Egypt, ahmed.saleh.csis@o6u.edu.eg.
[2] Faculty of IS & CS, October 6th University, Egypt; Ayman.Hasanein.comp@o6u.edu.eg
[3] Faculty of IS & CS, October 6th University, Egypt; aahafeez.scis@o6u.edu.eg
[4*] Correspondence: thms78@gmail.com; (AD R&D Center, Cairo, Egypt)

Abstract: The Internet of Things (IoT) is a paradigm in which objects equipped with sensors, actuators, and processors communicate with each other to serve a meaningful purpose. The current study is the quickly growing topic of interior design as detection for the IoT. To proceed with this development, we need to examine current gaps and trends in application. These papers include sensor monitoring, smart home and innovative city applications, network and infrastructure security, and many other expanding areas. The need to research the many IoT interior design as detection applications has grown because of recent developments in the industry. The classification of IoT detection algorithms is covered after a brief overview of the detection techniques and applications. This survey paper highlights the taxonomy for IoT technologies, highpoints some of the most significant technologies, and profiles some applications that have the potential to make a substantial impact on society. There needs to be more IoT detection approaches in recent papers, where there is a need for Ground Truth data. Finally, we discuss these current issues and propose fresh viewpoints in areas where more research is needed.

Keywords: Space use monitoring; Data-driven facility management; intelligent systems; indoor navigation; mobile application.

1. Introduction

Computer scientist Kevin Ashton coined the term Internet of Things (IoT) in 1999. During Ashton's time at Procter & Gamble, he suggested the implementation of radio-frequency identification chips on products to monitor their movement through the supply chain. The idea of the IoT, which impacted both internal and external space, was defined to make it simpler for the learner to study and comprehend all its components to activate this. A new vision for a lecture hall's interior (floors, walls, communications) was presented to the College of contemporary art and Design, and it was determined that the designer should be able to use IoT technologies in the lecture hall's environmental design. This technique for using it in contemporary interior spaces was identified. Design teams should be able to comprehend IoT technology at the initial stages of the design process. Richer, enabling them to find and include sustainable solutions into the design from the ground up to produce sophisticated interior design components and solutions, using the proper design materials with a positive, sustainable impact at every level of environmental design. IoT helps universities move to new ways of operating facilities with little cost and effort. They are, furthermore, minimizing the adverse effects of environmental factors on learning by using the latest technologies and methods.
The remainder of the paper is divided into the sections below. The IoT's related research works as properties, interior design, and numerous applications are all covered in Section II. Section III discusses the technologies used on the Internet of Things (IoT). Section IV provides a detailed description of the techniques used in interior design for interior spaces. Section V summarizes the application of IoT technology in E-Learning systems for

higher education, including a discussion on the application of IoT technology in university lecture halls. Moreover, Section VI highlights the ongoing research issues related to connecting the lecture hall content with IoT. Section VII discusses the data flow from the edge to the server/cloud. The final discussion is presented in Sections VIII and IX, which discuss the future scope and conclusion of the work, respectively.

2. Notations and Related work

The primary objective of the upcoming Internet of Things (IoT) is to connect different types of devices together to enhance the intelligence, responsiveness, and strength of existing systems. The impact of IoT on the economy and society is expected to be significant. Experts predict there will be over 4 billion IoT-connected devices [1,2]. Due to the diverse use cases and unique requirements, customized communication technology is essential to meet these demands.

2.1 Internet of Things

The term "Internet of Things" describes all current Internet-connected objects and their communication with one another and their environment's inhabitants. Therefore, most individuals had internet-connected smart home devices or wireless sensors in mind when they thought of the Internet of Things in the past. The Internet of Things encompasses much more than that because it primarily addresses massive data and how it is analyzed, utilized, and sent through networks. There are now billions of connected devices, and each day they generate trillions of bytes of data. Its integration with the appropriate interior design will help to manage this vast amount of data in a way that adds many advantages to the interior space and the users of the place.

2.2 What is the Internet of Things in Interior Design?

There is no universal interior design for IoT employment because of the constantly increasing technology of IoT devices and the vast range of sensors. However, some basic techniques will be similar from one space to the next.

To achieve this, the interior designer follows the following stages:

- Develop a preliminary proposal for the interior design of a space, considering the possibility of expansion.
- Determining the data that will be dealt with over time while calculating the possibility of accommodating its long-term development.
- Ensuring the availability of a flexible system for the possibility of developing the technology used at any time to accommodate rapid and frequent changes in interior space design without significant loss.

2.3 Related work

Many research groups are currently interested in the growth of IoT systems and applications. Many industries use IoT applications and systems extensively. In general, IoT systems and applications gather data from sensors and utilize it to either optimize processes or derive potentially valuable insights from the data. The research problem is How can the interior designer keep pace with the development in the technology of the Internet of Things and benefit from it in enriching the design thought of the interior space of the classrooms. In addition, modify the current interior spaces of the classrooms in the university faculties, structurally and functionally, by adding IoT technologies.

A smart IoT-based air quality monitoring infrastructure for industrial settings was introduced in [3,4]. The authors presented a comprehensive infrastructure for monitoring air quality that is fully integrable with current industrial systems and is based on the IoT paradigm. The infrastructure is equipped with precise small devices to aid in monitoring. This allows for real-time monitoring of air pollution and particulate matter levels. This system collects Big Data, which is then processed using machine learning methods to determine whether safety standards might be exceeded. An IoT-based air quality monitoring system to continuously track the air quality inside a room was described by authors in [5,6]. The system records temperature, humidity, dust, and gas concentration data. Each piece of information is kept in a database and shown on the room's LCD in real-time.

The Global System for Mobile Communication module sends a warning message to the homeowner's mobile device when the measured values exceed threshold values. Smart homes also use IoT technology. An intelligent, energy-efficient home automation system that allows for remote access to and control of household appliances was proposed by many researchers [7-11]. A Cloud-IoT-Based Home Energy Management System's design and implementation were described in [12]. The created system enables the gathering and archiving of data on the primary load of the home and appliance energy consumption. The authors created two scenarios and collected data stored in an Amazon Web Services cloud. The first scenario involves a local home energy management system that operates without internet access and relies on an edge device for processing and storage. The second scenario uses IoT for a cloud home energy management system.

3. Technologies of The Internet of Things

The primary technologies for designing the structure of the Internet of Things for any internal space vary and can be identified as three, four and five-layer technologies [13-18].

3.1 Three-layer technology

When designing the interior area, use the three-tier system for the Internet of Things applications. These layers are summed up as follows:
• Perception: This layer contains the sensors, from which data is gathered from any number of sensors on the linked device in the interior space.
• Network: A system that connects many devices and transmits massive volumes of data to the proper background services throughout the program.
• Application: What users see is the application layer. This could be a dashboard displaying the status of system devices or an app for controlling a device in an intelligent vacuum ecosystem.
Figure 1 illustrates the three-layered architectures of IoT.

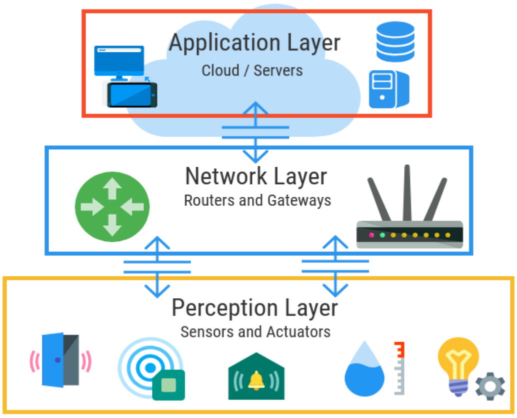


Figure 1. Three-layer Architecture of IoT.

3.2 Four-layer technology

Using a four-stage method is another way to explain the interior design of an IoT system [19]. Edge computing is given more importance than other suggested designs. In Figure 2, the Four-Layered Architectures of IoT are illustrated, as shown below:
• Hardware: The actual hardware used in IoT systems is the focus of this stage. These gadgets in the perception layer could be sensors or actuators. In the case of sensors, these devices will produce data, and in the case of actuators, they will change their surroundings. The generated data is digitally transformed and sent to the Internet portal stage. Due to the hardware's constrained resources, data is frequently transmitted to the following step in an initial condition unless a crucial choice is taken.
• Internet portals: accept unprocessed data from equipment sent to the cloud. This Internet gateway may be a standalone unit that connects to the device physically, or it may be able to connect to sensors via low-power networks and send data to the Internet.

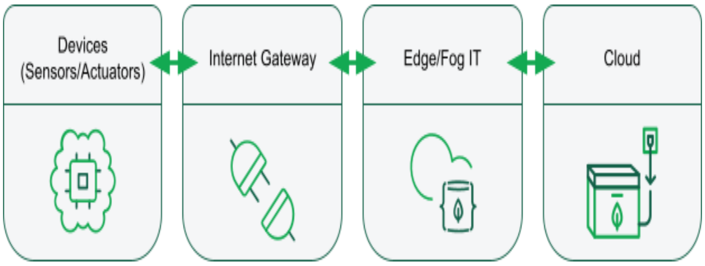


Figure 2. Four-layer Architecture of IoT.

• Foggy computing: also known as edge computing, processes data as quickly as possible, examining the data to see if anything needs immediate attention. This layer solely cares about current information required for operations that must be completed promptly. Some preprocessing is also done at this stage to reduce the data uploaded to the cloud.

• Cloud or data center: Data is stored here for processing later. Data stored in the cloud can feed dashboards or management tools. A deep analysis or resource-intensive processes like machine learning training will occur at this point.

When creating the interior space of lecture halls in universities, the four-layer technique is the most appropriate since it addresses the components of the interior space of lecture devices. Figure. 3 illustrates the four Stages of IoT Architecture and interior space.

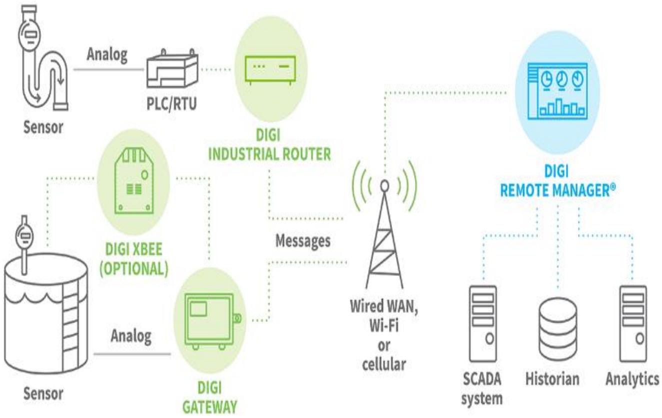


Figure 3. The four Stages of IoT Architecture and interior space.

3.3 Five-layer technology

Additionally, two more levels are added to the Internet of Things technology when creating an interior design for any space: the transport (network replacement), processing, and business layers, in addition to the realization and application layers of the three-layer design model [20,21]. The distinction between interior design's three and five layers is depicted in the following diagram. In Figure 4, the five-layered architectures of IoT are depicted.

It can be distinguished that the three extra layers and their significance as follows in addition to the layers of perception and application:

- Transport: This layer depicts the data transmission through various networks between sensors in the perception and processing layers.
- Processing: Also known as the middleware layer, this layer stores, evaluates, and performs preliminary processing on data from the transport layer. In contemporary software programs
- Business: The "Business Intelligence" layer. The choice is based on the data present and used at the application layer, located at a lower level than the business layer.

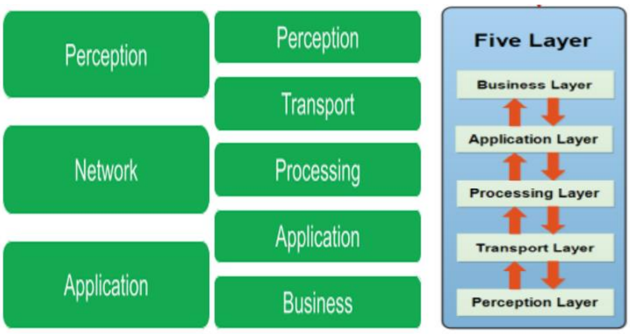


Figure 4. Five layered architectures of IoT.

4. The applied techniques to interior design for interior space.

Despite its size, figuring out how to effectively handle the data the perception layer produces takes much work.

- Check out View-Database-as-a-Service, as it is one of the technologies that can be used at many perception layer levels.
- Test Realm SDK with MongoDB Server to store accessible data and give users a mobile interface.
- Configuring private servers to prepare for data transfer from the device to the Atlas network layer.
- Initiate data deployment to the edge, enabling workload isolation in the private edge group.
- Uses native Time-Series support to store data in groups suitable for IoT applications because it is optimized to collect metrics from various sources over time.
- A lousy network connection must be planned, which is done by Realm, which helps to provide initial sync capabilities in the offline state.

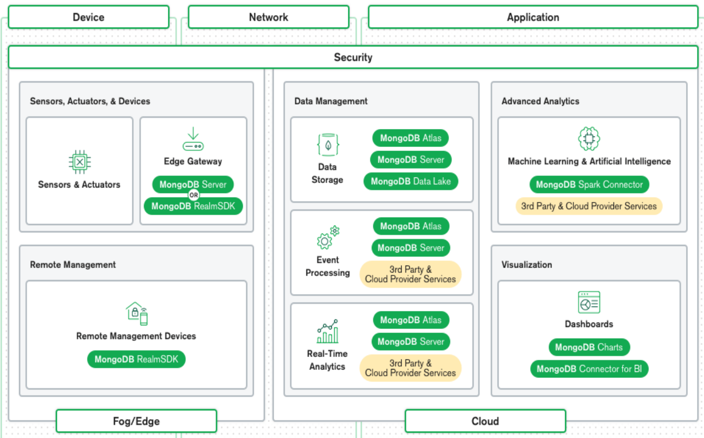


Figure 5. Components of special servers to prepare for data transfer from the device to the networks in the internal space.

- A visual representation of the data can be obtained through some connectors.

In Figure 5, the special servers' components are shown to facilitate data transfer from the device to the networks within the internal space. The application of IoT technology to the interior design of the lecture hall in one of the colleges at the university [22-24].

5. Applying IoT Technology in University Lecture Halls:

The demand for increased efficiency in lecture halls at higher education institutes is steadily growing [25]. Many students have chosen to balance their studies with work and other commitments in recent years, with greater access to online content. As a result, anecdotal evidence suggests that lecture halls may impact enrollment numbers.

With management changes, such as increasing space usage efficiency and supporting massive data from the IoT, it is possible to improve the environmental sustainability of academic buildings. Universities are highly interested in using IoT tools for facilities management because of the potential benefits. However, there are not many empirical investigations on this subject. One of the best applications of the Internet of Things is lecture hall automation. The Internet can connect electronic devices such as audio transmitters, lighting fixtures, fans, and air conditioners. The user can control these gadgets remotely. The advantages of using IT in lecture halls are as follows:

5.1 Helping to achieve the basic dimensions of the university's mission.

- Improving teaching, learning, and assessment processes.
- Encouraging scientific research and innovation.
- Participation in the transfer of societal knowledge to the beneficiaries
- Developing work tools for the beneficiaries of the university, such as teachers, students, administration, non-profit organizations, and scientific research...
- Facilitate evaluating and analyzing students' questions in lectures or external activities.

5.2 Achieving Sustainable Development Goals.

Through six main axes related to the environment and sustainability.

- Infrastructure
- Energy efficiency and reduction of greenhouse gas emissions
- The extent of application of the principles of integrated solid waste management
- The extent to which integrated liquid waste management principles is applied.
- Transportation
- The level of the educational process.

It is worth noting that IoT technology allows the hall and the attendees some services, such as: Connecting and operating gadgets in the hallway with smartphones, such as lighting fixtures, annotation and clarifying tools, and cooling or heating technology, which allows for the recording and analysis of these actions as data that is delivered to the cloud or data center.

5.3 Designing an Internal Space for the Auditorium.

These are four stages must be considered when designing an internal space for the auditorium, detailed as follows:

5-3-1- Stage 1: Actuators and sensors

Sensors and actuators, connected devices that monitor or operate a physical "object" or process, are the first step in this phase. The sensors, including temperature, humidity, chemical composition, fluid levels in the tank, fluid flow in the pipe, assembly line speed, and more, can measure any process or environmental condition.
When a crisis or rapid event necessitates an immediate response, the operator takes prompt corrective action.
For instance, it changes an industrial robot's actions or the hall's air flow rate. In these scenarios, it is necessary for there to be an extraordinarily slight delay between the sensor and the analyzer/actuator. This crucial processing is done close to the process being watched or managed to prevent delaying the round trip of data to the server, analysis of the data to identify the failure, and transferring control to the "thing". A system on a device module (SOM), such as a Digi-Connect module or a Digi-Cellular router with Python, can conduct this "edge" processing.

5-3-2-Stage 2 Internet portals and data acquisition systems

Raw sensor data is gathered by the Data Acquisition System (DAS), which then transforms it from analog to digital. The DAS then collects and prepares the data before transmitting it through wired or wireless WANs (such as Wi-Fi or cellular) to the Internet gateway for further processing.

The data volume has reached its peak currently. For instance, hundreds of sensors gather data simultaneously in the lecture hall. Quantities can be enormous. The data is additionally filtered and compressed to make it the right size for transmission.

5-3-3- Stage 3: Preprocessing the data at the edge.

Once the IoT data is digitized and aggregated, it is processed to reduce the amount of data further before it travels to the data center or the cloud. The edge device may perform some analysis as part of the preprocessing. Machine learning can be beneficial at this point to provide feedback into the system and continuously improve the process without waiting for instructions to come back from the corporate data center or the cloud.
This data is processed on a computer near the sensors, like an on-site wiring closet.

5-3-4- Stage 4: Thorough examination in the data center or cloud

Data analysis, management, and storage may all be done safely using robust IT systems. This occurs in a corporate data center or in the cloud, where data from various field locations and/or sensors can be merged to give a more comprehensive view of the end-to-end IoT system and deliver helpful information to IT and business managers. A corporation may operate in several regions, and IoT data analysis can be used to spot significant trends, patterns, and anomalies. Incoming data indicates desired changes in device settings or other ways to improve the process, forming a loop that facilitates continuous improvement. Phase 4 also includes storage in the data warehouse for record-keeping and further analysis. The architecture of the Internet of Things based on Fog and Cloud is shown in Figure 6.

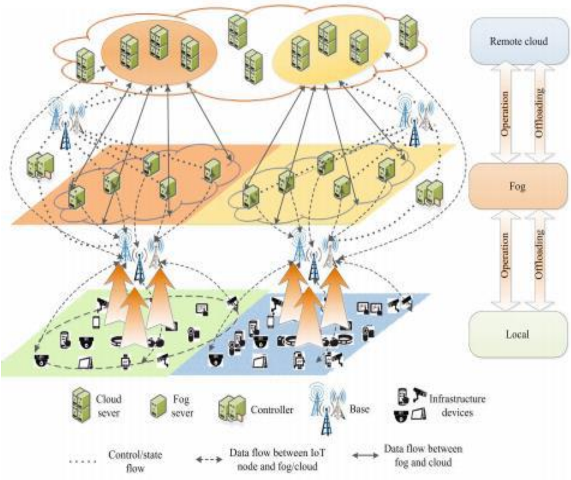


Figure 6. Fog-cloud-based IoT architecture.

6. Contents of lecturer hall connected with IoT

The significance of overseeing various aspects of a lecture hall's interior sustainable space in light of the Internet of Things. Cameras, motion detectors, glass break sensors, systems that outperform frequency dampers, doors and windows, smoke and humidity sensors, and refereeing equipment empty cards are the most widely used components. In Figure 7, the Interactive Lecture Hall featuring IoT devices is depicted. Steps and importance of using Internet of Things technology when studying audio in the lecture hall:
- Include audio in the QSC Q-SYS environment linked to a Zoom PC so distant learners can easily communicate with classmates and teachers.
The college's LAN network was used to direct the sound to various halls; - the number of channels required by the halls to distribute sound through the multiple arrays and groups has been calculated; - teachers can enter the classroom, start the system using the touch screen, and then concentrate on the lesson at hand.

6.1 Controlling audio

It is important to note that traditional system components like microphones, headphones, loudspeakers, and other devices can all be done away using Internet of Things technologies.

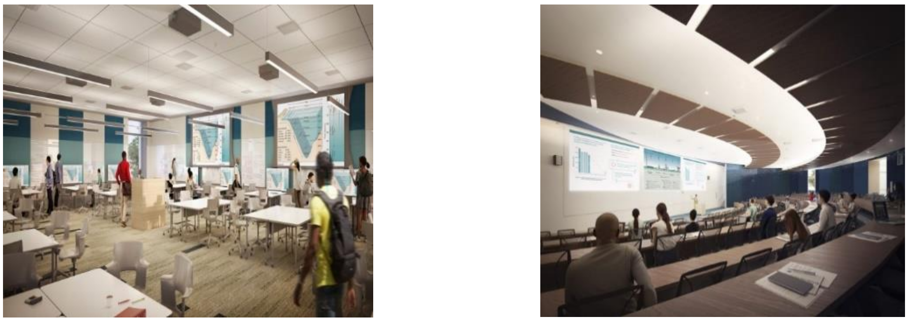


Figure 7. An Interactive learning lecturer hall.

The Internet of Things makes anticipating and handling emergencies in lecture halls simpler. For instance, a variety of sensors can be installed to detect fires. These sensors closely monitor the carbon dioxide level and room temperature. Regularly, a complete report is sent to a shared monitoring center. In a fire, a warning is sent to the command center, police station, and firefighters. IoT helps us prepare for emergencies and respond quickly when they happen.

6.2 *Using biometric security systems.*

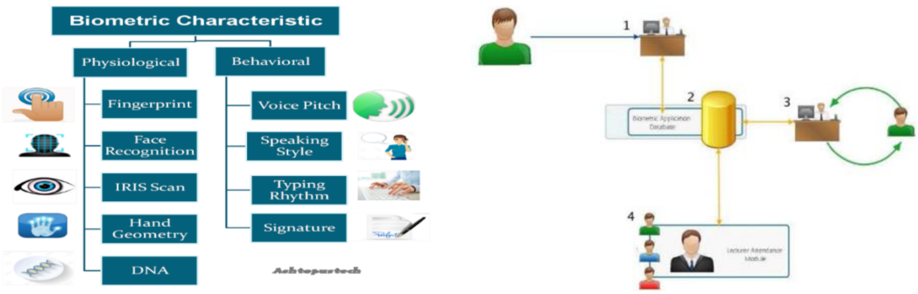
Security organizations widely use biometric systems to track daily attendance, restrict access to only authorized people, and perform other related functions [26-28]. Modern security, data transmissions, fingerprints, voice, eyes, and faces are known as biometric technology. The hardware components of biometric security systems are interconnected. Each time the host computer is used, data is split. The scanned data is saved for later use, and relevant data is retrieved following the needs.

6.3 *Controlling presence and absence.*

Each student's existing barcode is scanned using a barcode scanner, which extracts the necessary data and delivers it to the host computer. The student's account, through which any assessments are given to the student after proper processing, is likewise connected to the computer. These gadgets are all connected by the Internet of Things [29-33].

6.4 *Automation of production processes in the workshops.*

Automation is used in manufacturing workshops where it is impossible and dangerous for humans to conduct repetitive activities by hand, such as label packing, furniture construction, 3D modelling, and packaging. Figure 8-a illustrates the biometric characteristic, while Figure 8-b shows a practical application in schools.



(a) (b)

Figure 8. (a) The biometric characteristic, (b) a practical application in schools.

Conveyor belts and manufacturing equipment must be connected to exchange information, status, and data. The Internet of Things is the foundation for this connectivity. To prevent faults from occurring, to maintain a consistent level of quality throughout the production process, to make the workshop safer and more efficient, and to minimize human error, reports on the state of manufactured products and the condition of the machines are transmitted to the manufacturer regularly.

6.5 Managing Generating Energy in the Floor Design of the Lecture Hall

Generating Energy is done by designing interactive floor tiles powered by solar energy by converting the mechanical energy generated when students walk into electrical energy. Energy is generated when the footprint is pressed against the board from a depth of 5 mm to 10 mm. The triangular design maximizes power output and data capture, characterized by high durability and ease of use, allowing it to be easily integrated anywhere [34-37]. Each step produces 2 to 4 joules through electromagnetic induction by copper coils and magnets, which generate an average of five watts of power. Figure-9. Shows Generating energy using Internet of Things technology on the floor.

Figure 9. Generating energy using Internet of Things technology on the floor .

The energy generated is enough to power the LED bulb for 30 seconds. This energy is stored in batteries that power lights or other devices, such as speakers. Bluetooth technology can connect to smartphone applications and communicate with building management systems.

6.6 Managing lighting.

Control the lighting (close and open) and control its intensity remotely through a computer or mobile phone. Smart lighting uses IoT-enabled sensors, bulbs, or adapters to allow users to manage their home or office lighting with their smartphone or smart home management platform [38-41]. Smart lighting solutions can be controlled through an external device like a smartphone or smart assistant, set to operate on a schedule, or triggered by sound or motion. Figure 10 explores the IoT applications in the lecture hall.

Figure-10. Applications used in lecturer hall using IoT.

6.7 Managing Intelligent Thermostats.

The presence of available technologies and groups, such as smart thermostats, or they are integrated into the solar panel system, provides the following capabilities:

- Architectural insulation and appropriate materials help control the flow of energy that maintains an ideal temperature within the interior space.
- Allowing the use of air conditioners according to the Internet of Things technology to manage their spatial and temporal settings (remote operation, period control, temperature control…)

6.8 Data Flow from the Edge to the Server/Cloud

According to the IoT technology, the following must be researched about any educational ecosystem: the movement of materials, energy fluxes, and Information exchange within the educational ecosystem [42-45]. All of them are investigated because they result in social benefits and volunteer work. The economic gains from developing talent or creating technological innovations are invested in education to support the rehabilitation of education and create a unique cycle of sustainable growth development. Figure-11. Shows the overall system architecture for the Smart Lecture Room.

7. Discussion

Consideration should be given to the IoT platform, which permits communication between phases. The architecture of the platform outlines the details of data traffic. It determines what data is sent and how much processing is done at each level. Depending on the system's specialization, the IoT platform can be customized to varying degrees. For instance, while the Internet of Things for lighting lecture halls may be comparable from one college to the next, anywhere in the world, the sensors and actuators in a specific auditorium for art institutions may be distinct from those in other colleges worldwide.

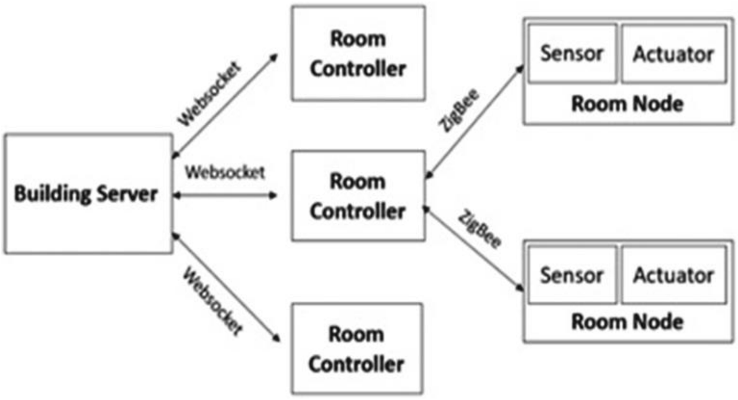


Figure 11. Overall system architecture for the Smart Lecture Room.

The Internet of Things may improve safety and environmental effectiveness in every hallway thanks to a solid understanding of interior design. Enhancing the university experience with the Internet of Things. It is not unexpected that schools and institutions are adjusting to keep up with this massive technological tsunami, given how quickly the Internet of Things (IoT) changes how people live and work in cities, businesses, and homes. Many believe that the Internet of Things is a tremendous opportunity for universities to construct and analyze the most cutting-edge technologies while considerably improving the educational process because universities work hard to foster innovation. Several improvements have already been made. Connecting a personal device to the college's free Wi-Fi, students and staff can access information about the campus based on their location. For instance, they may use interactive map data to show lost students where to go, tell visitors about the local history, or see if any study rooms are available. Universities can use the IoT to track individuals entering and exiting buildings and make appropriate HVAC system adjustments to maintain ideal room temperatures. Even wearable technology is being considered by several institutions to monitor students' well-being and better satisfy their needs.

5. Conclusions

The main objective of utilizing the IoT in education is to simplify the process, engage students more in learning, and provide innovative learning. IoT technology allows for managing vast volumes of data, which has helped develop a few solutions for constructing a sustainable interior environment. IoT applications are not commonly employed due to the astronomically expensive installation costs, but hall automation has a bright future. The IoT offers a central control interface that enables users to manage the hall and control the interior design elements. IoT held many design elements like; lighting, power, heat, and activating and closing doors and windows. The paper presented the design and implementation of a functional IoT-based connected university system. This system is a large-scale IoT system that can integrate numerous services as subsystems. Subsystems, including bright lecturer halls or offices and universities, were proposed. The IoT architecture implements the subsystems, making them dependable, scalable, highly maintainable, and independently deployable. Future services can be added with no problem to the system design.

Funding: This work is sponsored by the Faculty of Information Systems & Computer Science, October 6th University.

Acknowledgements: The authors would like to thank the editor and anonymous reviewers for their valuable suggestions and comments that helped in this work.

Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. H. Chougrani, S. Kisseleff, S. Chatzinotas, Efficient Preamble Detection and Time-of-Arrival Estimation for Single-Tone Frequency Hopping Random Access in NB-IoT, IEEE Internet of Things Journal, **2021,** vol 8, no 9.
2. J. Chen et al., Multiple Nodes Access of Wireless Beam Modulation for 6G-Enabled Internet of Things, IEEE Internet of Things Journal, **2021**, vol 8, no 20.
3. L. Zhao, W. Wu and S. Li, Design and Implementation of an IoT-Based Indoor Air Quality Detector With Multiple Communication Interfaces, IEEE Internet of Things Journal, **2019**, vol 6, no 6.
4. J. Jiang et al., On Real-Time Detection of Line Sags in Overhead Power Grids Using an IoT-Based Monitoring System: Theoretical Basis, System Implementation, and Long-Term Field Verification, IEEE Internet of Things Journal, **2022**, vol 9, no 15.
5. M. J. Diván et al., IoT-Based Approaches for Monitoring the Particulate Matter and Its Impact on Health, IEEE Internet of Things Journal, **2021**, vol 8, no 15.
6. M. Nuruzzaman et al., Design and Implementation of a Feasible Model for the IoT Based Ubiquitous Healthcare Monitoring System for Rural and Urban Areas, IEEE Access, **2022**, vol 10.
7. G. Kaur, P. Chanak and M. Bhattacharya, Energy-Efficient Intelligent Routing Scheme for IoT-Enabled WSNs, IEEE Internet of Things Journal, **2021**, vol 8, no 14.
8. H. Al-Shammari et al., Resilient Service Embedding in IoT Networks, IEEE Access, vol 8, 2020.
9. S. Gandhi et al., Eliminating Energy Waste in IoT System with Enhanced Functionality, 2022 IEEE 7th International Conference for Convergence in Technology, **2022**.
10. M. Alghamdi, Modelling and Implementing an Energy-Optimised IoT Architecture for Smart Homes, 2022 International Conference on Emerging Trends in Computing and Engineering Applications (ETCEA), **2022**.
11. M. Khan et al., Modeling of Intelligent Sensor Duty Cycling for Smart Home Automation, IEEE Transactions on Automation Science and Engineering, vol 19, no 3, 2022.
12. F. Condon, Design and Implementation of a Cloud-IoT-Based Home Energy Management System, Sensors, **2022**.
13. Y. Wu et al., IoT Cloud-Edge Reconfigurable Mixed-Signal Smart Meter Platform for Arc Fault Detection, IEEE Internet of Things Journal, **2023**, vol 10, no 2.
14. A. Celik et al., A Top-Down Survey on Optical Wireless Communications for the Internet of Things, IEEE Communications Surveys & Tutorials, **2023**, vol 25, no 1.
15. Y. Lieu et al., Identification and Resolution for Industrial Internet: Architecture and Key Technology, IEEE Internet of Things Journal, **2022**, vol 22, no 9.
16. J. Liu et al., Joint Dynamic Task Offloading and Resource Scheduling for WPT Enabled Space-Air-Ground Power Internet of Things, IEEE Transactions on Network Science and Engineering, **2022**, vol 9, no 2.
17. L. García et al., Smart Air Quality Monitoring IoT-Based Infrastructure for Industrial Environments. Sensors, **2022**, vol 22.
18. B. Olivo, A. Pan, Internet of Things: State-of-the-art, Computing Paradigms and Reference Architectures, IEEE Latin America Transactions, **2022**, vol 20, no 1.

19. J. Li et al., A Remote Monitoring and Diagnosis Method Based on Four-Layer IoT Frame Perception, IEEE Internet of Things Journal, **2019**, vol 7.

20. Q. Zhao et al., A Tutorial on Internet of Behaviors: Concept, Architecture, Technology, Applications, and Challenges, IEEE Communications Surveys & Tutorials, **2023**, vol 25, no 2.

21. T. Qiu, Underwater Internet of Things in Smart Ocean: System Architecture and Open Issues, IEEE Transactions on Industrial Informatics, vol 16, **2020**, no 7.

22. H. Anumala et al., Air Monitoring System Using IOT, In Advances in Information Communication Technology and Computing; Springer Nature: Singapore, **2022**, pp. 327–333.

23. Jabbar, W.A.; Subramaniam, T.; Ong, A.E.; Shu'Ib, M.I.; Wu, W.; de Oliveira, M.A. LoRaWAN-Based IoT System Implementation for Long-Range Outdoor Air Quality Monitoring. IEEE Internet of Things, **2022**, vol 19.

24. M. Guzmán et al., IoT-Based Monitoring System Applied to Aeroponics Greenhouse, Sensors, **2022**.

25. T. Sutjarittham et al., Experiences with IoT and AI in a Smart Campus for Optimizing Classroom Usage, IEEE Internet of Things Journal, **2019**, vol 6, no 5.

26. B. Yuan et al., SmartPatch: Verifying the Authenticity of the Trigger-Event in the IoT Platform, IEEE Transactions on Dependable and Secure Computing, **2023**, vol 20, no 2.

27. X. Jiang et al, Enhancing IoT Security via Cancelable HD-sEMG-Based Biometric Authentication Password, Encoded by Gesture, IEEE Internet of Things Journal, **2021**, vol 8, no 22.

28. S. Wu, P. Hung and A. Swindlehurst, ECG Biometric Recognition: Unlinkability, Irreversibility, and Security, **2021**, vol 8, no 1.

29. V. Dhuri et al., Real-Time Parking Lot Occupancy Detection System with VGG16 Deep Neural Network using Decentralized Processing for Public, Private Parking Facilities. International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT), **2021**.

30. S. Farahsari et al., A Survey on Indoor Positioning Systems for IoT-Based Applications. IEEE Internet Things J., **2022**, vol 9.

31. Y. Zhuang et al., Bluetooth Localization Technology: Principles, Applications, and Future Trends. IEEE Internet Things Journal, **2022**, vol 9.

32. Tamer H. M. Soliman, F Yang and S Ejaz, A polar coding scheme for secure data transmission based on 1D chaotic-map. International Conference on Computer Information Systems and Industrial Applications, vol 18, **2018**.

33. H. Ye and J. Peng, Robot Indoor Positioning and Navigation Based on Improved Wi-Fi Location Fingerprint Positioning Algorithm. Wirel. Commun. Mob. Computer, **2022**.

34. M. Vashishtha et al., Security and detection mechanism in IoT-based cloud computing using hybrid approach. Int. J. Internet Technol. Secure. Trans, **2021**, vol 11.

35. S. Junoh, S. Subedi and J. Pyun, Floor Map-Aware Particle Filtering Based Indoor Navigation System. IEEE Access Journal, **2021**, vol 9.

36. D. Sarpal, R. Sinha and M. Jha, AgriWealth: IoT based farming system, Micro process. Microsyst, **2022**, vol 89.

37. E. Palomar and M. Valls, Flexible IoT Agriculture Systems for Irrigation Control Based on Software Services, Sensors, **2022**, vol 22.

38. M. Ahmed et al., LoRa Based IoT Platform for Remote Monitoring of Large-Scale Agriculture Farms in Chile, Sensors, **2022**, vol 22.

39. M. Humayun, S. Alsaqer and N. Jhanjhi, Energy Optimization for Smart Cities Using IoT. Appl. Artif. Intell, **2022**, vol 36.

40. H. Zhu et al., Integrating IoT-Sensing and Crowdsensing with Privacy: Privacy-Preserving Hybrid Sensing for Smart Cities. ACM Trans. Internet Things, **2022**, vol 3.

41. H. Canli and S. Toklu, AVL Based Settlement Algorithm and Reservation System for Smart Parking Systems in IoT-based Smart Cities. Int. Arab J. Inf. Technol, **2022**, vol 19.

42. E. Kadusic et al., A Smart Parking Solution by Integrating NB-IoT Radio Communication Technology into the Core IoT Platform. Future Internet, **2022**, vol 14.

43. H. Kim and J. Yoo, Analysis of Security Vulnerabilities for IoT Devices. J. Inf. Process. Syst., **2022**, vol 18.

44. G. Cay et al., NeoWear: An IoT-connected e-textile wearable for neonatal medical monitoring. Pervasive Mob. Computer, **2022**, vol 86.

45. A. Kumar and A. Pandey, Design of Internet of Things (IoT) System Based Smart City Model on Raspberry Pi. IETE J. Res., **2022**, vol 1.