The Fire Alarm System Architecture via the Intelligent Things Technology for Higher Education

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Abstract

The purposes of the research were (1) to design the fire alarm system architecture via the intelligent things technology for higher education and (2) to evaluate the fire alarm system architecture via the intelligent things technology for higher education. The research procedure was divided into two phases. The first phase is the fire alarm system architecture via the intelligent things technology for higher education design, and the second phase is the architecture evaluation by experts. The samples were 5 experts in the Internet of Things, computer science and the information chosen by purposive sampling. Data collection tools were the system and the assessment of the appropriate model with a 5-level rating scale. The statistics used in data analysis were means and standard deviation. The results showed that (1) the system architecture of a fire alarm system using the Internet of Things for higher education included 3 tiers: 1.1) the Application Tier, 1.2) the Network Tier, 1.3) the Context-Aware and Sensing Tier, and (2) expert opinions on the system developed were at a reasonable level ($\bar{x}$=4.52, S.D.= 0.54).

Keywords: System architecture, Fire alarm system, Intelligent Things, Higher education

Introduction

Implementing smart fire alarm systems that utilize IoT technology in higher education settings offers several potential benefits, including enhanced safety and security through real-time monitoring and response capabilities. These systems can improve the accuracy and speed of fire detection by leveraging a variety of sensors, such as smoke, heat, humidity, and flame sensors, to identify actual fires more reliably[1,2]. IoT-based systems can also facilitate effective evacuation and rescue efforts by incorporating Building Information Modeling (BIM) to optimize evacuation routes and provide three-dimensional visualizations of the site, enabling a more efficient response to fire incidents[3]. Additionally, the integration of machine learning algorithms can predict and prevent potential fire incidents, further enhancing the safety of educational facilities[3]. However, there are challenges associated with the implementation of these systems. One significant challenge is the risk of false alarms, which can be triggered by erroneous signals not related to actual fire signs[4]. This issue underscores the need for high-end, sophisticated fire alarm systems that can discern between false alarms and genuine fire incidents. Another challenge is the complexity of deploying these systems in the diverse and complicated interior environments of public buildings, which requires careful consideration to ensure the safety of individuals in the event of a fire. The cost of implementing such advanced systems may also pose a challenge, especially for institutions with limited budgets. Moreover, while IoT technology offers the potential to significantly improve fire safety in higher education settings, it also introduces concerns related to data privacy and security[5]. Ensuring the protection of sensitive information collected and transmitted by IoT devices is crucial to maintaining the trust and confidence of the individuals these systems are designed to protect. In conclusion, while smart fire alarm systems utilizing IoT technology present promising benefits for enhancing fire safety in higher education settings, addressing the challenges of false alarms, system complexity, cost, and data security is essential for their successful implementation[5,6].

The integration of the Internet of Things (IoT) in fire alarm systems within the context of higher education presents a transformative approach to enhancing safety and operational efficiency. The IoT's capability to interconnect various sensors and devices across educational institutions allows for real-time monitoring, early detection, and efficient response to fire incidents, thereby significantly improving emergency preparedness and

minimizing potential hazards[7]. A notable advancement in this area is the development of an IoT-based automated emergency response system, which leverages wireless and Bluetooth sensor networks to gather real-time data. This system utilizes machine learning algorithms for predicting potential fire incidents and incorporates Building Information Modeling (BIM) to optimize evacuation and rescue routes, ensuring early detection, accurate alarms, and effective evacuation guidance[8]. However, the adoption of IoT in higher education, especially in developing countries, faces challenges such as financial constraints, technical support, and individual proficiencies, which can hinder the integration of sophisticated systems like IoT-based fire alarm systems[9]. Despite these challenges, the potential for IoT to enhance fire safety in smart buildings through the use of advanced fire alarm systems equipped with smoke and high-temperature sensors has been demonstrated[10]. Research emphasizes the importance of evolving IoT architecture to meet the complex needs of higher education's operational processes, suggesting that a more sophisticated model is necessary for the effective implementation of IoT, including fire alarm systems[11]. The integration of IoT in educational settings, particularly in engineering domains, has shown significant benefits in improving academic performance, which indirectly supports the case for adopting advanced technologies like IoT for safety and operational efficiency[12]. Smart Education, powered by IoT, not only focuses on enhancing learning outcomes but also plays a crucial role in creating safer educational environments through improved monitoring and response strategies[13]. User adoption and perception of IoT services, including safety systems, are influenced by factors, such as social influence, expected effort, privacy, and performance expectations, highlighting the need for educational institutions to foster awareness and trust in these technologies[14]. Moreover, the application of IoT in higher education extends to various domains, including the optimization of higher English education systems through IoT technology, demonstrating the versatility and potential of IoT to improve educational outcomes and operational efficiency[15]. Lastly, the development of logic circuits for fire detection using IoT and Arduino showcases the technological advancements and practical applications of IoT in enhancing fire safety measures within higher education institutions[16]. This involves devising new concepts for making the system architecture of a fire alarm system using the Internet of Things for higher education aware of their learner's security.

Objectives

1. To design the fire alarm system architecture via the intelligent things technology for higher education

2. To evaluate the system architecture

Following 3 parts.

1. Population, samples groups and variable:

Population:

• Population is the experts in the field of IOT, information and computer science.

Samples Groups:

• Samples are 10 experts in the field of IOT, information and computer science.

Chosen by purposive sampling. They are highly-experienced experts in these fields for at least 5 years.

Variable:

• Independent variable is the system architecture of fire alarm system using Internet of Things for Higher Education.

• Dependent variable is the appropriateness of the system architecture of fire alarm system using Internet of Things for higher education.

2. Research tools

The research instruments were an evaluation of System Architecture of Fire Alarm System using Internet of Things for Higher Education.

3. Data analysis

The data obtained from the experts were collected and analyzed by using the statistics as follows:

• Arithmetic mean

• Standard deviation

Methods

Phase 1. System architecture design

• Design the fire alarm system architecture via the intelligent things technology for higher education.

• Create an instrument for assessing the appropriateness of the fire alarm system architecture via the intelligent things technology for higher education.

Phase 2. Evaluation of the appropriateness of the fire alarm system architecture via the intelligent things technology for higher education

Results

Stage 1. The fire alarm system architecture via the intelligent things technology for higher education is composed of 3 main tiers which are:

The researcher designed conceptual framework to explain and make clear understanding of the fire alarm system architecture via the intelligent things technology for higher education system working processes. The system consisted of 3 processes.

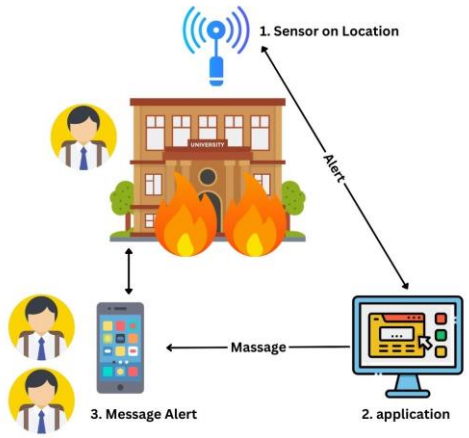

Figure 1. Conceptual framework of the fire alarm system architecture via the intelligent things technology for higher education

Figure 1 revealed conceptual framework of the fire alarm system architecture via the intelligent things technology for higher education. It consisted of 3 processes as follows:

1. Set up sensor on location

This process is the beginning of the fire alarm system architecture via the intelligent things technology for higher education. The staff set up the default of the activity and alarm including the recorded details through the application. Then the transmitter sensor was installed at the activity location. The staff was able to monitor each past performance.

2. Coordinate signal

This process accrued after staff or admin completely set up the alarm. At the beginning of the alarm location, students joined going into the restricted location or student inside the building. The system sent the connection signal to students' card or smartphone to identify students who were inside the dangerous location.

3. Transfer to application

This process followed the Coordinate Signal process. It was signal connector between transmitter sensor and students' card or smartphone, the receiver. This meant the data in students' card or smartphone which was connected was sent to application. The data recorded in cloud database including alarm activity data set up in process 1.

4. Reporting

Reporting is the final process. It was the process that students checked the activity participation status through the application. Students checked the number of activity they already participated. They could print the report and send it to the unit that needed the data.

After the explaining the framework to show the detail of the system working processes, the researcher presented the system architecture of fire alarm system using Internet of Things for higher education as shown in figure 2.

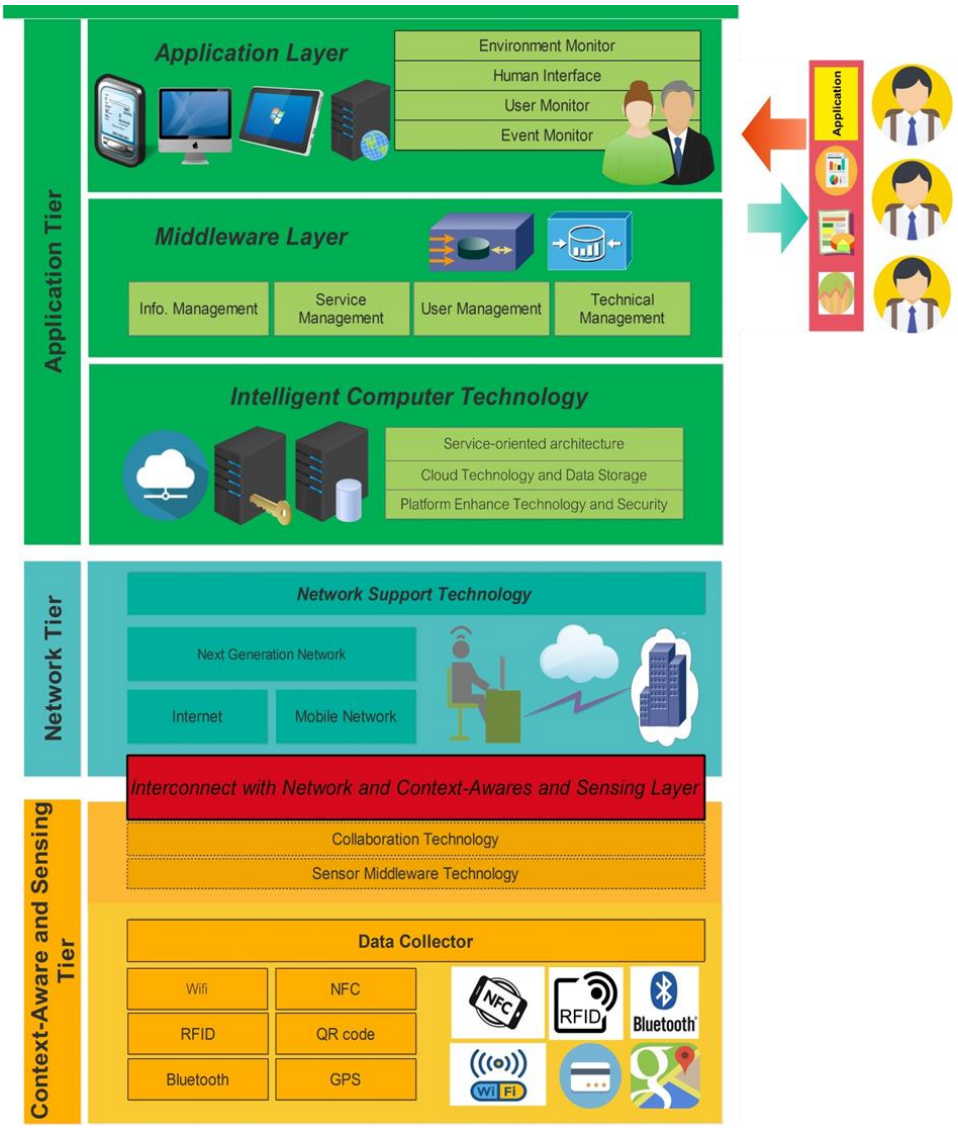

Figure 2. The fire alarm system architecture via the intelligent things technology for higher education

The generally accepted architecture of IOT consists of three layers: perception (sensing), network, and application[16,17]. Therefore, the fire alarm system architecture via the intelligent things technology for higher education included 3 tiers as follows:

1. **Application tier:** it was the interface that connected with user while the fire alarm system architecture via the intelligent things technology for higher education. It is consisted of 3 components as follows:

Application layer: it was the interface working as connector with user in setting up alarm program, monitoring accuracy of activity and overall system. Monitoring and control systems collect data on tools performance[18], energy usage, and environmental conditions, and allow managers and automated controllers to constantly track performance on context-aware principle[16].

Middleware layer: it was system data management part for information management, service management and technical management. Middleware is described as a software layer inserted between software applications to make it easier for software developers to operate communication and input/output[19]. Its feature of hiding the details of various technologies is fundamental to make IOT developers free from software services being not exactly relevant to the specific IOT applications[17].

Intelligent computer technology: it was the needed hardware and technology system such as, database server, cloud severs service oriented, platform technology, and security technology. A number of IOT applications need massive data storage, high processing speed to enhance real-time decision making, and high-speed broadband networks to flow data, audio, or video. Cloud computing assigns a perfect back-end solution for handling huge data streams and processing them for the unexceptional number of IOT devices and human[19].

Cloud Technology is a model for access to share resources, such as servers, storage, applications, services and software that can be provisioned as Infrastructure as a Service (IaaS) or Software as a Service (SaaS)[16,19]

Service-oriented architecture (SOA) means an approach which is applied to create architecture based on the application of system services. The SOS approach is today being implemented in IOT domain, applying the principle of middle ware (a software layer superimposed between application and technology layer that hides the inessential details from the developed). It helps to reduce the time of product development and simplify the design workflow, lessening the process of advertising the business outcomes in a short time duration[20].

2. **Network tire**: it was the network for connecting with such parts as mobile network, Wifi and internet. In addition, it worked as the connector with the next part; context-aware and sensing tier. Wireless sensor networks (WSN) is composed of dispersed autonomous sensor-equipped devices to monitor physical or surrounding conditions and be able to cooperate with RFID systems to improve the

status of things, for example, their site, temperature and movement[19]. WSN provides various network topologies and multihop communication. Today technological progress in low-power integrated routs and wireless communications have brought possible efficient, low-cost, low-power miniature devices for utilization in WSN applications[21].

3. Context-Aware and sensing tier: It was sensing hardware that worked as both signal transmitter and receiver. It was installed in activity location. The type of signal can be chosen based on suitability organization, such as RFID, Wifi, Internet and GPS. Sensing hardware has to have ability to collect data following context-aware principle.

Stage 2. The results of appropriateness evaluation of the fire alarm system architecture via the intelligent things technology for higher education

Table 1 The appropriateness evaluation of the fire alarm system architecture via the intelligent things technology for higher education

The fire alarm system architecture via the intelligent things technology for higher education consisted of 3 main tier	$\bar{x}$	S.D.	Appropriateness
1. Application Tier consisted of • Application Layer • Middleware Layer Intelligent Technology Computer	4.6	0.54	Most appropriate
2. Network Tier consisted of • Network Support Technology	4.6	0.54	Most appropriate
3. Context-aware and Sensing Tier consisted of • Collaboration Technology • Sensor Middleware Technology • Data Collector	4.6	0.54	Most appropriate
4. Workflow sequence of System Architecture of the fire alarm system architecture via the intelligent things technology for higher education	4.4	0.54	Most appropriate
5. Suitability to use the fire alarm system architecture via the intelligent things technology for higher education	4.4	0.54	Most appropriate
Total	4.52	0.54	Most appropriate

As shown in Table 1, the results showed the most appropriate assessment, with an average performance score ($\bar{x}$= 4.52 and a standard deviation (S.D.) of 0.54), conducted by experienced experts.

Conclusions

Higher education-intensive competition makes the organization to realize academic development. Therefore, higher education uses ICT such as E-learning, Mobile Learning, Cloud Technology, Augmented Reality, Virtual Reality and Intelligent things in teaching and learning process. One of the most important aspects is using ICT to create student satisfaction. Activity or instrument development for learning creates satisfaction the researcher designed the fire alarm system architecture via the intelligent things technology for higher education. The objective of the design is to set an automatic fire alarm system. The result of in building the design was 3 tiers architecture: Application Tier, Network Tier and Context-Aware and sensing Tier. The design accorded with Jaehyeon et al.[16] and Ray[17]. Then the developed architecture was examined for its appropriation by 10 experts. The result revealed that the architecture appropriation was at the most appropriation level. The next step of research is the implementation system.

Recommendation

This research process is the architectural design of the system. The next step is to implement and develop the system further. In the development process developers must choose the technology. That is appropriate to its own context

Adding automation in further development will add value and expand the interest of the fire alarm system architecture via the intelligent things technology for higher education system, such as calculating the intensity of a fire and notifying the responsible agency or giving orders to the robot to extinguish the fire.

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