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Using Wireless Networks and Internet of Things for Enhanced Monitoring of Students During Virtual Class

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Abstract: The entire educational model has undergone a significant change as a result of the Internet of Things (IoT)'s introduction to the educational sector. Universities have a significant chance to take advantage of the IoT technology in a variety of ways, including data collection and analysis to improve the educational experience, promote the achievement of learning objectives, and enhance overall school operations. Since the IoT promises, among other things, to improve education process and quality of life, as well as increase resource efficiency and management, the IoT has emerged as a highly debated research topic. Meanwhile, the Internet of things have temptation of using mobile devices and other technology while virtual session start for non-educational purpose, strength is always a reason for weakness. Therefore, student monitoring is a key part of many educational services. Especially during the virtual session. It can reduce the number of students who not completing the course, while increasing the access to education to those who really need these monitoring. In a variety of settings, wireless and mobile technologies are being used to monitor students: Courses and online sessions. The quality and dependability of student monitoring, however, have not been particularly satisfactory due to a number of restrictions, such as Wireless Networks (WN) unforeseen and fragmented coverage of users. In this study, we describe a method for monitoring students that makes use of ad-hoc Wireless Networks (ad-hoc-WN) that may be created on an ongoing basis between wearable and mobile devices. This enables the vital signs' transmission in both routine and emergency circumstances. In order to make student monitoring through ad-hoc-WN a reality, we clarify a wireless architecture, go over emergency message routing, and bring together numerous relevant technical and non-technical difficulties. The suggested student monitoring method is made with the intention of being trustworthy and doable in the near future.

Keywords: Student Monitoring, Mobile and Wireless Network (WNs), Ad-Hoc Wireless Networks, Wireless Architecture, Internet of Things (IOT)

Introduction

There are many different e-learning platforms available today, but the most widely used ones include the open-source platforms ILIAS, Moodle, OLAT, and Sakai (Cuomo *et al*., 2015) as well as the commercial systems Blackboard, Clix, and Desire2Learn. Many educational institutions are using the IoT in their online learning platforms as a result of modern technological advancements in order to gather, store, and transmit data to a centralized database system. Due to a rise in the number of data obtained, the data collection has become more complex and difficult (Van Leemput, 2014; Holmström, 2022).

It will be necessary to develop wireless and mobile technology, incorporating the ability for a mobile device to store a sizable amount of data, radio-enabled watches, and a grid of body sensors. These developments will increase the effectiveness and usefulness of student monitoring. One option is to keep up-to-date instructional information on a student's mobile device and update it as necessary. This will enable to access important data from projects, group assignments, and individual assignments to quickly and effectively respond. The ability to recognize one or more vital signs and send alert signals to instructors and emergency response providers has recently been developed in handheld devices like cell phones and personal digital assistants.

Instructors and educational providers can work more efficiently and under less stress overall by employing wireless and mobile technologies to monitor students. Wireless technologies for student monitoring and preventive education are affordable, portable, and reusable, which will lead to long-term decreases in the cost of educational services. The issue of wireless and mobile network-based student surveillance is covered in this essay. We discuss the limitations of the most current studies on student monitoring before explaining the potential fix.

The IoT is a huge network of various objects, including people, intelligent devices, information, and data, that all acquire and share data about one another and their surroundings (Singh, 2023). The Internet of Things has already started to make people's lives better in a number of fields, including smart cities, smart healthcare, home automation, safety and security, and education. The entire educational model has undergone a significant transformation since the IoT entered the educational space. In any educational organization, it has produced a platform for information exchange and communication among individuals and the environment.

Both the number of courses offered online and the number of users are growing quickly. There are questions about how to raise the caliber of materials and distribution strategies. In addition, student monitoring is a main part of many educational services. Especially during the virtual session. It can reduce the number of students who not completing the course, while increasing the access to education to those who really need these monitoring. The goal of this study is to develop a wireless ad hoc network solution for student monitoring that may be dynamically constructed among mobile and wearable devices in order to enhance the online programmers provided by Higher Education Institutions (HEIs).

The primary contribution of the student monitoring system makes use of ad-hoc-WN that can be created dynamically between mobile and wearable technology. This enables the transmission of vital signs in both routine and critical circumstances, enhancing online learning and teaching for both instructors and students. This study is structured as follows. Section 2 illustrates the concepts of IoT from the characteristics of technology and potential use of IoT in Higher Education Institutions. Section 3 delivers a review of the related work.

Internet of Things

The term "Internet of Things" (IoT) alludes to the future generation of the Internet, which will include billions of nodes that represent a wide range of items, from modest handheld sensors and web servers to massive supercomputer clusters and little ubiquitous sensor devices (James *et al*., 2009; Singh, 2023). It is the third major technological advancement following the Internet and computer revolutions. It constructs the development path of the future generation of the internet by integrating new computer and communications technologies (such as sensor networks, real-time localization, Radio Frequency Identification (RFID), mobile communication technologies, ubiquitous computing, and IPV6, etc.,) (Pappas *et al*., 2022). Based on modern information and communication technologies, the internet can be used for communication between Internet of Things smart devices (such as actuators, sensor inputs, etc.,) (Todorov and Vela, 2023). IoT is defined as "a world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes" (Haller *et al*., 2009). Services are available to query the state of these "smart objects" and any information related to them through the Internet while taking security and privacy concerns into consideration.

According to Lin (2009), the IoT is a merger of sensor networks, which comprise RFID, and ubiquitous networks from a technological and economic perspective, respectively. It is an open thought that incorporates new connected productions and services, technologies and applications, R and D, industry, and market from an economic point of view.

Large amounts of data will be generated through the Internet of Things. As an illustration, consider a grocery store in a supply chain that uses RFID technology. Raw RFID data is formatted as EPC, location, and time. The EPC stands for the distinctive identity read by an RFID reader, whereas the location, time, and reader's position all refer to specific locations and times. A raw RFID record requires roughly 18 bytes to be saved. There are around 700,000 RFID tags in a supermarket. Therefore, if a supermarket had readers that scan the items once per second, the amount of RFID data created would amount to 12.6 GB every second, or 544 TB each day. Therefore, it is essential to create efficient processes for organizing, processing, and mining RFID data.

The data in the Internet of Things can be categorized into a number of different groups, including RFID data streams, address/unique identifiers, descriptive data, positional data, environment data, and sensor network data (Chen *et al*., 2015b). It carries with it significant hurdles for the Internet of Things' data management, analysis, and mining. Every object on Earth should be connected to the internet, according to IOT (Tsai *et al*., 2013; Bhatia and Patel, 2015; Chen *et al*., 2015b). The major developments in information technology and computer networking, a wide range of applications are now feasible (Stankovic, 2014). The most recent internet generation is known as the Internet of Things. It is projected that IoT would help connect the trillions of nodes of various items with the enormous web servers and cluster of a supercomputer. New computer and communication technologies can be more easily integrated thanks to IoT (Bin *et al*., 2010). Since a decade ago, ubiquitous services and portable technology have allowed users to connect with anybody, anywhere. People can connect with one another today without any limitations thanks to these technologies (Chen *et al*., 2015b). The creation of systems like the "smart home," "smart pen," "intelligent transportation," "global supply chain," and "healthcare" has piqued the interest of numerous researchers with experience in a variety of industries, including academia, research facilities, and governmental organizations (Wu and Zhang, 2003; Chen *et al*., 2004; Keller, 2011; Bhatia and Patel, 2015).

Related Work

The internet of things is still in its early stages of research as a brand-new paradigm for the internet. The following three issues are primarily covered in works about data mining in the Internet of Things at the moment: Managing and mining RFID stream data is the topic of some works. For instance, Hector Gonzalez *et al*. unique model (RFID-Cuboids) for storing RFID data was proposed in their paper by Gonzalez *et al*. (2006c). This approach provides significant compression and path-dependent aggregation while maintaining object transitions. Three tables are kept by RFID-Cuboids: Chen *et al*. (2015a) map table, that covers path information for doing structure-aware analysis. Bhatia and Patel (2015) Info table, which holds path-independent information about product. Bin *et al*. (2010) stay table, which stores information about objects that stay together at a location.

Gonzalez *et al*. (2006a) Flowgraph was utilized for multi-dimensional analysis of commodity flows as well as adoption to represent the transit of goods. In the cited study (Gonzalez *et al*., 2006b), the researcher proposed a class of compressed probabilistic processes that capture the movement and significant exceptions of RFID flows. In the RFID data stream, (Masciari, 2007) studies the mining of outliers. Some projects are interested in searching, analyzing, and mining the moving object data produced by different IoT devices, such as GPS devices, RFID sensor networks, RADAR or satellites, etc. For instance, a brand-new framework for moving object anomaly detection termed ROAM was proposed Li *et al*. (2007). Referring to Lee *et al*. (2008a), A novel partition-and-detect approach was created by Lee *et al*. (2008b) to identify moving object trajectory outliers. The TraClass approach, developed by Lee *et al*. (2008a) utilizing hierarchical region-based and trajectory-based clustering, is another innovative trajectory classification technique.

A partition-and-group approach is suggested in reference Lee *et al*. (2007) for trajectory clustering of moving objects. Knowledge discovery from sensor data is another area of research. There are several properties of a sensor network, such as limited resources, simple sensor deployment, no maintenance, multi-hop, large amounts of data, etc. Data mining in sensor networks therefore has unique characteristics. A broad probabilistic framework was proposed by Ghosh (2008) that permits supervised learning while being constrained by computational, memory, and power constraints. To model and exploit sensor data, (George *et al*., 2009) proposed Spatio-Temporal Sensor Graphs (STSG). Different patterns can be found using STSG models, including anomaly patterns, centralized sites at each time period, and future hotspot nodes.

An innovative adaptive mining framework for pattern mining from sensor data was created by Rashidi and Cook (2008) and can adapt to changing data. Despite the fact that IoT has made a number of contributions to data mining, most of them are still very basic, like sensor networks and RFID. IoT, a brand-new Internet paradigm, lacks models and theories for student monitoring.

Requirements of Student Monitoring

The present infrastructure-oriented wireless and mobile networks, such as cellular networks and wireless LANs, have uneven coverage due to time- and location-dependent channel quality and signal attenuation, which causes dead spots. Although attempts have been made to increase coverage through various technical improvements, including overlapping base stations, some areas of any building or school still have inconsistent reception. No information is known regarding the severity of this issue, but it has been noted that buildings often have patchy coverage, particularly in remote areas. The students' wireless coverage can be greatly enhanced by the usage of ad-hoc-WN.

The requirements for student monitoring include the periodic transmission of standard vital signs as well as the transmission of alerting signals when vital signs go above a given threshold, students cross a certain line, or the device battery gets too low. Projects, group and individual assignments, and other knowledge pertaining to schooling may be among them. Numerous usability difficulties, such as user comfort and trust, should be addressed when student monitoring through wireless and mobile networks includes the use of wearable, portable, or mobile devices. Due to the diversity of students, especially those who struggle with technology use, it may be difficult to monitor students utilizing WN due to potential paranoia surrounding handheld or wearable wireless devices.

Student monitoring will need broad and rapid access to WN, scalable and dependable wireless infrastructure,

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safe and quick databases, and the use of network intelligence and information in addition to end devices. Another difficulty is the volume and frequency of information that must be conveyed. While some students require continuous monitoring every few seconds, others require specific vital signs to be reported every few minutes. Any significant changes in the vital signs for any student should be reported right once. To transmit a reference value or differential changes from the last time in a wireless setting, it may be preferable to send less information. This would raise the likelihood that other people would accept you.

Students will use portable or mobile gadgets that can connect to public or private WN in greater numbers. These devices could be made to function in ad-hoc wireless mode in order to enhance the caliber and dependability of pupil monitoring. The use of ad-hoc-WN can also be used to overcome coverage gaps and variable coverage provided by infrastructure-oriented WN in some areas, as well as the presence of students in places that are inaccessible to others, increasing monitoring reliability and increasing the likelihood that alert signals will be transmitted. The range of the sent signal is probably going to be limited because of the size and power needs of these devices. Additionally, the frequency of operation and the type of spectrum employed (licensed vs. unlicensed) are likely to have an impact on the range. The assistance of others with wireless devices in an ad-hoc configuration will be used to monitor pupils who are not covered by infrastructure-oriented WN. This study, we suggest a wireless architecture for monitoring students, go through several features of our approach, and offer routing techniques to make student monitoring easier. By utilizing ad-hoc networking and network intelligence, the suggested method will improve the accessibility and caliber of student monitoring.

The functions of the proposed systems can be classified to two possible users including student and lecturer. To understand the functions and the privileges of each user, a use case diagram is illustrated in Fig. 1. Both users can create account, login, insert progress data, update existing data, and logout. Although the students can insert or update data, the lecturer has the ability to check what the data has been inserted or updated by the students. In addition, the lecturer can monitor the students' attendance, homework, and their progress.

Proposed Solution for Student Monitoring

IoT solutions for education have provided solutions to improve education quality by making it accessible to everyone and simple to grasp across the globe. Due to the high cost of the investment, some schools are implementing IoT at their own pace.

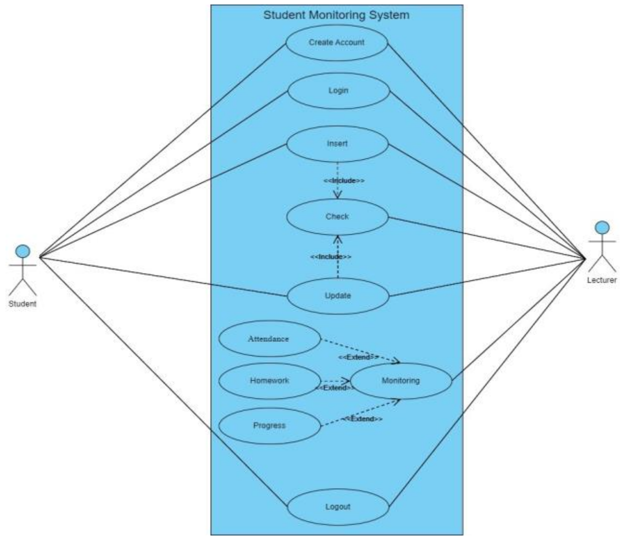

Fig. 1: The use case diagram the shows the users' functions

Given the benefits of IoT and its broad scope of use, this is a worthwhile investment for this industry. Since IoT-enabled gadgets offer features of extended education on simple, user-friendly, and secure platforms for teachers and students, many educational platforms have lately emerged.

The educational sector is one of the most adaptable and successful when it comes to using IoT devices. All students' educational experiences will become more open, participatory, and collaborative as a result. Students have reliable access to everything they need to learn, including communication channels and comprehension, through IoT devices. They also allow instructors to monitor learners' academic development in real-time. IoT merely makes the transition from conventional to digital educational techniques easier while providing a variety of supplementary benefits and improving efficacy. This can be used to educate a variety of disciplines, from languages to arithmetic to teaching practical skills like medical sciences while utilizing graphics and animation to increase student comprehension.

A proposed framework for the student monitoring system has four components, as shown in Fig. 2. The student and lecturer panel page make up the system. However, because it will serve as the platform for data collecting, the approach concentrates on the student site. Students must enter statistics about their academic progress every day. The creation of the student monitoring system is the initial step. The system only has a few features, like viewing, inserting, and deleting. A video insert into the system serves as the student's guide in addition to that. For the second stage, logging in is a requirement for students. It will make sure that they can keep track of their assignments, directions, and other tasks. In addition, a login account can assist in identifying which student has the proper username and password, eliminating data misconfiguration. The third step has the student entering university information. If the data is inaccurate and incomplete, the student may also change, insert, and delete it. The data entry can be seen on the same page that the student fills out with their information. The final step recommends the student to log off the computer. They can prevent unauthorized students from using the system without permission by using the logout session. Additionally, it can stop any data modification that might be overlooked or revealed to the public.

Monitoring students is one of the most significant considerations in an education filed in the distance learning/online learning, where academic achievement may change the life of students permanently (Otto *et al*., 2006; Yuce and Khan, 2011; Mahmud *et al*., 2017; Wu *et al*., 2017a-b). In order to create a reliable monitoring system, we have taken into account the Wireless Body Area Network (WBAN), Low-Power Wide-Area Network (LPWAN), and Internet of Things infrastructures. These considerations include wireless technologies appropriate for WBAN, the network coverage range of LPWAN, the power consumption of sensor nodes, and the IoT cloud server. As illustrated in Fig. 3 there are two subsystems that make up the overall system architecture: IoT gateway and wearable sensor nodes are the primary two.

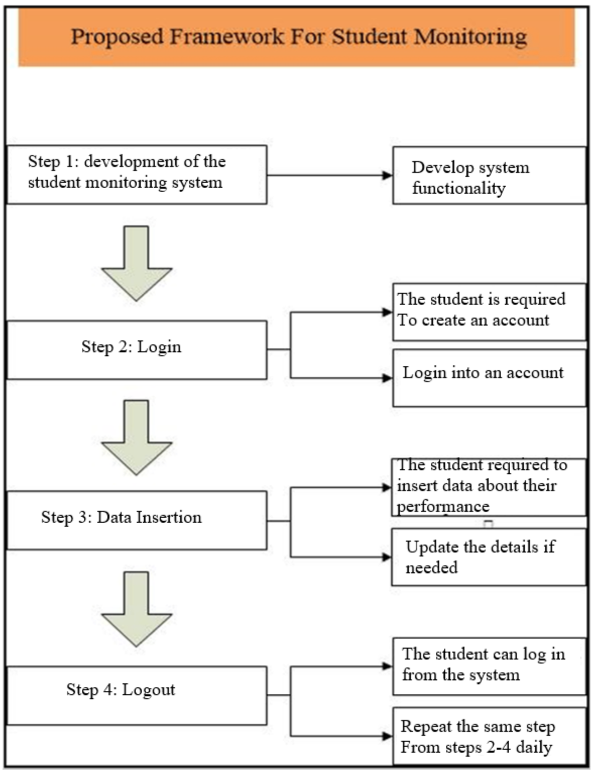

Fig. 2: The proposed framework for student monitoring

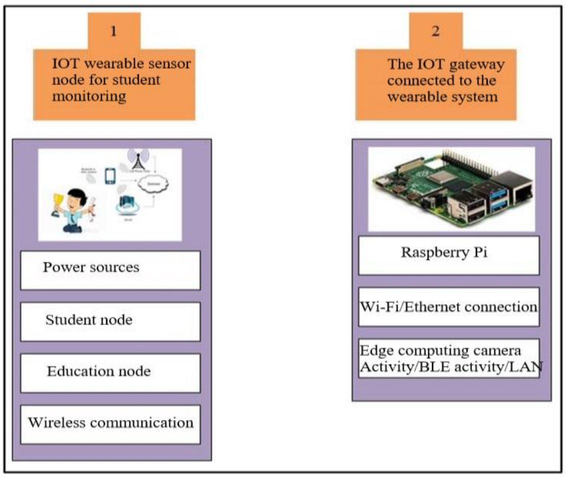

Fig. 3: The overall system architecture

Each student has two wearable sensor nodes: One for monitoring the student and the other for measuring physiological indicators. A Bluetooth Low Energy (BLE) module for WBAN communication and a sensor for concentration monitoring are both included in the education node. The BLE for WBAN communication is one of two wireless modules that make up the education node.

The education Node's BLE is in charge of gathering sensor data from the WBAN, which will then be sent via the network to a distant gateway. As a result, in the suggested hybrid network design, BLE is employed to transfer data inside the WBAN while the proposed model is adopted for long-range data transmission. The BLE may wirelessly send data to a smartphone for display in addition to receiving data from the education Node. For this, a web-based smartphone application is created.

The IoT gateway's primary function is to execute edge computing while connecting the wearable network to the IoT cloud. One Raspberry Pi and an Internet connection make up the gateway. The Pi that is connected to it gets information from the education Node, processes it, and stores it in a local MySQL database. For data visualization, a web application that may display the data on a local website is created.

Academic accomplishment is one of the requirements for a high-quality institution, therefore progress is crucial for students in higher education. However, due to the abundance of data in educational databases, projecting student progress has grown more difficult.

The administrators of the institutions and their management systems are able to update and enhance their choices, policies, and procedures thanks to the rules produced by the suggested model, which also increases the efficiency of the control system. Additionally, the managers of the educational system can use this information to upgrade their techniques, enhance the structure of the board, and better their arrangements. One of the most intriguing ideas is to gather information about student learning from the student database at the university. This database includes academic information for students, such as personal information and information on enrolment, courses, grades, and degrees.

Conclusion

As developed appliances, systems, infrastructures, and their applications have demonstrated their promise in recent years, the IoT has grown in importance as a research area. We predict that in the near future, these technologies will be used to create smart homes and smart cities. However, many customers are wary of "smart" environments and information systems, especially as we enter the IoT era. In this new era, there are a lot of high expectations for IoT and the items that relate to it. Consumers of IoT goods and services would prefer to see IoT technologies create more intelligent settings and systems as opposed to just smarter systems. The primary distinction between a "smart thing" and a "intelligent thing" is that the former uses predefined rules to provide services to a user, whereas the latter uses predefined rules as well as the analytical output from intelligent mechanisms to find services that are appropriate for users. More specifically, the restricted number of rules may prevent utilizing just the preset rules to account for every conceivable circumstance. We can give more information to an IoT system to help it better comprehend the demands of a user by using the findings from data analysis. Because of this, data analytics has emerged as a promising IoT technique.

In both households and universities, wireless and mobile technologies are being used to monitor students in various settings. The effectiveness and dependability of student monitoring, however, have not been very satisfying due to a number of restrictions. In this study, we present and examine an ad-hoc wireless network-based student monitoring method. We talked about routing student data, wireless design, and other technical and non-technical challenges. Numerous unresolved problems have also been found and can be dealt with in further studies.

Student monitoring presents a number of unresolved problems and difficulties that essential to be overcome. One is the variety of environments and students needing supervision. The duration of the monitoring may also vary, such as short-term monitoring at a university and long-term monitoring at a residence. To match the capabilities and weaknesses of the students, mobile devices used for student monitoring must also be portable and easy to use.

The implementation of the IoT gateway and cloud server will also be a priority in future evolution. The edge computing inside the local network, hosting a local server for users, and tying the neighborhood sensor network to the cloud infrastructure are all tasks performed by the IoT gateway.

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Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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