Smart Evaluation: A New Approach Improving the Assessment Management Process through Cloud and IoT Technologies

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***Abstract*—The constant advancement of Information and Communication Technologies (ICT) has sparked growing interest across various domains, with education being one of the most significant. However, this digital transformation presents significant challenges for organizations and educational institutions that must adapt to rapid technological advances. This study aims to integrate smart technologies such as the Internet of Things (IoT), artificial intelligence, and cloud computing into current online learning platforms. To address these challenges, we propose a new model for a smart learning environment (SLE-Model) and a comprehensive architecture based on IoT is suggested as the implementation of our smart learning model. Furthermore, this study proposes a practical application of this concept in the form of "Smart Evaluation," a specific microservice integrated into e-learning platforms. This module includes two important progressive elements: Online Exam Management and Automated Correction of Exam Papers. Finally, we substantiated our study by conducting a comparative experiment, employing the Mann-Whitney U test, involving two groups of students during their evaluation session. The results indicate statistical significance at a 95% confidence level, leading us to the conclusion that the utilization of IoT technologies in online exam management and automated correction of exam papers has proven more effective than traditional methods.**

***Keywords*—smart education, ICT, Internet of Things (IoT), Artificial Intelligence (AI), cloud computing**

I. INTRODUCTION

The introduction of new technologies and the Internet of Things into an institution's infrastructure, especially in classrooms, labs, and simulated classrooms, will allow education to evolve into a smart education [1]. To prepare students for such a learning environment, smart classrooms must decisively encourage creativity, teamwork, interaction, and communication. Smart devices enable students to create an interactive classroom environment that allows them to improve their skills [2]. They allow teachers to personalize the e-learning experience, providing learners with more information and relevant content and engaging e-learning courses. These tools can collect and analyze voices, conversations, presences, behaviors, and more to obtain a status of teacher course progress and learner feedback. This allows educators to constantly create better lessons with greater impact, while audiences benefit from the high-quality learning content [3]. IoT in e-learning is facing tremendous challenges such as interoperability, security, reusability, portability, scalability, etc [4].

Introducing IoT into education, which enables communication between several connected devices, has radically changed higher education institutions. IoT facilitates seamless communication among various interconnected devices, leading to substantial changes. This technology enhances the learning experience for students, making it more engaging, while also providing valuable insights into the learning process. These insights, in turn, enable educators to better understand their students' learning pace and needs [5].

Higher education institutions are starting to use solutions on IoT platforms where they can collect, manage, and analyze large amounts of data. IoT collects data from smart classrooms and stores it in the cloud for further processing and analysis. Devices equipped with sensors are installed on classroom doors and are directly connected to teachers' and students' ID cards. These devices mark teacher and student badges [6]. The devices installed in the classroom doors allow institutions to build an attendance base of students and teachers since all teacher and students must check their ID Cards to get access to the class. Many institutions use RFID cards as ID cards for teachers and students and can integrate many functions such as access to campus and laboratories, security, library, parking, payment, and other functions [7]. The collected data can be downloaded or linked directly to other learning management platforms, such as LMS, MOOCs, etc. [8]. These platforms synchronize this data promptly to track and manage online learning. Therefore, learners can access their courses even outside of their classroom, stakeholders will have real-time access to the activities of students, administrators, and teachers. This will allow institutions to make decisions to improve the learning experience and student achievement [9].

This study focuses on the integration of IoT (Internet of Things) into contemporary educational systems, showcasing novel modes of interaction between students and educators within the context of a smart learning environment. Our proposed approach is based on a sophisticated IoT architecture, specifically addressing the Smart Evaluation: "exam management process from exam paper distribution to

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grading," and tackling the issues and challenges outlined in Section II. This architecture exhibits key attributes like reusability, interoperability, and high scalability. Noteworthy features that ought to be inherent in proposed IoT architectures encompass loose coupling, modularity, platform independence, and adherence to open standards. The architecture we present manages requirements, forming a comprehensive array of functionalities, structures, and mechanisms, designed to remain adaptable to evolving future needs.

Section III introduces a fresh paradigm of Smart Learning Environments (SLE-Model). This approach adopts micro-services to ensure the implementation of smart learning systems remains flexible, adaptable, extensible, and interoperable. Additionally, a global architecture rooted in micro-services is unveiled as an embodiment of our smart learning model, specifically the Smart Evaluation: "exam management process from exam paper distribution to grading," as elucidated in Section IV. Concluding our discourse, we furnish a case study that demonstrates the shift from conventional review practices to the utilization of our review process management system based on our approach. The primary objective of this case study is to substantiate the efficacy of our proposed methodology. In our conclusion, we synthesize the key points explored in our study, shedding light on the potential avenues for future research endeavors.

II. Literature Study

The availability and rapid development of new technologies are affecting the way traditional educational processes are designed. This has led to the introduction of several smart solutions in institutions to enhance the quality of life and enhance the performance of teachers and students.

Qureshi *et al*. proposes a secure Internet of School Supplies (S-IoST) system for smart schools based on a new advanced communication system integrated with 5G cellular systems, sensor technologies, intelligent transportation systems, and IoT networks [10]. The proposed system provides a safer alert mechanism and facilitates the users during school and commute. The proposed system was evaluated in terms of data transfer, time and response to alarm parameters.

Al-Turjman *et al*. proposed a new centralized routing and scheduling algorithm, and a new method evaluated through extensive simulations of the algorithm, the results showed that the approach works better than existing ones in terms of various quality of service (QoS) measures [11]. Villegas-Ch *et al*. highlighted the necessity of big data and how it can help to develop smart universities by providing an already deployed architecture, and in part aiding in data processing and analysis so that the needs of everyone can be identified, and services tailored to their needs [12]. Adebiyi *et al*. proposed a Radio Frequency Identification (RFID) card-based transportation solution, which turned out to be a suitable alternative and a better and more efficient ticket price payment method [13]. Du and Yu analyzed the benefits of using RFID technology to decentralize the use of blockchain to solve network security problems [14]. In a recent study based on an adaptive e-learning strategy for real-time detection of IoT botnet attacks, Shao et al. used real IoT traffic data, including benign traffic data and Mirai-infected botnet traffic data. The experimental findings demonstrate the significant success of the adaptive e-learning approach they proposed [15].

According to the review, RFID and IoT should be an important part of smart education that strongly supports smart education features. Technology-based learning enables better interaction between learners and teachers and offers better education that meets the expectations of learners and recruiters.

Chen and Huang [16] proposed an online teaching system that combines various applications of e-learning with IoT technology. They proposed a reference model to improve students' learning outcomes, but the experimental results show that after applying this online teaching system, the time required for students' English test scores is significantly higher than that of the traditional education system. Liu, Wang, and Xiao proposed another decision support system, which assumed the functions of test score collection, online teaching, and attendance management [17]. According to Vermesan *et al*. IoT can serve as the backbone of ubiquitous learning environments, enabling intelligent environments to recognize and identify objects and retrieve information from the Internet to facilitate their adaptive functions [18]. A recent study by Maatuk *et al*. identified the main issues and challenges of e-learning systems in public universities during the Covid-19 pandemic and examined teachers and students as the sample for this study [19]. The study shows encouraging results from the use of e-learning systems in higher education. A previous study by Hameed *et al*. analyzed the journeys of two groups of students taking the same course, one taught using traditional methods and the other using IoT-enabled interactive systems where they conducted various tests and analyses, finally, they concluded that IoT as technology can support the education process and improve student achievement [20].

Kumar and Al-Besher proposed a new method combining IoT and electroencephalography (EEG). The results show that the proposed method can be used to distinguish between the user's attentional state and the level required for teaching methods [21]. However, other technologies and other architectures based on IoT have been the subject of research, Batool *et al*. proposed a smart ecosystem model for smart cities using artificial neural networks [22]. Further research has also shown future perspectives on using artificial intelligence and emerging technologies in smart classrooms [23].

According to the literature, there are many IoT architectures and there is a huge demand for new models and concepts. With the development and current technology trends, a global IoT architecture for smart education is required, therefore, the goal is to design an IoT architecture that includes the solutions to various issues mentioned below.

The integration of Internet of Things (IoT) technology within the realm of education, particularly in the context of e-learning, presents opportunities for revolutionizing education through the concept of intelligent or "smart" education. The substantial data generated by IoT devices can be amassed, exchanged, and processed through advanced AI and analytics algorithms, ushering in novel avenues to enhance the learning experience. The convergence of IoT with cutting-edge technologies like Artificial Intelligence (AI), Big Data, and cloud computing holds the potential to reshape online learning, offering enhanced connectivity and the prospect of sophisticated virtual classrooms in the foreseeable future. This transformation necessitates the cultivation of fresh skills and teaching methodologies that effectively harness these technological advancements.

Most e-learning platforms furnish methodologies and tools to adeptly engage with learners, customizing content to cater to individual requirements. The adaptability of course materials for seamless integration and compatibility across various devices is a hallmark, rendering the content easily accessible from any connected device. This encompassing approach also encompasses the deployment of intelligent learning applications that grapple with substantial datasets sourced from IoT devices. As a result, educational institutions must upgrade their technological infrastructure to effectively manage the substantial volume of e-learning content produced by IoT devices.

Nevertheless, these endeavors encounter challenges in relation to the incorporation of IoT and Information and Communication Technology (ICT) within the domain of e-learning. A few of these challenges include:

- Integrating smart learning into existing learning systems.
- The integration of IoT into e-learning business processes.
- Addressing Heterogeneous Standards and Protocols for IoT Connectivity.
- Implementing an adaptable, scalable and interoperable architecture that supports connected devices in an intelligent learning environment and enables large amounts of data to be managed and analyzed.

Indeed, it is imperative to devise a smart educational model and execute it using a technical architecture tailored to this model. This approach aims to establish an e-learning environment capable of surmounting the challenges and issues tied to the utilization of IoT and ICT in such contexts. The objective is to enhance interoperability, adaptability, portability, and scalability within these learning environments, streamlining their development by integrating an intelligent layer into their operations.

III. Smart Learning Environments Model (SLE-Model)

The potential inherent of smart technologies, such as the Internet of Things (IoT), within the education sector lies in their capacity to dismantle barriers and amalgamate diverse technologies into streamlined and effective service units. Within this paradigm, we advocate for the complete automation of all facets tied to institutional education systems. To harness the full potential of IoT technology, educational institutions must integrate sensor-equipped devices with wireless communication capabilities. Illustrated in Fig. 1 are the distinct constituents of the proposed smart learning model. This model, founded on microservices, offers the capability to enhance prevailing frameworks while streamlining their expansion and evolution. It facilitates the incorporation of requisite functionalities, irrespective of the platform employed, to effectively realize the facets of intelligence within the instructional process in response to demand.

The outlined model conceptualizes smart learning environments as the foundational containers for core teaching functionalities, akin to a basic Learning Management System (LMS). This forms the basis to which intelligent microservices are incorporated to introduce novel intelligent capabilities into the learning process of both preexisting and emerging platforms. This approach ensures the adaptability, transferability, compatibility, and expandability of these solutions.

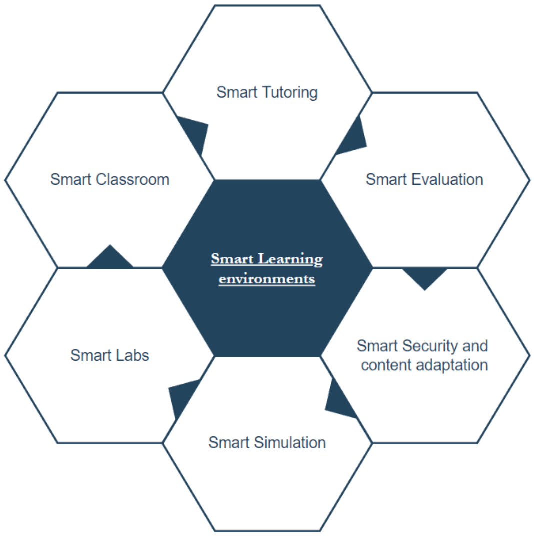

Fig. 1. Smart Learning Environment Model (SLE-Model).

In this proposition, every element and service within the smart education system is equipped with IoT chips (sensors) to detect and retain information concerning themselves and their surroundings. Central entities within this smart model encompass teachers, administrators, and students. Students and faculty utilize IoT-driven smart ID cards and wearable smart devices that continuously gather, transmit, and exchange information with controllers within the IoT system.

The Smart Learning Environment Model (SLE-Model) is engineered to furnish opportunities for intelligent learning environments, fostering the acquisition of tailored knowledge, self-directed learning, and self-assessment. Such an intelligent learning environment empowers learners to actively engage in the knowledge-building process, thereby nurturing their self-assurance. Through the integration of IoT, a smart learning environment facilitates real-time interactions between learners and tangible objects like smartphones, smart student cards, tablets, intelligent whiteboards, and digital textbooks. This transformative capability reshapes the conventional perception of educational institutions.

Smart education goes beyond traditional methods by giving students unlimited access to digital resources from anywhere. It is based on six complementary pillars, which are as follows.

A. *Smart Classroom*

IoT-based smart classrooms employ advanced technology like cameras, microphones, and sensors to create smart learning environments. These devices serve various purposes, including assessing student satisfaction, improving classroom management, and enhancing education overall. They allow teachers to better understand students' learning preferences [24]. One key advantage is the streamlined administrative tasks, such as attendance tracking, achieved through RFID tags on student ID cards or Near-Field Communication (NFC) technology on smartphones. Additionally, smart classrooms can collect real-time student feedback through reaction detection and monitoring [25].

The integration of IoT devices in education is a global trend, revolutionizing the way education and classroom management are approached. Common IoT devices in these settings include interactive whiteboards, tablets, 3D printers, student ID cards, security cameras, wireless door locks, room temperature sensors, and lighting controls.

B. Smart Labs

An IoT-supported lab leverages IoT technologies and mobile apps to improve laboratory experiences. Students can remotely interact with lab equipment like microscopes and oscilloscopes using IoT devices, thanks to a learning management system (LMS). They log in, choose experiments, and control equipment remotely.

IoT modules enable students to gather pre-experiment data and save it for future use. IoT also helps in defining scoring and evaluation criteria. After completing experiments or when the time's up, IoT sensor modules integrated with the LMS automatically assess student performance [26]. Data is stored on the LMS and reflected in student profiles, reducing administrative work for faculty members. This IoT integration streamlines the lab experience and boosts efficiency.

C. Smart Tutoring

Smart tutoring, or adaptive tutoring, utilizes AI and machine learning to customize and improve students' learning experiences by tailoring educational content to their specific needs. It aims to provide personalized instruction, feedback, and assistance. While it can enhance learning outcomes and accessibility, it cannot replace the role of qualified teachers and human interaction in education [27].

Smart tutoring should be seen as a supplementary tool for educators to offer personalized instruction. Ethical concerns, such as data privacy and responsible AI use, must be addressed when implementing smart tutoring solutions.

D. Smart Simulation

Smart simulation refers to the use of advanced technologies like AI, VR, AR, and computer simulations to create immersive and realistic learning or training scenarios. These simulations mimic real-world situations, providing hands-on experience without real-world risks [28].

Smart simulations are used in education, healthcare, military training, engineering, business, and entertainment. Examples include medical students practicing surgery in virtual environments and pilots using flight simulators [29]. While valuable, smart simulations work best when combined with traditional methods and guided by human facilitators or mentors. Ethical considerations, such as data privacy and responsible AI use, are crucial when implementing smart simulation solutions.

E. Smart Evaluation

Smart Evaluation is an innovative approach that employs cutting-edge technologies such as Artificial Intelligence (AI), machine learning, and data analytics to assess learning outcomes effectively. It utilizes IoT devices, including wearable sensors and connected learning environments, to gather data on student activities and interactions with educational resources. This data is analyzed using AI and data analysis techniques to provide personalized feedback to both students and teachers [30].

The benefits of Smart Evaluation include real-time data collection, continuous assessment opportunities, and the ability to conduct large-scale data analysis for enhanced assessment efficiency.

F. Smart Security and Content Adaptation

Smart security and content adaptability use advanced technologies like AI and IoT to enhance digital content security and personalize user experiences. Smart security detects and prevents online threats, while content adaptation customizes content based on user preferences, devices, and capabilities. These approaches enable secure and personalized content delivery across platforms [31].

In education, IoT and AI help ensure data and content security. Security concerns span digital access, including exams, reports, content, and physical security like door locks. Wireless networks and IoT are prevalent in smart educational environments, emphasizing security's importance [32]. IoT provides wireless data security through automation, enhancing reliability and privacy across the education system.

IV. The Proposed Architecture

A. The Overall Structure of the IoT Architecture

The global structure of our IoT architecture is based on the ISO/IEC 30141:2018, This standard serves as a basis for the development and design of our context-specific architecture illustrated in Fig. 2, which includes an Infrastructure Layer, a Smart Learning Layer, and an Application Service Layer.

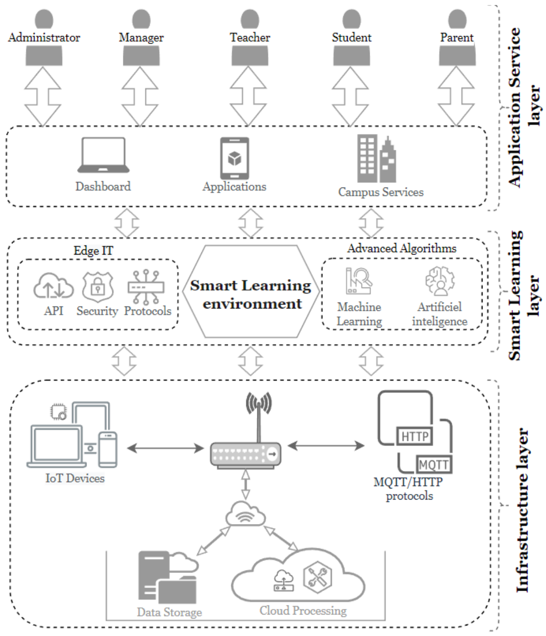

Fig. 2. The overall structure of the IoT architecture.

The Infrastructure Layer of the architecture integrates storage and Cloud components, network configurations and devices. it integrates all these configurations into a stable and unified IoT environment through virtual software and hardware technology. This layer supports integrated transmission across several devices using the Internet, wireless, RFID, etc. These technologies facilitate asset management, student, staff, and faculty attendance, transportation, and tracking, and ensure the safety of students, teachers and staff on campus.

The Smart learning layer encompasses smart learning environments such as the Learning Management System that utilizes technologies like artificial intelligence, Big Data, machine learning, etc. It enables the creation of personalized analyses using intuitive spatial modeling to generate powerful and iterative insights. Furthermore, through an Application Programming Interface (API), users can integrate data from multiple educational systems, thus facilitating the exchange and processing of data. This layer also allows real-time visualization of information from connected devices, thereby providing powerful and up-to-date real-time reports. Table 1 provides more details on various aspects of this layer.

The Application Service Layer communicates through the API of the smart learning layer, which acts as an interface for communication between various applications. This layer contains the business logic that supports the core functionalities of intelligent educational applications. It can be hosted in the cloud based on the specific needs of the educational applications.

Once IoT technology is deployed, students and teachers (users) send service requests through the application service layer. These requests can combine data from smart objects in cloud services with other sources of information. The data can be exported, analyzed, and transmitted to other services for validation and processing. The necessary resources are then sent to the user interface for display after data exploration.

Table 1. Aspect for the smart learning layer

N	Aspect	Description
1	Interoperability	Provides interoperability between protocols and standards, enabling shared learning that can be used with learning management systems (LMS).
2	Performance	• Provide personalized feedback or guidance. • Provide cross-situational learning guidance or support. • Advance support for learners in real and virtual environments.
3	Discoverability	Discover and explore relevant published smart learning content.
4	Extensibility	Allows you to create new types of learning content using existing content.
5	Scalability	Provide the ability to handle many concurrent requests for learning content.
6	Learning Analytics	The analyzed data can be used to improve course content, measure success rates, and create better training programs.

Compared to the traditional architecture in the field of education, the proposed architecture offers numerous advantages. It incorporates smart educational systems and provides a high degree of reusability, leading to various benefits, including accessibility, reusability, integration, redundancy avoidance, sharing of services and information, interoperability, and scalability.

B. *Cloud and Network Architecture*

The key characteristics of IoT architecture according to ISO standards (ISO/IEC 15416:2016) are data manning, communication, integration and interoperability, as well as security and privacy. Since the IoT generates immense data and Cloud services manage the traffic of this data, the use of the Cloud in IoT infrastructure adds value to institutions by allowing them to realize savings to reduce their overall cost structure.

Serval IoT technologies such as Cloud, Big Data and AI are used for different applications thanks to a wireless communication system which can be a chip RFID, Bluetooth, or Wi-Fi. These communication standards (IP address, SMTP protocols, HTTP...) allow devices to exchange data over a network., enabling network connectivity and application coupling.

From a cloud and network perspective, IoT architecture follows a 3-layer approach. The characteristics of the proposed architecture shown in Fig. 3 are as follows:

- Exposing Data to the Cloud Layer
- Regrouping Models and Business Data layer
- Business Apps and Dashboard layer

The architecture provides flexibility in terms of composability and scalability to support various technology choices dictated by specific requirements.

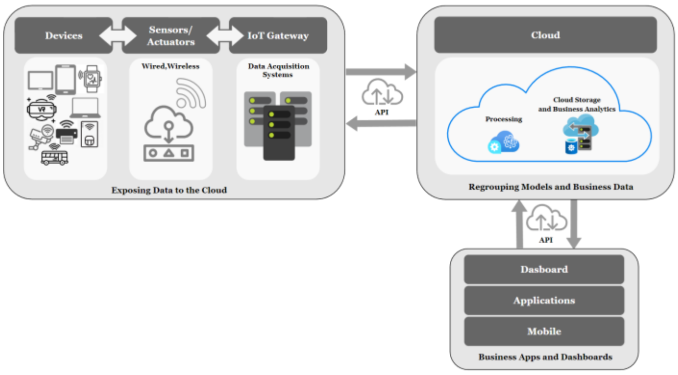

Fig. 3. Overall network-cloud architecture.

Exposing Data to the Cloud Layer establishes a link between the physical and virtual worlds, utilizing various devices and communication technologies. Sensors and actuators record and control relevant aspects of the physical world. These sensors, operating on smart devices like mobile phones, gateways, and dedicated servers, gather real-time data that is subsequently stored in the cloud.

Regrouping Models and Business Data Layer facilitate data and service access by exposing the data to the cloud layer. At times, the data may exist in raw format without common abstraction, especially when different technologies and devices are in use. The data is then structured and analyzed using machine learning and artificial intelligence algorithms. The Learning Management System (LMS) platform manages the entirety of campus information systems.

The Business Apps and Dashboard Layer are where end users interact with the applications. These applications primarily access the clustering models and the business layer, enabling various campus information systems to securely access real-time data, and assisting users in carrying out their respective tasks. Users directly interact with the applications and can obtain required information and insights via primary-level IoT devices.

Through this IoT connectivity architecture, a wide range of interoperable ecosystems can be developed and optimized, offering benefits such as scalability, security, data management, and analytical support. The connection between these different layers occurs through secure interfaces that enable applications and services to exchange data and functionality. APIs provide numerous possibilities, including data portability and system interoperability.

The IoT connectivity model shown in Fig. 4 is based on data flow and can simply be modeled in three steps: creating, transferring and using data. This can be done through a simple system that requires the user to interact directly with the device, such as interacting with a laptop via an app on a smart device.

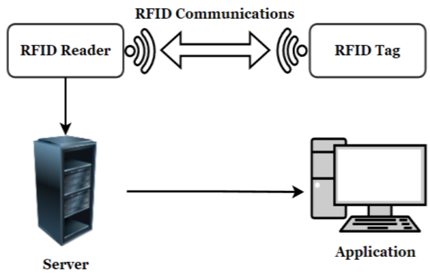

Fig. 4. RFID working principle.

The network is used and handled by various applications and is backed by a variety of communication technologies like RFID, Cellular (5G), Zigbee, NFC, Z-Wave, Bluetooth, Wireless Fidelity (Wi-Fi), and Ethernet.

Among all the technologies mentioned in this section, we chose RFID technology because of its reasonable cost and many positive properties as shown in Table 2.

Table 2. Comparison between RFID, Zigbee, NFC, and Bluetooth

Specification	RFID	Zigbee	NFC	Bluetooth
Network type	Point-to-point	WPANs	Point-to-point	WPANs
Communication	Unidirectional	Bidirectional	Bidirectional	Bidirectional
Security	Hardware & protocol level	Protocol level	Hardware & protocol level	Protocol level
Range	Up to 100 m	Up to 75 m	~0.4 m	~50 m
Frequency	LF / HF / UHF / Microwave	HF / UHF	HF	HF / UHF
Bit rate	Varies with frequency	Up to 250 kb/s	Up to 424 kb/s	2.1 Mbit/s
Set-up time	~0.1 s	~0.1 s	~0.1 s	~6 s
Power consumption	Varies with frequency	Varies with band	Low	Varies with class
Cost of devices	High / Low	Low	Low	High
Continuous sampling	No	Yes	Yes	Yes
Interoperability	Different devices	Same devices	NFC compatible devices	Bluetooth compatible devices

Note. UHF (Ultra High Frequency), HF (High Frequency), LF (Low Frequency).

Sensors and actuators work in tandem to convert energy into electrical data, the sensor provides a signal, and the actuator adjusts according to this signal. All this data from devices and sensors activities are stored in the cloud.

C. *Functional Structure of the IoT System*

In our proposed approach, we focus on the process of taking and managing exams, as well as automatically correcting exam papers and reporting results in real-time. The user interface and interoperability between e-learning systems and cloud services are the three main components of this approach. In the User Interface, students and their teachers interact using IoT devices. Students using smart cards can check their status and progress at any time, as well as their absences, tuition payments, etc. The smart cards also give them secure access across campus and allow administrators, teachers and parents to remotely track and monitor their students anytime, anywhere.

Interoperability between IoT devices is a significant challenge. IoT devices gather data from multiple information systems. Data analysis yields meaningful insights from this raw data, facilitating savings, enhancement, and acceleration of decision-making. Campus information systems need to comply with the latest online learning protocols and standards like SCORM, xAPI, Cmi5, etc. [33]. This fosters interaction among systems for more meaningful and cost-effective deployments, as well as efficient analysis of data collected by IoT devices. The proposed IoT architecture is illustrated in Fig. 2.

Various entities involved in educational systems are integrated with sensors that store information about these entities and their environment. Administrators can extract pertinent information using diverse data preprocessing techniques. They are connected to the IoT system, which guides them in executing user-requested actions. Furthermore, system administrators can employ context-adaptive AI algorithms to adapt and improvise as needed. Fig. 5 outlines how the proposed architecture works.

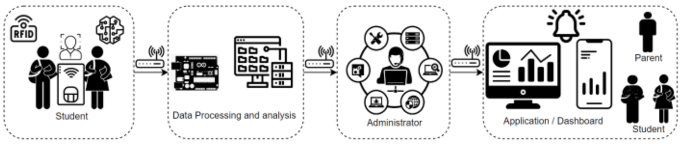

Fig. 5. Functional structure of the IoT system.

The overall architecture of our proposed System consists of two main phases:

- Online Exam Management

- Automated Correction of Exam Papers (MCQs)

1) Online exam management

Our overall architecture for the proposed "Online Exam Management" consists of three main stages: Exam Success Detection, Real-Time Notification, and Decision Making. During the Detection phase, the system gathers information about learners and compares it to various relevant student data for decision-making. Subsequently, the system instantly informs the school management and parents about the student's situation without teacher intervention. In the final stage, if the student is permitted to take the exam, the system grants access to the classroom and allows them to take the exam only if their facial capture is recognized by the system. Otherwise, if identity fraud is detected, the system immediately alerts the management and parents (manual authentication can be performed if system anomalies are detected).

The IoT Exam Management System employs an Ultra-High Frequency (UHF) reader with a range of 6 meters and a passive RFID tag attached to the student's card. The UHF reader first detects the student's signal, and then transmits it to the web server via the ARDUINO card to verify the student's file. If our system subsequently detects a student being absent during an exam, real-time notifications are sent to parents via email or SMS, and the system can automatically reschedule tutoring sessions.

Fig. 6 presents and summarizes the core exam management process, highlighting the key steps. To prevent instances of fraud, such as students lending their ID cards or others enrolling in place of students, identity detection sensors have been added to identify present students in class and compare them against the registered students in our system.

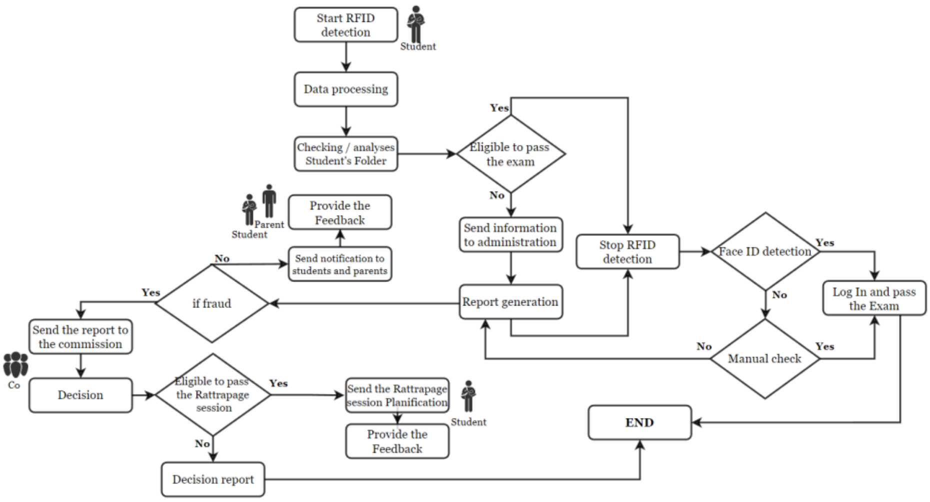

Fig. 6. Schematic diagram of the online exam management.

2) Automatic correction of exam papers (MCQs)

The overall architecture of our "Automatic correction of exam papers (MCQs)" system is presented in Fig. 7. It comprises the following steps: exam and answer sheet upload into the online learning system, real-time automated grading, and real-time result display. During the exam and answer sheet upload phase, teachers have the ability to create exams and their corresponding answer keys, while students are directly assigned to exams after being verified by the administrator. Exam paper printing is done automatically and anonymously, generating an identical QR code for each copy of each student.

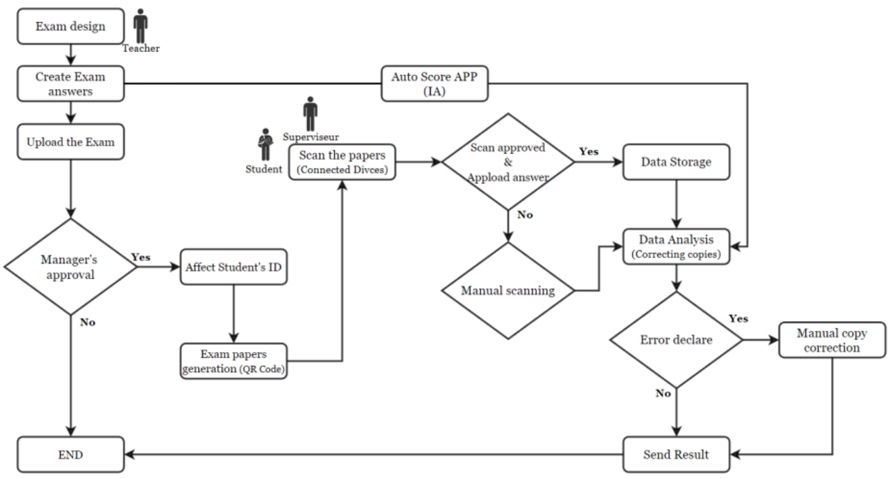

Fig. 7. Schematic diagram of automated correction of exam papers.

The real-time automated grading occurs after the exam concludes. Any connected device equipped with a camera can scan the answer sheets at any time. If no issues are detected during the scan, the application proceeds to automatically grade using advanced AI algorithms. If any potential issues are detected, manual grading of the answer sheet is conducted. In the final phase, teachers, students, and parents can immediately access the results without teacher intervention. The results are displayed clearly and made accessible to all relevant users.

This architecture enables swift and accurate grading of MCQ exam papers, providing immediate feedback to students and facilitating progress tracking by teachers and parents.

D. Implementation

In this section, we present a concrete example of Python code used to develop a specific service within our process, namely, Exam papers generation with QR Code. This service is broken down into four essential steps. First, we establish the working environment by installing the necessary dependencies, including Python libraries and modules (Script 1). Second, we focus on authentication and communication with the LMS API, ensuring a secure connection and data exchange (Script 2). Third, we retrieve course-related information, identifying and gathering details such as course names and schedules (Script 3). Finally, in the fourth step, our service generates and prints customized answer sheets for multiple-choice questions (QCMs) in each course, complete with QR codes for easy identification (Scripts 4 and 5). This comprehensive approach streamlines the distribution process, enhancing organization and efficiency within our broader workflow.

Script 1: Dependencies installation script

```
```bash
$ pip install requests reportlab qrcode [pil]
```
```

Script 2: Authentication script and communication with LMS API

Algorithm:

```
# Questions answer document
```python
import requests
import qrcode
from PIL import Image
from reportlab.lib.pagesizes import A4
from reportlab.pdfgen import canvas
# Set your LMS API credentials and course ID
CLIENT_ID = 'YOUR_CLIENT_ID'
CLIENT_SECRET = 'YOUR_CLIENT_SECRET'
BASE_URL = 'https://univ.instructure.com/api/v1'
# Authenticate and get an access token
auth_url = f'{BASE_URL}/oauth2/token'
auth_data = {
   'client_id': CLIENT_ID,
   'client_secret': CLIENT_SECRET,
   'grant_type': 'client_credentials',}
response = requests.post(auth_url, data=auth_data)
access_token = response.json().get('access_token')
```

Script 3: Course recovery script

Algorithm:

```
# Set the headers for API requests
headers = {
   'Authorization': f'Bearer {access_token}',}
# Make the API request to get the list of courses
courses_url = f'{BASE_URL}/courses'
response = requests.get(courses_url, headers=headers, params=params)
```

Script 4: Script for Exam papers generation for the different MCQs of the course.

Algorithm:

```
# Check if the request was successful
if response.status_code == 200:
   courses = response.json()
   # Print the list of courses
   for course in courses:
      course_id = course['id']
      course_name = course['name']
      # Get the list of students
      course_users_url =
       f'{BASE_URL}/courses/{course_id}/students'
     students = requests.get(courses_url, headers=headers,
       params=params)
      # Fetch questions from LMS
     questions_url = f'{BASE_URL}/courses/{course_id}/quizzes'
      headers = {'Authorization': f'Bearer {access_token}'}
     response = requests.get(questions_url, headers=headers)
     quizzes = response.json()
```

Script 5: Script for Exam papers generation with QR Code.

Algorithm:

```
# Print questions, answers, and QR codes to PDF
for quiz in quizzes:
   quiz_id = quiz['id']
   quiz_title = quiz['title']
   # Create a PDF document
   pdf_filename = f'{course_name}/{quiz_id}/{student_id}
    _questions.pdf'
   c = canvas.Canvas(pdf_filename, pagesize=A4)
   c.setFont("Times-Roman", 12)
      for student in students:
         student_id = student['id']
         student_name = student['name']
         # Get Student Location
         course_users_url =
          f'{BASE_URL}/courses/{course_id}/quizzes/{quiz_id}/locations
          /{student_id}'
          student_location = requests.get(courses_url, headers=headers,
          params=params)
         # location = f'{room} > {sit_location}'
         c.drawString(50, 700, f'Location: {student_location}')
         c.drawString(50, 725, f'Student: {student_name}')
         c.drawString(50, 750, f'Quiz: {quiz_title}')
         questions_url =
          f'{BASE_URL}/quizzes/{quiz_id}/questions?per_page=100'
          response = requests.get(questions_url, headers=headers)
          questions = response.json()
      y_position = 770
      for question in questions:
           question_text = question['question_text']
           answers = question['answers']
           c.drawString(50, y_position, f'Question: {question_text}')
           y_position -= 20
           for answer in answers:
               answer_text = answer['text']
               is_correct = "Correct" if answer['weight'] > 0 else
                  "Incorrect"
              c.drawString(70, y_position, f'- {answer_text}
               ({is_correct})')
          y_position -= 15
              # Generate and insert QR code for student ID
                 qr = qrcode.QRCode(
                   version=1,
                   error_correction=qrcode.constants.ERROR_CORREC
                   T_L,
                    box_size=10,
                    border=4,  )
                 qr.add_data(student_id)
                 qr.make(fit=True)
                 qr_img = qr.make_image(fill_color="black",
                back_color="white")
                 qr_img.save("temp_qr.png")
                 qr_image = Image.open("temp_qr.png")
                 qr_image = qr_image.resize((50, 50),
```
```

```
                    Image.ANTIALIAS)
                    c.drawImage(qr_image, 200, y_position + 5, width=50,
                        height=50)
                y_position -= 10
            # Save the PDF document
            c.save()

        print(f'Course ID: {course_id}, Course Name: {course_name}')
    else:
        raise Exception(f'Error: Unable to fetch courses. Status code:
        {response.status_code}')
```

In summary, our service relies on these four fundamental steps to ensure the efficient distribution of answer sheets for exams with QR codes, providing an integrated and automated solution within our overall process.

V. Results and Discussions

In this section, we will present the results of the evaluation, and explain our experience and our evaluation method from different aspects. We conducted a comparative study between two classes of students when taking the exams. One class used traditional methods for classroom exams, while the other class used IoT technologies to take the exams online, with auto-correction. The participants in this study were students of the same level of education and from the same institution. Class A, also known as the experimental group, consisted of 25 students who used traditional methods for exams. Class B, also known as the control group, consisted of 22 students who used IoT technologies to take the exams online.

The conditions were equivalent between the two grades, except for the method of taking the exams. The measurements were made over one week during the first phase of the study. To compare the differences between the two independent groups (experimental group and control group), we used the Mann-Whitney U test. This nonparametric test is appropriate for comparing the distributions of two groups when data are not normally distributed, or samples are not matched.

Using the Mann-Whitney U test, we assessed the performance of both groups when taking the exams. The results of this test will allow us to determine whether the performance of students in the group using IoT technologies differs significantly from that of the group using traditional methods.

We will present the results of this assessment in the next section, highlighting the significant differences between the two groups and providing an interpretation of the results obtained.

A. *The Mann–Whitney U Test*

The Mann–Whitney U test is a nonparametric statistical test used to compare the distributions of two independent samples. It is used to compares the ranks of observations in the two samples to determine if there is a significant difference between the two groups. The test evaluates whether the distributions of the two groups are stochastically different or whether they differ systematically in their position in the distribution.

It should be noted that the interpretation of the results will depend on the p-value associated with the U statistic and the level of significance chosen. If the p-value is below the significance level (for example, $p < 0.05$), it can be concluded that there is a significant difference between the groups.

B. *Ethical Considerations*

Our comparative study between the two student groups during the examination process was underpinned by rigorous ethical considerations. Here are the key measures we took to ensure the ethical integrity of the study:

- *Informed Consent:* We prioritized obtaining informed consent from all participants, including students, teachers, and parents/legal guardians. We offered them a comprehensive understanding of the study's objectives, procedures, and potential risks, underscoring their right to withdraw from the study at any point.
- *Confidentiality and Anonymity:* Data confidentiality was paramount. We ensured the privacy of participants by employing unique identifiers and implementing stringent security measures to prevent the unauthorized access of personal information.
- *Equity and Impartiality:* Our approach upheld fairness for all participants. We ensured equal opportunities and eradicated any potential discrimination, ensuring a level playing field in the implementation of examination methods.
- *Conflict of Interest:* To maintain the study's credibility, we were transparent about any possible conflicts of interest that could have influenced the study's outcomes or interpretation.
- *Reporting of Results:* Our reporting was characterized by clarity, accuracy, and transparency. We refrained from embellishing or distorting data, providing an equitable representation of the study's strengths and limitations to support a well-rounded interpretation.

By adhering to these ethical benchmarks, we ensured that our comparative study was executed with the highest ethical standards, upholding the rights and welfare of all participants involved.

C. *Data Presentation and Analysis*

In this section, we will present the results of the evaluation, explaining our experience and evaluation method from different aspects. The key elements we assessed included:

- *Exam scores*: We compared the average scores of the two groups to assess academic performance. This allows us to determine whether the use of IoT technologies has an impact on exam scores compared to traditional methods. We analyzed the results using appropriate statistical tests to assess the significance of the observed differences.
- *Correction time:* We also compared average correction times between the two groups. Using IoT technologies for auto-marking can potentially reduce the time it takes to mark exam papers. We measured and compared these correction times to determine if IoT technologies offer increased efficiency compared to traditional methods.

We assessed academic performance, correction times and student satisfaction to compare the two groups as part of our study. These elements allow us to evaluate the effectiveness of IoT technologies compared to traditional methods and provide useful information for making informed decisions about the use of these technologies in school exams.

H1: *It is assumed that using IoT technologies improves students' performance on exams compared to traditional methods.*

Variable of interest: Exam scores

Collecting data for each class, we recorded students' exam scores.

- Group A: [80, 85, 70, 65, 90, 75, 85, 78, 82, 76, 88, 70, 92, 80, 85, 78, 80, 75, 90, 82, 86, 68, 72, 80, 84]
- Group B: [88, 92, 85, 90, 94, 85, 78, 82, 88, 90, 95, 82, 86, 90, 88, 92, 85, 90, 94, 85, 80, 78]

The use of the Mann-Whitney U test to compare the distributions of test scores between the two groups.

Hypothetical results

- Statistics U observed (Uobs): **115**
- Critical value U (Ucrit): **275**
- Z-Score is **-3.4**
- P-value associated with Uobs (p): **0.00034**

Given that the p-value (0.00034) is lower than the significance level of 0.05, it can be concluded that the exam scores in the group using IoT technologies are significantly different from those in the group using traditional methods. Therefore, the use of IoT technologies seems to have a positive impact on students' performance in exams.

H2: *It is assumed that using IoT technologies for correction exam papers improves efficiency and accuracy compared to traditional methods.*

Variable of interest: Exam paper correction time

The data collection for each class, we recorded the correction time of the exam papers for each student.

- Group A: [15, 20, 18, 25, 17, 22, 19, 20, 23, 24, 21, 16, 19, 20, 18, 21, 22, 23, 19, 18, 16, 24, 25, 22, 21]
- Group B: [10, 12, 11, 13, 14, 15, 12, 11, 10, 14, 13, 12, 16, 15, 13, 12, 11, 10, 14, 13, 12, 16]

The use of the Mann-Whitney U test to compare the distributions of copy correction times between the two groups.

Hypothetical results:

- Statistics U observed (Uobs): **5**
- Critical value U (Ucrit): **275**
- Z-Score is **5.75**
- P-value associated with Uobs (p): **0.00001**

Given that the p-value (0.00001) is lower than the significance level of 0.05, it can be concluded that the exam paper correction times in the IoT group are significantly different from those in the traditional methods group. IoT technologies therefore seem to allow faster correction of exam papers compared to traditional methods.

D. Discussion

The results of the comparative study indicate that the test statistics, U Obtained, for each variable are greater than the Critical U-value, for a significance level of $p < 0.05$. These results are therefore statistically significant at the 95% confidence level. This allows us to conclude that the use of IoT technologies in exam taking, and automatic correction has been more effective than traditional methods.

By analyzing exam scores, we observed a significant improvement in the academic performance of students who used IoT technologies compared to those who followed traditional methods. In addition, the time required to mark exam papers has been significantly reduced thanks to automatic correction facilitated by IoT technologies.

In summary, the results of the study demonstrate that the integration of IoT technologies in exam delivery offers significant benefits in terms of academic performance, correction efficiency, fraud detection and security. These findings suggest that the use of IoT technologies can improve the exam experience for students and teachers while preserving the integrity of the assessment process.

E. Study Limitations

Several potential limitations should be acknowledged in our comparative study, which assesses the effectiveness of traditional methods versus IoT technologies for automated exam correction and fraud detection among student groups. The following limitations warrant consideration:

- *Uncontrolled Confounders:* There exist external factors, such as instructional quality, student motivation, and prior technology exposure, that could potentially sway student performance. Managing and isolating these variables to ascertain the exclusive impact of IoT technologies on exam outcomes can be complex.
- *Initial Learning Effect:* The integration of IoT technologies may necessitate an adjustment period for students. Consequently, their initial performance may not wholly reflect the full potential of IoT technologies, which may become more apparent after prolonged exposure and familiarity.
- *Technical Limitations:* Technical glitches, such as network disruptions, connectivity complications, or hardware malfunctions, may be experienced with IoT technologies. These technical hurdles could influence on the study's findings.

Recognizing these limitations in our study is crucial. It helps prevent an overestimation of the impact of IoT technologies and provides valuable insights for future research. Additionally, acknowledging these limitations allows us to offer recommendations to address these challenges.

VI. Conclusion

In conclusion, the development of an online exam management system that seamlessly integrates with online learning platforms marks a pivotal stride in automating and enhancing the student assessment process. Leveraging scalable modules, we can adeptly administer online exams and automate paper grading, this endeavor not only conserves time and resources for educators but also ensures an impartial and consistent evaluation of students' performance.

It remains imperative to fashion an adaptable system capable of harmonizing with diverse target environments, thus catering to the distinct requirements of each online learning platform. In devising these modules, we have erected a robust infrastructure grounded in microservices, adept at orchestrating exams efficiently and securely. Ultimately, this online exam management system will catalyze the refinement of assessment efficacy and equity. Simultaneously, it will furnish educators and administrators with invaluable insights to gauge student progress and make informed educational decisions.

Future work proposes combining artificial intelligence technology and data mining techniques with advanced algorithmic recognition and analysis objects to provide a secure interconnected framework. These smart algorithms allow us to detect fraud cases by comparing the similarity of the answers and analyzing the results obtained to determine if it is a fraud. We can even simplify the search for cheating based on predefined criteria, for example, considering a student's location to determine whether a student is cheating nearby (Classroom) or via a smart device using a social network. These detection algorithms are still in the early stages of development and offer promising metrics for overcoming this hurdle.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

R.D. and A.B. have played a crucial role in formulating and shaping the final draft, as well as overseeing the study's progress. M.T. and R.D. have contributed valuable perspectives to the theoretical framework and upheld the data's integrity in this study. The ultimate approval of the final work was granted by M.T., R.D., and A.B. All authors had approved the final version.

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