# An IoT Enabled Cloud Based Virtual Classroom Assisted e-Learning System



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## Abstract

The evolution of global Internet in recent times has led to the emergence of a more convenient method of global data communication called the Internet of Things (IoT) that could practically enable communications among various smart devices in a secured manner independent of any human interventions. Applications of this innovative global communication have been extended to all the fields of applications, and in particular, IoT is being successfully applied to improve the processes related to the area of education in recent times, has virtually led to various novel approaches in teaching and learning at all levels of education. Several applications, as well as learning tools, are successfully devised by multiple researchers and scientists for innovations to be incorporated into the field of education, teaching, and learning process, to be more specific. Many research contributions have been brought into the existing global Internet relating to IoT-based e-learning approaches. Flip classrooms, along with the concepts of flip learning and gamification, etc., are being implemented by various authors in devising e-learning systems making use of IoT systems and the necessity for its tools.

**Keywords:** IoT; e-Learning systems; IoT Security; Cloud; Flip Learning; Flipped Classrooms; Gamification

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## 1. Introduction

The existing Internet is supposed today to be one of the most convenient approaches to worldwide communication among different people in the world as of today. However, the biggest limitation in such communication using the services of the global Internet is that in its present form, it supports only human-to-human communications, and communications among various devices could be achieved only under human interventions. Further, innovations incorporated into the global Internet have successfully led to an approach by which several devices could communicate among themselves without the help of any interventions carried out by a human. It has led to a novel approach to communication, popularly called as "Internet of Things (IoT)," that could virtually enable machine-to-machine (M2M) or device -to-device (D2D) Communications successfully and in a very much secured fashion. IoT is nothing but a further proliferation brought into the existing conventional worldwide Internet communication technology only. Nonetheless, it is associated with a wide range of issues and challenges affecting its effective implementation in real-life practices [1]. As per the view of various experts in the field of Internet, the amount of wireless-connected smart and mobile devices on IoT may rise to a few billion by the year 2025, consequently referring to the increasing popularity as well as the diversity in worldwide communication this novel communication method is capable of providing. Applications of IoT in practically all the fields of human society tend to rise every day. Today, IoT-based applications are effectively implemented in most industries such as healthcare, agriculture, human welfare, education, and various other real-life fields [2, 3]. Further extension of the domain of applications of IoT needs a proper understanding of the underlying features, specific characteristics, and motivations for innovations within a particular area of its application. As claimed by the authors in [4], it is important to effectively devise prototype systems to implement IoT technology-based systems for any specific application area.

As far as the successful implementation of IoT in education is concerned, for practical refinement of teaching and learning processes, a student must be capable of understanding various characteristics of an IoT-facilitated prototype system before proceeding toward its real-life implementation. For developing an IoT-based prototype education system, necessary sensors must be deployed to capture relevant data. Relevant programs need to be designed in order to process the captured thereby data. A relevant IoT communication protocol must be chosen for communicating the processed data to an IoT gateway, and finally, the data can be delivered to the cloud environment. A strong motivation for self-learning of IoT-based prototype systems needs to be created. The student can be capable of devising the critical IoT prototype systems, thereby being able to implement the developed thus prototype system autonomously. A student can be able to do so by making use of a “problem-based learning approach”. To explore new choices for refinement of the conventional learning and teaching approaches, in this research work, we mainly aim at the extensively detailed aspects related to the e-learning strategies making use of all the diversified, innovative services as catered to by the IoT technology as a whole.

The remaining part of this paper has been structured as follows. The system architecture of IoT is detailed comprehensively in Section 2. Section 3 comprises various security-related issues and challenges specific to IoT-based systems. IoT-supported e-learning systems and multiple aspects of it are clearly explained in Section4. Section 5 includes the proposed in this paper e-learning model and its elaboration. In Section 6, we conclude the paper by suggesting possible extensions to the proposed e-learning system.

## 2. IoT System Architecture

The term “Things” in IoT necessarily refers to all those devices, which consequently reveal the aspect of “device-to-device communication (D2D communication)” in IoT. It incorporates many mobile, smart hand-held devices operating in a wireless channel, as shown in Fig.1. Each wireless device is supposed to be connected to the global Internet via a radio-frequency-driven channel. Hence, every such device here is allocated with a “Radio-Frequency Identifier (RFID)” for its unique identification across the underlying network. The IoT protocol stack has been split into a few variations. Very much in the beginning, when IoT was innovated, it used to operate with a three-layer protocol stack that comprised of “physical layer” or “perception layer,” “network layer,” and “application layer.” Afterward, it was further modified to a four-layer protocol stack comprising of “physical layer” or “perception layer,” “network layer”, “transport layer,” and “application layer.” As of now, the IoT protocol architecture implements a five-layer architecture that comprises “physical” or “perception,” “network,” “transport,” “application,” and “business” layers. In all three versions, the physical layer implements physical sensors to sense the desired data in the surrounding environment, actuators for executing the necessary actions as and when necessary, and various wearable devices for recording human-specific information. Further, the network layer functions upon the wireless platforms, particularly IEEE 802.15.4. It presumably relies on network routing protocols, namely, “Routing Protocol for Low Power Lossy Networks (RPL)” and “IPV6 over Low-Power Wireless Personal Area Network (6LoWPAN)” and a few other network routing protocols for data transmission along with provisioning of the desired level of data security. The application layer here incorporates IoT-supported various communication protocols, namely, “Extensive Messaging and Presence Protocol (XMPP),” “Constrained Application Protocol (CoAP),” “Advanced Message Queuing Protocol (AMQP),” “Representational State Transfer (RESTFUL),” “Message Queue Telemetry Transport (MQTT)” and a few other IoT communication protocols.

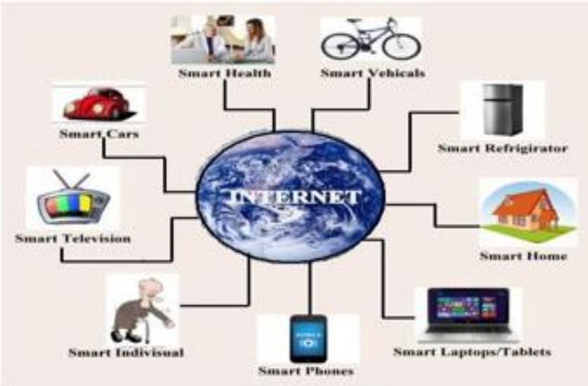


**Fig.1:** IoT Architecture

## 3. IoT Security Issues and Challenges

The IoT environment comprising various heterogeneous wireless smart mobile devices is supposed to be extremely vulnerable to a wide range of external and internal attacks coming from internal and external malicious nodes. Thus, a variety of issues along with a set of challenges have been identified, which may lead to the disruption of communication across IoT-based systems [5]. As claimed by the authors in [6], security issues about the perception layer represent "malicious node attack," "node capture", "replay attack," and "distributed denial of service (DDoS) attack". Several issues affecting the network layer represent the issues related to the network scalability, heterogeneity of devices in the network, and data revelations. Further, the issues related to the application layer mainly refer to node identification, mutual authentication, data management, data privacy, and specific other vulnerabilities related to the particular underlying IoT application.

## 4. IoT Based e-Learning Systems

Nowadays, professionals working in various fields and performing their relevant job may be required to improve their existing professional skills to proliferate further, thereby advancing their professional careers. Nevertheless, it is difficult for them to participate in the conventional classroom learning processes. Hence, online learning is supposed to be one of the most convenient methods for them the advancement of their respective professional career. However, students continuing their education in various disciplines can also usefully avail the services extended by different online platforms specifically meant to improve their domain knowledge in any specific course. There is a wide spectrum of online learning websites which make available online teaching courses and training for various professionals as well as students.

Nonetheless, such online platforms, commonly known as e-learning systems, can also be further enhanced by using the innovative services offered by IoT. These days, ample research papers and reports are accessible from the online literature in the context of e-learning systems that are necessarily integrated with IoT technology. Here, we cover a few of such proposed in the literature on e-learning systems.



### *4.1 A Data Mining Approach to IoT in Education*

The authors in [7] have proposed a quality-centric and quantitative e-learning system based on IoT. In this work, the aspirated data sets are time-stamped to support the required level of completeness and accuracy by using the sensors. Further, they are presumably analyzed using the R programming language that produces the desired reports. The data collection relates here to brain signals, eye movement, heart bit rates, etc. It is worth observing that data samples aggregated by IoT devices will hopefully perceive the students in making out the IoT devices' utility. A questionnaire set is prepared for collecting data in specific time intervals or chunks. The user is allowed to respond only in those intervals rather than till the expiry of the session. To establish a correlation among the collected data using IoT-supported devices and the questionnaire, the authors use OSS (Open-Source Software). Authors affirm that the sensor data model can necessarily increase the grasping by the students, and in case a significant number of students do not make out. The respective teacher needs to be required to modify the contents.

### *4.2 A Flip Learning Using IoT*

IoT F LiP, a flip learning platform developed specifically for the medical students that is based on IoT technology, is suggested by the authors in [8]. A 8-layer Flip learning platform has been exhibited by the authors with the detailed functionality of each layer. Two separate blocks have been derived from the above cited 8 layers. Here, the first block consists of four layers namely Data Aggregation, data perception and preprocessing, Access Technologies and Local Security layers. In the second block Presentation, Application, Cloud Security and Business layers are arranged. A dialogue based "Case-Based Flip Learning Tool (ICBFLT)" and an underlying flowchart describing the functions provided by the tool is also introduced by the authors. This tool is expected to prepare a summary of all the cases pertaining to "Case Based Learning (CBL)" along with the involvement of the medical experts and students. By the use of virtual patients this tool tends to enable the students in grasping the services extended by case-based learning. Three users for ICBFLT are defined by the writers namely Student, Expert and Administrator. The job of the Administrator is to manage the courses and the associated modules. The Expert manages all the cases pertaining to the CBL and the solutions to the corresponding models, examines the students thereby providing a feedback for the respective students. The course information, student-prepared case abstracts, real world cases and expert's feedback generated for the students are the output results of this new tool.

### *4.3Crowdsourcing Based E-Learning System*

By virtue of using the services extended by the IoT, a smart model for environment is presented in [9] that is specifically developed for crowdsourcing based e-learning system. In reality on the worldwide Internet, a small group of people provide a solution that is practically used by several billions of users on the worldwide Internet. But in recent years, an absolutely reversed paradigm has come out wherein a significantly large group of professionals generate solutions that can be virtually used by a single organization. This reversed approach is termed as "crowdsourcing". These kinds of systems have been found to be extremely useful with an aim of archiving solutions to the desired assignments. It totally depends on the services provided by the worldwide Internet. Collective intelligence decides fully the reliability of these models. Usage of IoT crowdsourcing in the field of education is primarily limited to the necessary for education logistics alone. It has to be more focused towards the teaching and learning process. These systems can produce innovations in pedagogy, if implemented in teaching and learning activities and hence their learning skill and their competency in professional course will improve substantially. Implementation of Crowdsourcing in academics passes through three separate phases such as processing, collecting and implementing. The authors have suggested different components of smart education model, out of which the smart classrooms constitute the major component. Two distinct classrooms are created wherein one of the classrooms uses the respective subjective parameters pertaining to the students and the other classroom tends to use the respective objective parameters of the students. Here, in subjective methodology, students become part of the classroom lectures surveys and subsequently suggest improvements in contents and refine the quality of teaching. Hence in this type of education system, students are involved in teaching and learning process in addition to the teacher'. The objective methodology helps in establishing a correlation among the satisfaction levels of various students and the features related to the environment like temperature, level of humidity that can be collected through the respective sensors. After this, collected thereby data are forwarded further in order for processing in the data centers that comprises of learning management systems along with various database servers. The results are processed in data centers and then posted to social networks.

### *4.4An Integrated E-Learning System*

The authors have shown a model in [10] which tends to integrate various objects with "virtual academic communities (VAC)" in order for improvement in the learning as well as teaching processes. Various equipment, books, computers, laboratories, etc. are considered here to be the objects in academics. By virtue of integrating such objects along with the VAC can fortunately ease the learning as well as teaching processes in a better way. Traditionally, communication of the students with the specified above objects are considered to be static which means that they communicate manually at a particular place. Nonetheless, by virtue of their integration with the VAC, such communications can be made to be more dynamic. IoT tends to play a central component in the elaborated here process of integration. Here, VAC comprises of a single or several groups of individuals having set a common goal in enhancing the processes of learning and teaching with the use of the respective ICT facilitated tools. The objects defined earlier refer here to the active components of the VAC. Those objects carry out the interaction activities, the processes of learning and teaching, observing and managing. VAC includes two spaces such as physical space and virtual space. The physical space comprises of the teachers, students along with the specified earlier objects whereas the virtual space comprises of the necessary contents, required tools and the learning process itself.

### 4.5 Analytics for IoE Based Educational Model

An "Internet of Everything (IoE)" based educational system incorporated thereby with a "Learning Analytics System (LAS)" making use of deep learning technique is addressed by the authors in [11]. Here, the teachers, students, parents, staff as well as people from the management that are considered to be the stakeholders of the educational system as well as the other associated entities belonging to the institutional premises namely, classrooms, auditoriums, laboratories, washrooms and canteens etc. are embedded with some necessary sensors, actuators as well as transponders by virtue of using fixed and also wearable devices. The embedded here sensors here are necessary for collecting the information pertaining to the environment thereby consequently forwarding the same to a pre-defined base station for further processing. The collected here information are further communicated through a wireless channel and thus, it needs the necessary security aspects of the collected thus information to be considered thereby. Authors have relied here on "Two fish" cryptographic process in order for facilitating the security measures. "Software Defined networking (SDN)" is implemented thus by the authors here for provisioning faster data transfer. The deep learning technique is used by the authors here for the necessary analytics to be carried out with the received thereby data. It should be mentioned that every stakeholder here must be embedded with the necessary sensors for capturing the necessary information regarding the environment surrounding it. The captured thus information are then forwarded to the "Data Encryption Standard Unit (DESU)" for further processing. Here, the DESU deals with the necessary transformation of the received thereby data into a pre-defined format thereby passing the transformed thus data further to an encryption sub-unit for generating secured data. Standardized data here passes through various phases like Data Source Identification, Authorization, Data Size along with the Type Identification, Choosing Data Standards, Data Cleaning and then, Data Normalization. Once the above mentioned phases are performed, sensor data that have been received here are further transformed into a pre-defined format. Subsequently, the formatted here data are forwarded to an encryption unit that need to be further decrypted by the targeted user who also uses Twofish Cryptographic approach.

### 4.6 A problem Based Learning Technique

A "problem based learning (PBL)" technique especially developed for facilitating critical as well as creative thinking in the students, decomposition of students that pursue higher education in visual arts education is detailed by the authors in [12] where the focus has been put by the authors on the effects coming from the problem based learning approach. This particular approach is mostly implemented by the teachers in order to enable the students to find solutions for especially non-routine problems. Here, the teachers necessarily expect their respective students to possess the skills of critical learning as well as creative learning in order for autonomously solving relatively more complex problems from real life. Thus, PBL is considered to be quite effective in facilitating critical thinking as well as creative thinking skills in the students. Practical understanding of visual arts by an individual student reveals the actual perception of that individual student regarding the real world scenarios. Creation of an artwork necessitates the resolution of a variety of problems which needs critical thinking in an individual. Thus, creation of an artwork is nothing other than problem solving only. Authors here have considered a specific problem to implement their proposed PBL approach for learning of the visual arts learning and claim thereby that their proposed PBL approach can be necessarily useful in facilitating creative thinking and critical thinking in the students which necessarily empowers the students so far as the problem solving skills are concerned.

### 4.7 Flip Learning Approach for Computer Network Education

A flipped classroom as an underlying element of the IoT technology in the process of learning has been successfully implemented as well as evaluated by the authors in [13]. Here, the authors rely on two different techniques like flipped classroom and gamification as the principal components for the implementation purpose. Flip classroom represents one of the learning approaches in order for altering the order of traditional education where the lectures and the homework are flipped in order, that is, homework needs to be accomplished first and then the lectures in the concerned subject are conducted. It is presumably absolutely different from the conventional teaching and learning processes. The students here require collecting the needed study materials, studying those materials at home as it is convenient for them and then needing to perform their homework in the presence of the teacher within the classroom itself. The significantly observable advantage of this approach refers to the fact that a student can study from the collected materials whenever and wherever it is convenient for them using the necessary study materials, video lectures as well as the relevant learning tools that are accessible online. This approach can make the student capable of autonomously solving even relatively more complex problems with the spectrum of knowledge that the student has acquired thereby making use of the resources mentioned earlier. In addition to this, an innovative learning approach detailed by the authors here is "gamification" which refers to the integration of the necessary course contents along with a particular game that creates sufficient passion within the student that also necessarily motivates the student towards the respective course. Application of gamification in education can be achieved five different steps such as: (i) understanding the target audience, (ii) defining the learning objectives, (iii) structuring the experience, (iv) Identifying the necessary resources and (v) applying gamification elements.

The authors here have successfully implemented their proposed integrated approach of flipped classroom and gamification in the process of learning thereby integrating the course of "Cisco Certified Network Associate (CCNA)" along with the Computer Networks course designated especially for the students at undergraduate level. The entire process of implementation here operates with an online portal developed using "Cisco Networking Academy (CNA)" which comprises of various resources need for self-learning resources like video lectures, laboratory assignments, quizzes, online examinations and the network simulator called "Packet Tracer". In addition to this, Cisco has developed a series of games which are necessarily used to motivate the students towards the study of the course of computer networks and out of these games, "Binary Game" is the most popular game which has been developed by virtue of using the underlying logic of the game called "Tetris". Authors thereby have also claimed that the video channel for the flipped classroom that they have posted on YouTube channel. has already been viewed by various YouTube users for 21,976 minutes that clearly points to the success of their proposed here approach.

## 5. An IoT Enabled Cloud Based Virtual Classroom Assisted e-Learning System

A cloud based virtual classroom assisted IoT facilitated e-learning system is depicted in Fig.2. A teacher can upload the video lectures along with the necessary study materials to a cloud server using an IoT module. Virtual classrooms can be connected to the respective cloud repository via Internet via IoT modules. Every user here is assigned with authentic login credentials using which a student can access the cloud repository, view the video lectures and download the necessary study materials from it. Then, the student can upload the home assignments to the cloud repository using his/her login credentials. The teacher can download the home assignments uploaded by the students, evaluate and then, can submit the evaluation results back onto the cloud repository. Then, the students can download their respective results. During the examination, the students need to connect to the online examination module using their respective login credentials. The teacher also needs to connect to the online examination module during examination for invigilation purpose. During the examination, every student must put on their cameras so that the invigilator can follow the activities of the student during the examination. If any student is observed by the invigilator to be using any unfair means, the teacher can logout the student from the online examination module following which the respective student is removed from the examination module and the teacher needs to send a report regarding this to the Admin of the system. After the examination time becomes over, every student must scan their answer sheets and upload them to the online examination module in the cloud repository. If any student fails to upload his/her scanned answer sheet within a stipulated time after the examination (say 15 minutes), he/she shall be logged out of the system automatically and cannot submit the answer sheet. During the examination, the attendance of the students is recorded by the online attendance module.

However, a student can be allowed to join the examination within a stipulated time (say 10 minutes and when this time expires, no more students can be allowed to join. After the scanned answer sheets are uploaded to the online examination module, the teacher can download them for evaluation. After evaluating the answer sheets of the students, the teacher uploads a consolidated grade sheet to the cloud repository that can be viewed by everyone who enters the system. A re-examination for all the absentees can further be conducted in a similar fashion. When a student acquires the necessary number of credits in a course, he/she can be declared to have passed out and the respective certificate can be uploaded to the cloud repository by the Admin. After a student graduates from the course, his/her login credentials can be deactivated.

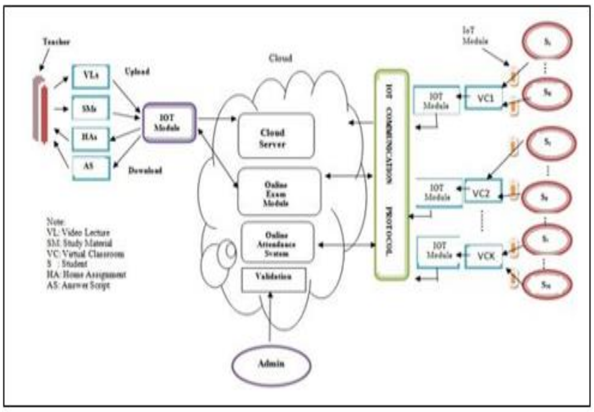


**Fig.2:** A Cloud Based Virtual Classroom Assisted IoT facilitated e-Learning System

## 6. Conclusion and Future Work

Currently, the IoT technology continues to play a remarkable role in enhancing the quality of education in the classrooms, and the observed output of imparting education makes use of the e-learning systems that have been developed using the underlying elements of the IoT technology is remarkably satisfactory as well. In this paper, we have attempted to comprehensively elaborate on the distinguishing technical features of IoT technology as a proliferation in the existing global communication technology and, in particular, its contribution to bringing innovative as well as very effective approaches to teaching and learning processes in the field of education as a whole. Continuing further, we have focused here on various aspects of varieties of e-learning systems. The concepts such as flip learning, flipped classrooms, problem-based e-learning, and gamification has been explained in detail, thereby focusing on their significance in real-life applications of these systems. These e-learning systems proposed by various researchers and, as claimed by them, have been effective and productively practiced in real-life scenarios in the context of imparting education. In addition, we have proposed a cloud-based virtual classroom-assisted IoT facilitated e-learning system that can be effectively implemented in practice, particularly when the students cannot attend physical classrooms, such as now, during the global pandemic. However, further innovations can be carried out in this direction to simplify the teaching-learning process and make it more effective in real-life practice. One of these approaches can be an agent-driven e-learning system wherein an intelligent agent can cater to all academic activities.

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