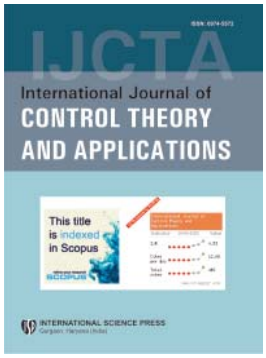

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Development of IoT Environment to Interact with Learning Management Systems

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Abstract: This paper proposes an application framework for integrating Internet of Things (IoT) environment with Learning Management System (LMS). It is a well known fact that Internet of Things is an emerging technology suitable for smart environment development. It further strengthens the ambient intelligence in Smart Environment. It finds applications particularly in ubiquitous learning environment. It also ensures "*anytime, anywhere*", way of learning facility. Learning Management System is an online learning facility with lot of features to learn in an effective manner. A number of research efforts have been so far made to integrate LMS with ubiquitous technology to facilitate more smartness levels. In spite of such contributions, due to the rapid development in technologies, there exist still a lot of issues to be solved. One such challenge is to offer still effective interaction mechanism with learning management system through IoT environment. Hence this paper develops an IoT environment using QR Code (Quick Response Code), NFC (Near Filed Communication) and Raspberry Pi3 (Rpi3) to ensure effective interaction with Learning Management System. An experiment was also conducted with a test user group to evaluate the users' satisfaction. The experiment results show positive significance over the contribution.

Keywords: *Internet of Things – Learning Management System – Ubiquitous Technology – Near Field Communication.*

1. INTRODUCTION

The rapid development of mobile technology introduces M-Learning [1] followed by U-Learning [2] techniques. Such kind of technology enabled education system to strengthen the learners' outcome through various facilities like collaborative learning, context aware learning and social learning. They mainly aim at enhancing the teaching and learning activities. They make the learning resources, for example LMS, to react dynamically with regard to various context of access. Ubiquitous learning [3] supports deeper and high flexibility way of learning mechanism. The ubiquitous learning environment consists of components like learning end-user device, communication network and learning resources. The problem in ubiquitous learning environment is with the storage mode *i.e.* centralized one. This mode does not suit for ubiquitous environments' learning

requirements for various transactions. IoT [4] has been becoming a hot research area to address various such kinds of issues related with ubiquitous technology for the past few years. The IoT environment integrates different kinds of electronic devices, controls them from web, gives real time information and permits people's interaction with it. The framework of IoT environment [5] development will usually have three different layers such as *perception layer, network layer* and *application layer*. The *perception layer's* main function is to recognize the objects in the network and to collect information. The *network layer's* activity is to transmit and process that information. The *application layer* provides ubiquitous characteristics and learning methods. This layer adopts IoT features to ensure realizing excellent learning environment. Table 1 shows the different ways to establish connections with a thing in the network. The Network layer uses mobile network, internet, M2M and expert network facilities. This layer's other activities include heterogeneous network convergence, remote control and resources & storage management. The perception layer, on the other hand, uses short reach technology, cooperative information process technique, sensor middleware technology and self organization network technology. It also uses 2d barcodes, sensors, RFID, NFC, multimedia, etc. for data collection to learn the objects in the network. The application layer is consisting of two sub layers such as ubiquitous learning system layer (ULS) and ubiquitous learning environment (ULE) support layer. The examples of ULS layer are LMS, exchange platform, Edu-system, learners' management, etc. The ULE support layer uses learning information platform, public intermediate system, life information platform, service support platform etc.

Table 1
Various ways to establish Connection

RFID	*Radio Frequency Identifier*
Zig Bee	IEEE 802.15.4 Protocol
WPAN	Wireless Personal Area Network
WSN	Wireless Sensor Network
DSL	Digital Subscriber Line
UMTS	Universal Mobile Telecommunications System
GPRS	General Packet Radio Service
Wi-Fi	Wireless Fidelity
Wi-Max	Worldwide Interoperability for Microwave Access
LAN	Local Area Network
WAN	Wide Area Network
4G	Fourth Generation
Li-Fi	Light Fidelity

This article proposes a framework to develop an IoT environment that consists of a network of various physical objects like Raspberry Pi3 Board, NFC, Camera, etc. (normally they have association with virtual objects) to make learners to get information for attaining a learning achievement on understanding the environment. In addition, this work aims at including LMS as one of the objects of IoT environment and to offer effective interaction mechanism for students with LMS through the network of other objects. Three different frameworks have been developed respectively for Admin Role, User Role and Course Creator Role. This environment is tested with a user group to know the effectiveness of the proposed methodology.

The remaining part of this paper is organized as follows: Section 2 reports the literature work. In section 3, the proposed framework for IoT environment to access LMS is described. Section 4 presents the report on experiment conducted with results. Section 5 concludes with the experience of this work.

2. LITERATURE SURVEY

The three different layers of IoT have research challenges like miniaturization of size of internet components, inability to link billions of objects in the network and inability to make life still easier all the time. As far as application layer is concerned, several works have been reported as solutions for its associated challenges and issues. An IoT framework [6] has been proposed in which the application layer uses a computing method to know the best transfer routes and to select communication arguments. In another work [7], a protocol for IoT environment was developed to ensure effective assessment on IoT entities' trust levels. This protocol simulated the mechanism of various social associations of object owners. Coming to the application area of education system, different efforts have been reported and most of them aim at offering effective teaching and learning process using IoT environment. An effective English teaching interactive system [8] is reported in the literature. This system uses visual sensors and integrates them with voice to clearly understand students' pronunciation. This environment motivates students to learn with regard to their level of aptitude. The NFC technology was used in another work [9] to facilitate effective transaction among the physical objects. A user-centered approach was developed in [10] to enhance learning experience. It uses e-learning and Internet of Objects. In the research work [11], a method to integrate objects with virtual academic communities was reported. This model integrated smart objects with virtual learning environment to collect more information about the various activities in classrooms and laboratories. This model was tested with a group of engineering students for digital electronics course.

In this paper, an effort has been taken for the benefit of students to make facilities to access learning management systems in an IoT environment.

3. METHODOLOGY

The Learning management system restricts its access at various levels like administrator level, course creator level and learners level. This research work assumes LMS as one of the objects in the IoT environment. It proposes frameworks for these three levels to realize IoT environment. The proposed IoT environment is consisting of objects such as Raspberry Pi3, NFC, QR Code, LMS, Visual Sensor etc. The main objective is to offer facilities for students to enable them to access learning management system through NFC & QR code and thus to provide an IoT environment with LMS.

As stated before, the framework for three different LMS access levels are described below:

Figure 1 shows the methodology for LMS administrators to access LMS in IoT environment. Whenever the administrator wants to access LMS, the login process to be done with the help of NFC card with QR Code. The visual sensor in Rpi3 will then sense the information in the NFC card and the card reader will read the input and match the input with the data base to recognize the validity. The Admin can then be allowed to access viewing LMS pages.

The framework for course creator role to access LMS in IoT environment is given in figure 2.

The Course creator, generally teacher, should first use NFC card with QR code to get login into LMS. The visual sensor and reader will then verify the input information by matching with the Database and grants access permission. The course creator then will be permitted to perform various activities like Add course, Remove Course, etc. in LMS.

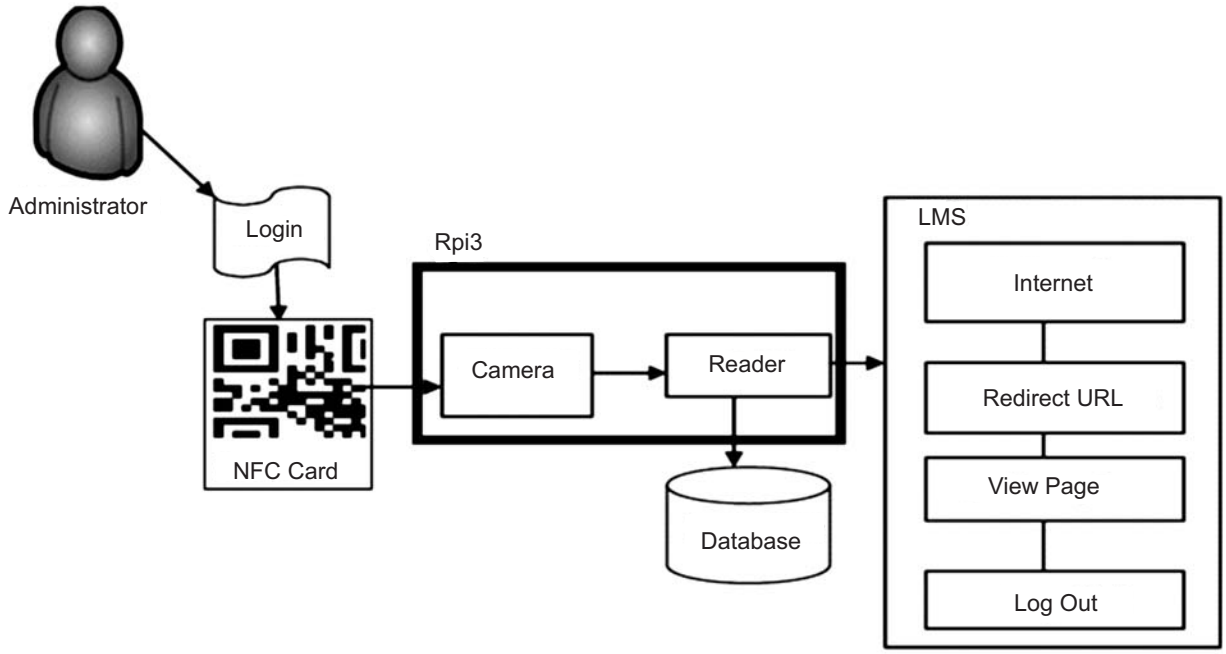


Figure 1: Framework for Admin Roles to access LMS

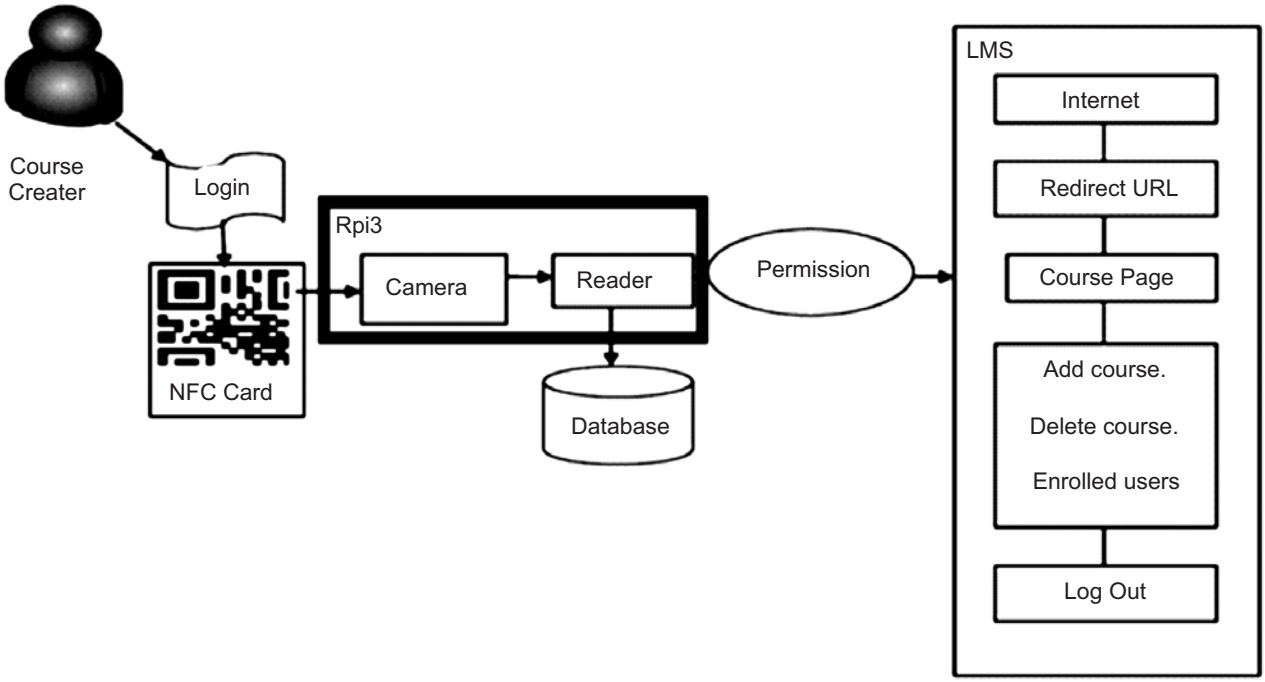


Figure 2: Framework for Course Creator Roles to access LMS

Figure 3 demonstrates the method for LMS learners to access LMS through NFC card.

First, the students have to show their NFC Card with QR Code to the system to get login to the LMS. After the verification by the mechanisms in the Rpi3, the students will then be permitted to view pages, read course content and use other resources in LMS.

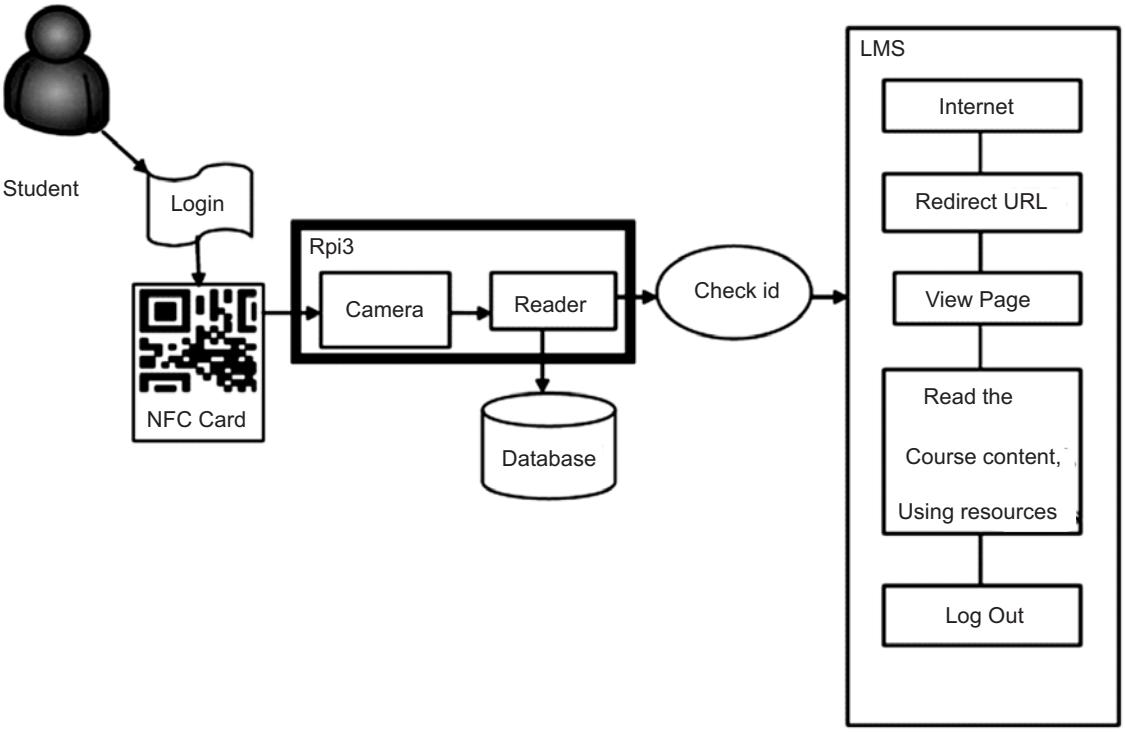


Figure 3: Framework for Student Roles to access LMS

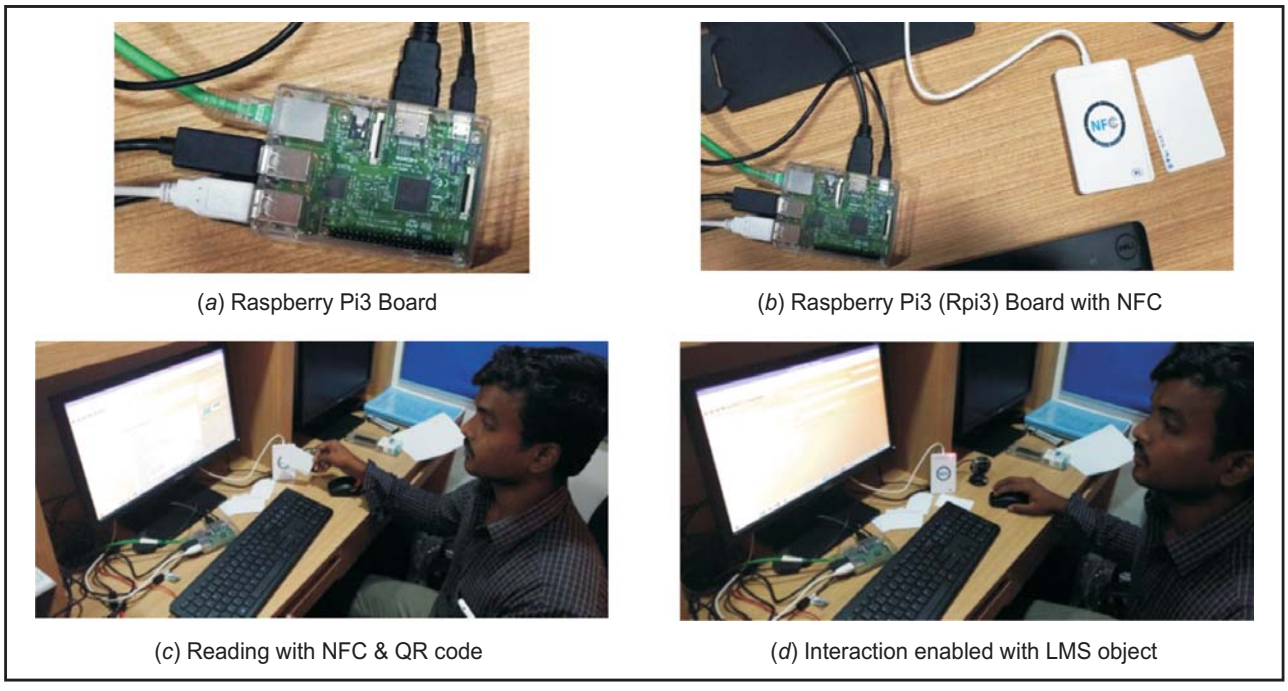
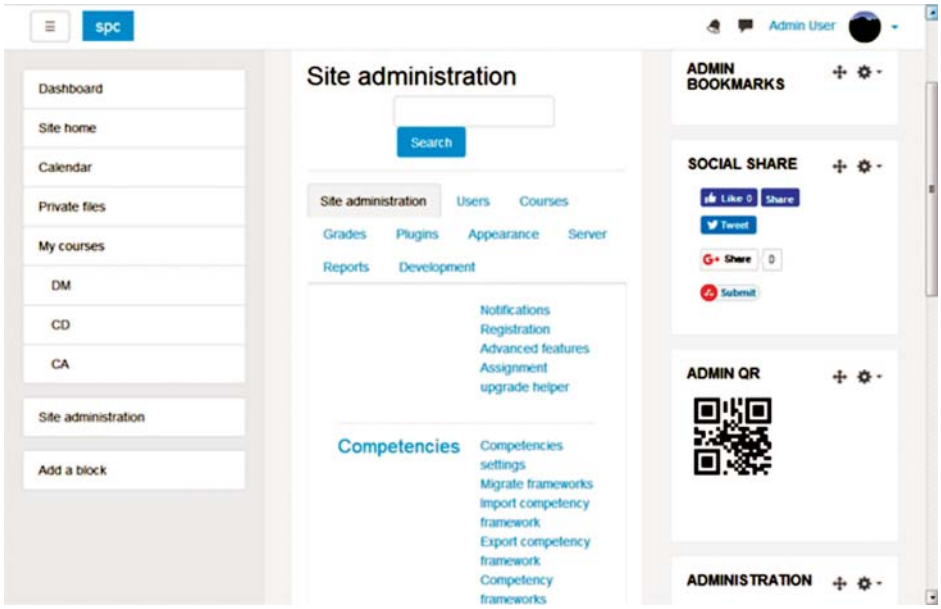


Figure 4: Illustration of system's working procedure

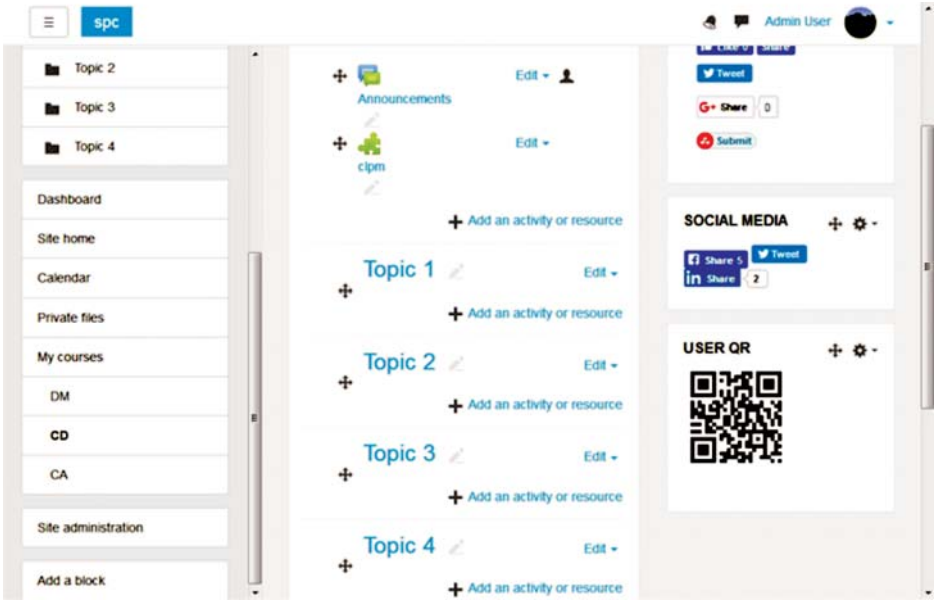
Figure 4 illustrates the various stages of working procedure of the proposed methodology to enable interaction with LMS object in IoT environment with the help of NFC and QR Code.

4. EXPERIMENT

The developed methodology was tested with a user test group of 45 students of Department of Computer Science, 5 Teachers and an LMS administrator of the Institute of A.V.V.M Sri Pushpam College, India. The main objective of this experiment was to know the users satisfaction on the effectiveness of the proposed methodology for IoT environment with LMS as one of the objects. The teachers assigned QR codes for different courses posted in the LMS (www.avvmspclms.com). The students were informed about those QR code assignments in LMS courses. The LMS users were then permitted to access LMS using NFC and QR codes, by this way an IoT environment was realized for effective interaction between the users and LMS.



(*a*) Admin Role



(*b*) Student Role

Figure 5: Sample Snapshots of IoT Interaction Sessions with avvmspclms.com

Table 2
Results of Cronbach's Reliability Computation

View	*Reliability Coefficient Value*
Utilization	0.761
Information accuracy	0.802
Interface's standard	0.724
Expectations' fulfillment	0.738
Sum	0.807

Figure 5 shows the Sample Snapshots of IoT Interaction Sessions with learning management system for the two different cases. The test user group was given a questionnaire to know their satisfaction on the effectiveness of the proposed methodology. The questions aimed at testing the students' level of satisfaction on system usability, interface quality, information quality and overall satisfaction. The reliability coefficient α developed by Cronbach [12] was used in this performance analysis test. Normally, $\alpha = 0.7$ will be accepted as lowest reliability value. Table 2 lists out the results computed using Cronbach's reliability test. The results show that the satisfaction level crossed the minimum acceptable value.

5. CONCLUSION

A framework for integrating LMS with IoT environment is proposed in this paper. In this work, LMS is treated as IoT object and made to access through NFC and QR code. By this way, the challenge of achieving effective communication in the application layer of IoT technical framework is met out with the solution of using NFC and QR code. An experiment was conducted to demonstrate the method of integrating LMS with IoT environment and the level of users' satisfaction on usability of the proposed method was also observed. The results of usability testing show good significant value on the overall expectations of the users. It is also planned to design an IoT desk for effective monitoring of students behavior in the class rooms.

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