education sciences

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Article

Teaching Management System with Applications of RFID and IoT Technology

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Received: 9 January 2018; Accepted: 7 February 2018; Published: 11 February 2018

Abstract: Currently, Internet of Things (IoT) technologies are used in many areas, such as intelligent transportation, smart city, hospital, games, education. Earlier interactive response system uses infrared or radio frequency (RF) wireless communication technologies to transmit the students' answer to teachers' managerment system, where there exists high cost, inconvenient usage, difficult deployment. How to use IoT to improve the quality of higher education becomes a very important topic in the researh area of teaching. Radio Frequency Identification (RFID) is one of key technologies to implement IoT applications, and most of universities use the High Frequency (HF) RFID card as the students' identification devices in China. In this paper, a kind of WiFi supported RFID reader (WiRF) is implemented using open source hardware platforms, such as Node MCU and RFID-RC522. Then the proposed WiRF system is used to assist teacher to perform automatic attendance record and students' behavior record. In addition, Quick Response (QR) code is another technology to enable IoT. In this paper, QR code is designed to quickly access course video and perform real-time interactive response in the classroom, which will provide multidimensional learning and strengthen the motivation of students' learning. This IoT system can improve the attendance of students, and give a positive impact on students' learning process for higher education.

Keywords: RFID; Internet of Things; WiFi network; education management

1. Introduction

Interactive Response System (IRS) [1], also called as Audience Response System (ARS) [2] which were first introduced at Stanford University in 1966 , is an phsical device that allows students to submit their responses using remote decives and the IRS gives the visual format to present the result. Because the cost is high with the use of special hardware in IRS, it is ultimately failed to get a wide range of applications. Currently, smart phones have become one of the necessary tools for college students. In addition, there are some mobile smart terminals such as IPAD, Android tablet, etc. Related research pointed out that the use of smartphones has reached over the rate of 120% [3]. As a result of a large number of intelligent technology products make some students without interests to learning in the classroom, who prefer to use these smart devices to play games, surf the Internet, movies and other activities which are irrelative to classroom teaching. With the development of information technology, especially the Internet of Things (IoT) technology [4] which is widely used in transportation [5], education [6], medical [7], environment protection [8], tracking [9], indoor positioning [10], etc., how

to apply the IoT technology to improve students' interest in classroom learning has become a hot topic in the field of modern higher education applications. Cloud computing has virtually unlimited capabilities in terms of storage and processing power, and is often integrated with IoT technology to perform better severvices for users [11]. To illustrate IoT systems, we will refer to Device-Cloud-Mobile (DCM) model shown in Figure 1, as it is widely used today in commercial IoT products. Here, the IoT devices need connect to the back-end Cloud system, and support services by an user app running on mobile devices. In some case, the app connects directly with the IoT device using the device WiFi hotspot capabilities, which either processes the requests directly or bridges it to the Cloud back-end system.

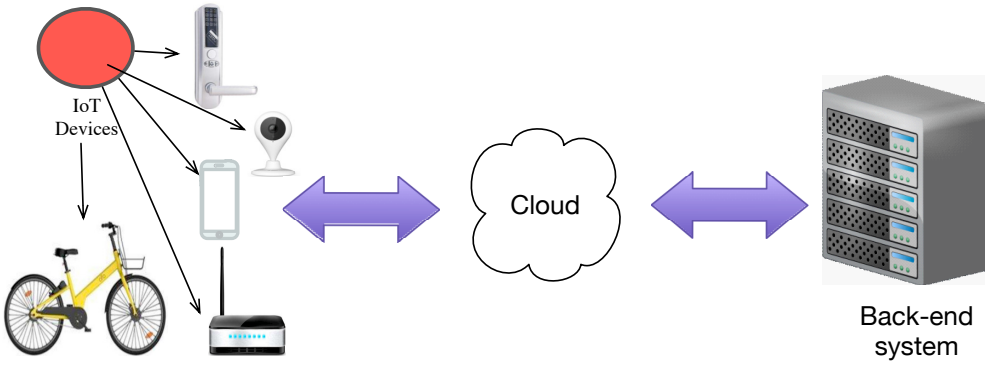


Figure 1. Device-Cloud-Mobile IoT Architectural Model.

In this paper, we design and implement an IoT-based teaching management system to assist teacher to perform automatic attendance record and strengthen the motivation of students' learning. This IoT system can improve the attendance of students, and give a positive impact on students' learning process for higher education.

The rest of the paper is organized as follows. Related works are reviewed in Section 2. We propose the system architecture for teaching management as a service of IoT in Section 3. In Section 4, we showed the implementation of WiFi-based radio frequency identification (RFID) reader based on open source hardwares. Section 5 gives the details of implementation of software. Section 6 tests the system and discuss the future work. Finally, the paper is concluded in Section 7.

2. Related Works

Radio Frequency Identification (RFID) technology [12] is one of the key technologies to realize the IoT. The typical RFID systems consists of tags, readers and back-end computer system. There are two types of tag: active and passive tag, where active tag has battery and can send the information at hundreds of meters, and passive tag depends on the emitted energy of reader's antenna instead of using battery to transmit information. There are four different RFID frequency bands [13], that is low frequency (LF)—125~134 kHz, high frequency (HF)—13.56 MHz, ultra-high frequency (UHF)—433~956 MHz, and microwave frequency (MF)—2.45 GHz. Patel et al. designed an online students' attendance monitoring system in classroom using UHF RFID, which can automatically record students' attendance at lectures or laboratories [14]. However, the UHF are not widely used in universities and colleges. In fact, HF RFID cards are widely used as IDs of students in campus management. Arbain et al. implemented a web-based laboratory attendance system by integrating RFID with Arduino platform [15], which is a cable network and not convenient to be used by IoT environment. In this paper, we will use HF RFID technology integrated with the WiFi network to implement a novel RFID reader to be used for an attendance record system, and our RFID systems work in wireless method, which is convenient to be deployed in current classroom.

Quick Response (QR) [16] code is another technology to enable IoT [17]. Su et al. use QR code to quickly extract the ID of cargo and use it to implement an intelligent logistics system [18]. QR codes have been discussed in the literature [19] as a valuable method to teaching and learning. The results show that students perceived QR codes as an easy to use and useful application to support learning activities, and also suggest that the pre-service teachers not only demonstrated positive attitudes towards the integration of QR codes in learning activities but also had clear intentions to use the system in the future. Dorado et al. propose an approach for mobile learning using QR codes to develop teaching materials [20]. Downer et al. use QR code to enhance nursing and midwifery student learning [21]. In this paper, we use QR code to give quick response link to the course's online video, and use QR code to show the practice excercises which need the students to take part in the classroom activities.

3. System Architecture

The system architecture is shown in Figure 2. In the proposed system, mobile terminal, RFID reader, RFID card, Node MCU and QR code are used to form an integrated IoT system for teaching management.

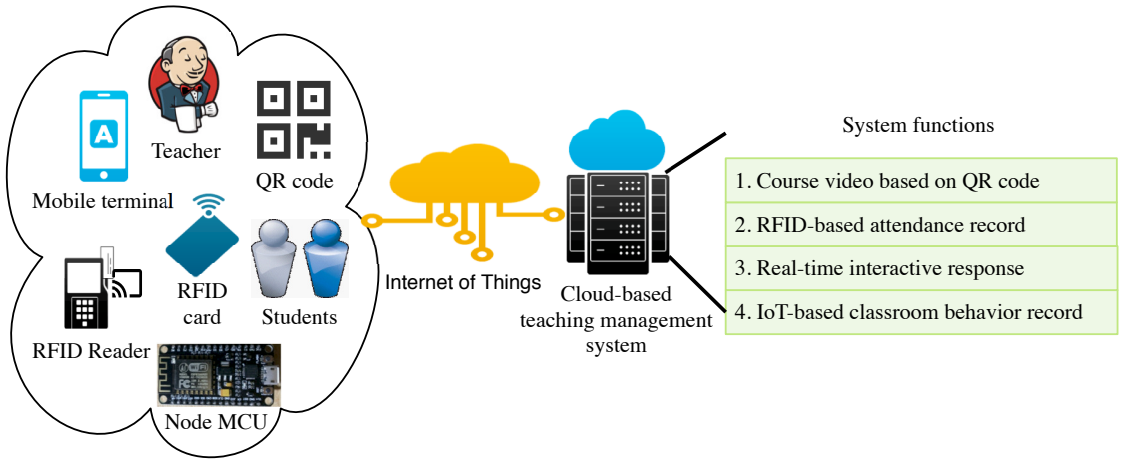


Figure 2. IoT-based teaching management system architecture.

The functions of this system are the following:

- Course video based on QR code

  The difficulties of the course are recorded into video materials stored on the Cloud-based teaching management system, and students can preview or review them as long as they use their own intelligent terminal through scanning QR code in the relevant knowledge of the book which can be directly connected to the part of the content. This is very convenient to the students' who are free and autonomous to arrange their learning.

- RFID-based attendance record

  In China, most colleges and universities have realized intelligent campus card system which uses HF RFID card as students' identification devices. We can request students to swipe the RFID card when entering the classroom before the course starts. The proposed system can record the time when the students enter into the classroom, which is an automatic record of absenteeism and late assessment. This system can urge students to participate in classroom learning on time.

- Real-time interactive response

  In the classroom's practice session, the teacher uses the system to show practice exercises through QR code presented to the students, and then students use smart mobile terminals (such as IPAD,

smart phones, etc.) to scan the QR code which can directly access the exercises in the Cloud-based system. If it is a single choice, students are required to answer questions immediately. At the same time, when students submit the answer, the system also needs students to provide with the students' ID number and name information. Then the system can record the results of the students answer (including the answer time the question, etc.). The teacher can check the overall students' answer to each question (how many people answer this question and how many people are wrong.). If it is found that most of the students are wrong in current classroom teaching, then the teacher can deduce the teaching effect is not ideal and need to adjust the process to re-talk and review of the course.

- IoT-based classroom behavior record

  In the classroom performance session, the teacher can ask the students to place the campus RFID card on the table. The system can give the teacher's right of the selection of the followin behaviors as the like: "bad attitude", "sleep", "play game", "conditions of answer questions", etc. After then, the teacher only needs to use RFID reader to swipe the card which will be able to achieve real-time record the classroom performance of the target students. The system also can support achieving randomized way to ask the students to answer questions which urges students to actively participate in classroom teaching.

4. Implementation of WiFi/RFID Reader

In this section, the WiFi supported RFID reader (called as WiRF reader) is implemented based on open source hardwares of Node MCU [22] and RFID-RC522 [23]. Node MCU (Figure 3 is the pin configuration of Node MCU) is an open-source firmware which includes ESP8266 WiFi module, and supports programmable platform for IoT application development at the lowest cost. RC522 (Figure 4 is the RC522 module) is a highly integrated reader/writer integrated circuit (IC) for contactless communication at 13.56 MHz which is widely used for HF RFID reader systems. Figure 5 shows the logic diagram of WiRF reader, and Figure 6 shows the physical realization of WiRF reader.

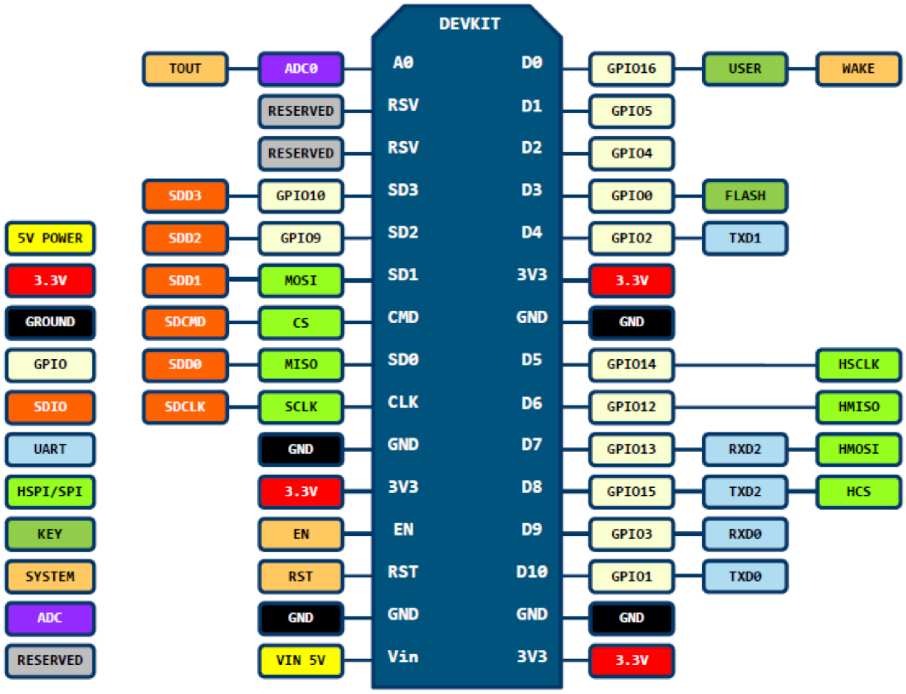


Figure 3. The pin configuration of Node MCU.

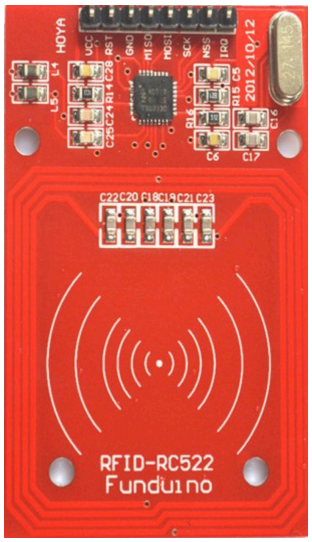


Figure 4. The RC522 module.

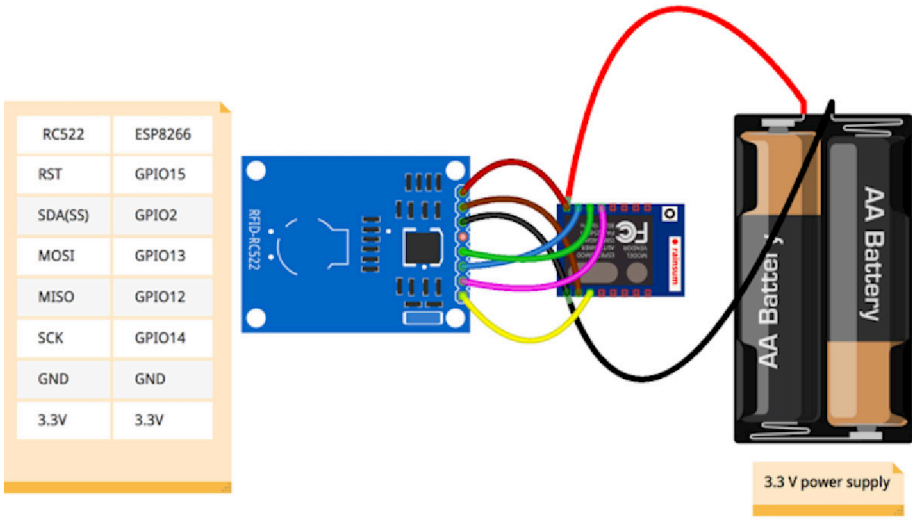


Figure 5. The logic diagram of WiRF reader.

Figure 6. The physical realization of WiRF reader.

5. Implementation of Software

5.1. Implementation of Registeration and Login Functions

We implemented an Android app which can support the students to register and login the proposed system to study. Figure 7 shows the registeration implementation, and Figure 8 shows the login implementation.

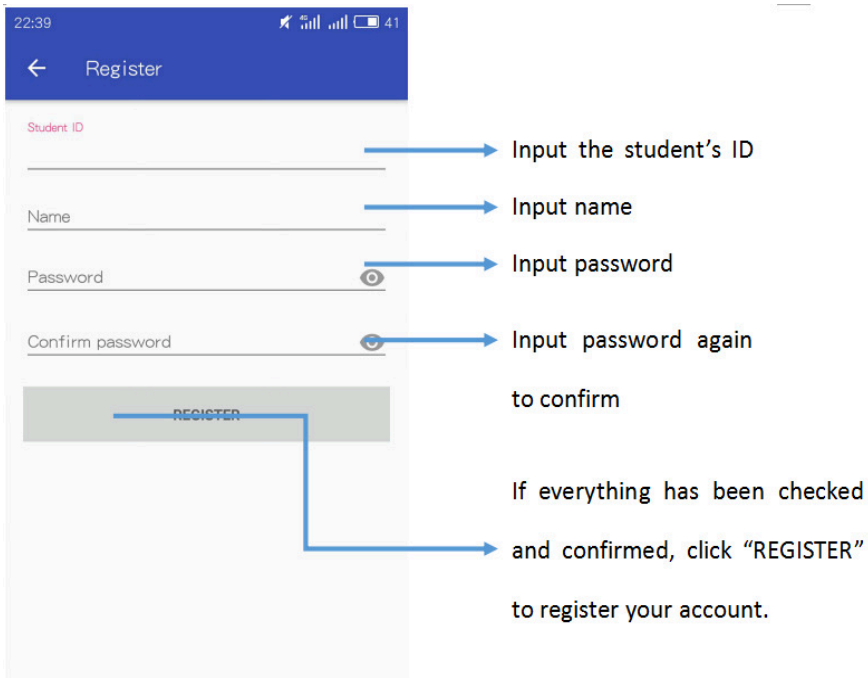


Figure 7. Implementation of registeration.

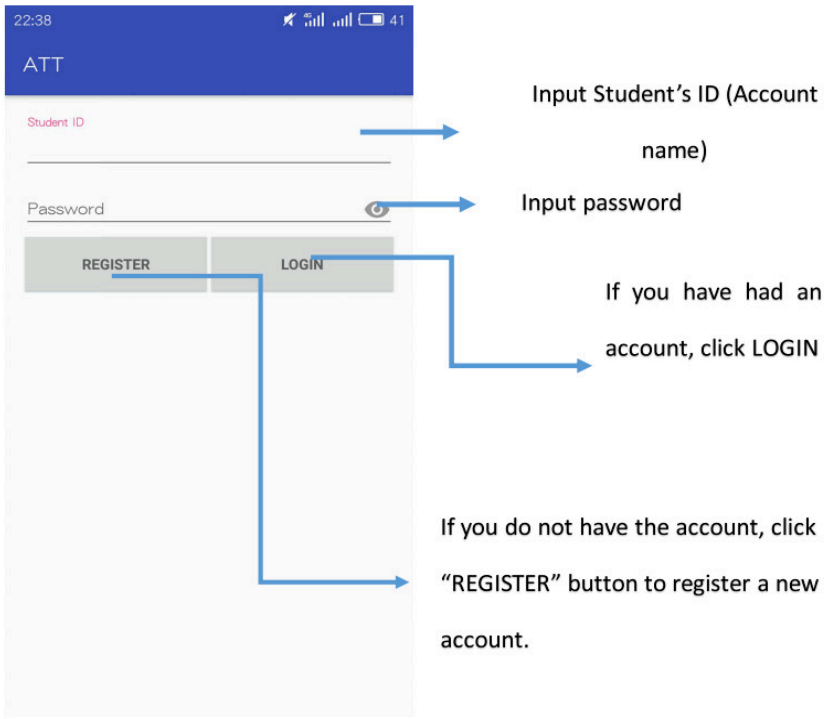


Figure 8. Implementation of login.

5.2. Implementation of Course Video Based on QR Code

The important and difficult knowledge points in each course can be recorded as video stored in the Cloud-based system. We have written a book called "Data Structure" which inserts the video QR code to each chapter for every difficult point. Figure 9 is the students' client which can use username and password to login the system and scan the QR code from the book. If someone sees the video, the system will record it, so the teacher can know how many students have studied the contents before the classroom teaching. Figures 10 and 11 are the knowledge point about "Huffman tree and its applications" in our book to use QR code to support online study at anytime or anywhere.

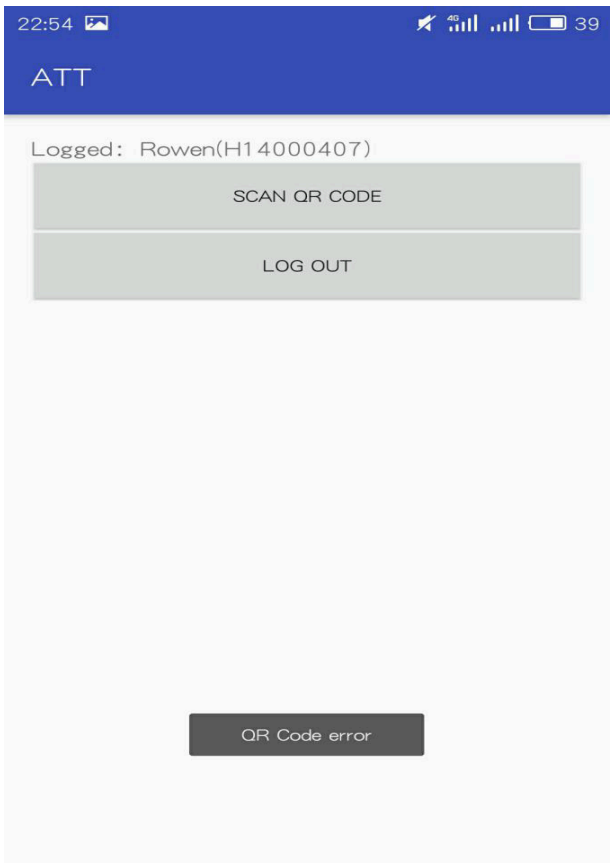


Figure 9. Student's clident app for scan QR code.

Huffman tree and its applications

Figure 10. One example of QR code in book.

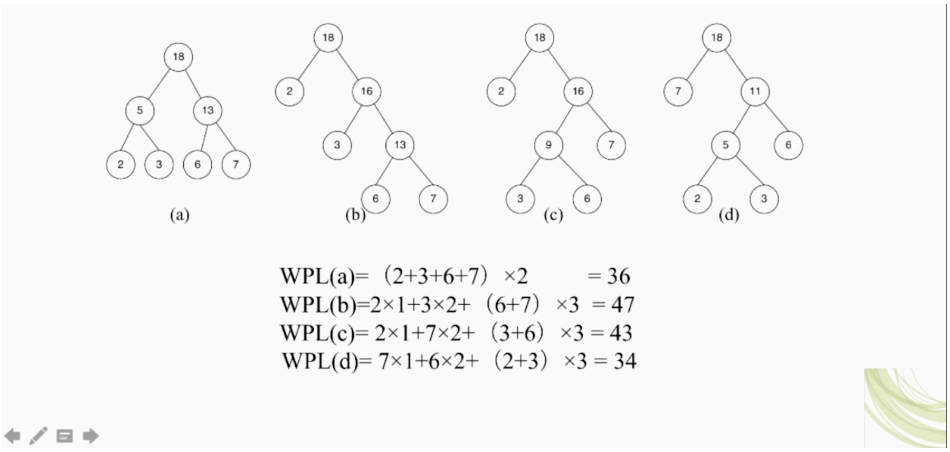


Figure 11. Online course's video.

5.3. Implementation of RFID-Based Attendance Record

When students enter into the classroom, they need to swipe the RFID card to register the time for this course. After then, they use mobile phone to confirm that the login time is right and click "ADD RECORD" button in the students' client app when they sit in the classroom. Note that the final entering time of this course is the RFID card reading time by WiFi supported RFID reader (WiRF). The "ADD RECORD" is used to give the attendance information to students. Figure 12 shows the confirmation function of students' app. The proposed system is built on Cloud environment, and allows users who are outside the classroom to login the system when they are absent. RFID card is used to urge the student to swipe for attendance. If the student does not swipe the RFID, the attendance record will not be added to the system. This function is designed for students to see if the RFID card is swiped successfully and to confirm the score of their attendance.

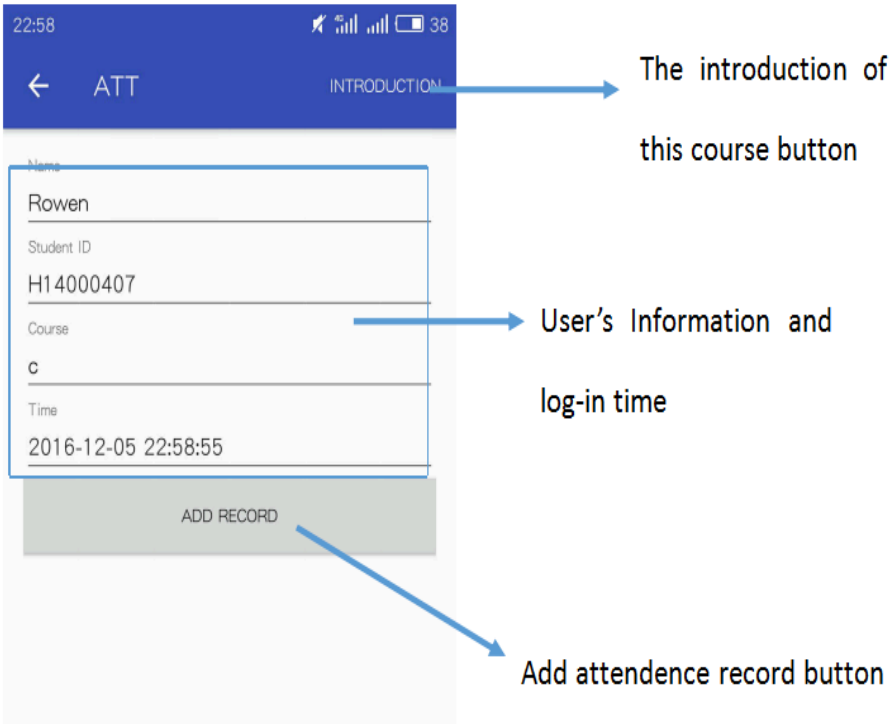


Figure 12. Implementation of attendance record.

5.4. Implementation of Real-Time Interactive Response

The teacher can use QR code to distribute the practice exercises to students. Students can use mobile phone to scan the QR code to see the questions and answer them. After then, the teacher can login the Cloud-base database system to see the answers of all students. Figure 13 shows the results of one question's answer conditions. The aim is to encourage students to use the mobile terminals to scan and get the questions by themselves. Because the proposed system is based on Cloud environment, students can login it through their own mobile network or local WiFi hotspot which can support Internet access services for students. The system requires all students should concentrate their eyes on teacher's classroom instruction and take the initiative to complete the exercises. In fact, the questions can be pushed to their phones directly when they are already checked-in, but this is a passive way and some students may leave early after checked-in. The proposed system will urge all students in the classroom can actively scan and participate to answer the questions.

QUESTION ID
SUBCHAPTER ID
submit

STUDENT ID	SUB CHAPTER ID	QUESTION ID	CHOICE	RIGHT ANSWER	TOTAL ANSWER RIGHT	TOTAL NUMBER OF STUDENTS
14540101	3.1	5	C	B		
14540103	3.1	5	B	B		
14540104	3.1	5	D	B		
14540102	3.1	5	B	B		
14540105	3.1	5	C	B		
14540106	3.1	5	C	B		
14540107	3.1	5	C	B		
14540108	3.1	5	B	B		
14540109	3.1	5	A	B		
14540110	3.1	5	A	B	3	10

Figure 13. Implementation of interactive response.

5.5. Implementation of IoT-Based Classroom Behavior Record

As shown in Figure 14, when teacher selects one behavior of classroom performance, and then the WiRF reader is used to swipe the target student. The system will automatically record the behavior to the Cloud-based teacher management system for future evaluating the student.

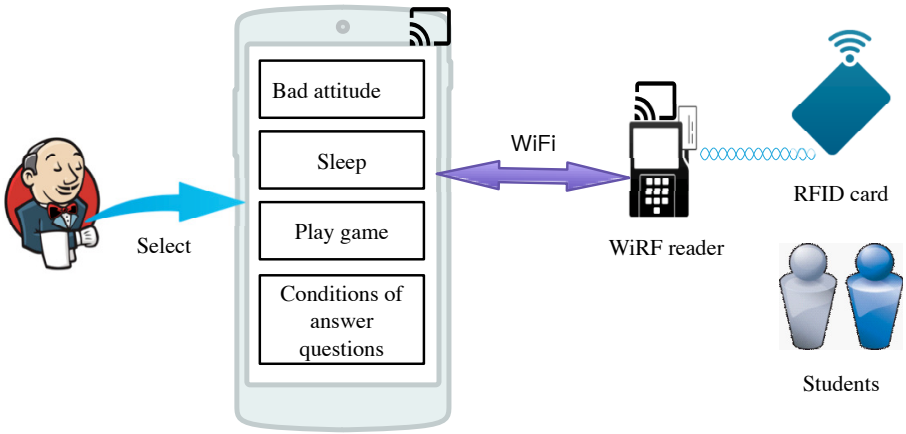
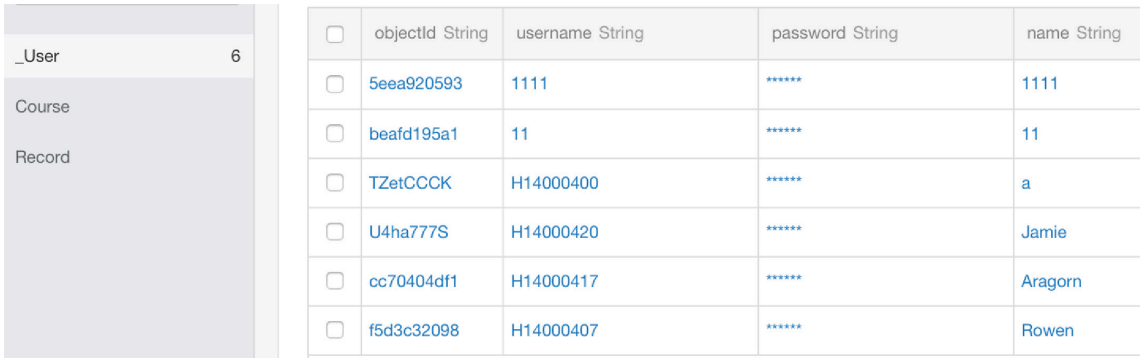


Figure 14. Teacher uses the IoT system to record students' classroom performance.

5.6. Implementation of Cloud-Based Database

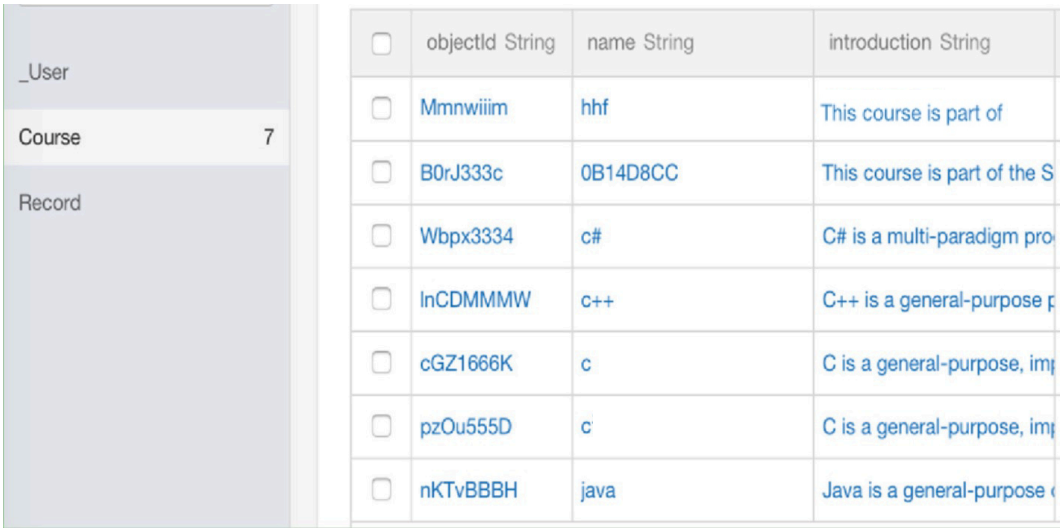
The tables in Cloud-based database includes the following: user table, course table, record table. User table records the students and teachers information, such as username, password, name, etc. Course table records the course's name, description of course, etc. Record table can record when the students take participate in the classroom and what answers the students have given. Figure 15 shows the user table, Figure 16 shows some contents of course table, and Figure 17 shows a part of record the attendace of students.



_User 6
Course
Record

objectId String	username String	password String	name String
5eea920593	1111	******	1111
beafd195a1	11	******	11
TZetCCCK	H14000400	******	a
U4ha777S	H14000420	******	Jamie
cc70404df1	H14000417	******	Aragorn
f5d3c32098	H14000407	******	Rowen

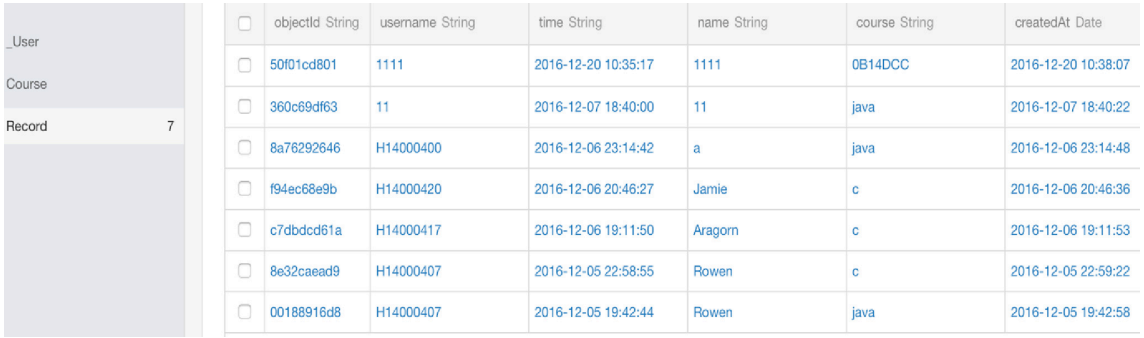
Figure 15. The user table.



_User
Course 7
Record

objectId String	name String	introduction String
Mmnwiiim	hhf	This course is part of
B0rJ333c	0B14D8CC	This course is part of the S
Wbpx3334	c#	C# is a multi-paradigm pro
lnCDMMMW	c++	C++ is a general-purpose p
cGZ1666K	c	C is a general-purpose, imp
pzOu555D	c	C is a general-purpose, imp
nKTvBBBH	java	Java is a general-purpose

Figure 16. The course table.



_User
Course
Record 7

objectId String	username String	time String	name String	course String	createdAt Date
50f01cd801	1111	2016-12-20 10:35:17	1111	0B14DCC	2016-12-20 10:38:07
360c69df63	11	2016-12-07 18:40:00	11	java	2016-12-07 18:40:22
8a76292646	H14000400	2016-12-06 23:14:42	a	java	2016-12-06 23:14:48
f94ec68e9b	H14000420	2016-12-06 20:46:27	Jamie	c	2016-12-06 20:46:36
c7dbdcd61a	H14000417	2016-12-06 19:11:50	Aragorn	c	2016-12-06 19:11:53
8e32caead9	H14000407	2016-12-05 22:58:55	Rowen	c	2016-12-05 22:59:22
00188916d8	H14000407	2016-12-05 19:42:44	Rowen	java	2016-12-05 19:42:58

Figure 17. The record table.

6. Discussion

Because the current RFID technology has been widely used in the daily management in campus, and intelligent mobile terminals are also widely used by college students, compared with the traditional IRS system, the proposed system is easy to be deployed and has low cost characteristics. The system can effectively reduce the college students to play mobile phone phenomenon in the classroom, prompte students to participate in teacher's designed classroom teaching activities. Through tests in one real classroom, the attendance rate has increased from 85% before usage to 98% after using this system. By issuing 108 questionnaires to students and 6 questionnaires to teachers, the result shows that 96 students think the system can promote curriculum learning for students, and all teachers believe that the system can improve the quality of classroom teaching. IoT-based information technology education application system will become a useful assistant for the rapid development of higher education. In the future, we will try to merge all modules to connect each other. Future extensions and improvements of the system may include: answering questions in interactive response module will account for attendance verification; course videos can only be made available if attendance to certain lectures was registered. In addition, we will test our system in real courses at the university and to interview students as well as teachers to capture their experience and feedback to revise our system for better use.

7. Conclusions

As an emerging field of information technology, IoT technology is applied to the management of higher education classroom, which is the inevitable trend of information technology used in education application. In this paper, through the construction of the teaching management system based on the IoT technology and applying it to the actual classroom teaching, it can promote students' active interest in learning, improve the teaching efficiency of teachers, and provide technical support for the effective management of education and teaching in colleges and universities.

Acknowledgments: This work is financially supported by Postgraduate Education Reform Project of Jiangsu Province(JGLX_024), the National Natural Science Foundation of P. R. China (No.61672296, No.61602261), China Postdoctoral Science Foundation (No.2014M561696), Jiangsu Planned Projects for Postdoctoral Research Funds (No.1401005B), Postgraduate Research and Practice Innovation Program of Jiangsu Province (SJLX16_0326, KYCX17_0798) and Teaching Reform Project of Nanjing University of Posts and Telecommunications(JG00417JX57, JG00417JX71).

Author Contributions: Ping Tan conceived and wrote the paper; Han Wu implemented the WiFi-based HF RFID reader; Peng Li contributed RFID and Node MCU hardware; He Xu performed the tests for the system. All authors are contributors to the final paper.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

IoT	Internet of Things
RFID	Radio Frequency Identification
IRS	Interactive Response System
ARS	Audience Response System
LF	Low Frequency
HF	High Frequency
UHF	Ultra-High Frequency
MF	Microwave Frequency
MCU	Microcontroller Unit
QR	Quick Response
IC	Integrated Circuit
WiRF	WiFi supported RFID reader

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