INTERNATIONAL BLACK SEA UNIVERSITY
FACULTY of COMPUTER TECHNOLOGIES
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Implementation of IoT (Internet of Things) Technologies into Educational Process of Universities and Schools

Azamat Zhamanov

Extended Abstract of Doctoral Dissertation in Computer Science

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Scientific Supervisor: Lela Mirtskhulava

(full name)

Assoc. Prof. at Ivane Javakhishvili Tbilisi State University, San Diego State University Georgia

(academic title)

(supervisor's signature)

Experts (full name & academic title):

1. Irakli Rodonaia, Prof. Dr.
2. Vakhtang Rodonaia, Assoc. Prof. Dr.
3. Micheil Rukhaia, Assoc. Prof. Dr.

Opponents (full name & academic title):

1. Wei Wang, Assoc. Prof. Dr.
2. Ilias Maglogiannis, Assoc. Prof. Dr.
3. Medea Tevdoradze, Prof. Dr.

Introduction

Society has dramatically changed in the last decade. Computers, smartphones, tablets, and other smart devices are all around students. Traditional teaching methods, based on listening to lecturers and taking notes, are mostly not interested to many students nowadays. To motivate them and give them desire to learn the subject we can use new methods of teaching that satisfy new requirements and interests. A lot of new methods of teaching have been developed adopting society change (Frederickson et al., 2012; Freeman et al., 2007; Maksimovic, 2017; Zhamanov, 2012). New technologies allow teachers to use fresh approaches to educate students.

Nonetheless, not all schools and universities have switched to educate students using new technologies. We may still observe that in universities lessons are provided with old methodology without implementing technological solutions (Akinogle and Tandogan, 2006). By using technology, we may build environment in which students and instructors can improve their results and achieve more successes. One alternative to the traditional teaching approach is to implement flipped classroom (Baker, 2012; Hwang and Soman, 2013) and gamification (Gamified UK). Using Internet of Things (IoT) elements into learning process of computer education can be a very promising approach (Hern and Serrano, 2016; Intelligence, 2016).

IoT – the current phase of internet evolution -- connects things, people, data and processes. IoT things are physical devices (objects) that are connected to the Internet and able to interact with multiple servers and clients to provide different types of service and statistics periodically and/or on demand. Smart scale is a good example which shows how IoT can impact on human health (Graziano, 2016). IoT people are represented as wearable devices. Today most people connect socially through web-accessible devices. As the IoT evolves, we will connect each other in new and valuable ways. Wearable devices and clothing are already changing the way that we connect to the global network (Statt, 2017). IoT data is information generated by people, sensors and things. The data, when combined with analytics, delivers actionable information to people and machines. Better decisions are made and better results are achieved. By using data, it is possible to analyze situation from different perspectives and enhance process (Marr, 2015). IoT processes occur between all other pillars in the IoT. With the correct processes, connections become more valuable. These connections provide the right information, delivered to the right person, at the right time and in the most relevant way.

Researchers have tried to apply IoT to education. Maksimovic (2017) describes the model of IoT in education and compares the model with traditional education approach. Online content, online community platform, smart portfolio systems, advanced data analytics, and gamification with virtualization are the parts of IoT education model. The author expects that this model will play the huge role in the transformation of educational process. Here, the author also explained how IoT in education will impact on environment till year 2030 (GeSi, 2015). Those impacts will reduce paper printing by turning off desktop computers in laboratories, using only own devices of students, BYOD (Bring Your Own Device), and using electronic materials and online quiz/test submissions. Abhimanyu Roy (2016) made research on how IoT based innovations can help poor people in big cities in their education. Roy found that one of the main problems for the urban poor is that they spend much money to buy printed learning materials. The situation can be improved by providing students with digital information on demand. Marti Widya Sari (2017) made research on smart campus development using IoT technologies. Marti designed a smart campus that consists of smart education (eLearning, virtual classroom helps students gain information anywhere, anytime with the Internet connection), smart parking (system provides information about vacant parking places), and smart room (room reservation system). Maqbool Ali (2017) made research on IoT-based Flip Learning Platform for medical education (ioTFLiP), where IoT infrastructure is exploited to support flipped case-based learning. The research describes the model of IoTFLiP and shows pros and cons of the model.

Research design

The work describes an implementation of Flipped Classroom as part of Internet of Things (IoT) in learning process of “Computer Networks” subject that is integrated with Cisco Networking Academy (netacad.com) and an implementation of IoT entrance system in Suleyman Demirel University. Research design begins with Literature Review (chapter 1) to find research gaps and problems of current technologies in the education sector. Then, we define research questions that will help close research gaps and problems. Methodology implementing IoT flipped classroom into educational process (th 1st attempt) is described in chapter 2. At the end of semester students submit feedback surveys according to the flipped course, and the instructor evaluates grades of students and compare them with grades of students who study by traditional educational approach. Next, using students’ feedback and scores, the methodology of the flipped classroom is reviewed. New research gaps are found and then improved by modifying the flipped classroom methodology. In chapter 3, we define the problems of monitoring staff and students in university. This can be solved by using IoT entrance monitoring system. We make research on ready products that can be used in university, make a comparison between them and make a decision to develop own IoT entrance system that will satisfy our requests and allow us to save budget. Then we show the comparison of staff monitoring reports before and after the implementation of the IoT entrance system. Figure 1 demonstrates the research design of doctoral dissertation.

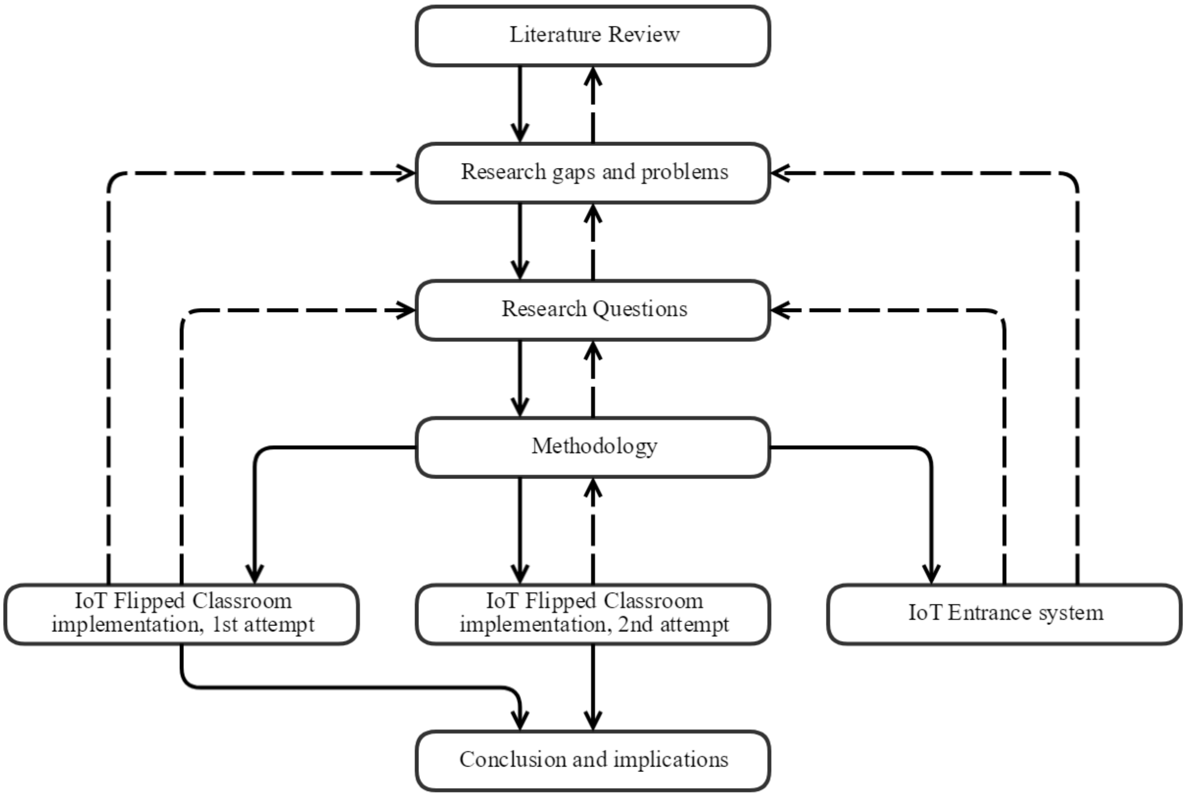


Figure 1. Research design of doctoral dissertation

Methodology

The thesis presents itself deductive research with observing and comparing the previous works, providing implementation experiments, taking feedbacks, changing model, and implementing new experiments that help us improve educational process.

Table 1. List the entire study

#	Task description
1	**Evaluation of prior researches and works:**

	Chapter 1 - Literature review of existent IoT applications in education of universities including IoT flipped classroom and elements of smart campus IoT RFID.
2	**Design of IoT flipped classroom:** Concepts of flipped classroom, IoT flipped classroom, applications used to flip the classroom described in chapter 1. Model of IoT flipped classroom explained also in chapter 1.
3	**Implementation and test:** IoT flipped classroom was implemented and tested twice during two semesters with different settings and IoT entrance system implemented once and used to monitor participation of students and staff.
4	**Evaluation:** After each implementation of IoT flipped classroom we took statistics from grades of participants, YouTube, students' surveys and regular semester reports taken from the administration.
5	**Dissemination:** Results of research were propagated via several papers. 1. Implementation of Flipped Classroom as Element of IoT into Learning Process of Computer Networks Subject in Suleyman Demirel University - *Journal of Technical Science and Technologies (JTST) Vol 6, No 1 (2017)* *2.* IoT smart campus review and implementation of IoT applications into education process of university - *International Conference on Electronics Computer and Computation "ICECCO 2017"* *3.* Implementation and Evaluation of Flipped Classroom as IoT Element into Learning Process of Computer Network Education - *International Journal of Information Communication and Technology Education (IJICTE) vol. 14, issue 2, April-June 2018, pp. 30-47.*

Above we described briefly the practical approach of the work done in this thesis. In upcoming chapters we will expand it into details with description of each model and technique and interpretation of the results.

Purpose of study

Purpose of the study is to verify thesis objectives by implementing and evaluating the results of IoT application like IoT flipped classroom in computer networks education and IoT entrance system as a part of smart campus to improve education and students/staff monitoring systems with IoT technologies.

Novelty of investigation

The novelty of this research is implementation of IoT technologies not used yet in education sector in Kazakhstan and other Commonwealth of Independent Countries (CIS). IoT Flipped classroom helps to improve students' results and allows university to save money by using once recorded video lessons during 3-5 years without paying money for instructor's lecture. Improve staff/students monitoring system by using IoT technologies have real time reports of participation that can be used to evaluate KPI of staff and students.

Scientific and practical importance

The research has both scientific and practical importance. By using empirical deductive research, we can define IoT technologies in education positively impacting students, and using the IoT technologies improve participation of staffs and students. Based on our experience, we can introduce this system throughout educational institutions to improve a general level of knowledge throughout Kazakhstan or even CIS countries.

Structure and volume of work

This PhD thesis has 135 pages organized as the following: acknowledgements, contents, list of tables, list of figures, abbreviations, introduction, research design, three main chapters (chapter 1 – literature review, chapter 2 - implementation of IoT flipped classroom in computer networks, chapter 3 – IoT entrance system for instructors and students), conclusion and future works, and reference.

Chapter 1 – Literature review

IoT concept and components

Four phases of Internet evolution

- Connectivity - started over 20 years ago, digitize access to information: email, web browsing, search.
- Networked economy - started in late 1990s, digitize business process: e-commerce, digital supply chain, collaboration.
- Collaborative experiences – started in the early 2000s, digitize interactions (business and social): social networks (Facebook, VK, YouTube, LinkedIn etc.), mobility and cloud (dropbox, google drive, mail cloud etc.), video cloud (YouTube, VK etc.).
- Internet of Things (IoT) – current phase of internet evolution, connects people, things, data and processes.

Flipped classroom characteristics

"The classroom lecture—it's been criticized, despised, even lampooned" (Bryan Goodwin, 2013). But lectures are not bad; they can be tools for additional ways of providing knowledge (Hattie, 2008). The problem of lecture classes is that students differ in their knowledge background, and they have different levels of perception of information. To a part of students a lecture can be slow and to other group of students the same lecture can be too fast. After the instructor assigns homework, regardless of whether a student understands the topic or not, the student has to do it. Some instructors generate video lessons and distribute them to students as an additional education material. In this case students can catch up with all others who understand the material in the lecture time. Students can feel themselves flexible and comfortable, for those who understand the material completely do not need to watch the video, for those who did not understand the lecture, all materials will be useful, and for some of them video lessons will be partially useful (Bryan Goodwin, 2013).

"The premise of a flipped classroom is simple: Instead of lecturing in class and giving homework at home, flip it: give the lectures at home, and do the homework in class" (Frydenberg, 2012).

According to (Flippedlearning, 2012) the number of members who have social web sites grew up from 2.5k users in 2011 to 9k users in 2012. A survey of (Flippedlearning, 2012) provides information that 67% (453 instructors) of instructors who flipped classroom reported an increase of student grades, 80% reported improvement of the attitude between students and the instructor and 99% want to flip the classroom in the next year.

There are many types/models of flipping the classroom. A report by (Panopto, 2017) mentioned that there are seven main concepts of flipped classroom: the standard inverted classroom, the discussion-oriented flipped classroom, the demonstration-focused flipped classroom, the Faux-flipped classroom, the group-based flipped classroom, the virtual flipped classroom, and flipping the teacher.

Flipped classroom and IoT

Flipped classroom is a part of IoT in education field, and it is a new approach that is not implemented yet into learning process of the educational sector in Kazakhstan. Flipped classroom is a model in which homework and lectures of a course are "flipped" (MF, 2012). Mostly flipped classroom involves students watching pre-recorded video lectures before they attend class and use classroom time to engage in activities like problem solving, inquiry, seminar and playing games. Classroom time can be also used for many other forms of time spending in class (John Moraros, 2015). One of the main goals of the implementation of flipped classroom is to provide students with an ability to learn course material at any time and at any place. When students attend class, they solve problems by using knowledge obtained from video lessons and online reading materials. Flipped classroom is a part of IoT in "process" and "data" pillars of IoT model.

Chapter 2 Implementation of IoT flipped classroom in computer networks

The course "flipped" non-officially in Suleyman Demirel University, since the administration of the university permitted "flip" starting from 2017 fall semester. Table 2 shows INF 314 Computer Networks 1 course structure.

Table 2. INF 314 Computer Networks 1 course structure

INF 314 Computer Networks 1 course structure	
Credits	3
Credits by ECTS	5
Lecture	1 hour
Seminar	1 hour
Laboratory work	2 hours

Participants of IoT flipped classroom

There were 84 computer science sophomore students enrolled into the class of Computer Networks 1 (integrated with Cisco Networking Academy and CCNA RS1, RS2 courses) during the academic year 2016-2017. 73 students out of 84 (86%) agreed to participate in this study.

Figure 2 describes the structure of how an instructor communicates with students.

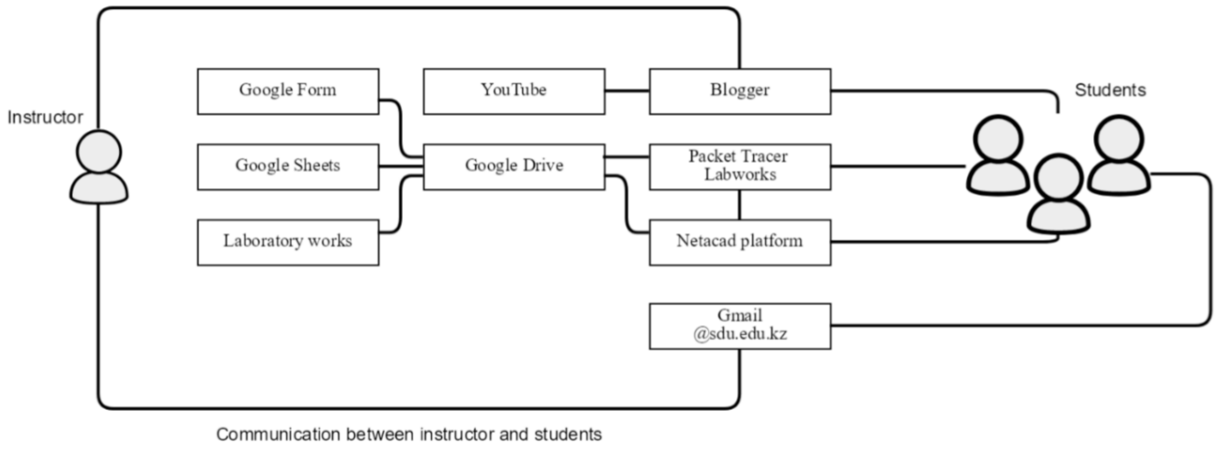


Figure 2 Communication between instructor and students structure

The flipped classroom was implemented non-officially during spring semester of 2016-2017 academic year using pre-class activities (online video lessons on YouTube https://www.youtube.com/channel/UCcQLKoayxTjAD28TVNAYzBw (YouTube statistics by countries demonstrated in Table 3) and interactive eBook provided by Cisco Networking Academy https://www.netacad.com/) and ii) in-class activities (seminars, laboratory works, interviews, hand-on-lab laboratory works and interactive tasks). Students attended one hour lecture (since we "flipped" the course non-officially we still needed one hour official lectures, but at that time students made presentations according to viewed video lessons and online materials from netacad.com), two hour laboratory works and one hour seminar.

Pre-class activity was mandatory to students who attend seminar and laboratory works. During each pre-class activity students should watch the videos (in different chapters, different length of videos), recorded and uploaded by the instructor to YouTube channel, read online materials from netacad.com.

Table 3. Statistics by geography

Geography	Watch time (minutes)	Views	Average percentage viewed	Likes	Shares	Subscribers
Kazakhstan	20320	3178	15.97	80	26	93
France	299	30	28.19	0	0	0
Iraq	234	46	10.88	4	0	1
United States	219	48	10.7	0	0	1
Austria	150	14	28.5	1	1	0
Hungary	129	11	32.85	0	0	0
Russia	126	23	14.29	0	0	3
UK	108	17	17.74	0	0	1
Denmark	52	4	36.32	0	0	0
Costa Rica	51	1	80.59	0	0	0
Malaysia	49	8	19.09	0	0	0
Latvia	48	2	41.89	0	0	0
Australia	32	1	111.11	0	0	0
South Africa	31	4	17.01	0	0	0
Saudi Arabia	30	8	11.3	0	0	0
India	25	34	1.8	0	0	3
Netherlands	13	5	7.7	0	0	0
Canada	10	7	4.77	0	0	0
Argentina	7	1	20.93	0	0	0
Germany	6	11	1.5	0	0	0
Ghana	4	3	5.35	0	0	0

Survey from Students and evaluation of the first attempt

At the end of the course the instructor provided these students with a survey about the flipped classroom implementation to Computer Networks 1 course. Table 4 lists survey questions and Table 5 lists responses from the students.

Table 4. Survey questions to students

No	Question
1	Is the quality of video lessons prepared by your instructor very good?
2	Are video lessons prepared by your instructor understandable?
3	Did you prepare lessons mostly using video lessons that were prepared by your instructor?
4	Did you prepare lessons mostly using other resources?
5	Did seminar questions come from video lessons and netacad.com?
6	Is the seminar in good format to evaluate the level of knowledge that you get from video lessons?
7	Do you like to participate in lectures that were prepared by students (group-mates)?

8	Are quiz questions and format good to understand the knowledge level?
9	Are online quiz from netacad.com questions and format good to understand the knowledge level?
10	Do you like to prepare lessons by reading materials from netacad.com?
11	Are laboratory works on Cisco simulator Packet Tracer very useful to configure routers and switches?
12	Do you like the format of laboratory works?
13	In general, do you understand what is computer network?
14	Would you like to have all other lessons to be in the same format (with video lessons and without traditional lectures in lecture hall)?
15	If the university will cancel traditional lectures and will implement flipped classroom format in which you have video lessons, do you think that it will be easier and more effective to learn?
16	In the future do you want to get Cisco CCNA Certificate?
17	Are video lessons better than traditional lectures in lecture halls?

Table 5. Answers from students (unit: %)

Question# in Table 7	strongly agree (A)	agree (B)	neutral (C)	disagree (D)	Strongly disagree (E)		A+B	D+E
1	50.7	43.8	2.7	2.8	0		94.5	2.8
2	38.4	50.7	5.5	5.4	0		89.1	5.4
3	32.9	49.3	11	5.4	1.4		82.2	6.8
4	1.4	37	30.1	23.3	8.2		38.4	31.5
5	27.4	50.7	17.8	2.7	1.4		78.1	4.1
6	8.2	35.6	26	24.7	5.5		43.8	30.2
7	9.6	38.4	32.9	11	8.1		48.0	19.1
8	4.1	46.6	38.3	11	0		50.7	11
9	11	32.9	39.7	12.3	4.1		43.9	16.4
10	6.8	28.8	43.8	19.2	1.4		35.6	20.6
11	43.8	46.6	8.2	1.4	0		90.4	1.4
12	21.9	47.9	20.5	9.5	0		69.8	9.5
13	21.9	74	4.1	0	0		95.9	0
14	17.8	37	30.1	12.3	2.6		54.8	14.9
15	13.7	41.1	26	15.1	4.1		54.8	19.2
16	12.3	41.1	35.6	9.6	1.4		53.4	11
17	24.7	45.2	19.1	11	0		69.9	11

During our research one part of students studied with flipped classroom IoT methodology and others with traditional approach. After getting results of grading we compared how flipped classroom impacted on learning process. Table 6 and **Error! Reference source not found.**

describe comparison between the flipped classroom and the traditional approaches. Attendance of students in flipped classroom is 15% higher than that in the traditional. Lectures prepared by students were much interesting to students because they understand and support each other on the lecture. Almost all of them attended practical and seminar lessons already, and they knew technology or protocol from video lessons and online materials in netacad.com. Average lab work point in flipped classroom is about 9% higher than that in traditional approach, average quiz 1 and quiz 2 points in flipped classroom approach are 32.5% higher than those in the traditional. Average online quiz 1 point is almost the same in both approaches with about 55%, but online quiz 2 point is considerably different, 80,25% in flipped classroom and 58,78% in the rraditional approach. Average final exam score differs about 20% in favor of flipped classroom. Ultimately flipped classroom approach bypasses the traditional with a difference of 19%.

Table 6. Comparison of Flipped Classroom results with Traditional

	Flipped Classroom	Traditional
Attendance	90,93	75,78
Lab works	60,96	51,78
Quiz 1	74,2	39,67
Quiz 2	75,22	45,35
Midterm	74,63	50,51
Online 1	57,32	55,57
Online 2	80,25	58,78
Final	80,45	60,41
Average	74,24	54,73

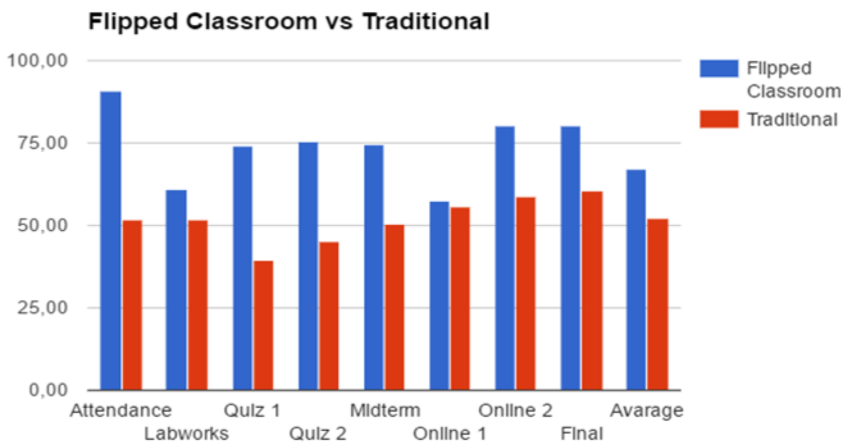


Figure 3 Comparison of Flipped Classroom and Traditional methods

IoT flipped classroom implementation 2nd attempt

Modifications in methodology

As the result of the previous experience of flipping classroom in Computer Networks 1 and according to the survey feedback from students, we decided to modify the model of implementation IoT flipped classroom into educational process as following:

Table 7. Changes in second attempt of IoT Flipped Classroom implementation

Changes in the second attempt of IoT flipped classroom implementation	
Removed element	Added element
Google blogger	Telegram
Seminars (partial)	Kahoot! sessions
Peers lectures (full sessions)	Peers lectures (brief sessions)
Google drive	Video lessons by peers
	Video presentations by peers

Table 7 lists changes in the second attempt of IoT flipped classroom implementation. In comparison of the flipped course from the previous semester and 2017-2018 fall semester, Google blog and Google Drive were removed because of Telegram usage. It has functionality of both Google products. Blogging is available in a new format of Telegram channel which can be public, searchable and accessible by anyone like blog and file sharing system developed by Telegram. It allows to transmit data via Telegram cloud with a maximum size of file 1.5 Gigabytes per single file. All transmitted files are encrypted by MTProto encryption protocol developed by Nikolay Durov based on 2048-bit RSA encryption, AES 256-bit encryption and Diffie-Hellman key exchange (Telegram, 2017) to support perfect security of stored files in Telegram cloud. Table 8 compares pre- and in-class activities.

Table 8. Pre class and in class activities

Pre-class activity	In-class activity
Watch video lessons	Brief presentation by schedule
Read material from http://netacad.com	Kahoot game (online test)
Packet tracer self-placed laboratory works from Cisco Networking Academy	Explore of laboratory work by instructor
Prepare for brief presentation	Laboratory work
Prepare for brief test (Kahoot game)	Interview according to submitted laboratory work

Cisco Aspire	Cisco Aspire
	Hands-on lab (laboratory works)

During 2017 – 2018 fall semester “INF 314 - Computer Networks 1” course was officially flipped with course design modifications. The course consists of three credits and five credits of ECTS, no lectures, two hours of practice and two hours of laboratory works.

Table 9 shows lifetime YouTube statistics by geographical locations.

Table 9 Lifetime YouTube statistics by Geographical locations

Geography	Watch time (minutes)	Views	Average view duration (minutes)	Average percentage viewed
Kazakhstan	57787	8381	6.9	18.08
United States	1284	198	6.5	16.84
Spain	891	80	11.1	26.47
Canada	591	70	8.4	22.91
France	311	36	8.6	23.81
Australia	280	36	7.8	20.63
Iraq	234	46	5.1	10.88
United Kingdom	226	42	5.4	14.11
India	211	80	2.6	6.32
Austria	170	17	10	27.62
Russia	134	34	3.9	12.07
Hungary	129	14	9.2	26.88
Romania	128	12	10.7	35.18
South Africa	120	77	1.6	3.86
Libya	113	31	3.7	9.57
Netherlands	80	17	4.7	11.49
Ukraine	77	15	5.1	11.32
Malaysia	73	12	6.1	16.3
Costa Rica	57	2	28.5	55.15
Denmark	52	5	10.4	28.45
Latvia	48	2	23.9	41.89

Table 10 demonstrates the comparison between the traditional education, IoT flipped classroom the first and the second attempts.

Table 10. Comparison of traditional, FP 1st and 2nd attempts

	Traditional	Flipped classroom 1st attempt	Flipped classroom 2nd attempt
Attendance	75,78	90,93	89,2

Labworks	51,78	60,96	72,3
Quiz 1	39,67	74,2	83,2
Quiz 2	45,35	75,22	79,1
Midterm	50,51	74,63	77,43
Online 1	55,57	57,32	75,4
Online 2	58,78	80,25	83,2
Final	60,41	80,45	79,4
Average	54,73	74,24	79,87

Survey to students and evaluation of the first attempt

At the end of the course the instructor provided these students with a survey about flipped classroom implementation to Computer Networks 1 course. Table 11 lists the survey questions and Table 12 lists responses from the students.

Table 11. Survey questions to students 2nd attempt

No	Question
1	Is the quality of video lessons prepared by your instructor very good?
2	Are video lessons prepared by your instructor understandable?
3	Did you prepare lessons mostly using video lessons that were prepared by your instructor?
4	Did you prepare lessons mostly using other resources?
5	Kahoot questions came from video lessons and netacad.com
6	Kahoot is good format to evaluate the level of knowledge that I get from video lessons
7	Do you like to participate in lectures that were prepared by students (group-mates)?
8	Are quiz questions and format good to understand the knowledge level?
9	I like that my instructor uses Telegram to announce information about course.
10	Do you like to prepare lessons by reading materials from netacad.com?
11	Are laboratory works on Cisco simulator Packet Tracer very useful to configure routers and switches?
12	Do you like the format of laboratory works?
13	In general, do you understand what is computer network?
14	Would you like to have all other lessons to be in the same format (with video lessons and without traditional lectures in lecture hall)?
15	If the university will cancel traditional lectures and will implement flipped classroom format in which you have video lessons, do you think that it will be easier and more effective to learn?
16	In the future do you want to get Cisco CCNA Certificate?
17	Are video lessons better than traditional lectures in lecture halls?

Table 12. Answers from students (unit: %) 2nd attempt

Question# in Table 7	strongly agree (A)	agree (B)	neutral (C)	disagree (D)	Strongly disagree (E)		A+B	D+E
1	42.1	52.6	5.3	0	0		94.7	0
2	43.9	45.6	3.5	5.3	1.8		89.5	7.1
3	22.8	66.7	8.8	1.8	0		89.5	1.8
4	0	14	22.8	36.8	26.3		14	63.1
5	19.3	56.1	22.8	1.8	0		75.4	1.8
6	12.3	40.4	31.6	12.3	3.5		52.7	15.8
7	10.5	40.4	40.4	8.8	0		50.9	8.8
8	8.8	38.6	47.4	5.3	0		47.4	5.3
9	59.6	36.8	3.5	0	0		96.4	0
10	8.8	24.6	45.6	10.5	10.5		33.4	21
11	33.3	47.4	17.5	1.8	0		80.7	1.8
12	26.3	50.9	19.3	3.5	0		77.2	3.5
13	21.1	66.7	10.5	1.8	0		87.8	1.8
14	22.8	36.8	24.6	14	1.8		59.6	15.8
15	17.5	49.1	19.3	12.3	1.8		66.6	14.1
16	24.6	50.9	21.1	3.5	0		75.5	3.5

Chapter 3 - IoT entrance system for instructors and students

Problem statement of entrance system

In a university it is important to distinguish the flow of incoming people, permit those who have rights and deny others. It can impact staffs and students' performance and security of the university. "*Many smart objects like RFID, smart card, sensor, etc. are connected to the Internet*" (Singh, 2017). Devices with limited resources, such as a sensor, smart cards, RFID, are used in many Internet applications of things. Many devices in the IoT are connected. They collect data from each other to carry out the assigned task (Singh, 2017). An IoT entrance system ensures that the card system is fully managed for different purposes without the need for software and device management from the manufacturer. Because existing card systems are in the ready-to-use package, different card and card systems are installed in business for many different purposes. Similarly, the functioning of ready-packaged systems is incomplete, and an integration with information systems used in enterprises is difficult.

The potential for commercialization of the project and the likelihood of other investors

The main feature that differentiates this system from the market is that a company has full control over the software and the device. Therefore, the company can change the software as it wishes and manage the card reader on various business logics. Since there are not many companies willing to make such a thing, this field is not a source of revenue to large companies. For this reason, this type of product is not very demanding, but it is a very important solution for those in need, which was the case at Suleyman Demirel University. Thus, one system for access to the university, another system for the dining room and a library were installed. The database used by each system and the cards distributed to the users were different. As a result, there was a different system for each different service within the same enterprise and different cards were provided users for any service. Nowadays, the use of peripheral systems is inevitable, as different digital services in companies.

Implementation of IoT entrance system consists of two steps:

- Hardware (card readers, turnstiles, network connectivity)
- Develop software and integrate with university portal.

The first prototype was developed by using SM5210 processor, RFID antenna, circuit board and Ethernet module USR-TCP232-T2. Figure 4 shows the initial prototype view.

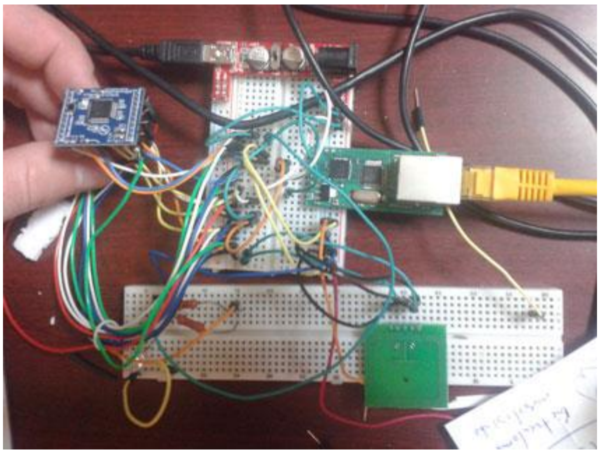


Figure 4. RFID reader prototype

After a successful prototype development, the administration of the university approved our project and we started to implement IoT entrance system in Suleyman Demirel University.

IoT Entrance system implementation in Suleyman Demirel University

A system was implemented in 2016-2017 education year which consists of five turnstile with five check-in and five checkout sensors (RFID readers) in the main entrance to check both staffs and students on foot, and 10 sensors (RFID readers) to check-in and checkout those by car. A car passes the entrance gate by using permission card provided by the university administration with the car plate registration, and a security looks for that permission paper and decides whether to permit or not. If a permission is given, the security opens barrier by using remote control. In future we plan to implement application that will use capture from the surveillance camera and make a decision according to the database of allowed car plates. In the main entrance RFID readers are affixed to the right side on turnstile.

Processor SM5210 controls all processes of RFID card reader responsible for reading signals from RFID antenna by using (UART) Rx mode and resends them to retranslation module USR-TCP323-T2, which retranslates signals into computer networks by using Ethernet. Figure 5 shows how devices interact inside RFID reader, with RFID card and with Ethernet switch.

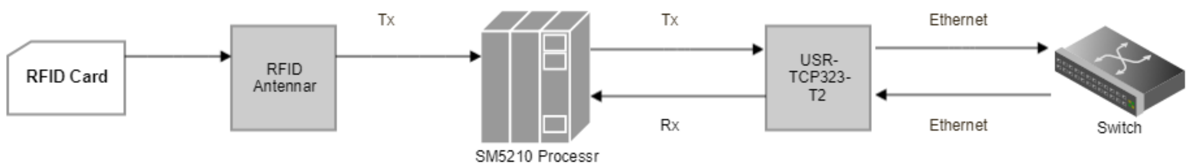


Figure 5. Communication inside RFID Reader

USR-TCP323-T2 is preconfigured via an integrated web server with its IP address and the destination IP address, all received from antenna information directed to server's IP address. IP configurations can be made directly and remotely via computer networks by using the IP address of the device and username/password.

The server receives information from the RFID reader and stores it in a database to monitor which a student/staff enters or exit from a building, compares received information with the permission list table and then returns, permitting or denying entrance. USR-TCP323-T2 module receives the answer from the server and retransmits it to SM5210 processor, then relays opened or closed according to the received answer and affects to turnstile. At the same time the processor sends a signal to LEDs according to the answer; if the answer denies, red colored LED turns on and in other case green LED works with a sound signal. Our server runs our developed C# service that can run on background, because if the system is unexpectedly restarted, a service will be working on background without login to the operating system.

By using service console it is possible to control and configure RFID readers. The server receives triggers from RFID readers (clients) and can monitor them working or not. If for 180 seconds (3 minutes) RFID reader does not send any triggered signals, the server sends a hello packet that is used to check whether RFID reader is working properly or not. Figure 6 shows possible flows between RFID readers and the server.

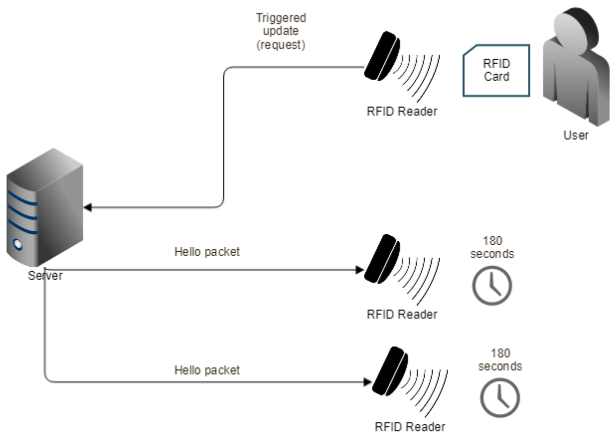


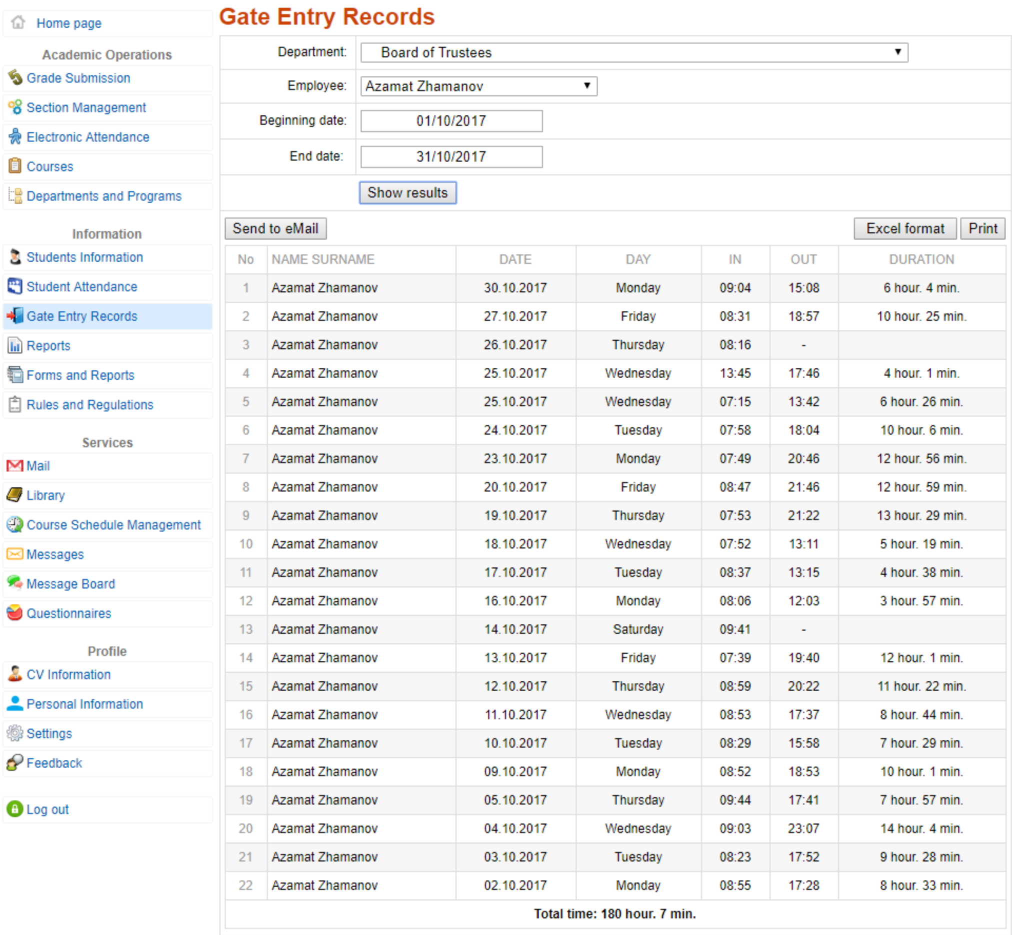
Figure 6. Flow between RFID readers and server

When a card is placed on the top of RFID reader, the card owner information is transmitted and stored into the database of the server. If many RFID readers are connected to the server, the information is written in sequence asynchronously. If too many requests come to the server from the readers at the same time, requests will stay in a queue until the server will be ready to operate it. For that reason, we track the time when a request was delivered and when it was processed. Figure 7 shows a screenshot of the database in which the following unique information is stored: (1) ACCESS_ID (defines the sequence number of requests received during semester), (2) CARD_NO (unique RFID card number defined by student affairs department), (3) READER_IP (local IP address of RFID reader, currently we have 20 IP addresses), (4) GROUP_ID (RFID reader classification, readers can be used in different purposes including entrance system, turnstile, automation of heating system etc., group 1 defines turnstile category), (5) ORDER_TYPE (identification of student/staff direction, in or out), (6) USER_TYPE (user category, “S” –students, “P” –staff), (7) USER_TOKEN (unique ID of a student in the university, it is used to bound a student with RFID card and show participation statistics in local portal https://pms.sdu.edu.kz and https://my.sdu.edu.kz), 8) ACCESS_DATE (defines date and time when a user sends a request via RFID reader), (9) SYSTEM_DATE (defines date and time when a request is placed into the database, time can be different according to the queue on the server, a server receives a request and immediately respond only after storing it in the database), (10) RESPONSE_CODE (defines whether the user takes permission to pass or not, "1" defines permit, "0" deny) and (11) CMD_STR_SENT (system codes used in SM5210 processor).

	ACCESS_ID	CARD_NO	READER_IP	GROUP_ID	OPER_TYPE	USER_TYPE	USER_TOKEN	ACCESS_DATE	SYSTEM_DATE	RESPONSE_CODE	CMD_STR_RCVD	CMD_STR_SENT	REF_ACCESS_ID
1	214419	FBBF9A74	[redacted]	1	IN	S	170207012	09.11.2017 12:54:31	09.11.2017 12:55:19	1		FF-00-02-92-03-97	
2	214418	002C1D57	[redacted]	1	OUT	S	170302101	09.11.2017 12:54:03	09.11.2017 12:54:51	1		FF-00-02-92-03-97	
3	214417	FBDC3364	[redacted]	1	IN	S	150103106	09.11.2017 12:53:59	09.11.2017 12:54:48	1		FF-00-02-92-03-97	
4	214416	FBE0C0C4	[redacted]	1	IN	S	170302062	09.11.2017 12:53:48	09.11.2017 12:54:36	1		FF-00-02-92-03-97	
5	214415	FC066024	[redacted]	1	IN	S	170302090	09.11.2017 12:53:47	09.11.2017 12:54:35	1		FF-00-02-92-03-97	
6	214414	FC1E9264	[redacted]	1	IN	S	160103097	09.11.2017 12:53:46	09.11.2017 12:54:35	1		FF-00-02-92-03-97	
7	214413	FBCD4214	[redacted]	1	OUT	S	170105007	09.11.2017 12:53:30	09.11.2017 12:54:18	1		FF-00-02-92-03-97	
8	214412	FBCFB894	[redacted]	1	IN	S	170302016	09.11.2017 12:53:03	09.11.2017 12:53:52	1		FF-00-02-92-03-97	
9	214411	FBCBDEE4	[redacted]	1	IN	S	170107044	09.11.2017 12:52:53	09.11.2017 12:53:41	1		FF-00-02-92-03-97	
10	214410	002DA027	[redacted]	1	OUT	S	170107157	09.11.2017 12:52:52	09.11.2017 12:53:40	1		FF-00-02-92-03-97	
11	214409	F6DB9D14	[redacted]	1	IN	S	170107123	09.11.2017 12:52:49	09.11.2017 12:53:37	1		FF-00-02-92-03-97	
12	214408	FBCD07C4	[redacted]	1	OUT	S	160103121	09.11.2017 12:52:47	09.11.2017 12:53:35	1		FF-00-02-92-03-97	
13	214407	FC15C9F4	[redacted]	1	IN	S	170107097	09.11.2017 12:52:43	09.11.2017 12:53:31	1		FF-00-02-92-03-97	
14	214406	FC1DDC24	[redacted]	1	IN	S	170107043	09.11.2017 12:52:40	09.11.2017 12:53:29	1		FF-00-02-92-03-97	
15	214405	00376F87	[redacted]	1	IN	S	170107062	09.11.2017 12:52:39	09.11.2017 12:53:27	1		FF-00-02-92-03-97	
16	214404	FBDD32F4	[redacted]	1	IN	S	140305032	09.11.2017 12:52:37	09.11.2017 12:53:25	1		FF-00-02-92-03-97	
17	214403	FBB9D454	[redacted]	1	IN	S	160103106	09.11.2017 12:52:33	09.11.2017 12:53:21	1		FF-00-02-92-03-97	
18	214402	FBDEDD84	[redacted]	1	IN	S	140107026	09.11.2017 12:52:31	09.11.2017 12:53:19	1		FF-00-02-92-03-97	
19	214401	F6DEAF34	[redacted]	1	OUT	S	170107183	09.11.2017 12:52:21	09.11.2017 12:53:09	1		FF-00-02-92-03-97	
20	214400	F63D1FD4	[redacted]	1	OUT	S	170107096	09.11.2017 12:52:20	09.11.2017 12:53:08	1		FF-00-02-92-03-97	
21	214399	FBE537B4	[redacted]	1	OUT	S	140401004	09.11.2017 12:52:17	09.11.2017 12:53:05	1		FF-00-02-92-03-97	
22	214398	FBE47F24	[redacted]	1	OUT	S	170107184	09.11.2017 12:52:16	09.11.2017 12:53:04	1		FF-00-02-92-03-97	
23	214397	FC05E634	[redacted]	1	OUT	S	150201004	09.11.2017 12:52:12	09.11.2017 12:53:00	1		FF-00-02-92-03-97	
24	214396	FBCEBCB4	[redacted]	1	OUT	S	170214018	09.11.2017 12:52:09	09.11.2017 12:52:57	1		FF-00-02-92-03-97	
25	214395	FBD255D4	[redacted]	1	OUT	S	170214012	09.11.2017 12:52:09	09.11.2017 12:52:57	1		FF-00-02-92-03-97	
26	214394	2D0B7C41	[redacted]	1	OUT			09.11.2017 12:52:09	09.11.2017 12:52:57	0			
27	214393	FBE358D4	[redacted]	1	IN	S	170107181	09.11.2017 12:51:42	09.11.2017 12:52:30	1		FF-00-02-92-03-97	
28	214392	FBCFCEA4	[redacted]	1	IN	S	170210018	09.11.2017 12:51:35	09.11.2017 12:52:23	1		FF-00-02-92-03-97	
29	214391	F63B6E94	[redacted]	1	IN	S	160107057	09.11.2017 12:51:27	09.11.2017 12:52:15	1		FF-00-02-92-03-97	
30	214390	95073C69	[redacted]	1	IN			09.11.2017 12:51:26	09.11.2017 12:52:14	0			
31	214388	FBDC1954	[redacted]	1	IN	S	160103011	09.11.2017 12:51:23	09.11.2017 12:52:11	1		FF-00-02-92-03-97	
32	214389	FB9A1704	[redacted]	1	IN	S	160102011	09.11.2017 12:51:23	09.11.2017 12:52:11	1		FF-00-02-92-03-97	
33	214387	FC1EC954	[redacted]	1	IN	S	150103007	09.11.2017 12:51:12	09.11.2017 12:52:00	1		FF-00-02-92-03-97	
34	214386	FBCF6F14	[redacted]	1	IN	S	150103011	09.11.2017 12:51:12	09.11.2017 12:52:00	1		FF-00-02-92-03-97	
35	214385	FBD60574	[redacted]	1	OUT	S	170105018	09.11.2017 12:51:04	09.11.2017 12:51:52	1		FF-00-02-92-03-97	
36	214384	FC060FD4	[redacted]	1	IN	S	160107036	09.11.2017 12:51:04	09.11.2017 12:51:52	1		FF-00-02-92-03-97	
37	214383	0055D5D7	[redacted]	1	IN	S	160107126	09.11.2017 12:51:03	09.11.2017 12:51:51	1		FF-00-02-92-03-97	
38	214382	FC0AD4F4	[redacted]	1	IN	S	140103023	09.11.2017 12:51:02	09.11.2017 12:51:50	1		FF-00-02-92-03-97	
39	214381	F6DF8CC4	[redacted]	1	IN	S	160107083	09.11.2017 12:51:00	09.11.2017 12:51:48	1		FF-00-02-92-03-97	
40	214380	FBD40934	[redacted]	1	IN	S	140107034	09.11.2017 12:50:56	09.11.2017 12:51:44	1		FF-00-02-92-03-97	
41	214379	F6DF4E54	[redacted]	1	IN	S	170117003	09.11.2017 12:50:55	09.11.2017 12:51:43	1		FF-00-02-92-03-97	
42	214378	00130297	[redacted]	1	IN	S	170201008	09.11.2017 12:50:53	09.11.2017 12:51:41	1		FF-00-02-92-03-97	
43	214377	FB977794	[redacted]	1	IN	S	150202017	09.11.2017 12:50:50	09.11.2017 12:51:38	1		FF-00-02-92-03-97	

Figure 7. Screenshot of database with card id

The database used by local portal of our university https://pms.sdu.edu.kz is able to provide monitoring information to the administration and for every single account of students and staffs. The statistics on staff participations monitored by Human Resources (HR) department directly impact on their salaries every month. Figure 8 shows a monthly report of a staff in hours.


Home page
Academic Operations
Grade Submission
Section Management
Electronic Attendance
Courses
Departments and Programs
Information
Students Information
Student Attendance
Gate Entry Records
Reports
Forms and Reports
Rules and Regulations
Services
Mail
Library
Course Schedule Management
Messages
Message Board
Questionnaires
Profile
CV Information
Personal Information
Settings
Feedback
Log out

Gate Entry Records

Department: Board of Trustees
Employee: Azamat Zhamanov
Beginning date: 01/10/2017
End date: 31/10/2017
Show results

Send to eMail | Excel format | Print

No	NAME SURNAME	DATE	DAY	IN	OUT	DURATION
1	Azamat Zhamanov	30.10.2017	Monday	09:04	15:08	6 hour. 4 min.
2	Azamat Zhamanov	27.10.2017	Friday	08:31	18:57	10 hour. 25 min.
3	Azamat Zhamanov	26.10.2017	Thursday	08:16	-	
4	Azamat Zhamanov	25.10.2017	Wednesday	13:45	17:46	4 hour. 1 min.
5	Azamat Zhamanov	25.10.2017	Wednesday	07:15	13:42	6 hour. 26 min.
6	Azamat Zhamanov	24.10.2017	Tuesday	07:58	18:04	10 hour. 6 min.
7	Azamat Zhamanov	23.10.2017	Monday	07:49	20:46	12 hour. 56 min.
8	Azamat Zhamanov	20.10.2017	Friday	08:47	21:46	12 hour. 59 min.
9	Azamat Zhamanov	19.10.2017	Thursday	07:53	21:22	13 hour. 29 min.
10	Azamat Zhamanov	18.10.2017	Wednesday	07:52	13:11	5 hour. 19 min.
11	Azamat Zhamanov	17.10.2017	Tuesday	08:37	13:15	4 hour. 38 min.
12	Azamat Zhamanov	16.10.2017	Monday	08:06	12:03	3 hour. 57 min.
13	Azamat Zhamanov	14.10.2017	Saturday	09:41	-	
14	Azamat Zhamanov	13.10.2017	Friday	07:39	19:40	12 hour. 1 min.
15	Azamat Zhamanov	12.10.2017	Thursday	08:59	20:22	11 hour. 22 min.
16	Azamat Zhamanov	11.10.2017	Wednesday	08:53	17:37	8 hour. 44 min.
17	Azamat Zhamanov	10.10.2017	Tuesday	08:29	15:58	7 hour. 29 min.
18	Azamat Zhamanov	09.10.2017	Monday	08:52	18:53	10 hour. 1 min.
19	Azamat Zhamanov	05.10.2017	Thursday	09:44	17:41	7 hour. 57 min.
20	Azamat Zhamanov	04.10.2017	Wednesday	09:03	23:07	14 hour. 4 min.
21	Azamat Zhamanov	03.10.2017	Tuesday	08:23	17:52	9 hour. 28 min.
22	Azamat Zhamanov	02.10.2017	Monday	08:55	17:28	8 hour. 33 min.

Total time: 180 hour. 7 min.

Figure 8. Monthly staff report from local portal https://pms.sdu.edu.kz

Information taken from IoT entrance system's database and evaluated by HR department of the university to calculate Key Performance Indicator (KPI) directly impact on salaries of staffs.

Figure 9 shows the overall structure of IoT entrance system.

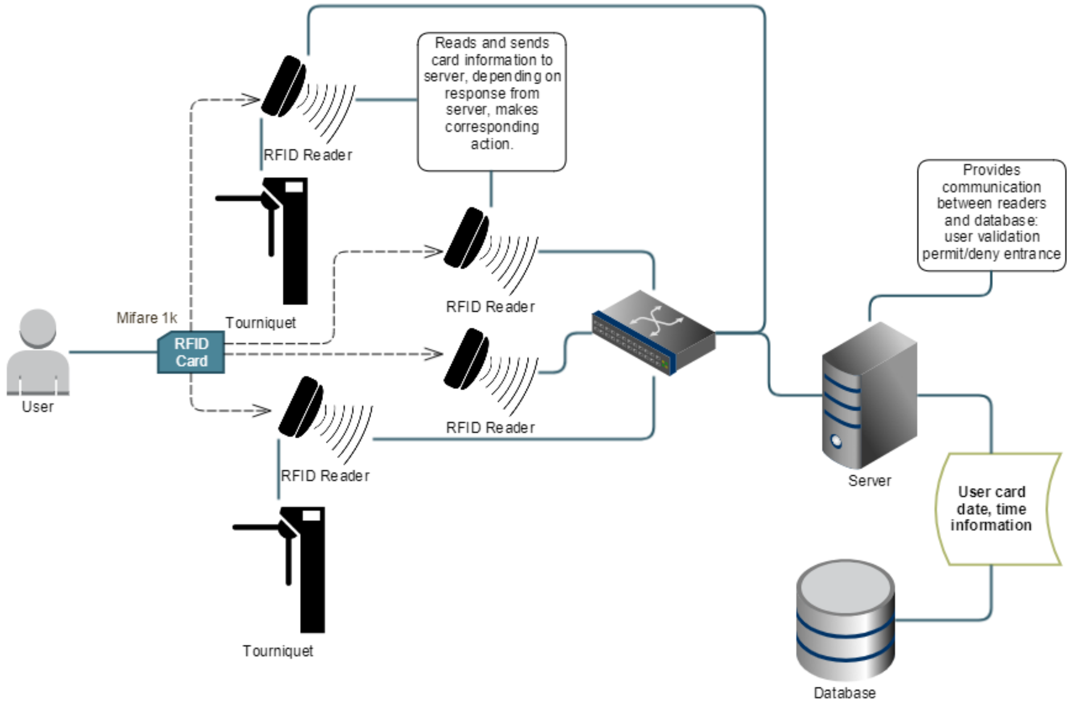


Figure 9. Structure of IoT Entrance system

Result of the IoT entrance system realization

In comparison with other ready entrance systems for universities, IoT entrance system project was more successful in budget saving, scalability, management, staff monitoring and students monitoring aspects.

The ready card pass-through systems usually operate in conjunction with a controller (a ready-box device). Readers added to the system are connected directly to the controller. Readers in ready-box solutions work by connecting them to a vendor's controller. Vendors' controllers are expensive and have a limited number of reader slots (24 slots, 36 slots, or 48 slots). If it is required to add more reader slots (for example, 26) when the limit is reached, a new controller has to be placed to the system, meaning that new financial resources are needed. Different vendors have different rules and some solutions can be limited with only two or even one controller in the system, which makes very static and non-scalable system solution. In the developed and implemented IoT entrance system at Suleyman Demirel University, there is no need to have a separate controller to be able to run RFID readers. A number of readers could be added at any time and at any place where a local Ethernet or global Internet is accessible with Ethernet technologies (in future we plan to extend variants of connection readers to the network, including Wi-Fi, Zigbee, 6LoWPAN etc.). There is no limit in the number of readers per one system, everything belonging to computer networks infrastructure and servers' performance. One of the most important factors that make other card access systems expensive is their software. There are few companies who are ready to share with customer clear code (open source). Mostly they sell ready solutions with ready close code that can not be customized for organizations that use the product. In short, since there are many closed systems, in which users can not be able to make changes according to their needs, users have to enter the existing card information system and update it continuously. Our implemented system is already integrated with automation, and our codes are clear (open source); thus, it can be modified according to any needs of any user. There is no need to re-enter information about the personnel list and the system to use. The system uses the same information as it is integrated. There are no other companies that work similar to our system. However, we have observed that the (http://www.avea.hk/, 2016) price $199 does not work as efficiently as ours. We have seen a lot of server resources (CPU and RAM) when we need continuous readers. We have observed that even if 20 of our readers have the same continuous card stroke test, the CPU does not even reach 1% and the RAM requirement is very small. In short, even if the number of readers added to the system is large, it does not affect an operation much. Even a standard PC or even notebook can be used as a server. We found a modifiable component usage. Suprema firm stands out as an alternative solution to our card access system. They really have very stylish reader designs. And it can be integrated with different systems like ours. Unfortunately, even these readers are very expensive (you can find between $ 350 and $ 500 for each reader). Also, consider that users have received the entire system, the number of readers needed and the license fee that users have to pay for the software. In addition to that, users have to buy the new one whenever any reader gets corrupted. The most expensive components used in our readers does not exceed $20.

Conclusion and future work

By using IoT flipped classroom we improved the average score of students for 25.1%, laboratory works became better done for 20.5%, average quiz results became almost twice better, midterm and final exams were also improved. According to the survey feedbacks from students, they really like new approach in which they feel free in new technologies and sharing knowledge with each other during peers' presentations, also they improved skills of public speaking, some of them got rid of the shyness before the public. Benefits of the instructor are that the instructor is ready for the next semester and does not need to prepare one more time for the same lecture, but can prepare new video lessons for another deeper subject, does not need to explain the same material on a student's demand to those students who did not participate in the lesson or did not understand during the lecture time. The administration has now more free space in lecture halls and also can use recorded video lessons for the next students without spending money for instructors' lecture salaries.

In Suleyman Demirel University there are 50 different positions described on Figure 10.

Position	2016	2017
Accountant	37.2	41.8
administrator	46.0	44.0
analyst	42.0	38.0
Archivist	47.0	35.0
Assistant of head of warehouse	31.0	41.0
Assistant	40.3	40.7
Assistant Professor	16.6	21.9
Assistant-instructor	36.2	41.5
Associate Professor	15.7	18.6
Chairman	33.3	35.3
Chief accountant	43.0	48.0
Chief expert	33.6	39.8
Dean	47.3	27.0
Designer	32.5	46.5
Director	39.8	45.8
Docent	22.0	26.7
Doctor	33.0	46.0
Driver	22.0	26.0
Electrician	36.5	45.0
Energy supply engineer	45.0	54.0
Executive Rector's Assistant	46.0	37.0
Expert	39.2	43.5
Head	28.4	37.0
Head of laboratory	31.0	36.0
Heating system operator	31.7	39.7

Position	2016	2017
Lawyer	18.0	28.0
Lecturer	26.9	30.5
Librarian	36.0	46.0
Marketing manager	30.0	31.0
Marketologist	35.0	39.0
Nurse	37.0	51.0
Operator	26.0	34.0
Pasportist	45.0	29.0
Plumber	42.8	43.0
Practician	33.6	38.7
Professor	15.5	21.1
Programmer	39.7	32.0
Psychologist	24.0	32.0
Rector	38.0	28.0
Secretary	42.5	49.8
Senior Lecturer	26.1	30.1
SMM-manager	40.0	43.0
Social Affairs Coordinator	50.0	50.0
System Administrator	40.0	50.5
Technical Support expert	40.0	58.0
Vice Director	33.0	36.0
Vice Rector	26.0	33.0
Vice rector on Administartive Affairs	45.0	33.0
Vice Rector on Social Affairs	42.0	50.0
Worker	36.0	35.8

Figure 10. Positions in Suleyman Demirel University

Staffs monitored by the administration in this form are less late coming to work for 9% more than by using the previous monitoring system in which all staffs of the university signed when they came and left the work. For example, Lecturers increased average hours of being in university from 26.9 up to 30.5, it is 11.8% of growth. Senior Lecturer's average grew for 13.3%, from 26.1 to 30.1 average hours for this position. Also we do not know how clear the previous system worked because a human factor could help hide some omissions from employees. Most people work 9:00 am – 6:00 pm, and a card system works in pairs with video control system from which the administration can reveal a deception of the system. Monthly reports are automatically generated and sent by the system via corporate email to HR department of the university, deans of the faculties and staffs. The transmitted report directly affect staff salary and it is good motivator to stay at work. Also the system allows us to define the number of both pedestrians (students and staffs) and those who come to university by car.

In future, this information can be used to analyze and manage free space on parking or make it possible to schedule parking places on demand by the students' schedule. Our next step is to develop attendance checking system (by using biometric, fingerprint readers) near each lecture hall to be able to automate the process and save time. Additionally, in future we want to implement an automation system that will send reports to the messengers of the parents of students, so that the parents will be notified each time when their child is absent on the lesson.

Publications

Zhamanov A, Mirtskhulava L. M. , Sakhiyeva Z., Zhaparov M.(2017). Implementation of Flipped Classroom as element of IoT into learning process of Computer Networks subject in Suleyman Demirel University. *Journal of Technical Science and Technologies (JTST)* , Issue 1, Volume 6, 17-22.

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Zhamanov A., Sakhiyeva Z. (2015). Implementing flipped classroom and gamification teaching methods into computer networks subject, by using cisco networking academy. *Implementing flipped classroom and gamification teaching methods into computer networks subject, by using cisco networking academy*. Almaty, Kazakhstan: IEEE Twelve International Conference on Electronics Computer and Computation (ICECCO), 1-4.

Zhamanov A., Sakhiyeva Z, Kaldikulova Z, Suliyev R. (2017). IoT smart campus review and implementation of IoT applications into education process of university. *IoT smart campus review and implementation of IoT applications into education process of university*. Abuja, Nigeria: IEEE 13th International Conference on Electronics Computer and Computation (ICECCO), 1-4.