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ORIGINAL ARTICLE

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ENHANCING SECURITY MEASURES IN STUDENT HOUSING THROUGH ADVANCED ACCESS CONTROL SYSTEMS

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Abstract

Student housing is adapting to meet the requirements of modern education. Safety has a significant impact on modern education in many different ways including physical well-being, emotional and psychological health, legal and ethical responsibilities and parental confidence. To keep student housing safe, ensuring the effectiveness of access control policies is vital. Student housing provides seat wise residence facilities to the students. Generally, students and allowed guests can enter and leave the student housing frequently. It often becomes difficult to keep track of each entry and exit manually. Therefore, unauthorized entry and exit can happen. This raises security concern. Several access control policies are currently being implemented. Biometric access control, smart card and video surveillance are some of them. A case study of access control policy using smart card is shown in our work. Our smart ID card-based housing system allows only valid person to enter the student housing, keeps track of each entry and exit and digitally manages seat allocation. RFID based card is used as smart ID card. Each student and guest who has permission to enter the student housing has the card. RFID reader reads the card to verify a student or a guest. Detail information of the student or guest is instantly visible to the security guard during entry or leaving the housing. Security guard can check the entry and exit history and assigned ID cards. Our system also gives student housing authority the convenience to manage and allocate seat digitally. Seat management includes creating and updating seat number, room number. Seat allocation includes assigning seat to the students, exchanging seat between students. Introducing our system to a student housing can increase its security by keeping tracks of all entries and exits and it can also help the housing authority to manage and allocate seat without any paperwork hassle.

Keywords: Case study, Smart ID card, RFID card, Authorized entry/exit, Student housing, Hall seat management

Introduction

In today's times, keeping students safe is very important in an educational institution. That's why it's really crucial to have strong security in student housing. Educational institutions are using high-tech access control systems to make sure their halls are safe. This isn't just about dealing with security issues – it also makes a good environment for studying and personal development.

Access control systems are like advanced keys. They use key cards and/or fingerprints to let people in. These systems also have a central monitor. They're not just regular keys; they can be changed to fit different needs. Access control systems in student housing offer several advantages including enhanced security by preventing unauthorized entry, controlled visitor access and convenience. These systems can be integrated with other systems like with existing automation system of an institution and with cameras and alarms to make a complete security setup. Using these advancements, educational communities can create a secure environment where students can focus on learning without worrying about safety. Here are some strategies and features to consider:

- Biometric Access Control: Fingerprint or retina scans can be used to control access and this makes sure only allowed people can enter certain places. Biometric data is special to each person, making it a very secure way to control access.

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- Smart Card Access Systems: RFID (Radio-Frequency Identification) technology can be used in smart cards. Smart cards can be easily deactivated and reactivated, providing better control over access permissions.
- Video Surveillance: Security cameras can be used to watch entrances and common areas. It helps to stop problems and find out what happened when there's an issue.

Among the strategies of access control policies, smart card-based access control policy is not only secured but also convenient. In this policy, only punching a card verifies the card holder. A case study using smart card is shown in our work, which makes an access control policy in a student housing. Hall seat management system is also developed. Our smart card-based access control system is integrated with the hall seat management system.

A radio-frequency identification (RFID) based identification system for the library was proposed by M. BAYGIN et al. (BAYGIN, YAMAN, TOPUZ, & KALELI, 2021). This system identifies the students by using their RFID-based cards and logged them into the library computers. After a fixed amount of time of using a computer, a student is automatically logged out from the system. The RFID tag of the cards is read by an RFID reader which is controlled by an Arduino. Using the information of the RFID tag, student information is retrieved from the server using software and the student is verified to use the computer.

Similar to our work RFID technology was used in other works. Danijel Mijić et al. (Mijić, Bjelica, Durutović, & Ljubojević, 2019) proposed a RFID based student attendance management system. After the teacher's card is read by the RFID reader, the class session starts. Then present students can give their attendance using their RFID card. They are automatically associated with the current session. Ria Mutiara Sari et al. (Sari, Sabna, Wahyuni, & Irawan, 2021) proposed a RFID based automatic gate system. Arduino is used to controlling all the utensils. After identifying the car from its RFID tag, Arduino opens the gate using a DC motor. Zeydin Pala et al. (Pala & Inanc, 2007) proposed an RFID technology-based smart car parking system. Registered vehicles' information is stored in a database. When they come near the parking lot, their RFID tags are read. The information of the tag is matched with the information in the database. If a match is found, the barrier of the parking lot opens. Chao Yang et al. (Yang, Wang, & Mao, 2021) proposed an RFID-based human movement tracking system. Several RFID tags are attached to different parts of the human body. The deep learning model is used to detect the tag phase variations and to transform them into the spatial rotation angle of each human joint. Human movement is remodeled from these angles. Mohd Shariq et al. (Shariq, et al., 2021) proposed a secure RFID authentication system for healthcare services. In Telecare Medical Information System (TMIS), a patient shares his/her medical conditions with a doctor via a wireless communication channel. RFID-based technology is used here to secure the exchange of data between a patient and a doctor. For monitoring blockage of sewer systems, an application was proposed by Sundra R. Tatiparthi et al. (Tatiparthi, et al., 2021). Clearing all the sewers of a city at a time is a tedious process. To solve this issue, a real-time monitoring system was proposed, which shows which specific sewer line is blocked so that that specific sewer line can be cleared. RFID sensors are used for this purpose.

The idea of smart card is not new (Smart card - Wikipedia, 2023). Many applications have been implemented using the smart card. Maximiliano Lizana et al. (Lizana, Choudhury, & David, 2023) proposed a model which analyzes data from smart cards to find out users' travel behavious. It shows how the travel habits changes after the covid-19 pandemic. Lukas Kolkowski et al. (Kolkowski, et al., 2023) used data from public transport cards in Stockholm, Sweden, to understand how different income groups separate when they travel. After a major rail project in 2017, they saw changes. The city center had a little less separation, but areas with commuter train stations had more. This study helps to figure out how people of different incomes move around the city and can help make better city plans. Security is really important in the Internet of Things (IoT) because many objects are now connected to the internet. Sarra Cherbal and Rania Benchetioui (Cherbal & Benchetioui, 2023) presented a smart card-based method to make sure users and servers can trust each other and have a secure connection. They used special math and calculations like Elliptic curve cryptography (ECC) and other simple operations. Tests showed that this method is good at protecting against attacks, works well for IoT devices, and is faster than some other methods. Students, especially new ones, can find it hard at university with services and talking to staff. Wael Y. Alghamdi et al. (Alghamdi, et al., 2023) made an app called TU-Smart Services to help with this. The app has four things: a smart chatbot named Cody, a map for finding way around campus, a digital wallet for university IDs, and a way to talk to academic advisors. Cody helps students talk to the university and staff, and the map helps them find their way on campus. They made this app to make university services better for students at Taif University.

The objectives of the work are

- Conducting a case study for access control system in a student housing of a educational institution (i.e., Khulna University) using RFID based smart card.
- Testing the secured system and conducting a relevant study of the system.

Materials and Method

Smart ID card can be used by different types of users such as students, teachers, office staff, etc. Additionally, there are times when we need to allow outsiders or guests to allow inside certain premises. So, a guest type of card is also required for a universal smart card system. When a student gets a seat in a hall, a smart ID card is assigned to him/her. Similarly, there are guest smart cards for teachers, employees, and guests who has access to enter the hall. All information about the students is stored in the server. An RFID reader collects a unique id from the RFID tag and the id is matched with the stored id for identification.

Smart Card Issuance and Usage Management

Two types of smart ID cardholders get access to the hall. They are student card and guest card. Fig. 1 shows the steps of assigning a smart ID card to a student. A student gets a student ID card when he/she associates to a university hall as a residential student. Each ID card has a unique id stored in its RFID tag. The ID card is scanned using an RFID reader to read the unique id. After storing the roll number and the unique id in RFID reader and database, the ID card is delivered to the student. Fig. 2 shows a sample ID card.

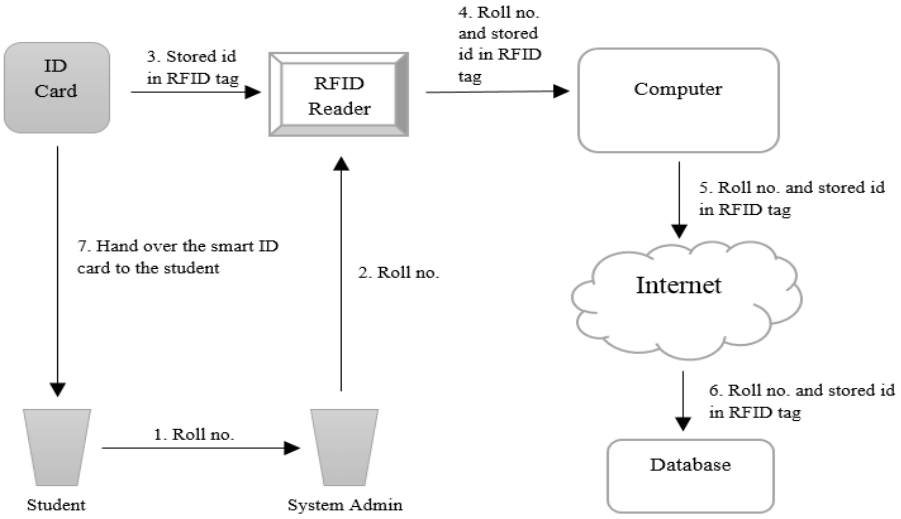

Figure 1. Steps of assigning an ID card to a student.

Figure 2. Sample ID card.

When a student punches his/her ID card for entering the hall, the id of the card is read by the RFID reader. If the id of the card is matched with one of the stored ids of the RFID reader, the cardholder is allowed to enter. Fig. 3 shows the steps for student verification. The computer that is attached with the RFID reader uses the roll no. associated with the id of the card to retrieve student's information from the database. The computer displays the student's information to the security guard. All the check ins and check outs are logged in the database. These can be monitored by the security guard.

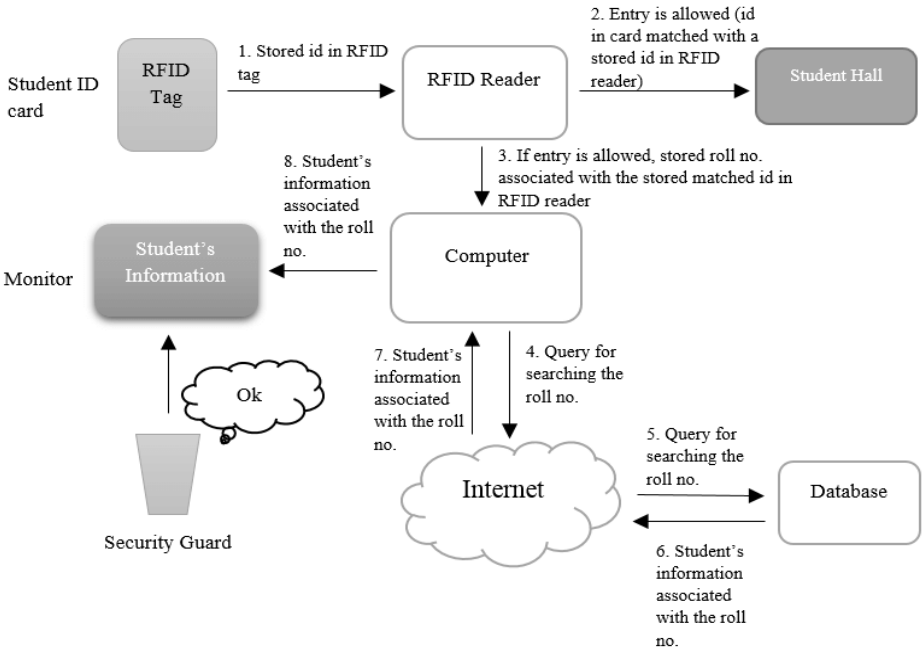

Figure 3. Steps of student verification.

There are also smart ID cards for the guests who want to get into the hall. Security guard enters the guest's name to the RFID reader and assigns an ID card for him/her. The name and id of the card are stored in the database. Fig. 4 shows the procedures for assigning a card to a guest.

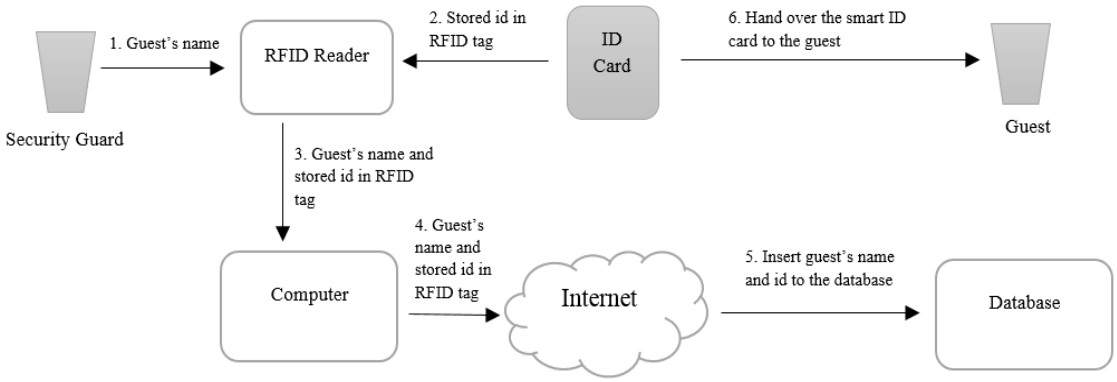

Figure 4. Steps of assigning a guest ID card.

The guest who has a guest ID card is able to enter the hall similarly to the steps of a student (Fig. 3) except in place of roll no. name of the guest is used. A guest's entry and departure are also be logged similarly like a student.

If a student loses his/her ID card, he/she has to immediately submit application with proof of his/her identity (e.g., copy of NID) for reissuing a new ID card. The authority will remove/block the lost ID card's id from the database to prevent any misuse. In presence of the student, the authority will match the proof of identity and the student's face with the information and picture stored in the database. A new ID card will be assigned to the student after verification. If a new ID card cannot be issued immediately, temporarily a guest ID card can be assigned to the student based on the situation. However, if a guest loses his/her ID card, the student/authorized person who is representing the guest must verify him/her again to get him/her a new guest ID card.

Web based Application for Hall Seat Management

A student housing has an infrastructure and some people are related to that structure such as students. All the information about the students is stored in the database. Information such as the room numbers and seat numbers of each room of a particular hall are also stored in the database.

There is a website as client-side application. Entering and updating room numbers, seat numbers, seat number of a particular student etc. into the database are performed using the website. Information such as room wise students list can also be retrieved using the website by an authorized person (e.g., Provost). Features of the hall seat management system are

- Create, read, update, delete hall room and seat information.
- Create, read, update, delete student information.
- Assign and unassign students to rooms and seats.
- See room wise students.
- Room change facility.

Prototype Implementation

The equipment that have been used to build the prototype are Laptop- Asus TUF Gaming F15, RFID reader- ZKteco iClock9000-G, Router, Software for connecting the RFID reader with laptop- ZKBio Time Software, and ID card- RFID card. This following sub-sections describe the step by step procedures of our system's prototype implementation.

Setting up the RFID Reader

The power adapter (12V 1.5A) needs to be connected to the wall socket for powering up the ZKteco iClock9000-G device (RFID reader). It also has a 2600mAh battery. In case of electricity failure, the battery can power the device for about 4 – 6 hours depending on the usage. The device has a 2.8-inch TFT non-touch screen and a numeric keypad for controlling it. The RFID reader's menu is accessible after turning it on. Fig. 5 shows the home screen of the RFID reader.

Figure 5. RFID reader.

Connecting to Local Area Network

We implemented our prototype system in a local area network (LAN) using a router. The procedures will be same when we are in the Internet. The RFID reader is connected to a router via an Ethernet cable. First, the ip address and other information for connecting to the LAN need to set up. From the menu of RFID reader (Fig. 6), COMM->Ethernet menu (Fig. 7) is accessed. In the Ethernet menu, DHCP is turned on so that ip address and other configuration of the RFID reader for accessing the LAN can be set up automatically. Here the ip address and the port are the RFID reader's identity in the LAN. Now the RFID reader is connected to the LAN.

Figure 6. RFID reader's main menu.

Figure 7. RFID reader's Ethernet menu.

Setting up the Cloud Server's (Laptop) Configuration

The RFID reader needs to know the address of the laptop so that it can be connected with it for information transfer. From the main menu (Fig. 6), COMM->Cloud Server Setting menu (Fig. 8) is accessed. Here the server address is the ip address of the laptop in the LAN and the server port is the HTTP port of the ZKBio Time software in the laptop. Ip address (IPv4 address) of the laptop in the LAN is found by running the 'ipconfig' command in command prompt (MS Windows Machine) (Fig. 9). HTTP port of the ZKBio Time software is written on the configuration window of the software (Fig. 9).

Figure 8. RFID reader's Cloud Server Setting menu.

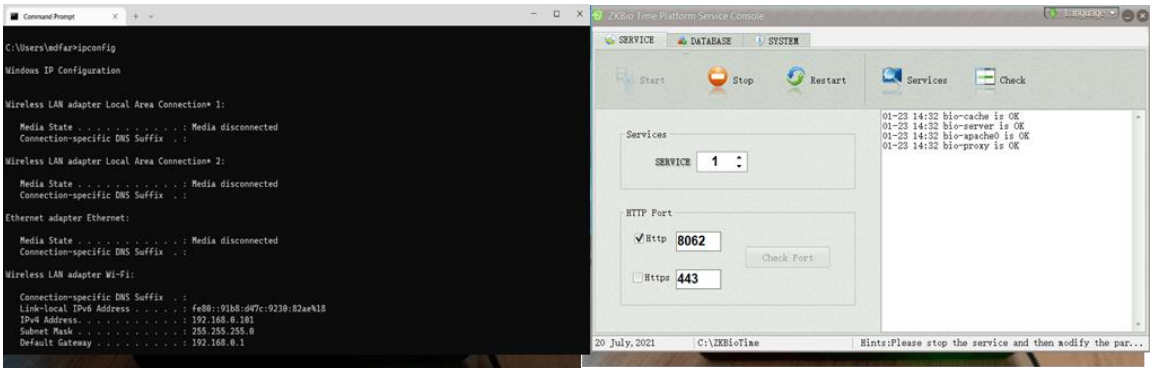

Figure 9. IP address of Windows machine.

Setting up the ZKBio Time Software in Laptop

ZKBio Time is a web based software which connects with the RFID reader, receives data from it and push the data to the database (local or cloud). It supports MySQL, MS SQL Server, Oracle and PostgreSQL database. In our prototype, mysql database is used locally. Laragon is used to create and access MySQL database in local machine. Mysql needs to be started in laragon before we start ZKBio Time software. By going to the address 127.0.0.1:8062 using a browser, the software is opened (Here 8062 is the HTTP port of the ZKBio Time software) (Fig. 10).

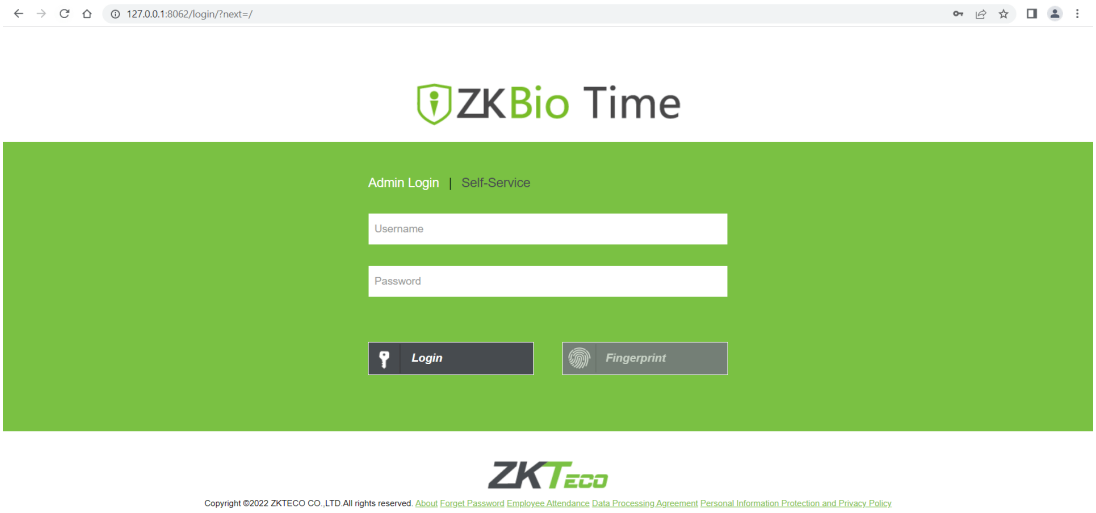

Figure 10. ZKBio Time Software.

After login, the a new device is added from the 'Device' tab (Figure 11). Here, the device ip is the ip address of the RFID reader in the LAN. Normally the software can connect and operate 500 devices simultaneously.

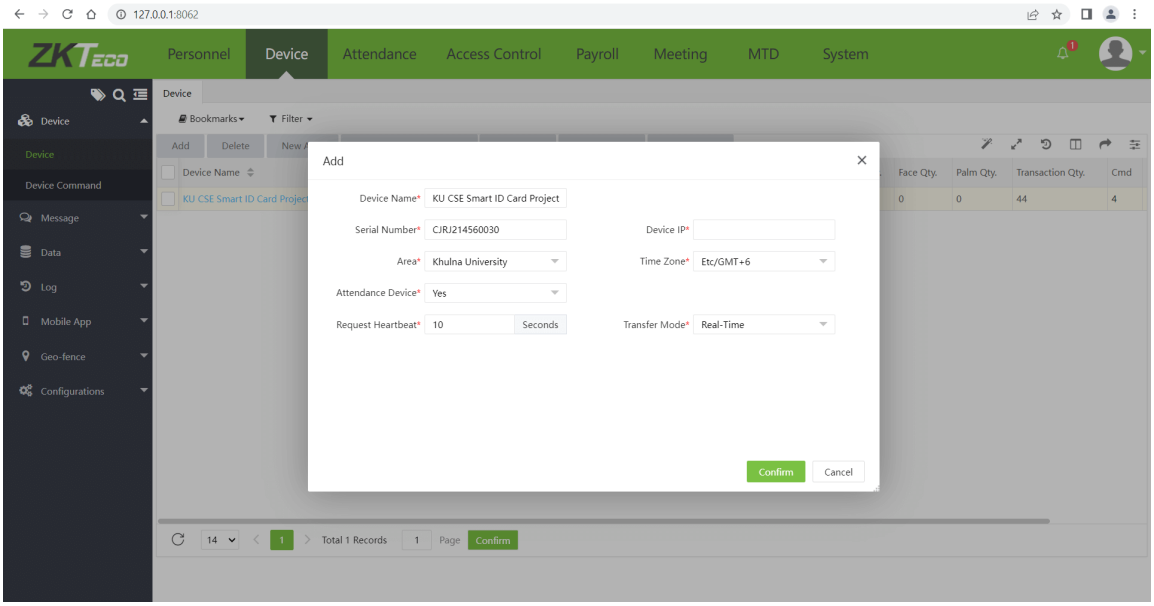

Figure 11. Adding new device in ZKBio Time Software.

If all the configuration and LAN are ok, the state is marked in green in the device list (Fig. 12).

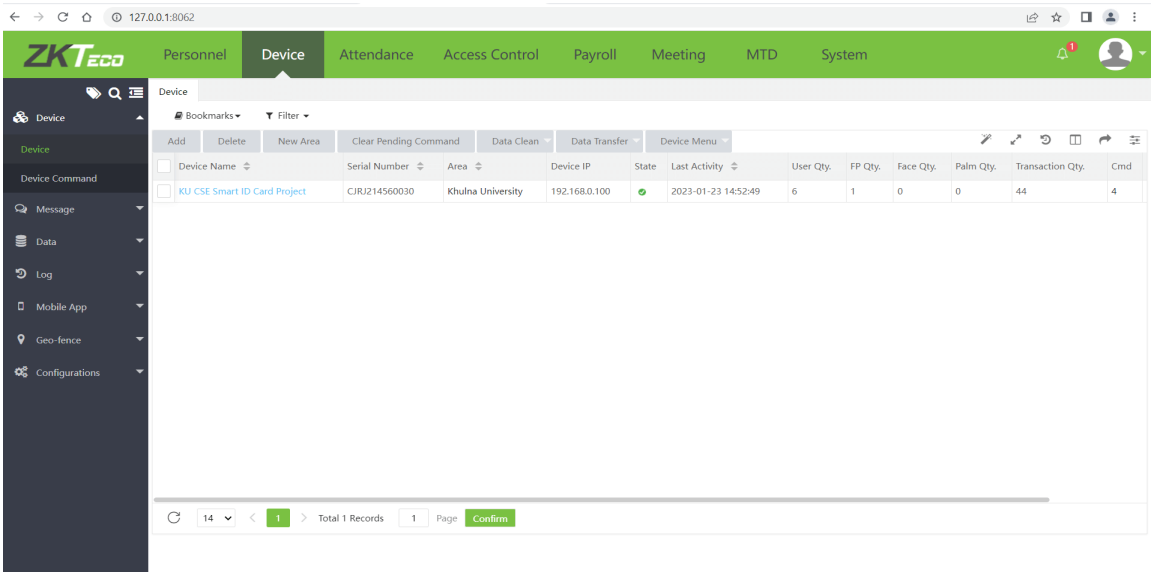

Figure 12. RFID reader is connected with the laptop.

Now the RFID reader is connected with the laptop and ready to work.

Assigning ID Card to a Student

From the main menu (Fig. 6), User Mgt.->New User menu (Fig. 13) is accessed. In the New User menu, 'Name' is the roll no. of the student and the card number is obtained by punching the ID card (Fig. 14). Now the student is stored in the RFID reader as a user. The RFID reader can store 6000 students. The laptop's ZKBio Time software also stores the roll no. and card number of the student in the mysql database since the RFID reader is connected with the laptop's ZKBio Time software. The fingerprint can also be taken and stored in the RFID reader as a biometric trait. By keeping both the fingerprint and ID card, the access control policy will be more secure, since ID card is transferable but a biometric trait is not. Even then both biometric and ID card verification can be a tedious process during the peak hours when lots of students are getting in or out. Moreover, generally a student housing has a security guard who can verify a student/guest by matching his/her face with the picture shown in the monitor after punching the card (Fig. 3). Considering the convenience and the alternative, only the ID card based access control policy is kept in our prototype system.

Figure 13. RFID reader's New User menu.

Figure 14. Enrolling ID card in RFID reader.

Verifying to a Student

When a student punches his/her card to the RFID reader, the reader checks if the card number exists in its storage. It takes less than 1 second. If the card number exists, the student is allowed to enter the hall. In the meantime, security guard can see the details of the students. The detail information of the student is stored in the database. It is retrieved using the student's roll no. which is supplied by the RFID reader. Fig. 15 shows an example of a student's information window for the security guard when the student punches his/her ID card to the RFID reader. Based on RFID reader's setting, student's punch status can be 'check in' or 'check out'.

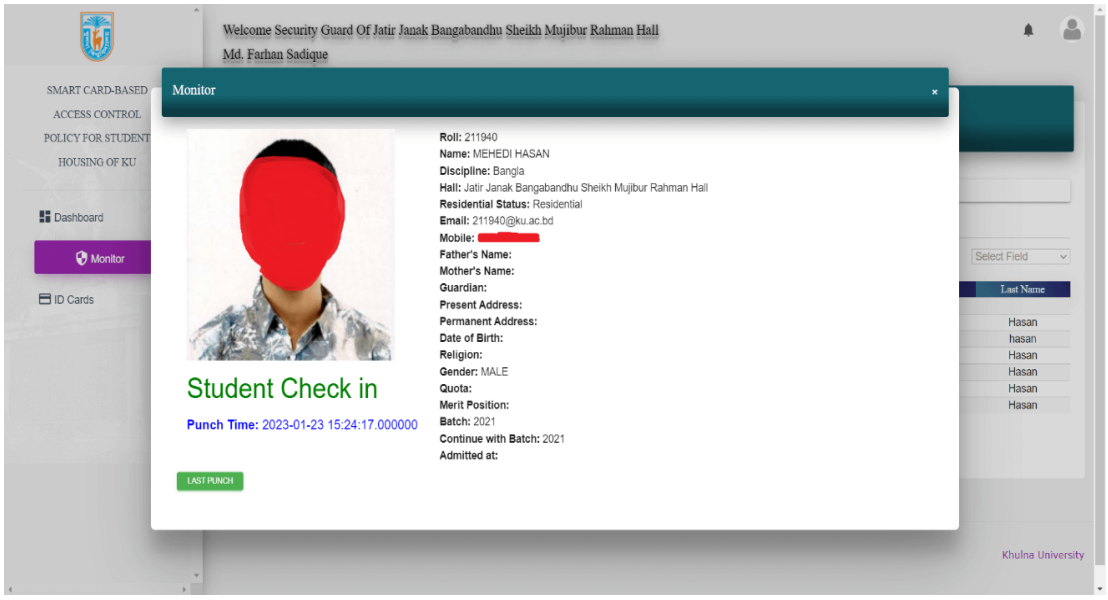

Figure 15. Student's information window when a student punches his/her ID card.

Assigning ID Card to a Guest

From the New User menu (Fig. 13), an ID card is assigned for a guest (teacher, employee or guest). In the New User menu, 'Name' is the name of the guest and the card number is obtained by punching the ID card. The name and the card number are stored in the RFID reader and in the database. Security guard can see the list of assigned ID cards to students and guests (Fig. 16).

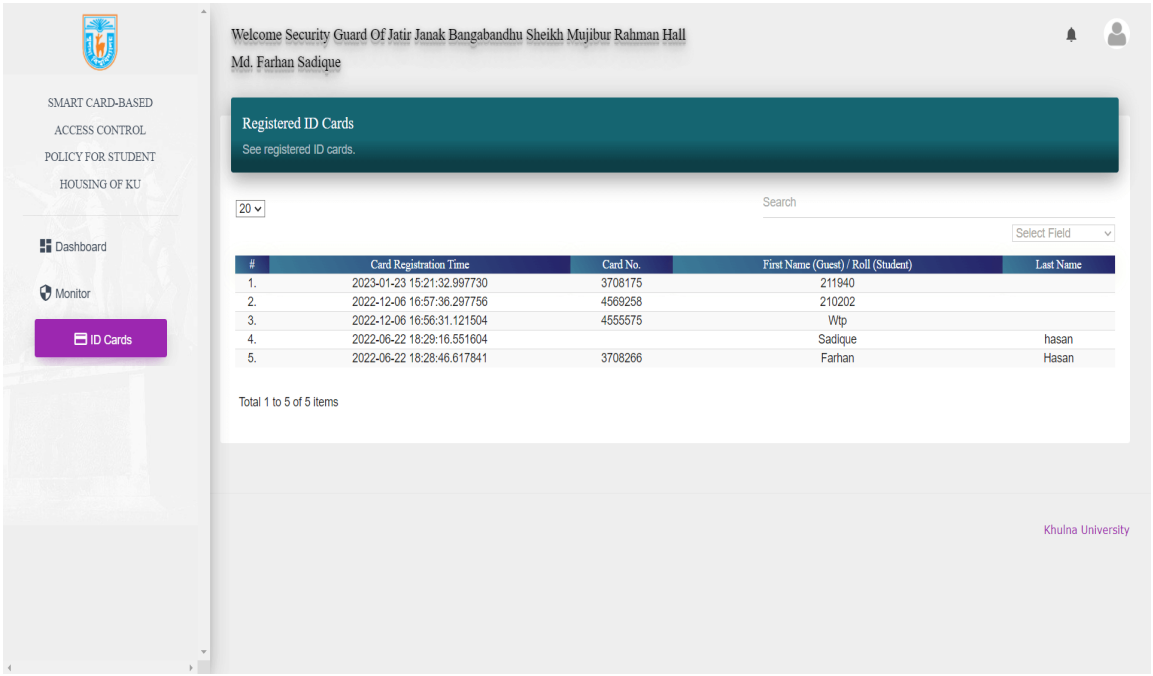

Figure 16. ID card list.

Verifying a Guest

When a guest punches his/her card to the RFID reader, the reader checks if the card number exists in its storage. If the card number exists, the guest is allowed to enter the hall. As roll no. is not stored in the 'Name' field like the student ID card, student's information cannot be retrieved using the value of 'Name' field. In this case, the system shows directly the value of 'Name' field to the security guard as detail information of the card holder.

Punch History

Security guard can see all the punches history. Check in and check out can be checked separately.

Hall Seat Management

Hall authority (e.g., Provost) can manage the rooms, seats and seat allocation. Provost can add room, add seat, update room no., delete seat and delete room of his/her hall (Fig. 17).

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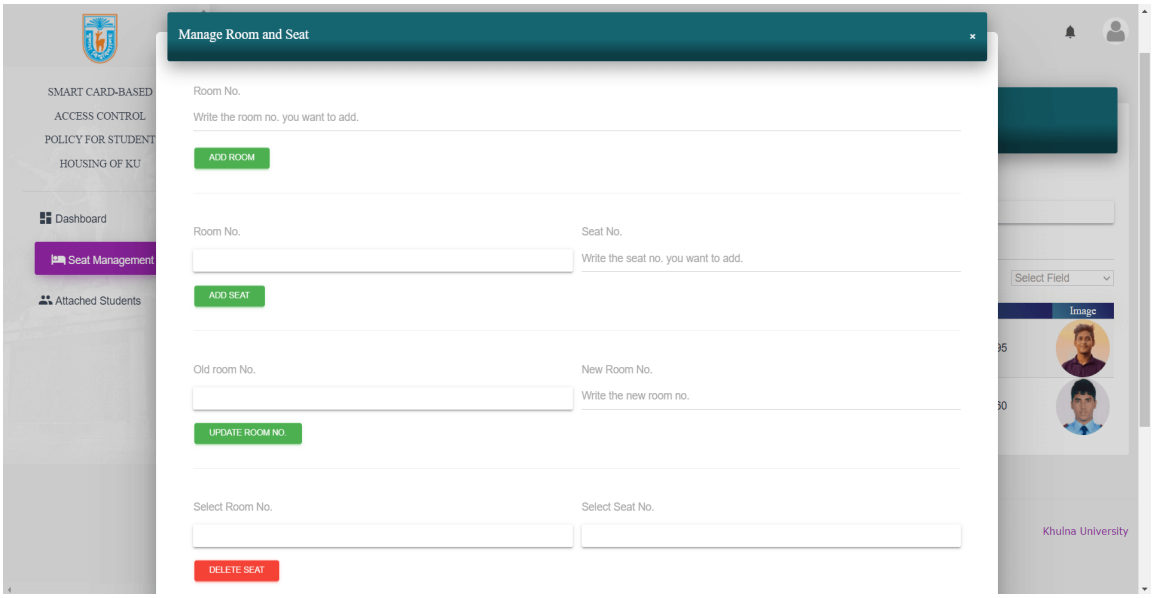


Figure 17. Room and seat management.

Provost can see the attached students to his/her hall and he/she can assign seat to a student from the attached student list (Fig. 18).

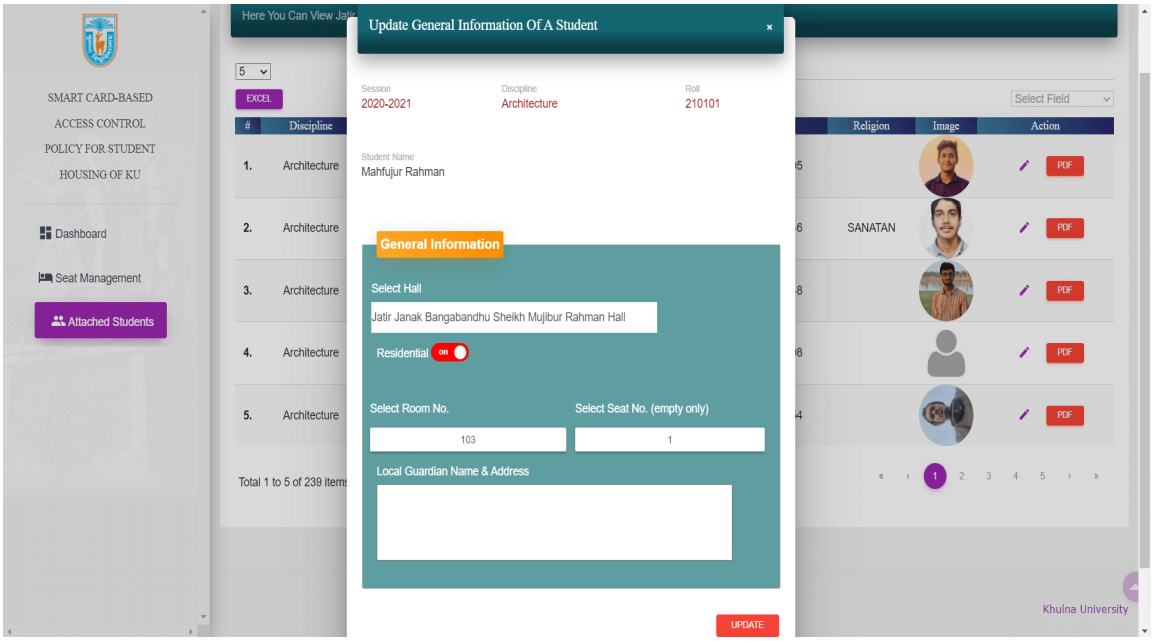


Figure 18. Seat allocation to a student.

Room wise student list is also available to provost (Fig. 19). Provost can exchange seats between two students (Fig. 20).

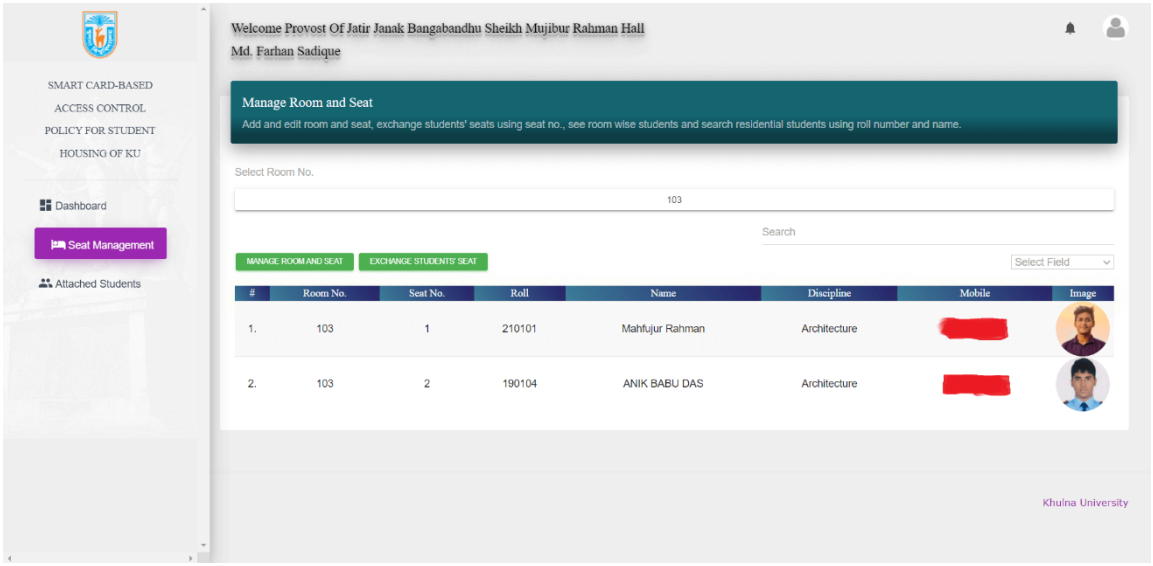


Figure 19. Room wise student list.

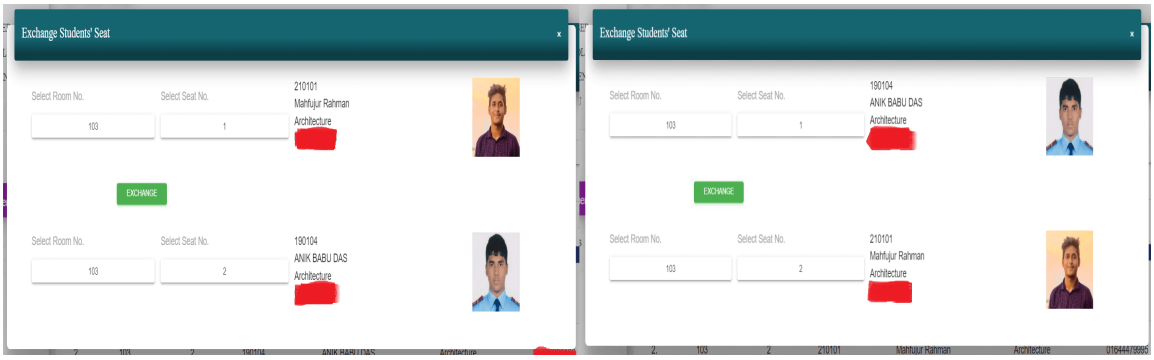


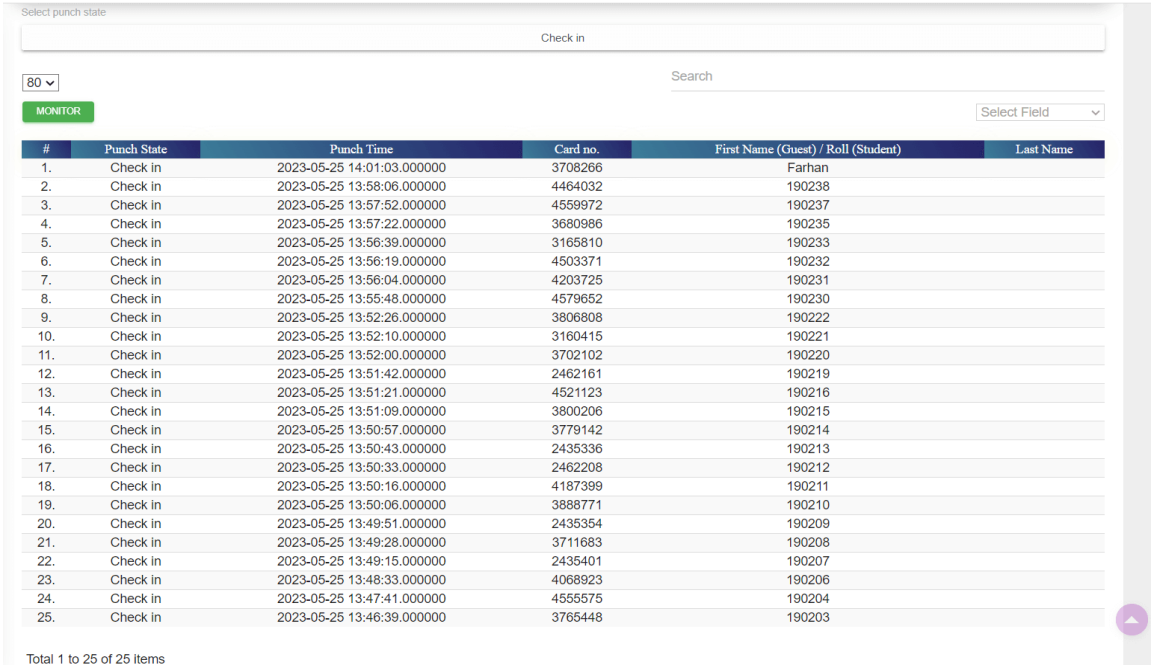
Figure 20. Seat exchange (before and after).

Results Analysis

The smart card-based access control policy and seat management system for student housing of Khulna University was demonstrated in front of the students of 4th year (2021 – 2022 academic session) of Computer Science and Engineering Discipline, Khulna University, Khulna. After that the system was experimented and evaluated by them.

Experiment

Smart ID cards were assigned for the students of 4th year and for a guest. Twenty four (24) students and the guest participated in the experiment. All of them checked in by punching their cards to the RFID reader while their entries were monitoring from the security guard role. Twenty three (23) students and the guest checked out by punching their cards to the RFID reader. Their check in and check out histories are shown in Fig. 21 and 22 respectively.



Select punch state

Check in

80

Search

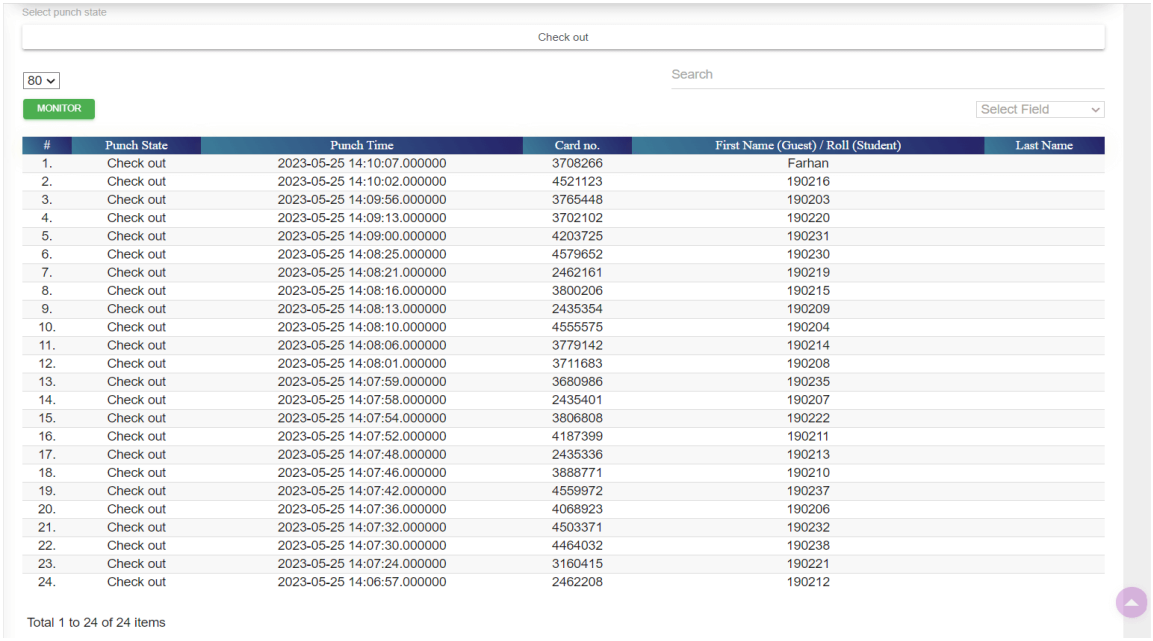
MONITOR

Select Field

#	Punch State	Punch Time	Card no.	First Name (Guest) / Roll (Student)	Last Name
1.	Check in	2023-05-25 14:01:03.000000	3708266	Farhan	
2.	Check in	2023-05-25 13:58:06.000000	4464032	190238	
3.	Check in	2023-05-25 13:57:52.000000	4559972	190237	
4.	Check in	2023-05-25 13:57:22.000000	3680986	190235	
5.	Check in	2023-05-25 13:56:39.000000	3165810	190233	
6.	Check in	2023-05-25 13:56:19.000000	4503371	190232	
7.	Check in	2023-05-25 13:56:04.000000	4203725	190231	
8.	Check in	2023-05-25 13:55:48.000000	4579652	190230	
9.	Check in	2023-05-25 13:52:26.000000	3806808	190222	
10.	Check in	2023-05-25 13:52:10.000000	3160415	190221	
11.	Check in	2023-05-25 13:52:00.000000	3702102	190220	
12.	Check in	2023-05-25 13:51:42.000000	2462161	190219	
13.	Check in	2023-05-25 13:51:21.000000	4521123	190216	
14.	Check in	2023-05-25 13:51:09.000000	3800206	190215	
15.	Check in	2023-05-25 13:50:57.000000	3779142	190214	
16.	Check in	2023-05-25 13:50:43.000000	2435336	190213	
17.	Check in	2023-05-25 13:50:33.000000	2462208	190212	
18.	Check in	2023-05-25 13:50:16.000000	4187399	190211	
19.	Check in	2023-05-25 13:50:06.000000	3888771	190210	
20.	Check in	2023-05-25 13:49:51.000000	2435354	190209	
21.	Check in	2023-05-25 13:49:28.000000	3711683	190208	
22.	Check in	2023-05-25 13:49:15.000000	2435401	190207	
23.	Check in	2023-05-25 13:48:33.000000	4068923	190206	
24.	Check in	2023-05-25 13:47:41.000000	4555575	190204	
25.	Check in	2023-05-25 13:46:39.000000	3765448	190203	

Total 1 to 25 of 25 items

Figure 21. Check in history of the 4th year's students and a guest.



Select punch state

Check out

80

Search

MONITOR

Select Field

#	Punch State	Punch Time	Card no.	First Name (Guest) / Roll (Student)	Last Name
1.	Check out	2023-05-25 14:10:07.000000	3708266	Farhan	
2.	Check out	2023-05-25 14:10:02.000000	4521123	190216	
3.	Check out	2023-05-25 14:09:56.000000	3765448	190203	
4.	Check out	2023-05-25 14:09:13.000000	3702102	190220	
5.	Check out	2023-05-25 14:09:00.000000	4203725	190231	
6.	Check out	2023-05-25 14:08:25.000000	4579652	190230	
7.	Check out	2023-05-25 14:08:21.000000	2462161	190219	
8.	Check out	2023-05-25 14:08:16.000000	3800206	190215	
9.	Check out	2023-05-25 14:08:13.000000	2435354	190209	
10.	Check out	2023-05-25 14:08:10.000000	4555575	190204	
11.	Check out	2023-05-25 14:08:06.000000	3779142	190214	
12.	Check out	2023-05-25 14:08:01.000000	3711683	190208	
13.	Check out	2023-05-25 14:07:59.000000	3680986	190235	
14.	Check out	2023-05-25 14:07:58.000000	2435401	190207	
15.	Check out	2023-05-25 14:07:54.000000	3806808	190222	
16.	Check out	2023-05-25 14:07:52.000000	4187399	190211	
17.	Check out	2023-05-25 14:07:48.000000	2435336	190213	
18.	Check out	2023-05-25 14:07:46.000000	3888771	190210	
19.	Check out	2023-05-25 14:07:42.000000	4559972	190237	
20.	Check out	2023-05-25 14:07:36.000000	4068923	190206	
21.	Check out	2023-05-25 14:07:32.000000	4503371	190232	
22.	Check out	2023-05-25 14:07:30.000000	4464032	190238	
23.	Check out	2023-05-25 14:07:24.000000	3160415	190221	
24.	Check out	2023-05-25 14:06:57.000000	2462208	190212	

Total 1 to 24 of 24 items

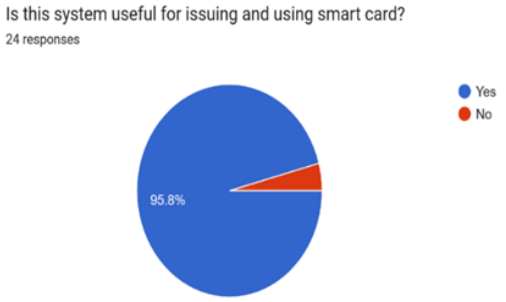
Figure 22. Check out history of the 4th year's students and a guest.

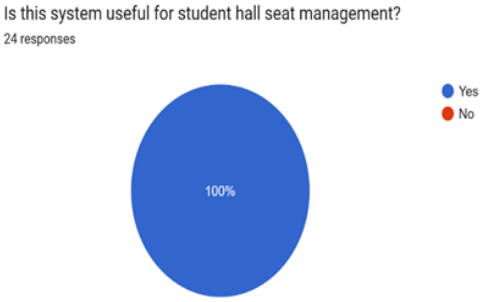
Evaluation

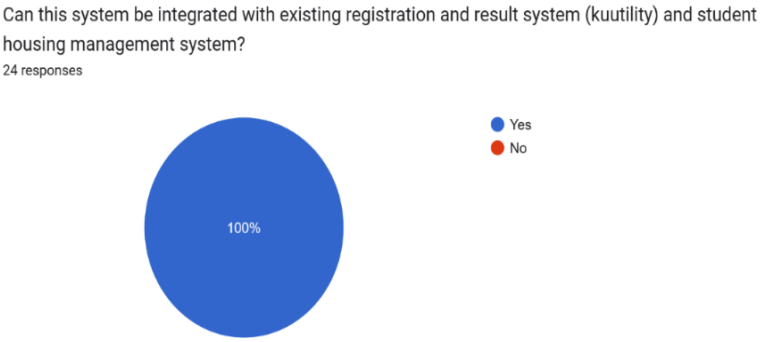
After completing the experiment mentioned in section 4.1, a questionnaire form was provided to the students. The questionnaire form has 4 sections- fulfillment of objectives, rating of the functionalities of the system, rating the

security measures of the system and suggestions. The questions of each section and summary of the answers are listed below.

Fulfillment of Objectives:

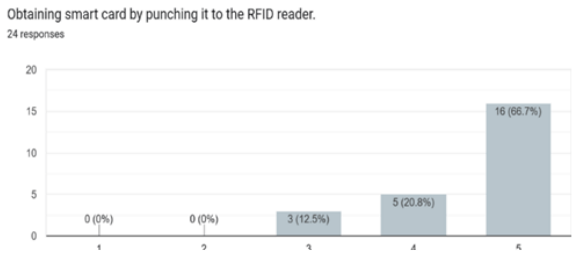


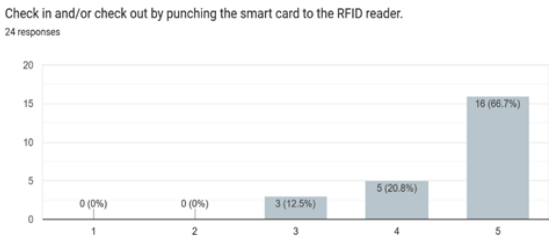


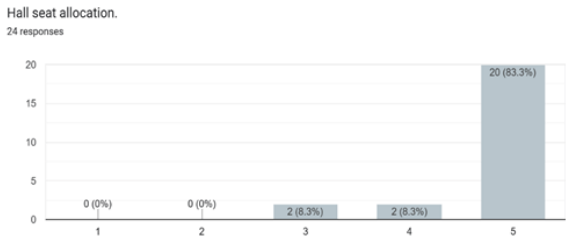


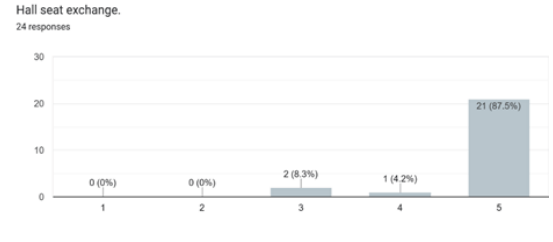
Rating of the Functionalities of the System:

Rating Guideline: 1 = Very glitchy, 2 = Glitchy, 3 = Ok, 4 = Smooth, 5 = Very smooth.



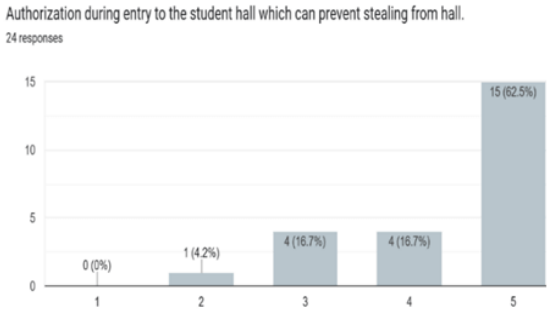


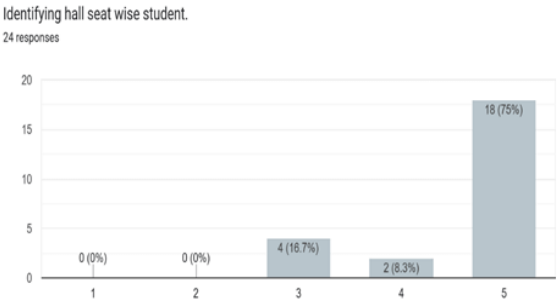




Rating of the Security Measures of the System:

Rating Guideline: 1 = Very glitchy, 2 = Glitchy, 3 = Ok, 4 = Smooth, 5 = Very smooth.





Suggestions:
The participants expressed their suggestions, comments and future directions.

Discussion and Conclusion

After the completion of the project, we have a web-based application for student housing, a setup to issue and verify smart card, and integrate a smart card system with the housing entrance. We accomplished a pilot study using the help of the 4th year students (2021 - 2022 academic session) of CSE discipline, Khulna University, Khulna. From the pilot study, we got relevant log files and experience data which can be useful for future adoption of such setups in different areas of a university. Experiment shown in section 4.1 shows the effectiveness of smart card in access control policy. The questionnaire form responses which are in section 4.2 shows that according to the most students, our smart card based system is a secured and convenient choice for access control policy.

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Conflict of Interest

None of the authors present any conflicts of interest.

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