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IOT & Cloud Based Attendance Collection and Student Information Chatbot

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***Abstract*— The system proposed in this paper addresses two main concerns in the higher education system. One is efficient attendance monitoring of students, and the other concern is implementing an effective mechanism to interact with students to clarify their issues. As for the first concern, an IOT based attendance collection system will be proposed and for the second concern a cloud based chatbot is proposed. The main purpose of the proposed attendance collection system is to provide more efficient methodology to both students and lecturers while eliminating frequent issues such as buddy signing, loss of attendance sheets while improving student attendance scores. There are two parts to the attendance collection system. One is an IOT based device with biometric authentication for attendance collection which was developed using Arduino, microcontrollers, and fingerprint sensors. Second part is a web-based attendance system designed for lecturers or administrators for report generation, which was developed using Structured Query Language (SQL), PHP, JavaScript and HTML. The generated reports can be converted into excel or PDF files as required. As students are more familiar with smart devices than ever, a student information chatbot is proposed as a mechanism to interact with students to clarify their issues. The system establishes transparent and efficient communications with students for their general questions. The prototype chatbot was implemented in google cloud infrastructure and it is integrated with an android application which was built using android studio. The application can be used to interact with the chatbot and have the scalability for more features in the future.**

Keywords*— *IOT (Internet of Things), Micro controllers, Web Application, Android Application, Chatbot, Cloud Infrastructure

I. PROBLEM IDENTIFICATION

Innovation of the technology and increased mobility demands the requirement of reliable and secure access technologies. Many sectors including the education sector around the world are trying to implement and introduce modern solutions for traditional issues and challenges. Internet of things, cloud-based computing solutions, natural language processing and biometric authentication solutions are highlighted technologies among industry leaders. Academic attendance and student issue addressing can be considered as crucial factors when it comes to knowledge and skill development of a student. Majority of the universities in Sri Lanka still uses the traditional signing sheet to gather attendance data. Fake signatures and signing sheet misplacements encourage students to skip lectures and this directly affects the academic performance [1].

China pharmaceutical university in Nanjing became the first higher education institution in the country to implement facial recognition for attendance collection and they stated that it provides a significant amount of improvement in attendance collection [2]. Although same kind of system was planned to be implemented in the university of California, Los Angeles in 2020 and it was forced to be stopped by students due to privacy issues [3]. Universities in different countries uses various techniques to uniquely identify students to gather attendance data. Most suitable, efficient, and ethical technique must be selected to develop the system accurately. Following table is a brief comparison of different biometric identifiers used in universities. Comparison was used to determine the most suitable mechanism for proposed attendance collection system [4] and H, L & M represents High, Low and Medium respectively.

TABLE I. COMPARISON OF BIOMETRIC AUTHENTICATION TECHNOLOGIES

Biometric Identifier	Universality	Distinctiveness	Permanence	Collectability	Performance	Acceptability	Circumvention
Face	H	L	M	H	L	H	H
Fingerprint	M	H	H	M	H	M	M
Hand Geometry	M	M	M	H	M	M	M
Hand/Finger Vein	M	M	M	M	M	M	L
Iris	H	H	H	M	H	L	L
Signature	L	L	L	H	L	H	H
Voice	M	L	L	M	L	H	H

When there are more than 500 students in a faculty while staff is almost 20-30 members it's difficult to address student issues individually. Usually, some issues students face is common day to day problems and these questions can be addressed easily by using a computer-based system [5]. Therefore, a cloud based chatbot named as "UNIBOT"

is proposed to provide efficient and updated solutions for students. Chatbot and individual attendance reports can be accessed by the students using an android application.

These two problem domains were addressed using one paper to permit the ability to integrate two systems together and make it more usable and efficient. Two systems can be developed in a way where each student can access their attendance records using the same application which does the chatbot integration. This implementation enables more future implementations for the application as well.

II. Objectives

By developing the proposed attendance monitoring system and chatbot it is possible to overcome current issues while increasing the efficiency and reliability of the university environment. Following are the main objectives identified during the research.

a. *Develop a replacement for the traditional student attendance system with a computerized and efficient system.*
b. *Introduce a portable IOT based device for attendance collection.*
c. *Develop a Web-based interface for attendance report generation for lecturers.*
d. *Gather reliable attendance data to evaluate student performance.*
e. *Provide pre-defined solutions for student issues using modern technologies such as chatbots and natural language processing (NLP)* [6].

III. Design And Development

IOT based attendance collection system has following functionalities.

A. Registering New Fingerprtint Templates

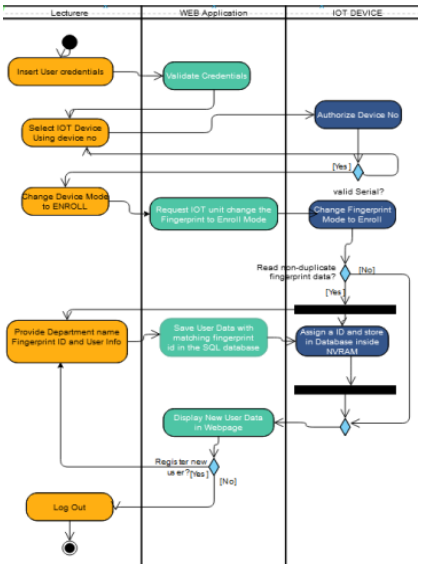

Fig. 1 – Activity diagram for student registration

Lecturers can login to the web-based authentication management system using predefined email/username and password. Available IOT devices can be connected to the web-based system using its device ID. The device ID will be generated automatically, and it can be changed as necessary. Device will have two main modes. Which is enrollment mode and attendance mode. When enrollment mode is enabled, a new user can be added by navigating to the user page. This page provides features to perform multiple modifications for existing or new users including new user registration. As the fingerprint database will be saved on the fingerprint sensors NVRAM (Nonvolatile Random-Access memory) the specific template for each user will be identified by using the unique fingerprint ID generated in the fingerprint database.

B. Registering Multiple IOT Devices

Web Application supports concurrent connection between multiple IOT devices from multiple departments. To achieve this criterion each device will be assigned with a randomly generated device ID. Alongside with the device ID each device will get a device name, department, registered date.

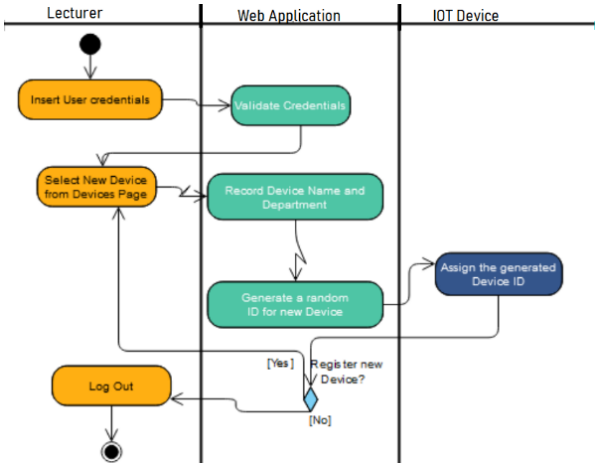

Fig. 2 – Activity iagram for IOT device registration

C. Update/Remove User Data Including Fingerprint Data

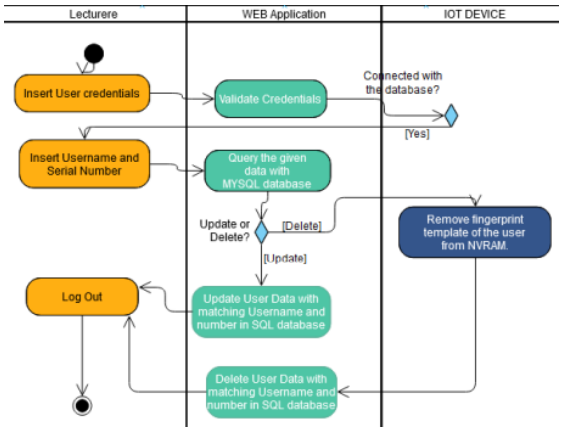

Fig. 3– Activity diagram for student data update and deletion

The user management page in the web application provides facilities to update or remove user data stored in NVRAM of the IOT device and in the hosted SQL database. The IOT device must be connected with the web application as it requires to remove/update the fingerprint data in its NVRAM.

D. Data Logging & Report Generation

For data logging and report generation web application provides multiple Filtering and Exporting methods. Filtering can be achieved for individual student if required. Also, data will be gathered including the students time-in and time-out. All the gathered information can be uploaded into an Excel sheet for further analysis. There will be a separate backup of each attendance report in the database. In a case of data misplacement, the database can be used to retrieve the previous data.

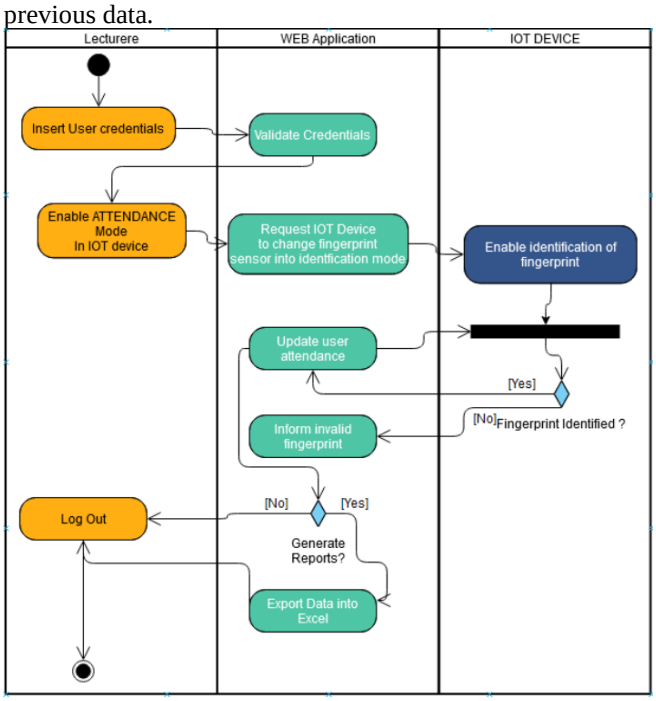

Fig. 4 – Activity diagram for data logging and report generation

E. Operating Principles of The IOT Module

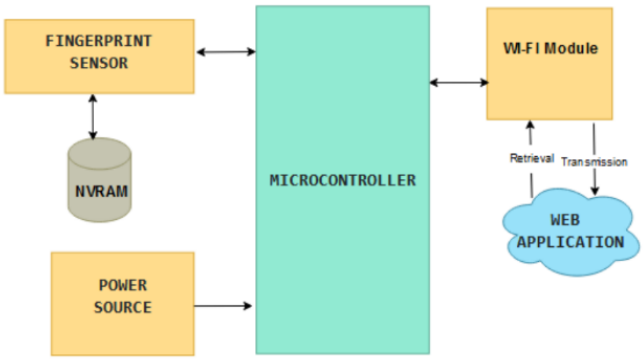

Fig. 5 – Block diagram of the IOT based module

The IOT device is managed by a separate micro-controller which can handle the power delivery, Fingerprint sensor processing requirements, network-based data transmission and retrieval and power management. Fingerprint sensor stores all the fingerprint vector images/templates inside its NVRAM. This approach provides more security for end-users as their fingerprint never leaves the IOT device. NVRAM maintains a separate database with fingerprint details alongside with a unique identifier. Information about the identifier is sent to the web application through the Wi-Fi module. The unique identifier works as the bridge between web application and fingerprint data inside the NVRAM. Unique identifiers will be used to inform authentication-status as well as user modifications.

Following use case diagram provides a representation about the overall attendance monitoring system, including all the hardware and software entities.

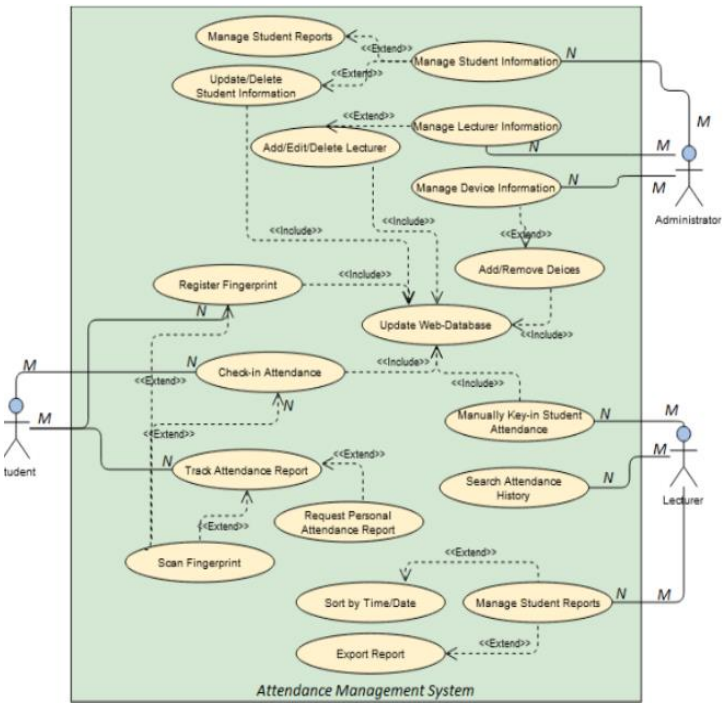

Fig. 6 – Usecase diagram of student management system

F. Database Design

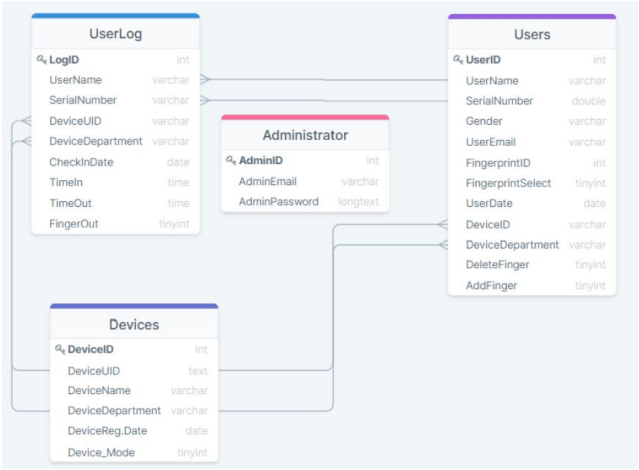

Fig. 7 – ER diagram for web application database

Database was developed using a relational model [7]. Following diagram represents four main tables and the relationships between them.

Cloud based chatbot has following functionalities.

A. Creating New Intents

The chatbot will save all the questions and solutions as intents. System administrators can introduce new intents to the systems once required information is available/identified. Each new intent will require special set of training phrases. These training phrases reflects how students can address a question towards the chatbot.

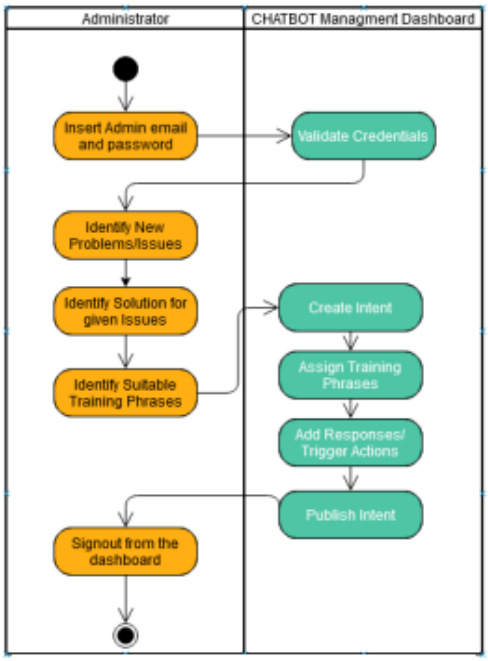

Fig. 8 – Activity diagram for chatbot intent creation

B. Updating Existing Intents

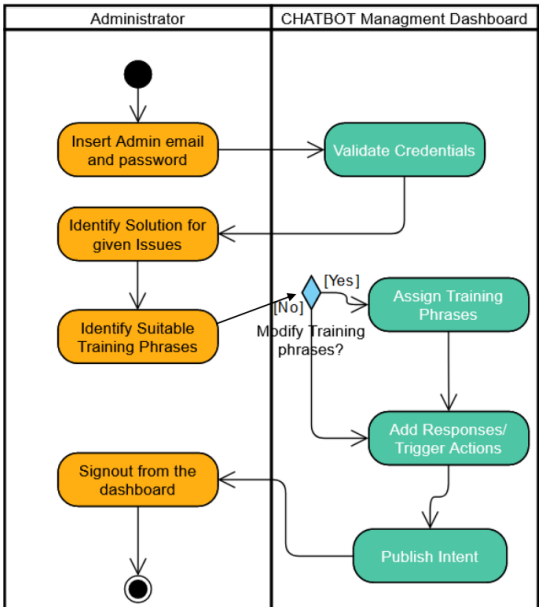

Fig. 9 – Activity diagram for chatbot intent update

Identified solutions for a particular question/issue can be changed or can be irrelevant with time. In that case modifying or updating an existing set of solutions is required. The chatbot provides the ability to change its intents without any downtime. Intent will not be changed as it acts as the problem domain. Although changes might be required for responses and in some cases for training phrases as well.

C. Adding Follow-up Intents

Follow-up intents can be considered as a child of a parent intent, in other words sub problems/solutions for a main problem. If a particular parent intent has two responses as 'yes' or 'no', the administrator can introduce two follow-up intents for each response. These follow-up intents add flexibility to chatbot by enabling the ability to answer different types of questions by customizing answers respect to user responses.

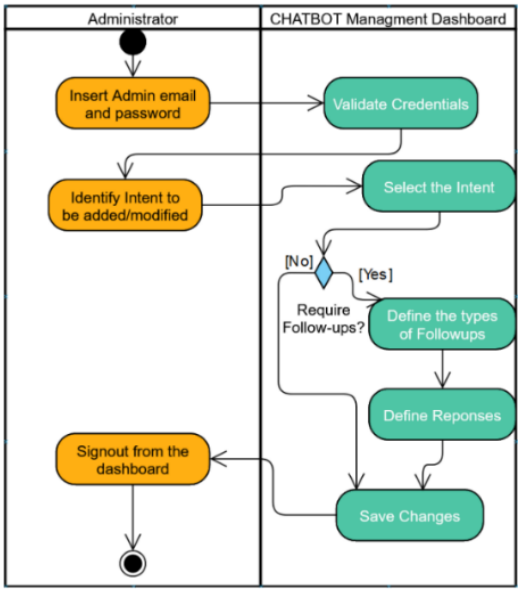

Fig. 10 – Activity diagram for follow-up intent creation

D. User Interaction

The chatbot provides multiple APIs and Libraries for integration. Student Information chatbot will be integrated with a mobile application. Users can ask any academic related questions/issues from the chatbot. Once the system identified user input with the help of training phases it will provide answers/solutions if they're available. If the chatbot fails to answer a given question, it will inform the user regarding the unawareness and store the question to be analyzed.

IV. DEMONSTRATION

The system was implemented in four stages.

a) Web Application for Attendance Collection and Management
b) Prototype IOT Device for Fingerprint Collection
c) Development of the cloud Based Chatbot
d) Development of the mobile application

Web application was developed using HTML, CSS, PHP, and JavaScript. SQL database was used, and the system was tested on a local server. User Report page provides necessary features to filter user data and generate reports. Filtering can be performed based on date, time, fingerprint id or department name.

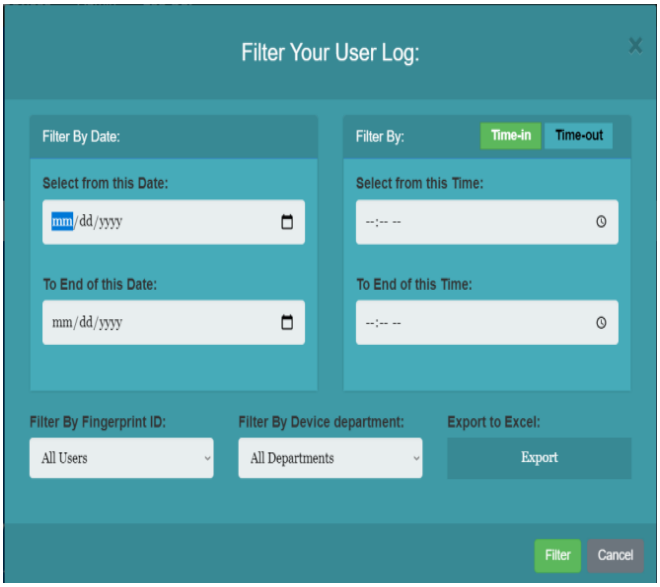

Fig. 11 – Data filtering page for report generation

IOT based device can be registered and managed in device registration and management page. Each device will have a unique id with a specific device mode for attendance and new user enrollment. Prototype attendance collection system was made using an ESP-32 Node MCU and a single optical R307 fingerprint sensor. IOT based device can be powered using an external 5v power source or using a built-in battery.

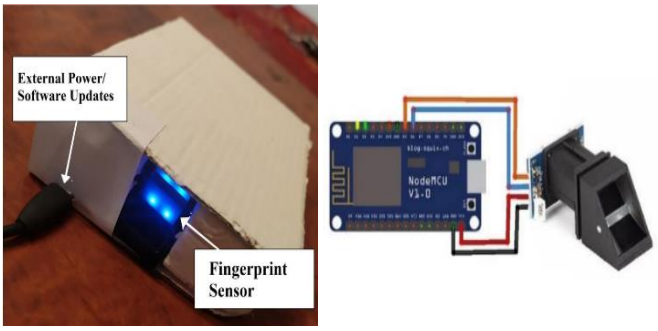

Fig. 12 –Prototype and circuitry of IOT device

Chatbot was developed using Dialogflow which is a natural language understanding platform developed by google. Chatbot required to be trained using training phrases. These training phrases can be created as intents in Dialogflow user dashboard. Built-in dialog flow natural language processing algorithms were used to trigger suitable responses for user queries. Chatbot can be implemented in different platforms such as web, mobile, social media, google assistant and within instant messaging services. Following figure demonstrate mobile application integration of the chatbot.

For testing purposes chatbot application was developed in android version 11 and tested in virtual devices as well as physical devices.

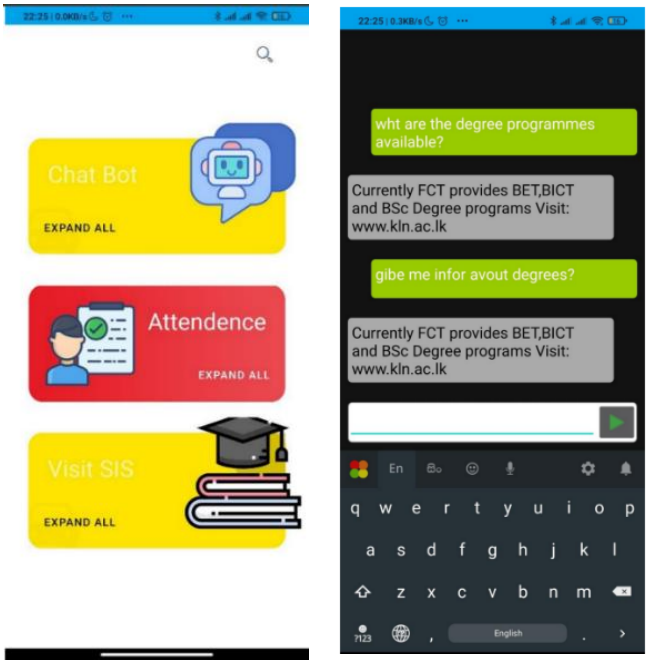

Fig. 13 – Home screen and integrated chatbot in mobile application

V. EVALUATION

Following performance measurements were identified in IOT based attendance collection system using the prototype system.

- Inability to identify the difference between the picture of a finger and finger itself.
- Captures two-dimensional images This results with a significant processing time to identify the fingerprint.
- Less secure and slower than existing fingerprint technologies.

To eliminate mentioned limitations, a capacitive fingerprint sensor can be used [8]. Changing the type of sensor for user authentication does not affect the existing system design.

Performance of the cloud based student information chatbot should remain even with hundreds of intents preloaded. From student standpoint, Mobile application should be responsive and should be able to work within low system requirements. Chatbot responsiveness will differ from network connection quality. The mobile application load times were reduced by using the following techniques.

- Perform Image Optimization as majority of the added images and elements were highest quality files. These files consume significant number of resources in the mobile device. Therefore, images were compressed to below 100Kb [9].

- Enable Caching for web views as it helps to reduce web page loading times. App caching techniques helps decrease load times significantly [10].

VI. Conclusion And Future Work

The IOT based student attendance system mainly focuses on eliminating drawbacks of the traditional paper-based attendance system, which can be affected by fake signatures. Significant amount of evidence indicates that fingerprint-based authentication will provide more secure and efficient results. The IOT based technologies were used to develop the system as it provides multiple methodologies to interact with web applications and for distributed computing.

Student Information chatbot 'UNIBOT' was developed with the introduction of a faculty mobile application. This system mainly focuses on providing solutions/recommendations for student matters and problems using Natural language processing and Artificial Intelligence.

A web application and IOT based device was designed to gather student attendance. The web application uses HTML, PHP, JavaScript, and SQL web technologies for implementation. IOT device was developed with the integrated optical sensor and micro-controller which is responsible for handling all the data transmissions and retrievals using included libraries. IOT devices have built in Wi-Fi functionality and can be implemented and run on the existing network infrastructure of a university.

Student Information Chatbot was developed using Googles' Back-end as a service (BaaS) cloud computing service model. Back end was designed on cloud using Dialogflow [11]. Dialogflow contains a dashboard to maintain the chatbot including adding new question and solution intents and training the chatbot by using training phrases. The prototype chatbot was integrated into an Android application which supports up to android version 11.

With the help of web application, future work will focus on providing the ability for students to monitor their attendance using the mobile application more importantly via the chatbot. This will encourage them to attend lectures more frequently and provide a transparent method to monitor their attendance information. Replacing the optical fingerprint sensor in the future with a capacitive sensor will increase the performance of the attendance system almost two times. Also due to the flexibility of Arduino platforms it is possible to add other verification mechanisms such as QR codes, bar code to student verification system if it's necessary.

Any of the mentioned upgrades will not affect the developed system. These two systems are recommended to use and integrated together on actual university environments to overcome the limitations of existing solutions. Transition towards these systems will bring digital development for universities as well as for students.

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