OPD-PMMAS: Patient Management and Mobile Alert System for OPDs in Sri Lankan Hospitals-A Prototype

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Abstract- *Unorganised crowds and queues of the people are a major issue in the public services and organisations, especially with the increased number in the population. Outdoor Patients Departments (OPDs) of the government hospitals are often observed to have uncontrolled areas of long queues of patients, especially during the peak hours of clinics and in infection seasons. Currently, there are different types of systems and simulation models experienced for the OPD system to manage the patients. The focus of our study is to develop a prototype for managing patients in OPDs to simplify the process of patient inspection, treatment and conveniently managing their time by sending alerts about the current updates of available patients. This prototype introduces the development of a patient information registration and management system for patients and hospital staff, and a Mobile application-based alert system for patients. The system was developed using JAVA and MySQL. The Mobile application-based alert system was developed in JAVA and an Android mobile device was used as the GSM Modem or SMS gateway to send SMS alerts to the specific mobile number within few minutes. The prototype was tested with users from both hospital staff and patients and produced higher user satisfaction after evaluation through demonstration and questionnaires. The proposed prototype will resolve the difficulties patients faced by minimizing the long queues and will further enhance the efficacy of the services provided to the patients by the hospital systems.*

Keywords: Patient management system, Android application, Mobile alert system, Outdoor Patients Departments

I. INTRODUCTION

The health care systems play a major role in the development of the country's economy and people should experience the services on time. The government hospitals play an important role in providing people with health facilities (Ngowtanasuwan and Ruengtam, 2013). Hospital is one of the most public crowded places in Sri Lanka due to rapid population growth. Outdoor Patients Departments (OPDs) in the hospitals are currently experiencing a high-level of crowdedness. Also paves the path to form queues to get public services. The crowd may lead to the spread of the COVID19 virus in public places and the mass gathering of patients disturb other patients in the hospitals.

The Outdoor Patients Departments (OPDs) of the government hospitals in Sri Lanka are often observed to have long and uncontrolled areas of long queues of patients, especially during the rush hours of clinics and in flu seasons. Many hospitals still use manual, paper-based methods for patient management which leads to lots of difficulties for OPD staff when managing the patients. Not only the staff but also the patients who come to assist them also face some inconveniences due to lack of facility to manage them and therefore, the people have to wait long hours to get their work done. However, in most of the government hospitals in Sri Lanka still, there is no proper mechanism to manage the OPD patients and most of the work is yet done manually or ad-hoc manner. A project named Hospital Health Information Management System (HHIMS) has been introduced to a few government hospitals in Sri Lanka starting from 2010 (Jagoda, Samarakoon, Rathnayake, 2014). The project has been implemented in Base Hospitals at Dambadeniya, Mahaoya, Awissawella, District Hospital Dompe and Base Hospital Karawanella. The HHIMS is capable of doing functionalities such as patient registration when arriving at OPD, report generation (OPD registers, dispensed drugs) and retrieving patient information. However, a mechanism to alert patients through SMS and online patient registration and management is not available in this currently implemented HHIMS system in government hospitals in Sri Lanka (Kulathilaka, 2013; Hewapathirana and Rathnayake, 2014). On the other hand, Multi-Disease Surveillance (MDS) project has been implemented in over 20 government hospitals in Eastern province including Chenkalady Rural Hospital, Batticaloa

Teaching Hospital, Trincomalee General Hospital. The MDS is also limited to certain functions such as storing patient information, drug control and so on. However, the MDS system also does not consist of any alert mechanism to send SMS notifications to patients or to register patients online without coming to the hospital (Pole, 2010). This depicts that online patient registration and patient alert systems are not yet implemented in government hospitals in Sri Lanka.

Therefore, people have to wait in long queues to get their work done and the increased number of people in the OPD section will cause the spread of infectious diseases in current pandemic situations. Insufficient space for seating patients and the people who assist them make them so inconvenient as a large number of people arrive at peak time to the OPD (Ngowtanasuwan and Ruengtam, 2013). Therefore, hospital administration is seeking an alternative approach to managing the crowded patients and following some ad-hoc methods to provide their services uniformly. Our study is focussing on developing a prototype for the Patient Management System in OPD which will help to resolve most of the issues faced by the patients as well as the staff in the existing system in hospitals.

The main goal of this work is to introduce a prototype for a patient management system, particularly in OPDs in Sri Lankan government hospitals which will eventually help both the staff as well as the patients. Therefore, we are introducing a patient's management system with mobile technology to send time to time alert messages to the registered patients by indicating how many patients are in the waiting queue within a particular time, so that any incoming patients can manage their time based on the availability of existing patients and doctors. The patients can register at the hospital using two methods, by arriving at the OPD or by registering through the web-based application when staying at home without arriving at the OPD. By registering through both methods, related information can be sent through alert messages. This not only reduces the unnecessary gathering at the OPD reception but also the workload of the receptionists. The overall system is well secured and password protected. The patients' treatment information can be viewed only by the doctors, nurses and other related staff. The solution will reduce the waiting hours of the patients; effectively manage the work and time of patients and hospital staff to indirectly support the social distancing concept due to the pandemic.

To achieve the goals, the following objectives are performed:

i. Development of patient information registration and management system for OPD.
ii. Integration of the patient alert system using the mobile application with the patient management system.

II. LITERATURE REVIEW

Many recent studies have been performed not only to develop new systems but also to analyse the existing simulation techniques in order to manage the patients in the hospital's OPD. Zero Queue Management System (ZQMS) in the past work used an Android application named "*Smart Medicare*" consists of a waiting list option that informs patients of the availability through SMS and the medical records can be viewed by using a one-time password (OTP) that is sent to the patient's mobile number. The doctor's fingerprint is taken when he enters and leaves the cabin to ensure the doctors' availability. The cloud server and the website are updated with the help of the Arduino through the Wi-Fi module and by the cloud server respectively (Thirupathieswaran *et al*., 2021).

In the work performed by Kavitha, Ramana and Raj (2012), an Embedded Management System for OPD was designed to help patients to identify the relevant doctor's cabin by displaying their token number and their name on a TFT screen which is placed outside the doctor's cabin. The number of TFT screens used depends on the number of departments in the hospital. The system comprises various embedded devices like Microcontrollers, SD card, LCD, RS-485, SPI, keyboard, and each Consultant's room has OPD slaves which are used to inform the Master OPD unit to send the corresponding consultants' token number. In another work (Soman *et al*., 2020), focused on Mobile-Augmented Smart Queue Management System for Hospitals, which is capable of generating unique tokens by using algorithms. The system provides various facilities such as estimation of patient's waiting time, generation of multiple tokens for the same family member, notifications and messages services at token generation and also notifications about the waiting time and the patients turn at the specific counter.

The work in Chandran *et al*. (2017) introduced Multiple Queue Management systems with real-time tracking that facilitates patients to make appointments after registering through the internet, by checking the doctors' available time slots. The appointments are given according to the date and time, the relevant department, the available doctor and the patients have to wait in separate digital queues for each doctor in different departments in each time slot. The appointment status is informed through messages and the cancel appointment, update appointment and waiting appointment options are available. In another work by Aizan *et al*. (2019), 'Walk-Away' Queue Management System Using MySQL and Secure Mobile Application is controlled by a central server, facilitates the patients to leave the area after getting the digital token and they are called back by the remainder messages send through Telegram app or SMS, five numbers before calling the specific ticket. The system uses an Android phone to replace the Callpad terminal and the token dispenser in the normal QMS. However, the bandwidth and transmission were detected as the main system issues in this system. The work in Ngorsed and Suesaowaluk (2016), introduced the Hospital Service Queue Management System which used wireless devices to monitor the queue status which can be accessed online through an open-source web application. An Arena simulation model was introduced in the work Kulkarni *et al*. (2021) and used to study the patient flow in different OPD sections. The patient movements are recorded when they enter the OPD and the patient flow data distribution at each section is determined by the Input Analyzer. Rema and Sikdar (2021) recently analyzed the flow of patients in an Indian hospital by considering a single consultant for a period of three hours and the time taken by patients to complete particular tasks were noted through observations, and snow ball sampling technique was used to take the general data by distributing a questionnaire among 25 OPD staff. Furthermore, the Monte Carlo simulation technique was used to analyze the queuing patterns where the results depict the ways to minimize the delays and increase their service. From the analysis of the recent literature review, there are some attempts that tried to sort out the issues of patients in hospitals. However, there are some issues in each approach and we try to introduce a simple and convenient method for both hospital staff and the public.

For the mobile technologies utilised in different applications, there are several methodologies used to send alerts messages from a computer system to a mobile phone through SMS. GSM (Global System for Mobile communications) modem is a device that is capable of sending and receiving SMS and data over a GSM Network. It not only provides the easy development of systems but also works in a remote area without telephone line connections (Sukanesh *et al*., 2010). A computer can send SMS messages when it is connected to a mobile phone or GSM/GPRS modem, but this method has a minimum transmission speed of about six messages per minute. Another method of sending SMS is sending the message from the computer to the recipient through the SMS centre or SMS gateway of a wireless carrier. Although this method is fast, this requires a higher amount of routing and network wiring (Ueng, Tsai and Chang, 2007).

The Ozeki message server consists of an SMS gateway application that enables users to send and receive SMS messages to mobile devices from a computer. The messages can be sent and received when a GSM mobile phone is attached to the computer using a data cable or through IP SMS technology (Abdel-qader, 2011). A computer equipped with messaging software such as Ozeki can be used as a Short Message Entities (SME's) that act as the source and destination for SMS messages (Mhapsekar *et al*., 2012). There are various systems developed using this Ozeki message server. A mobile-based medical alert system (MAS) was built to send SMS alerts to patients' and medical practitioners' handheld devices such as mobile phones and PDAs. The SMS alert message is forwarded in MAS using the Ozeki SMS server that consists of a GSM modem. The system consists of a MYSQL database, application and web server. An automated scheduler that runs with PHP and Ozeki SMS server integrates to execute this application (Watfa, Johnston and Snavely, 2011).

In another way, FrontlineSMS is freely available open-source software that provides facilities to send large scale SMS messages (Mahmud, Rodriguez and Nesbit, 2010). A two-way text messaging hub was created by connecting a computer running with FrontlineSMS to a GSM modem or a cell phone. The phone numbers with a valid SIM (Subscriber Identity Module) can receive and send SMS to and from the console. This software facilitates the users with various options such as managing contacts, auto-forwarding and replies. There is a work that uses IoT devices to send and receive messages

(Rajkumar, Srikanth and Ramasubramanian, 2017). Raspberry pi is a high-performance computer that can be programmed using programming languages like Python to send SMS alerts that are used in implementing health monitoring systems. Raspberry Pi can be combined with a GSM module through a serial port to send and receive SMS using AT commands (Gupta, Patchava and Menezes, 2015). Since the existing systems have so many software-hardware modules to be integrated, we have introduced a simple implementation that can send SMS alerts to the patient's mobile phone from a Java based patient registration and management system.

III. METHODOLOGY

An overview of the overall Patient Management System in OPD is shown in Figure 1.

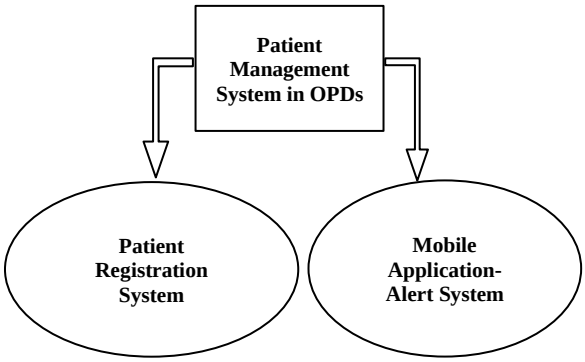


Figure 1: An overview of the overall Patient Management System in OPD which consists of patients' registration and mobile application modules.

The overall system consists of two intrgrated research componenets.

i. Development of a patient's information registration and management system for OPD.
ii. Development of mobile application based alert system for the patients.

A. Development of patients' information registration & management system.

The patient's information registration and management system consist of several processes. The receptionist is able to add the users to the system. A user (receptionist and doctor) can thereafter login to the system with the user credentials and can direct into the main form which consists of several processes such as patient registration, doctor registration, channel creation, view channel, create items, create user, view doctor and log out. The receptionist is also able to register the patients who are coming to the hospital by putting their information such as the patient's name, age, address and a mobile number which should be an active number as it is used for the mobile alert system for patients. In the system, the patient's registration number is a unique number that is generated by the system. The patient can use his or her registration number whenever they visit the OPD. The patients' information can be updated and deleted. The *Create User* function in the main form is used to insert users for the system by the receptionist.

The doctor is also able to register using the *Doctor button* with information such as Name. The doctor is able to delete, add and update the information. The receptionist can use the *Create channel* button to create a channel. The receptionist can select the doctor's name from the drop-down list and the patient's name, room number and channel date can be entered. The doctor is able to view the channel and also to add items.

B. Development of mobile based alert system for patients and hospital staff.

Mobile technology is not only used for making calls but also controlling the crowdedness in public places. Today, gaining government services in public places is threatening everyone's health due to the pandemic. The report provided a mobile alert system to control the crowd in Out Patient Department (OPD) in hospitals. The purpose of producing this framework is to reduce the waiting time in the queue and control the crowd of patients at OPDs. The proposed system consists of two main parts: Mobile application and Mobile alert system. They explain how the patients receive alert messages from mobile applications with the number of patients and time through SMS. The alert system was developed using the JAVA programming language. The proposed framework produces an effective method to alert the patients when the crowd is high in OPD. The system consists of two main parts. One is the mobile-web based application and mobile alert system. The report depicts how these two main parts work together to control the crowd in the OPDs in Sri Lanka. Mobile applications can only be used by those who have phones.

The mobile alert system has the ability to send the alert message to the patients when they are registered at the hospital's OPD. The web-based mobile alert system facilitates the users to register themselves at home without arriving at the hospital, and the system is capable of sending alerts as an SMS to the patient's phone number

which they gave during the registration process. The proposed system can be used by both Android users as well as normal mobile phone users. The mobile alert system is capable of sending SMS to the patients' normal type mobile phone when they go to the hospital and get registered if there is no facility to register through the web-based application or any Android phone usage. This alert system was developed using JAVA and an Android mobile device was used as the GSM Modem or SMS gateway to send the SMS alert to the specific number.

The tools and techniques used for this system are:

C. *Patients' information registration and management system:*

The system was developed in JAVA using NetBeans IDE 8.2 and MySQL is used to create the database using Xammp Control Panel v3.2.4.

D. *Mobile application based alert system for patients and hospital staff:*

The patient mobile alert system was developed in the JAVA programming language by using the NetBeans IDE 8.2. An Android mobile device was used as the GSM Modem or SMS gateway to send SMS alerts to the specific number within a few seconds. This exposes a set of APIs for two operations, sending and receiving SMS. This supports programming languages such as Java, Spring, C, C++, PHP, Laravel, Codeigniter, C#, ASP.NET, etc.

IV. DESIGN

A. *Object oriented based analysis and design of the patient management system*

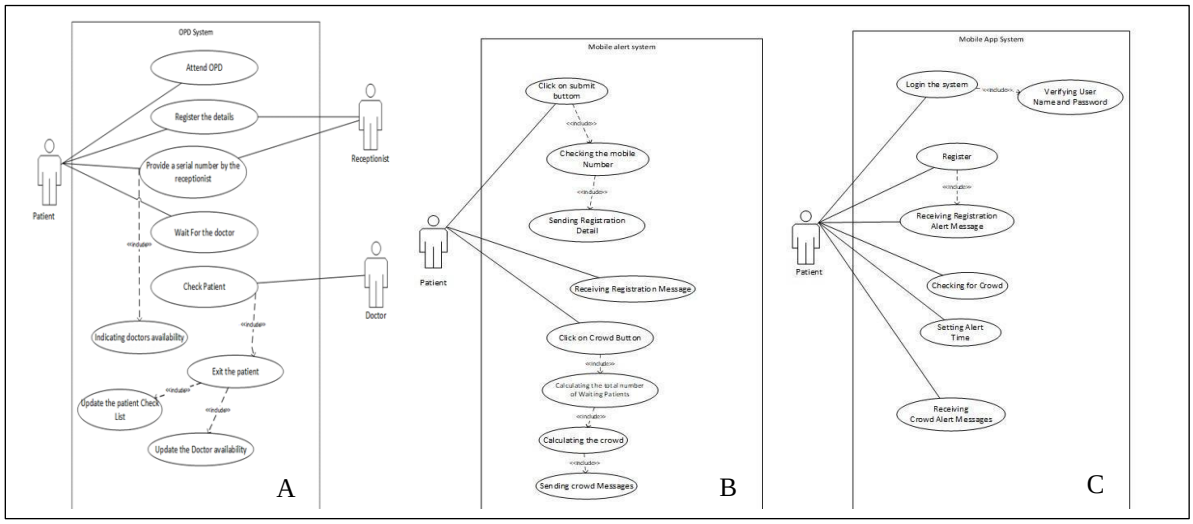


Figure 2: The use case diagram of: A) Patient's information and management system that illustrates how the system interacts with its users; B, C) mobile-based alert system illustrates how the system interacts with patients.

V. IMPLEMENTATION

A. *Patient management system*

The patient management system is used to facilitate the hospital staff and the patients who arrive at OPD to get their treatments. It helps to reduce the waiting time of patients. Figure 3 depicts the Login screen. There are different users with different user privileges.

The administrator is able to create users such as doctor, receptionist and other roles using *create user* button for the system and is able to create a user by giving a username and password. The patient registration process is done by the receptionist by selecting the *patient button* on the *Main Page* or online based by the patients. Figure 3-C depicts the patient registration page where the receptionist can add, update and delete patient information. They can enable the system to send alert messages time to time to the registered patients. The receptionist can also create a channel by the *Create Channel* button on the main page and the doctor is able to view the channel through the doctor login as shown in in Figure 4. *Create Item* page is available to the doctor login option where the doctor or doctor's assistant is able to create prescription items, update and delete them in the existing list (Figure 5C). The top-level administrator has more privileges and each user is provided required access and process in the system.

Receptionist's View

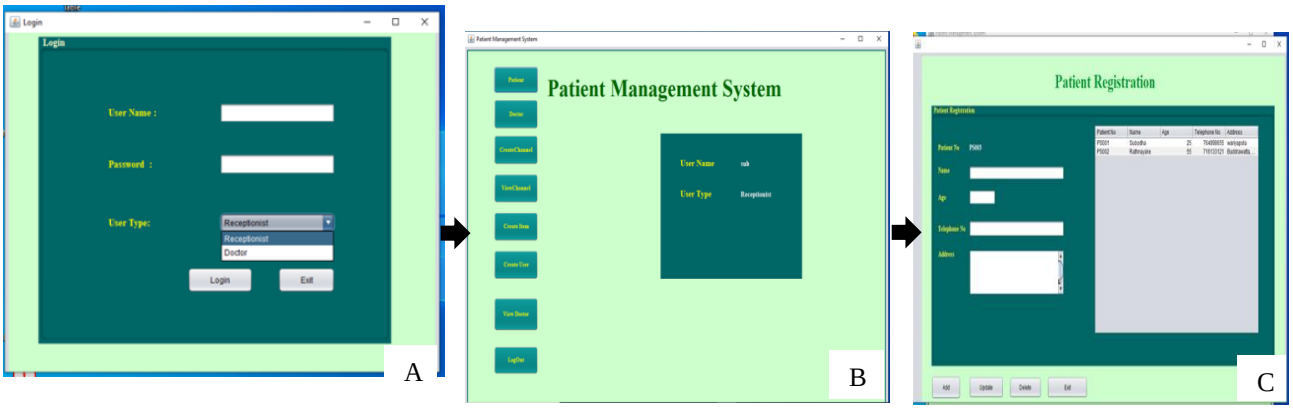


Figure 3: Patient management system- Initial login environment of the system with different users who need different user privileges; The Main Page consists of main processes of the system such as patient registration, doctor registration, create user, create channel, create drug items etc. The user creation process is handled by administrator by giving user credentials and the receptionist registers, updates patients' records and create channel.

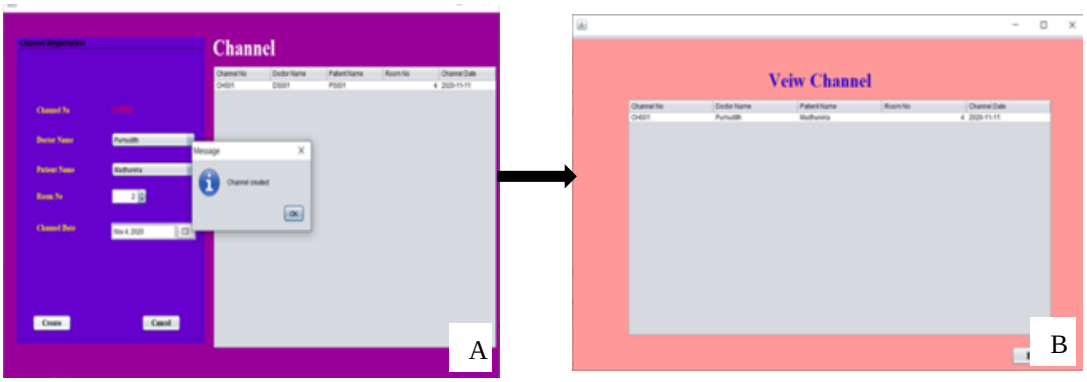


Figure 4: *Channel Creation* Process: A) The channel creation page where the users are registered under various doctors and room numbers; B) The view channel option is visible to the doctor where it contains information about the channel number, doctor name, patient name, etc.

Doctor's view

The user is directed to the *Main Page* when they login to the system as a doctor. The doctor can register, update and delete the details using this page as shown in Figure 5B; C) Create Item page is available to the doctor login option where the doctor or doctor's assistant is able to create and update prescription items.

B. Mobile based alert system

The mobile alert system has the ability to send alert messages to the patients when they are registered at the hospital's OPD. The web-based mobile alert system facilitates the users to register themselves at home without arriving at the hospital. The alert is sent as an SMS to the patient's phone number which they gave during the registration process and is sent to the patient from time to time when the patient management system gets updated. This facilitates the patients to identify the number of patients in the relevant doctor counter at a specific time and also to know about the current ongoing patient's number that is called at the doctor counter although they are not at the hospital premises. This will help to reduce the unnecessary gathering at the OPD.

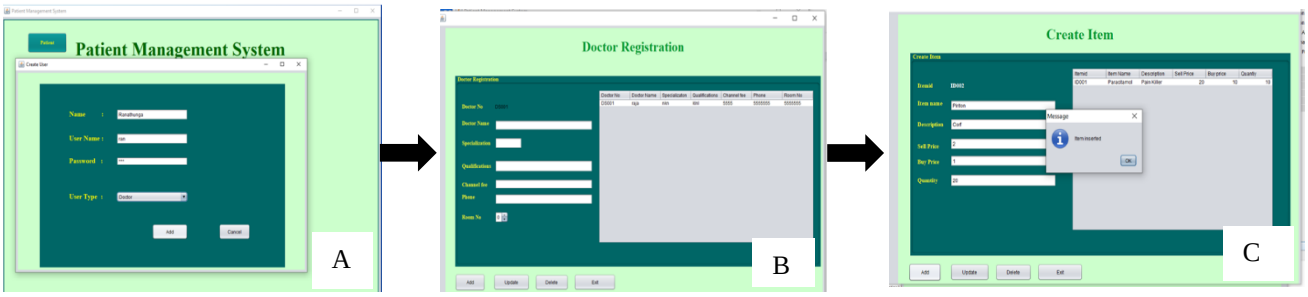


Figure 5: Patient management system-A doctor's view where the doctor can register, update, delete the doctor's information: A) Log in process of staff; B) Registration process of clinical staff; C) Create drug items.

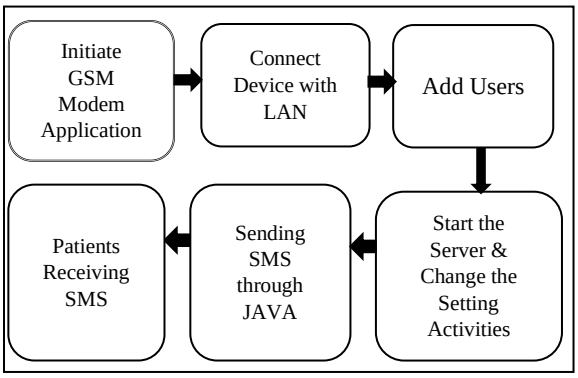


Figure 6: This model shows the overall process of sending the SMS alert messages to the registered patients.

The following steps are exploited during the process of mobile-based alert system:

i. Initiate the GSM

Initial and final state of the interfaces of the GSM modem application with its components at initial state.

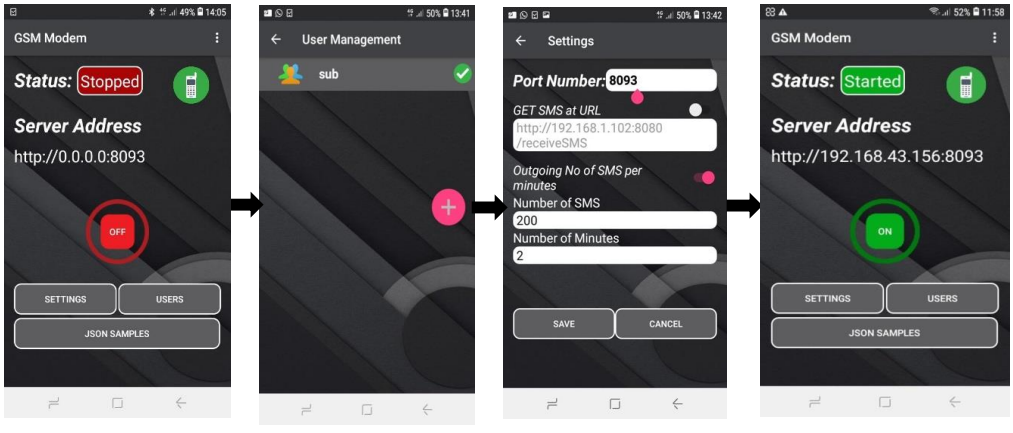
ii. Addition of users with the password.

Users must be added for authentication before sending a request for SMS.

iii. Changing the setting activities.

iv. Request for sending SMS.

The Android device and the computer must be connected to the same Local Area Network to communicate with each other. Then the SMS server must be started (The Red Circle button becomes green). Then search through the Chrome browser to get the HTTP request in the browser with the credential parameters. This will send the JASON in return. Next, the JAVA code has to be executed by adding the suitable parameters such as the patient's mobile number and the message, which then will be sent to the relevant patients and the status of the message is represented as a response. The sender's and receiver's view of the mobile alert system is depicted in Figures 7 and 8B, respectively.



The initial interface of the GSM modem application with its components at initial state.	Addition of Users with the password.	The interface of the settings section and its components at final state.	The final interface when sending SMS, the server address is also displayed.

Figure 7: Mobile alert system: Sender's view

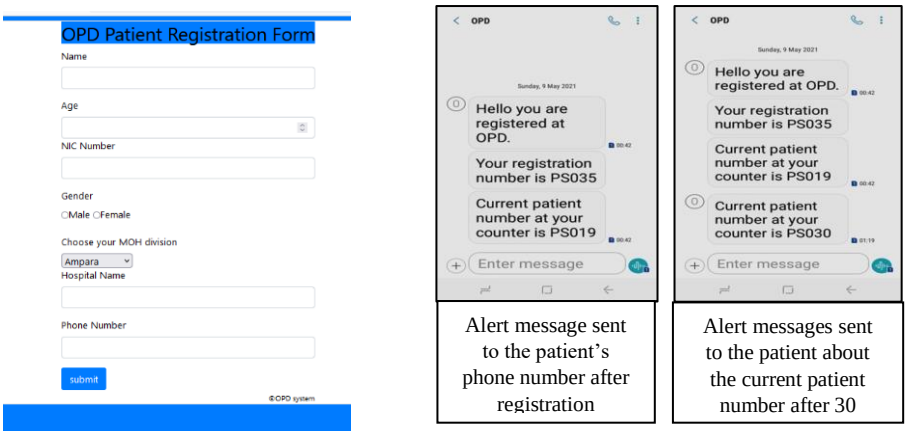


Figure 8: Web-Based Registration & Mobile Alert System: A) Mobile-web based alert system interface where the users can register through the interface; B) Mobile alert system: Receiver's view

We have tested the prototype using several sample users with different types of mobile phones. We have selected around eighty-six users from different age groups particularly, elders and youngsters in both patients and staff category. From the questionnaire made with the users, a higher percentage of user satisfaction is achieved as the simplicity of the system. It was analysed that 87.2% of the users were satisfied with the prototype while 77.9% of users found the prototype is easy to use. It is successfully working well and users are convenient about the system. The suggestions and feedback obtained from the users are considered to the revised version of the system in the future with an automated crowd detection module.

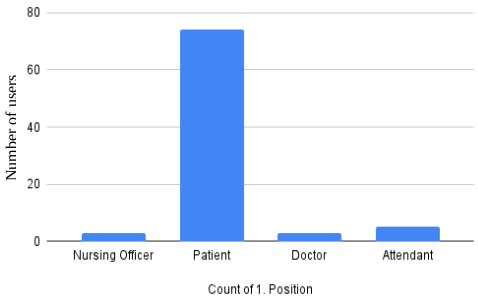


Figure 9: The prototype was tested using doctors, nursing officers, attendants and the general public who become patients

Challenges

There are some challenges faced during the development of the alert system. The major challenge is finding a suitable SMS gateway. There are so many SMS gateways available to use, but they are not freely available. Although SMS APIs enable the integration of SMS services with systems easily, most of the APIs such as Textlocal's SMS API does not support signing up from Sri Lanka.

VI. DISCUSSION

Our study was focused on developing a prototype for the Patient Management System in OPDs which will help to resolve most of the issues faced by the patients as well as the staff in the existing system. The major challenge we faced while developing the system was the development of a mobile application (alert system). It was difficult to find a suitable SMS gateway. There are so many SMS gateways available to use, but they are not freely available. Although SMS APIs enable the integration of SMS services with systems easily, most of the APIs (for example, Textlocal's SMS API) do not support sign up from Sri Lanka.

The patient management system in OPD that we have developed differs from the existing system due to the availability of sending SMS alerts for the patients. The patients who receive the SMS alerts do not need to install any software or mobile app on their phones. Their phones do not need to be any Android or smartphone. SMS service is available to all kinds of mobile phones which have a phone number registered at OPD. This will facilitate the people with different economic levels to access the service without any technical or financial difficulty. The other feature of the system is people can access the system at home and register and update their details and get alert messages and plan their visit to OPDs at their convenient time. For this purpose, we are developing the system with Angular JS front end,

Java back end and MySQL database, which enables the system to be accessed by any patients outside of the hospitals.

The future work of this system will be the adding of new features and introducing automated crowd detection techniques using deep learning. The state-of-the-art methods will be investigated to develop a novel technique for crowd detection in public hospitals and OPD premises. This will help to eliminate hospital staff and indicate those who are inside the OPD premises.

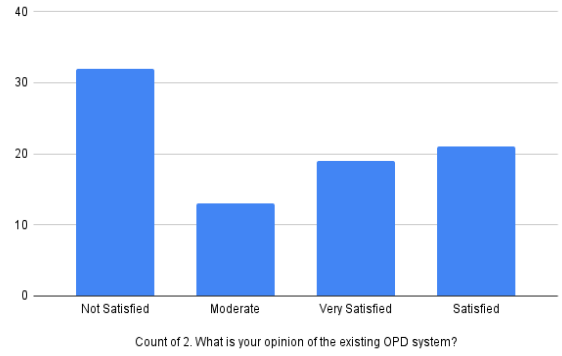


Figure 10: The opinion of the existing manual OPD system and the proposed prototype model: Test with manual system where 37.2% are not satisfied with the existing manual system while 15.1% of users are moderately satisfied, which depicts the need for a new system;

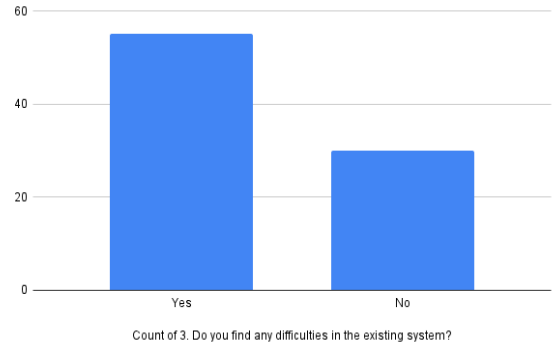


Figure 11: The opinion of the existing manual OPD system and the proposed prototype model: 58.1% found that they are having difficulties in the existing manual system.

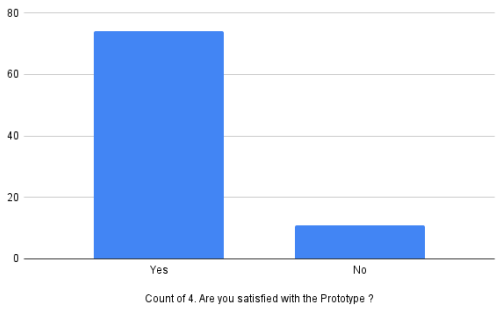


Figure 12: The opinion of the existing manual OPD system and the proposed prototype model: The prototype is tested with the users and 87.2% of them are satisfied with the developed prototype.

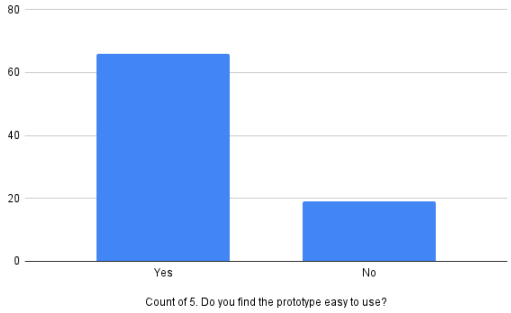


Figure 13: The opinion of the existing manual OPD system and the proposed prototype model: User satisfaction with the prototype testing where 77.9% of them found that the prototype was easy to use.

VII. CONCLUSION

The current work presents the development of a prototype for the patient management and mobile alert system in OPD where the overall system consists of two integrated research components. The patient's information registration and management system was developed to provide an effective service to the patients as well as the staff as a solution to the difficulties they faced in the current manual process. The mobile alert system was developed to provide alert messages to the patients, which will facilitate the patients to identify the number of patients in the relevant doctor counter in a specific time period and also to know about the current ongoing patient's number that is called at the doctor counter although they are not at the hospital premises. This system will help to solve the problems with time management and over crowdedness of the current OPD systems.

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