

Patients Management System using Fuzzy Logic: An easier and dynamic appointment system

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Abstract—Patients have long complained about the wait time at their doctor's office. Now a days, in Bangladesh, patients are to go before the day or more than one week, even one month ago to the hospital to get the appointment of doctors. There exist some corruption regarding the serial list of the patients and is the so called bribe. Sometimes patients are to face difficulties hearing at hospital that- doctor is late for a while or doctor is not meeting today. In this case patient's financial loss is directly associated with the time spent waiting. So patients queue management at doctor's office according to time is one of the vital problem in Bangladesh perspective. Another one is referring a patient to a different doctor. Here the referred patient has to face some complexity with the newly visited doctor because, for the new doctor it's not possible to discern the patient completely by analyzing patient's previous prescription record within the short checkup time. To solve these problems, the paper proposes a model Patients Management System (PMS) using artificial intelligence which offers both the solutions- Fuzzy logic based patients queue management and real time referring patients to different doctors including prescription management. The system has been tested using some real time data to face the real life complexity.

Keywords—Patients Management, Referred Patients, Prescription Management, Fuzzy

I. INTRODUCTION

Bangladesh is a country with over population. Here the ratio of doctor to patient is 1 4000 [4]. Medical facility is one of the most important fundamental needs of human being. About 35% of the people of Bangladesh are deprived of quality [4], modern medical services and proper treatment. Many of them can not manage proper treatment because of complexity of taking doctor's appointment and wastage of time and money for taking appointment. Another one important fact for proper treatment is doctor-patient relationship. Sometimes improper doctor-patient communication hinders from reaching the proper treatment. Finding the desire doctor's actual location sometimes become much more difficult for a patient. According to the current traditional system, taking doctor's appointment is so much complicated and patients have to survive sometimes a lot. The main focusing point of the proposed system is taking doctor's appointment directly through mobile SMS or a smart phone device with a serial number which is totally unique. Patients can be able to make an

appointment with a doctor over the traditional time and money wasted system. Time to time feedback messages, both doctor and patient individual profile management with effective information, searching and finding area wise doctors list, individual patient's prescription management, doctor's office location view to the appointed patients, easy and real time referring patients to another doctors are the effective services for both doctors and patients through the system. Proper maintenance of individual doctor's and patient's profile management is the way of increasing doctor-patient relationship. The prescription management section is directly related to patient referring and important also. The system is designed for both doctors and patients in a friendly way. Three part of the system- web application figure. 7, smart phone application figure. 8 and desktop application figure. 6 are able to provide a secure and benefited service to both doctors and patients. Many researchers have tried to study the patient queue management system from different perspective, many have tried to implement this system. BIHS [10] with Business Automation Limited Provides an effective and systematic smart queue solution. This process starts with the visiting Patients as firstly visited patient presses "NEW" button for new appointment. And "OLD" button for old appointment from the KIOSK. The system will automatically generate a printed "SLIP". Not any kind of SMS of smart phone app facility existing here. ZocDoc [8] is an online medical care scheduling service, providing free of charge medical care search facility for end users by integrating information about medical practices and doctors individual schedule in a central location. DoctorPage [9] design for the practicing physician. Here doctors find wide range of resource for patients handpicked to fit doctor's daily information needs. STREET HEAVEN HEALTH CARE COMPUTING: Inpatients [16]- is another online scheduling service to simplify and manage admissions, transfers and discharges. With real time information being easily available. It manages planned and emergency admissions recording all relevant booking and insurer information along with any admission notes. With the ability to store an insurer's authorization code and the expiry date. Users can change how information is viewed, for example listing all patients who are due for admission by a particular consultant, date, patient category or specialty. Doc Soft (Patient Management Software) [11] is a product of eSoft and the features of this patients management software are- Patients registration, reconfirmation, patient list clock, schedule

maintain, queue waiting list, consultation, investigation, search old patients, symptoms, history of patients, treatment, bill entry, auto format for prescription with printing, auto format for bill with printing, etc. eAlth [15] is a secure and reliable hosted software solution for PMS. Some important features of the system is- Send SMS and Email messages to multiple registered patients directly from the appointment screen and the waiting list, Automated SMS and Email reminder for appointed patients and their future appointment.

II. EXISTING PATIENTS MANagements SYSTEM OF BANGLADESH

The current PMS of Bangladesh can be inspected from two major viewpoints. They are-

- Taking an appointment going at hospital
- Finally meeting with doctor

A short description of existing PMS can be grasped from the bellow in figure. 1

A. Taking an appointment going at hospital

Taking an appointment of a doctor in Bangladesh is conducted totally in a traditional way. According to the current traditional system a patient first has to go to the hospital physically and then meet with the assistant of that particular doctor. The patient requests to the doctor's assistant for an appointment date, time and serial number. The assistant allocates a serial number for that patient and give a date for appointment. In this case the total queue management of that doctor's appointed patients is done by the assistant. Sometimes patients face difficulties going at hospital hearing that doctor is not available on schedule date and time.

B. Finally meeting with doctor

After taking an appointment from the assistant, the patient then finally go to hospital for meeting the doctor. The patient also has to wait a long time at the hospital and sometimes the assistant replace his/her queue with another one because of bribe. For such kind of corruption regarding the doctor's appointment, the patient has to suffer a lot by wasting time and money. In this case, the queue of appointed patients doesn't maintain properly or in a dynamic way. The current traditional patients management system is not suitable for both doctors and patients. Using the proposed system it's possible to overcome the traditional problem of taking appointment. In this case patients don't have to come to the particular hospital and meet with the doctor's assistant for taking doctor's appointment. Patients also don't need to wait a long time for meeting with doctor. The system is capable of being given up all kinds of corruption regarding with taking appointment. If any patient takes an appointment of any particular doctor through the system then he/she doesn't get any option to pay extra money to the doctor's assistant and the assistant also unable to keep the extra paid patient's serial in the first row. It also possible to increase the doctor-patient relationship through the system.

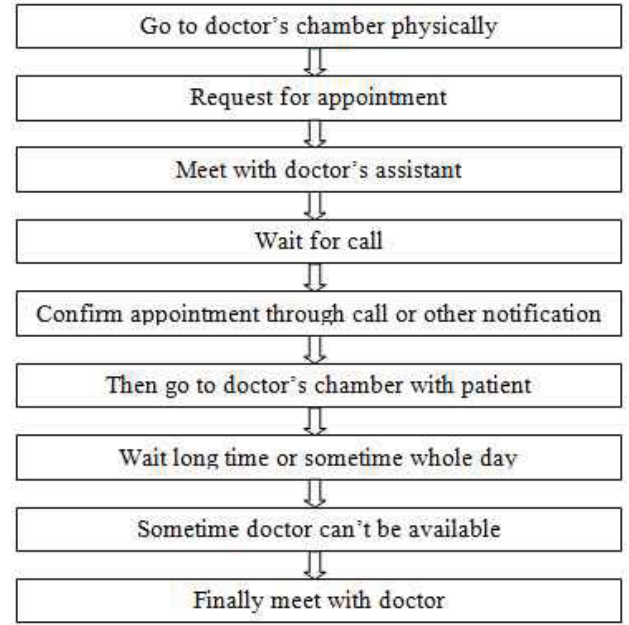


Figure 1. Conventional Doctor's appointment procedure

III. DRAWBACKS OF THE EXISTING SYSTEM

The current PMS in Bangladesh is backdated and time and money consuming. The system has disfavor performance to both the doctors and the patients. Wastage of time and money are the vital issues in case of current system. That's why patients have complained against the system. According to the current system, if a patient wants to take appointment of a doctor in a particular hospital, he/she has to first go to the hospital, meet with the assistant of the doctor and then take an appointment from the assistant of the doctor. After taking appointment, the patient has to wait a long time to meet with the doctor on the appointed day. It costs time and money both. Sometimes some patients have to be the sufferer of the so called bribe. In many cases, some patients pay some extra money to the assistant of the doctor for keeping his/her serial in the first row which is totally illegal. In Bangladesh perspective, the doctor-patient relationship is not so good. But a good doctor-patient relationship is essential for proper medical treatment. There is no positive sign in current traditional system for improving the doctor-patient relationship. Referring a patient to an another doctor is one of the vital problem in the current system. Both doctors and patients have to face this problem. According to the traditional system, doctor is not capable of being perform a successive reference.

IV. PATIENTS MANAGEMENT SYSTEM AND IT'S KEY FEATURES

PMS using AI is our proposed model system by which a patient can easily take an appointment of any particular doctor through mobile SMS or the smart phone device. The system is capable of being removed all the bottlenecks of the traditional system. The overall functionality of our system is performed in several steeps according to figure . 2 The appointment section manages the patients appoint-

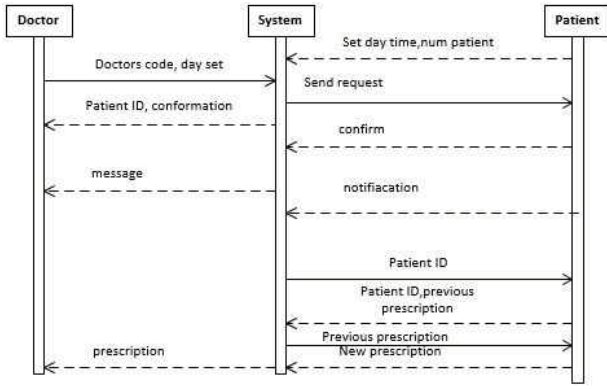


Figure 2. Functional diagram

ment regarding serial number, the prescription section stores all previous and current prescription data and using the reference section a doctor can easily refer a patient to an another doctor. These key features are described in the following-

A. AI based patient's queue management

The most important features of PMS is artificial intelligence based patients queue management. Fuzzy logic is used here for maintaining the patients queue dynamically. We suppose that Dr. D is available from tomorrow 2:00pm to 8:00pm at the hospital H. Patients have to take the doctor's appointment one day before. Dr. D has may some requirements for accepting patient's appointment. Let's say, Dr. D wants 30% previous patients appointment, 50% new patients appointment and 20% emergency patients appointment for that particular day. Fuzzy logic will perform calculation based on those requirements and accept or deny patient's appointment and finally notify the patient through mobile SMS or smart phone app notification. In this case, if previous appointment patients are less than 30% then remaining percentage will include with new patients and if emergency appointed patients are less than 20% then remaining percentage will include equally with the previous patients appointment and the new patients appointment. Emergency patients are also calculated from their previous prescription status. So key component of artificial intelligence based queue management are- Calculate incoming appointment request from patients based on the doctor's personal requirements. Identify emergency patients by analyzing previous prescription record. Patients have to take appointments through mobile SMS or smart phone device in the following way- Send message to a particular doctor typing "doctor's code" space "hospital name" space "day" space "patient's name" space "patient type". Suppose patient P wants to take an appointment of Dr. D in H hospital at Friday and doctor code is "d". In this case the

patient has to type in the SMS "d H Friday P" and then send it to a particular number. A replay SMS will confirm the patient about his/her appointment status. On the other hand if a patient wants to take an appointment through the smart phone app, the patient has to login

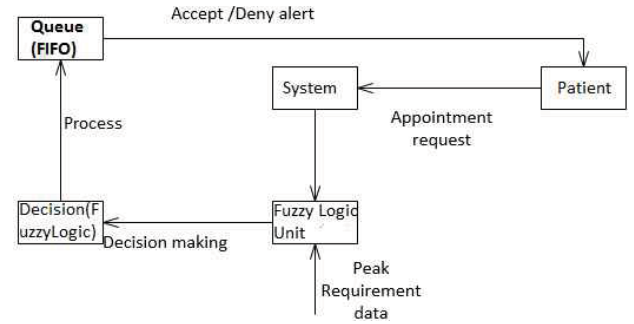


Figure 3. Functional diagram of PMS

first to the app, search desire doctor and take appointment directly through app.

B. Prescription management

The prescription management section is for storing patient's prescription data in order to use by fuzzy engine to identify the emergency patients. This section is also important for patients referencing to an another doctor. At the time meeting doctor, the doctor will include patient's current symptom of diseases, required tests and medication through the real time digital prescription.

C. Pseudo Code of Algorithm

```

OP ← Old Patient, NP → New Patient
EP ← Emergency Patient Enque(Packet pkt, Date d)
u ← OP + EP + NP
if (OP > 0) then
    addWaitQueue(pkt(OP))
    OP --
else
    addWaitQueue(pkt(OP))
end
if (EP > 0) then
    Eq.1 & Eq.2
    addQueue(pkt(EP))
    EP --
else
    addWaitQueue(pkt(EP))
end
if (NP > 0) then
    addQueue(pkt(NP))
    NP --
else
    addWaitQueue(pkt(NP))
end
Time ← Q.length μ + StartTime
Return Time

```

Algorithm 1: Pseudo Code of Algorithm

The evaluation of the proposed model was done by using statistical measurements. These measurements are root mean square error (RMSE), percentage root mean square error, and the accuracy (%RMSE). The triage prediction category from both systems was compared to the triage category diagnosed by the doctor in the medical records. The triage category (doctor's requirements) gold

standard in this model. The RMSE and %RMSE and the accuracy are presented in Eq (1) and Eq (2), respectively.

Eq. 01:

$$RMSE = \sqrt{\frac{1}{n-1} \sum_{i=1}^N (y' - y)^2} \quad (1)$$

Eq. 02:

$$\%RMSE = \frac{RMSE}{mean(y)} \quad (2)$$

where y' is the predicted target value, y is the actual output value and n is the number of data items. Usually the statistical method gives us the average accuracy or average error. It is useful if we can find which packet has confused with which during the test. To find this we need to use the confusion matrix. It shows which packet has been classified properly or almost properly and which have confused with another packet. To use the confusion matrix we need to have a reference standard to compare with this technique. The reference standard in this work is the triage category made by the doctor. According to the algorithm, μ can contain different values (0.90, 0.98, 0.99, 1.0) and this values are used to study the sensitivity of the algorithm to μ . The burstiness of the short flow is increased by splitting a single short flow of 20 packets into two short flows of 10 packets each figure. 4 shows the evolution of the queue length for the different values of μ . Here smaller values of μ results in smaller queue size. As a result, smaller values of μ results in smaller number of dropped packets. Note that if μ is less than or equal to 1, packet drops

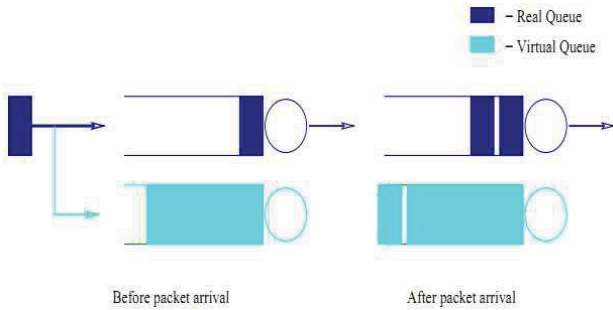


Figure 4. Functionality of virtual queue and real queue

are primarily caused by the sudden load change at 100s. After a transient period in which the algorithm tries to adapt to the new load, there are no more packet drops. But the duration of the transient period seems to increase as μ is increased. When $\mu=1$, the transient caused by new short flows is sufficient to cause buffer overflow in certain instances. According to the figure. 5, the virtual queue accept unorganized packet data. This unorganized packet data then transfer to the fuzzy engine and the fuzzy engine produce an organized queue. Figure. 4 shows that for $\mu=1$, each packet contains large number of queue. So for $\mu=1$ (set as default value), the system (fuzzy engine) will capable to calculate large number of data at a time which define the efficiency of the system.

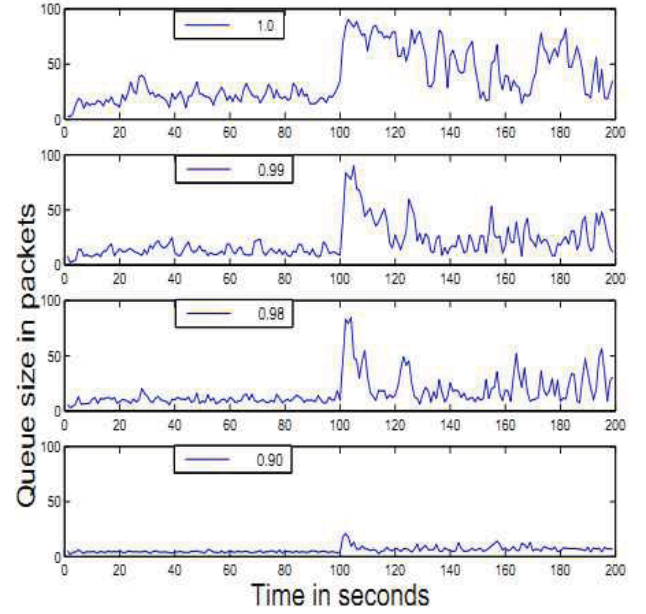


Figure 5. Evolution of the queue length for different values of

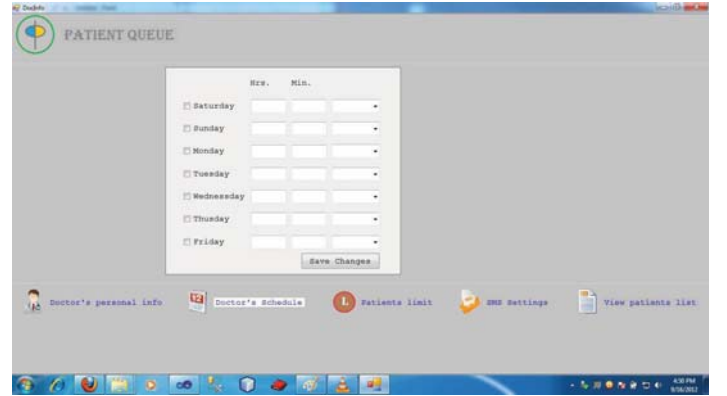


Figure 6. Desktop app of PMS

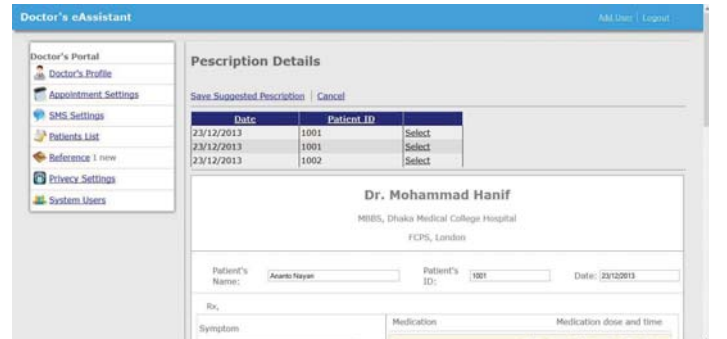


Figure 7. Web app of PMS

V. IMPLEMENTATION AND CASE STUDY FOR TESTING AND VALIDATION OF PMS

The open source Free Fuzzy Logic Library (FFLL) from <http://ffll.sourceforge.net> has been used to develop

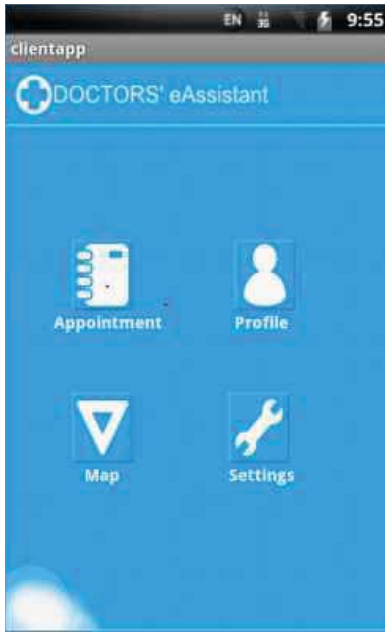


Figure 8. Android app of PMS

the system and the fuzzy parameters and fuzzy rules are constructed as input to the FFL. The entire implementation procedure is partitioned in four major units- Data Input, Data Analysis, Fuzzy Engine and Data Output (figure 9). Consider a set of real data from various numbers of patients against doctor code- "d101", Square Hospital and Friday: <Robiul Maruf> <Normal>, <Ananto Nayan> <Normal>, <Sharmin Ahmed> <Emergency>, <Foysal Moinul> <Normal>, <Shuvo Roy> <Emergency>, <Mostafiz Rana> <Normal>, <Deep Roy> <Normal>, <Ana Riodas> <Normal>. Two emergency and six normal patients are existing in this data set as input data. The system will allocate queue for normal and emergency patients according to the previously mentioned doctor's requirements in "AI based patients queue management" section. Before allocating the appointment serial for emergency patients, the fuzzy engine will analysis previous records and make a decision whether the applied patients are actually emergency or not. For the Boolean true decision, the fuzzy engine will generate an output keeping emergency patients at the top of the queue. If the gist of previous data analysis failed to fulfill the emergency criteria, the system will consider those emergency data as Boolean false and unable to perform any kind of operation over those data.

VI. FEASIBILITY AND PROSPECT OF PMS

Implementation of PMS is a computerized system for taking appointment. This system is capable to increase efficiency of queue management system. It will minimize the processing time of appointment procedure and corruption regarding the appointment serial number. It is apposite at this juncture to establish an approximation of the system with desktop application and gradually update web app and mobile application. In desktop app we can't share patient with other doctor like as referred doctor. We over-

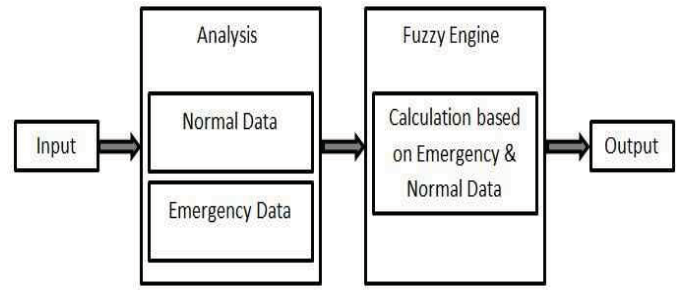


Figure 9. Data interpretation procedure

come this problem with web application. But still here we face some other problem, in the current situation computer and internet user is not so high on our country. But the system's patients may all class of people. Although, doctor will feel comfortable with desktop application rather than web application due to internet connectivity problem. To overcome this problem we used desktop application as a temporary database and sink data to server when internet is available. We have used mobile SMS for an appointment request.

VII. CONCLUSION

In Bangladesh, the current traditional Patients Management System is not suitable for both doctors and patients because of complicated appointment procedure, wastage of time and money and corruption regarding the serial number. To remove such kind of complexity, wastage of time and money and develop a better doctor-patient relationship, our system is perfectly suitable.

Table I. APPROXIMATE COST ANALYSIS FOR SETTING UP PMS

Setup Materials	Quantity	Approximate Cost in Taka
Computer	1	50,000
Modem	1	2,000
Internet Connection	1	1,500
Smart Phone Device	1	10,000
Total Cost		63,500

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