Improving the Emergency Services for Accident Care in Saudi Arabia

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***Abstract*—The road safety is one of the serious challenges faced by most of the governments due to the involvement of various issues. Being perfect in driving is not enough on the roads but tackling the mistakes of other persons is also an important aspect of the present day driving. Dealing with the accidents, injured personals, communicating the emergency services and dealing with other legal formalities is a serious challenge in present conditions. Providing emergency services is a real challenge due to increased population, heavy traffic and communication problems.**

In this paper, a novel technique is being introduced to avoid delays and major setbacks by emergency services at the time of accidents. The proposed technique works along with traffic control system of Kingdom of Saudi Arabia (KSA). By introducing such system in the healthcare, the serious drawbacks of communication can be avoided to a maximum extent. The proposed system can prove to be very effective at a place like Saudi Arabia, where millions of Hajj pilgrims visit for socio-religious gatherings.

Keywords*—Accidents; Communication; Emergency Services; Hajj Pilgrims; Healthcare; Saudi Arabia

I. Introduction

Saudi Arabia (SA) is a country with a population of about 28.83 million giving shelter to many (2.5 million) visitors to holy cities like Mecca and Medina every year to perform Hajj [1]. Apart from these more than 6 million visitors go throughout the sites for the whole year. These numbers are increasing year by year and managing people and facilitating the emergency services always been a challenging task for the officials to deal with. Many technological aids are being provided to the pilgrims to ensure their safe and peaceful stay during the Hajj. But some mishaps takes place due to various reasons keep the authorities on their heels. Most of the accidents and demand for the emergency services needed by these pilgrims are reported due to lack of awareness, ignorance, over enthusiasm, lack of understanding, communication problems and rush to deal with formalities. Apart from these unauthorized pilgrims from nearest cities/ countries will overcrowd or burden the facilities provided by the local authorities. Due to these reasons, many people face serious problems of hygiene, health, and demand for emergency services increases.

A. Background

At least hundreds of people will suffer or lose their life due to accidents in KSA at the time of Hajj. More than 270 pilgrims were stampede killed during devil ritual in May 1994 [1]. A similar incident was seen in Mina stampede where more than two thousand pilgrims suffocated and many crushed to death at the time of 2015 Hajj in Mecca. Various accidents and number of deaths due to increasing pilgrims reported by Ministry of Healthcare in KSA are shown in Table 1.

TABLE I. Different Accidents and Number of Deaths Registered During Hajj

Accident Type	Stampede		Airplane Crashes		Fire		Protests and Violence	
Sl. No.	Year	Deaths	Year	Deaths	Year	Deaths	Year	Deaths
1	July 1990	1,426	Jan 1973	176	Dec 1975	200	July 1987	400
2	May 1994	270	Dec 1974	191	April 1997	343	July 1989	17
3	April 1998	118	Nov 1978	170	Nov 2011	2		
4	March 2001	35	Nov 1979	156				
5	Feb 2003	14	Aug 1980	287				
6	Feb 2004	251	July 1991	247				
7	Jan 2006	334						
8	Sept 2015	4,173						

Note: Data accumulated from various sources.

Only deaths were reported in the above Table 1 and injuries are plenty to be considered at the time of such accidents. Apart from these many road accidents due various reasons as listed below are increasing the number of death [11] and injury cases in KSA.

- Due to bad behavior of drivers
- Failure to follow the regulations due to lack of awareness and inability to read Arabic on the sign boards by most of the foreigners
- Over speeding, jumping the signals, and wrong route driving
- Using mobile while driving
- Driving under the influence of drugs and alcohol
- Tampering with vehicles on the road
- Laxity in dealing with vehicles
- Disregard for roads and patrons or people

The emergency services in Saudi Arabia needs to cover long distances due to a nation with larger in size and population as compared to any other middle east countries.

Strong winds in disserts also comes out to be one of the important reasons for serious accidents in Saudi Arabia. Recent accident in Mecca due to crane collapse is due to strong winds.

B. Motivation

The ultimate goal of this work is to provide a usable approach for people living in Saudi in the emergency situations as the services provided by the authorities being absolute at the time of rush hours. In emergency situations even a common man must be able to get in contact with the services like police, hospitals and insurance agencies when an accident is reported. The proposed technique in this paper will help the authorities to establish a free corridor for the people suffering due to accidents or any kind of health related issues in emergency times.

II. Related Work

Earlier many authors worked in this area to establish the best services at the time of disasters and to manage the emergency situations. Alrajeh and Bounabat [2] proposed decisional reactive agent (DRA) based approach for formal modeling and checking the disasters at the early stages. Rapid assessment and intervention team (RAIT) was established to respond quickly to different events which perform the initial assessment of the accident so as to provide needful assistance. However the communication between people visiting from different countries faced the language problem during Hajj times. To solve the issue Mohandes proposed a near field communication (NFC) technology [3], which helped to improve the services in an efficient manner. NFC helps to identify the nearest checkpoints, medical camps and to maintain the medical records of all pilgrims during emergency situations. This technology tracks the pilgrim status (alive, dead or injured), guides them in emergencies, things to do, hotels, camps, and works as an information platform.

An automatic and intelligent system was introduced by Ullah et al. [4] to observe and report the patients on time. These systems are using sensory networks to communicate the signs of heart rate, respiratory rate and mental status of patients. Such records and continuous monitoring will help the emergency services to deal with such patients in crowded gathering easily as they are traced using GPRS systems installed in the devices.

The importance of using information technology (IT) services and their applications during emergency situations were discussed by Hijji *et al.* [5]. The role of disaster management cycle to mitigate, preparedness, response and recovery were explained in detail. They conducted a study on the emergency situation at Jeddah in 2009 due to the flash flood which killed 163 people and affected more than 10,000 citizens. Such high intensity flash flood is expected in the city for about next 10 to 15 years [5] needs a preparedness of keeping emergency services available not only for its citizens but also for the pilgrims visiting every year. Yang *et al.* [6] suggested an intelligent shelter allotment (ISA) for such emergency situations, by which it assigns the route and information of destination to reduce the evacuation time.

To tackle with asthma patients in emergency situations, a runtime monitoring system was proposed by Dowaihi *et al.* [7]. The technique proposed by these authors will help many pilgrims in the country, who are within the range of emergency service providers. Necessary care from the hospital sources will be provided for such patients with the help of android based mobile applications and wireless web-based applications. Alerts will be delivered to the patients' mobiles and emails at the emergency times by using this method. Harrou *et al.* [8] proposed an early detection method for overcrowding issues in most of the emergency departments (ED). The key challenge of ED is to handle the emergency situation and early detection of abnormal patients. Harrou *et al.* discussed a statistical technique to detect the indications of abnormal situations observed with patients using ED [9]. Similar research is being carried out in India by Sangle and Kadam to establish a real time tracking system for pilgrims at Kumbh Mela [10] by using the embedded devices included with global positioning system (GPS) modules with different sensors.

In the above discussions, most of the authors are providing a solution based on the accidents or upon receiving an emergency situation. However, the present system proposed in this paper will help the healthcare industry and public to communicate and get aid easily at the time of emergencies.

III. Existing Emergency Service System in Saudi Arabia

Present emergency system will have to depend on the traditional method of communication systems when an accident takes place. During this time people around the patient will call the healthcare emergency numbers and the ambulance services will be alerted to reach the accident location [5, 6]. In the meantime, they have to go through all the hurdles of traffic and need to maintain a continuous track of the patient location until they reach the destination.

In case of pilgrims from other countries the problem of language will be a huge challenge for the emergency service providers and doctors; hence they need to depend on alternate mode of communication. Possible failures of the present emergency system to reach the accident locations are due to (a) communications failures [10] (b) delayed facilities (c) ignorance of people and (d) crowded roads.

There should be a serious alerting system functioning in KSA to deal with accidents and emergency services due to unending rush to the kingdom with pilgrims throughout the year. The alert system must be able to establish a communication with hospitals, ambulance, police for traffic controlling, insurance agencies and rest of the people passing through the accident routes. Such alert system will help authorities to clear the premises and restore the services to a normal position.

IV. Proposed Technique

There are various parameters to be considered before proposing a new technique for smooth emergency services during different emergency conditions. A careful attention was taken to draw some of the reasons for emergency conditions are explained below. Most of the emergencies listed below are very commonly seen in Saudi Arabia at normal and rush times

[12]. During Hajj times the health problems include variety of challenges to emergency service providers.

- Due to rash driving, signal jumping and driving against rules
- Due to sudden health problems (i.e., heart attacks, blood pressure, glucose levels, etc.)
- Due to protests, wars, terrorist activities, etc.
- Due to ignorance of others
- Due to bad light or weather conditions (heavy rains, floods, etc.)
- Due to fire accidents and short circuits, etc.

Hence the arrangement of emergency services is unavoidable in any kind of accident scenario to save the life of victims/ patients. The entities which perform key role at the time of emergency situation are shown in Fig. 1. In such scenarios establishing a good communication seems to be an important criterion which needs to be of less effort and easy to use. In this paper, the author proposed an efficient communication system based on Google applications based priority checks for road traffic detection, GSM for continuous updates and wireless networks for continuous communication.

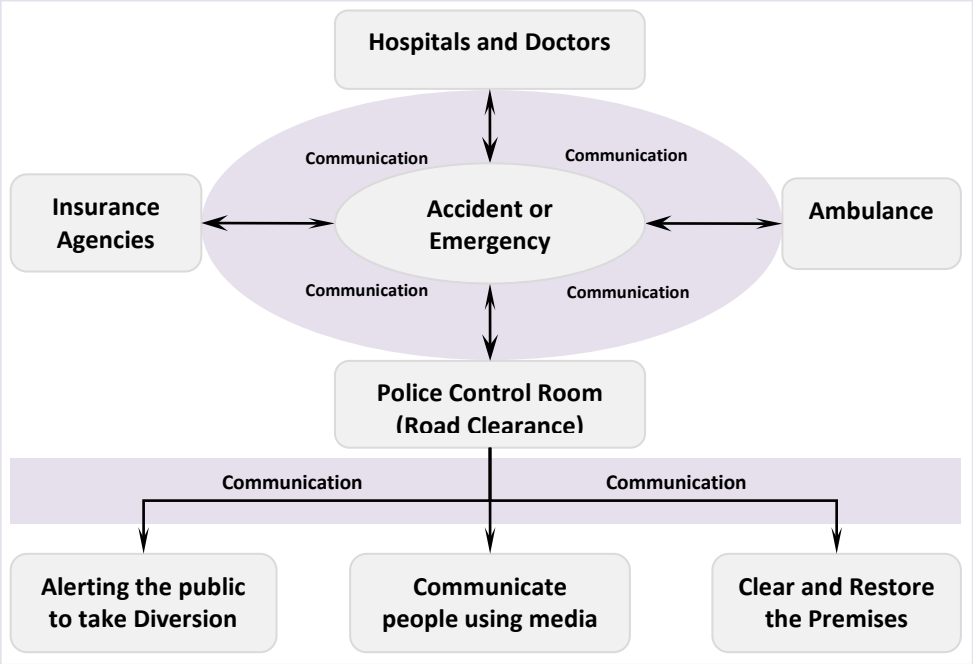

Fig. 1. Key entities performing important roles during emergency

In the case of an accident or an emergency the patient or any nearest common person will pass the information to the emergency service providers. The location of the person calling will be traced by GSM (Global System for Mobile Communication) technology [13] and the same will be communicated (raising alerts) to hospitals, ambulance, police and insurance agencies. Hospitals will decide the doctors and ambulances based on the requirement and distance to reduce the time in reaching the location.

The Google provides traffic information in one of its applications, i.e., Google Maps. Very clearly it shows the less traffic to heavy traffic with a color code of green to red respectively. The decisions taken by the emergency services in the proposed method are mostly based on the scientific approach to identifying the best route to be followed to reach the accident location. It explains the emergency services best possible route with less traffic and based on a road which is free from traffic as shown in Fig. 2. In the Fig. 2, there are three routes defined to reach a hospital with nearest possible distances. However, heavy traffic is indicated by red lines [15]. So based on the distance and less number of red lines in the possible routes the decision will be taken. Now-a-day most of the vehicles are using GPRS (General Packet Radio Service) system [14] to locate the vehicle movement and the corresponding vehicle information carrying or about to carry the patients will be provided to the police control room. Based on the decisions by the proposed runtime monitoring system the drivers will be advised to follow the road.

On the other hand the police control room establishes a free corridor for the emergency services to ensure easy supply of facilities and emergency activities. The traffic police at all check posts for a distance of 3 – 5 km will get alerts from control room to ensure that the ambulance is moving freely till the hospital. This is possible only when the people are aware of such events and for which the proposed technique establish a free communication between police control room and local media (like radios, TVs, etc.) to cover such events as an alert for the common public during their journey. An awareness always helps the emergency service providers, police to control the situation and also to the authorities to clear and restore the regular services at the earliest possible. Otherwise a lot of

delay due to overcrowded people is observed in most of the accident locations or emergency scenarios.

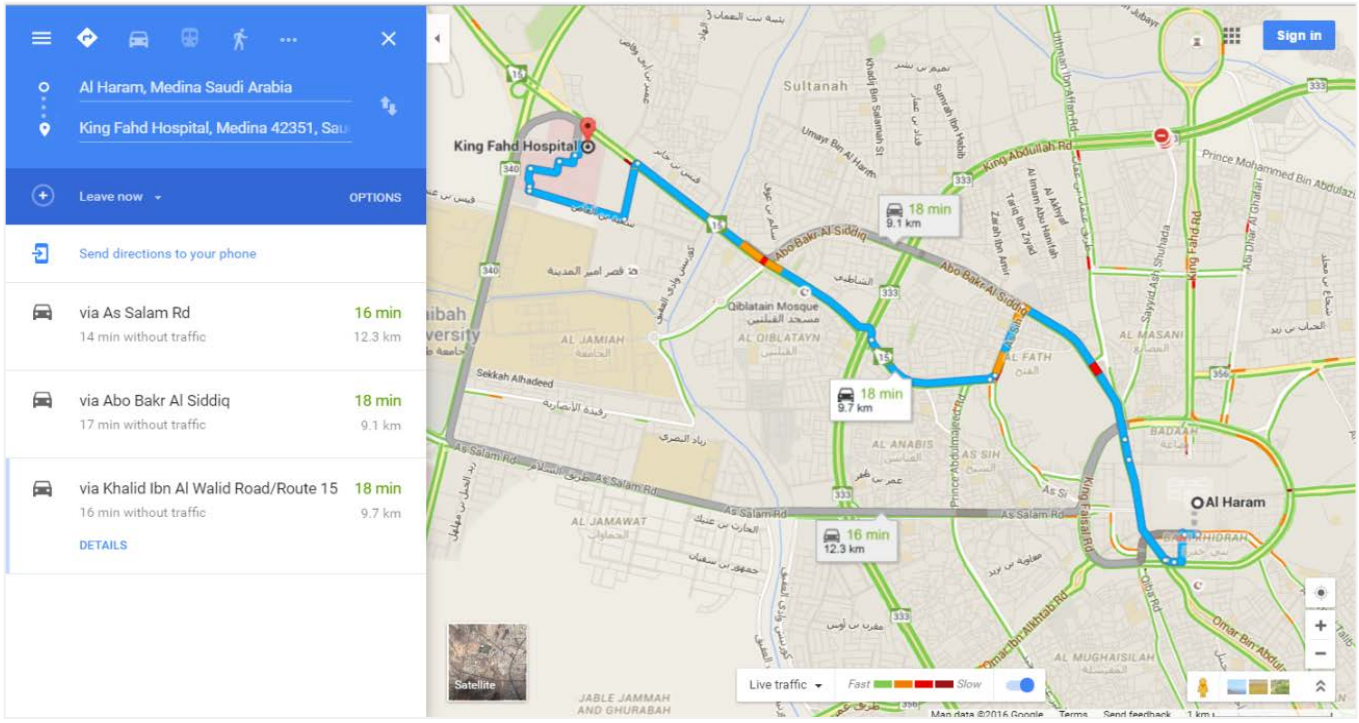

Fig. 2. Decision making during Emergency Hours

At the same time it is observed that almost all the roads near to the mosques in KSA are observed to be very busy as shown in Fig. 3. Being an Islamic State, the number of mosques in SA is more and majority of its people do visit these holy places for their prayers. At such places the authorities needs to ensure a special corridor for the smooth passage at the time of emergency situations.

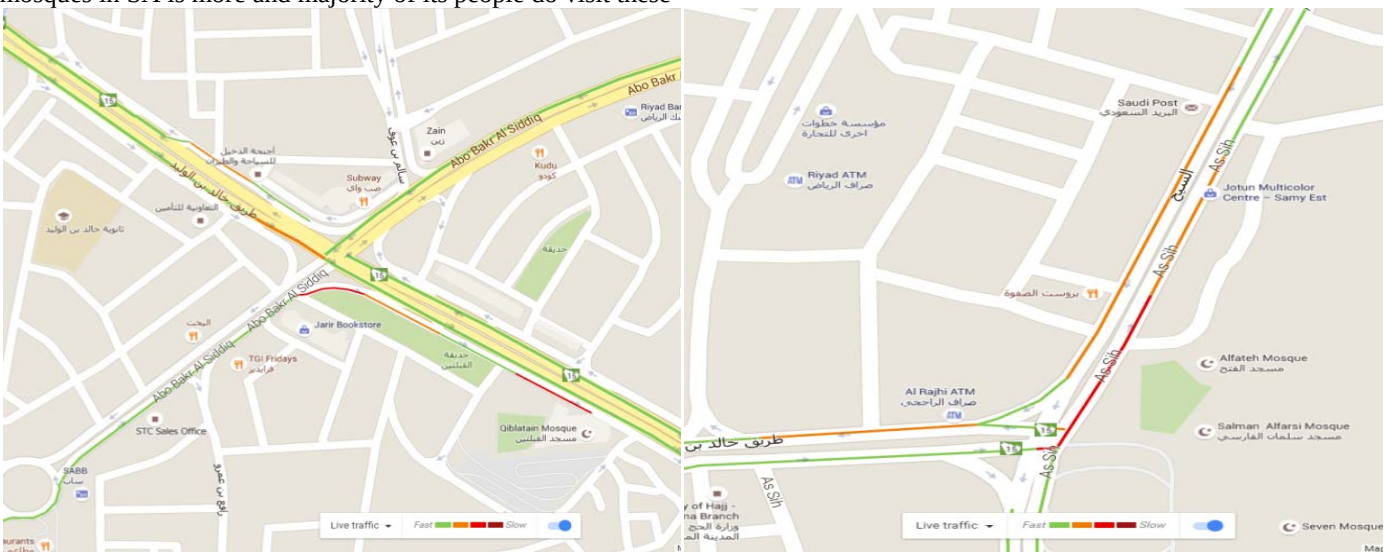

Fig. 3. Indication of Heavy Traffic Density near the Mosques

The need of passing information to the insurance agencies (as shown in Fig. 1) is essential to maintain a clean record of the emergency events to avoid delays in sanctioning the funds and to avoid wrong people to claim the policies. At the same time the insurance companies can assess the damage and help the patients on the spot and the financial aid or support without the knowledge of the diseased patients is possible by this method/ approach. Otherwise, in general the patients family members need to claim the bills after damage is over and patients may need to suffer extra tensions at the time of emergency to arrange hospital bills at a sudden note. So this technique will not only help the patients and insurance agencies but also to the police in terms of reducing extra time to verify the details after a considerable gap.

V. Case Study: Assessment of Events During Emergencies

A simple flow diagram of events according to the proposed technique during emergencies is given below (Fig. 4). Some of the highlights of the proposed technique are listed below:

- Tracing of emergency location will be done automatically based on the communicating mobile or telephone service provider.
- Based on the situation and demand the nearest hospital / ambulance will be selected automatically.
- The police control room will generate an alert to corresponding police stations in the selected route. Once the ambulance and doctors finish their task at the emergency locations, local authorities will be allowed to restore the operations immediately.

Insurance agencies will updates their database and check the eligibility of patients for policies and immediate funding process will be sanctioned if they are eligible.

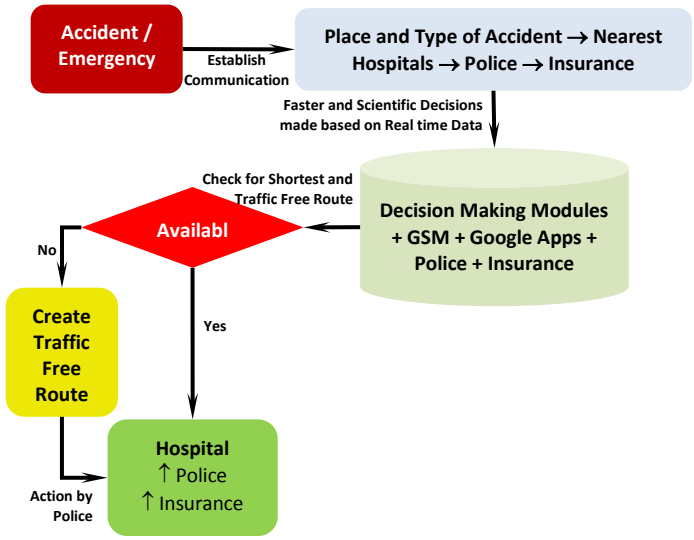

Fig. 4. Events based actions during Emergency Conditions

A system boundary for emergency services to the proposed method is shown in Fig. 5. The actions performed by the emergency services during emergency situations are shown in Fig. 6 using a sequence diagram.

1) The details of accident area and patient conditions are being noted carefully.

2) The patient or a random person will communicate the emergency services for the help.

3) A decision will be delivered to hospitals, ambulance, police and insurance agencies and municipal authorities with respective actions.

4) The ambulance with appropriate doctors and staff will reach the patients locations in the traffic free corridor.

5) Patient will be shifted to hospital and other support from insurance agencies and municipal authorities will be into action for providing the insurance funds to the patient and to restore the services on accident area respectively.

6) Finally the patient will be treated with dignity and maximum care will be provided and with reduced pain for his family members and authorities.

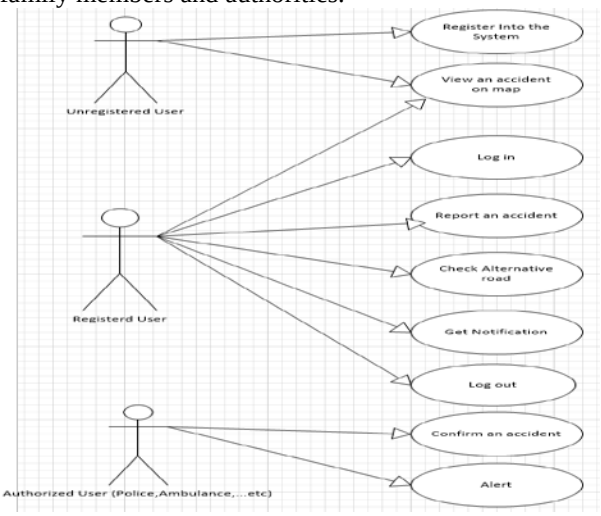

Fig. 5. The designed System boundary for Emergency Services

The system boundary shown in Fig. 5 explains the rules and procedures to follow at the time of emergency situations. It will try to identify the people calling to the emergency services along with location and try to identify the kind of aid needed by the patients, so that, a strategic plan or decision is made to react immediately. A detailed description of actions and interactions between components at the time of emergency are shown in Fig. 6. Establishing a faster communication, decision-making and quick reactions to the problem are the key aspects of the entire proposed work.

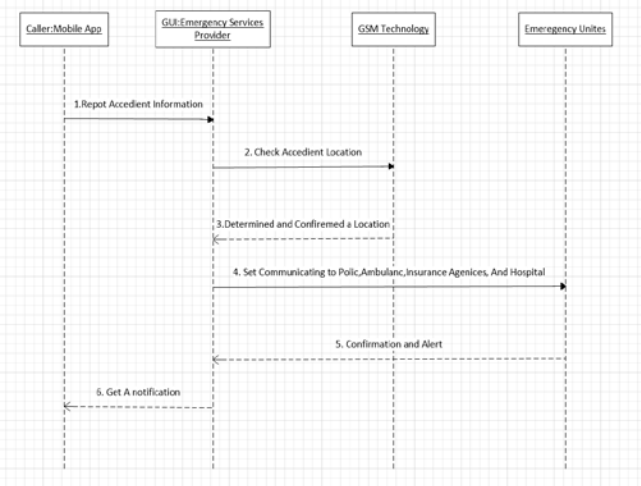

Fig. 6. Interaction components of events during emergencies in Saudi Arabia

The prototype class diagram representing different attributes and their operations in the proposed architecture are shown in Fig. 7. It explains the actions and the departments to be responded at the time of emergencies.

The emergency service provider will ensure to get the complete details of the caller and further procures the relevant location information from the GSM. Different units will be communicated and decision making process to direct each unit will be carried out automatically based on different scenarios and priorities based or risk levels.

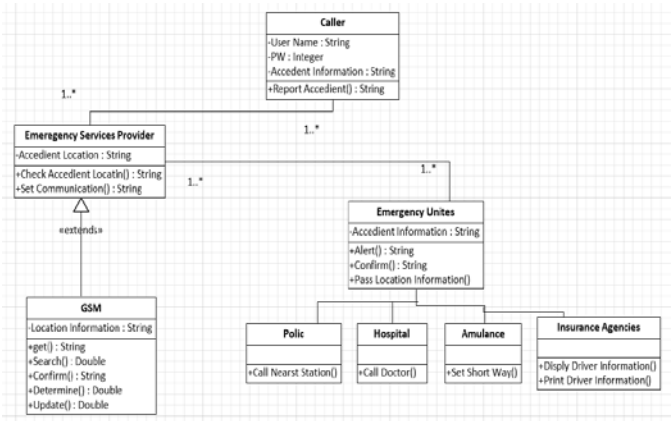

Fig. 7. The Proposed Prototype Class Diagram

The corresponding user interface of the architecture is shown in Fig. 8. This interface is user friendly and even a person with minimum knowledge of English can comprehend and operate it easily.

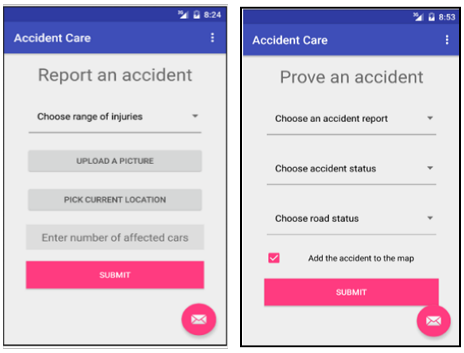

Fig. 8. The User Interface of the Proposed

Such a system will help the patients, hospitals, police, insurance agencies and local authorities to serve the people effectively in emergency situations.

VI. Conclusions

The proposed technique to enhance the emergency services in Saudi Arabia can be implemented with ease due to its usability and flexibility to adopt with existing system. Few modifications and certain modifications with low budget also can review the proposed model in Saudi Emergency services. So far the usage of traffic density system was not included in any kind of applications in SA. Hence by adopting the proposed technique the KSA will be able to create a healthy environment to tackle with emergency situations. Number of patients and possible casualties can be treated in less time effectively and properly during the accidents and emergency conditions so that a reduction in number of deaths can be seen in the nation. In the future work, testing of the modules in real-time environment can be extended for uncertain situations.

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