

# Virtual E-Medic: A Cloud Based Medical Aid

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**Abstract**—This paper discusses about an intelligent system to be installed in ambulances providing professional support to the paramedics on board. A video conferencing device over mobile 4G services enables specialists virtually attending the patient being transferred to the hospital. The data centre holds detailed databases on the patients past medical history and hospitals with the specialists. It also hosts various software modules that compute the shortest traffic –less path to the closest hospital with the required facilities, on inputting the symptoms of the patient, on a real time basis.

**Keywords**—4G mobile services, cloud computing, data centre, intelligent system, optimization, real time traffic reporting, SaaS, video conferencing.

## Acronyms—

VeM	- Virtual e-Medic
GPS	- Global Positioning System
SaaS	- Software as a Service
SPF	- Shortest Path Finding
ID	- Identity
UML	- Unified Modeling Language
DB	- Database
SW	- Software

## I. INTRODUCTION

THE recent studies have shown that there is an increased rate of road accidents in the world due to high speed vehicles, carelessness of the drivers, etc. Saving the injured gets difficult due to lack of proper medical aid and congested roads, however according to the statistics, it turns out that much of the casualties can be reduced by timely medical attention.

Ambulance facilities are limited and to provide a full fledged medical support, the victim may have to be transferred to a hospital which can be time consuming. Therefore giving full medical support to the victim at the accident site could be beneficial. For this to happen one needs not only equipments but also an expert medical advice to the personals treating the victims at the accident spot. Not only road accidents, it has been noticed that the transferring of the patient in an emergency gets delayed due to traffic jams and not knowing the traffic free routes. A real time traffic reporting device and the optimization embedded system can be a boon to find nearest hospital and the route to reach in time.

## II. PROTOTYPE OF VEM

The objective of VeM is to develop a patient monitoring

system, by providing a cloud embedded infrastructure to the ambulance so as to attend the patient in an effective way. Firstly, this model includes a system that provides an interface between the patient and the expert in the hospital who monitors the patient and guides the paramedics on board. Secondly, access to the medical records of the patient is provided to the paramedic on board and the specialist in the hospital from the data centre, thus making the treatment more effective and successful. Lastly, this system has real time traffic reporter for quick transmission of the patient to the hospital. The Fig. 1 gives the schematic block diagram of the VeM prototype model.

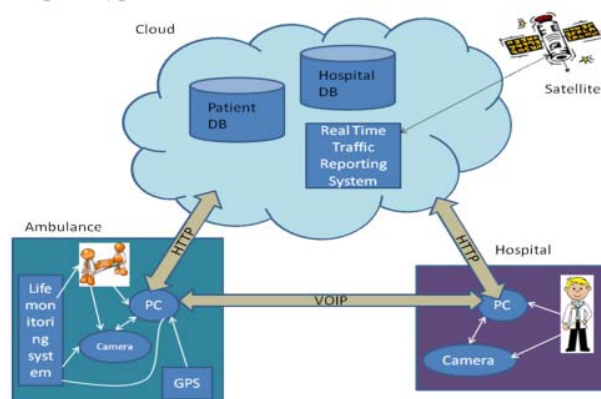


Fig. 1 Prototype Model of VeM

## III. VEM COMPONENTS

This prototype VeM model has the following components:

- (A) Cloud enabled ambulance
- (B) Hospital
- (C) VeM Cloud

### A. Cloud Enabled Ambulance

When most people think of "ambulance service" they think of sirens, flashing red lights and a life-threatening situation. But with VeM first aid has been re-defined the existing system and our system contains the following sub-components:

#### 1. Life Monitoring System

The ambulance has equipments for monitoring vital signs, advanced drug therapy, cardiac monitoring, oxygen, IV therapy and other sophisticated devices [1]. It is also equipped with a heart and blood pressure monitoring equipment, pulse oximetry, IV pumps, oxygen delivery devices including a CPAP (Continuous Positive Airway Pressure) and advanced medications used to treat a variety of illnesses and provide pain relief [2]. All these devices are linked to the computer on board and data from these devices are worked upon by the

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various program modules on the cloud and transmitted to the specialist in the hospital via 4G mobile services.

## 2. Camera

The camera on board is a high definition camera which transmits a live streaming of information in terms of video images and recording the scenario in the ambulance to the specialist in the respective hospital. It gives the specialist more information on the patient's condition and also allows the super specialty doctor to monitor the drugs and treatments being administered to the patient by the paramedics on board.

## 3. GPS Sensor

The ambulance is tracked by a GPS Software on the cloud and the sensor on board. This will give the exact location of the ambulance to the other software modules that will then compute the shortest traffic-less path to the closest hospital with the concerned specialist.

## 4. Computer on Board

The computer links to the cloud and provides the paramedics on board and the specialist in the hospital by providing the detailed medical information of the patient from the patient database available at the datacenter. The information of the closest hospital with the concerned specialist is also got from the Hospital database in the datacenter of the cloud.

The hybrid computer on board is connected to the various Life Monitoring Equipments and works on the data from these devices using the software available on the cloud and hence transmits the processed information to the specialist in the hospital via 4G mobile services. Further a video conferencing with the specialist makes possible a better and more effective treatment of the patient. The live streaming and transmission of the specialist instructions is received via 4G mobile services to this computer and he is able to demonstrate various procedures required for the treatment of the patient and to monitor the treatment being administered.

The computer also gets information regarding the shortest traffic-less path to the closest hospital computed by the software modules on the cloud. Hence crisp directions are got and given to the driver to transport the patient as soon as possible.

## 5. Networking

The computer as mentioned in the *section (d)* will interact with the data center and different software modules on the cloud via a high speed mobile 4G internet service. The network inside the cloud [3] connects the virtual instances of an application on the ambulances and hospitals, and connects them to cloud- provided persistent storage service.

## 6. Paramedics

A few paramedics are in the ambulance to administer general first-aid and the instructed treatment to the patient. These paramedics also run basic tests on the patient and give

the required results to the specialists for the most effective treatment while being transported.

## B. Components on VeM Cloud

### 1. VeM Data Center

VeM uses the medical details of the patients and the available doctors in the nearest hospitals in order to facilitate paramedics on board. It gets really exhausting to maintain databases for all of them on the PC as it might reduce the processor's speed. One solution to this is maintaining a data centre which is a networked online storage where data is stored in virtualized pools of storage which are generally hosted by a data centre operator (here the VeM Cloud). These Operators virtualizes the resources according to the requirements of the paramedic and expose them as storage pools, which they can themselves use to store files or data objects. While using the patient's personal ID, the VeM data center keeps the security and authorization of the other details of the patient intact. It makes sure only the required field that is the medical history is tapped and the other records are secured and are not displayed at all. Physically, the resource may span across multiple servers. The VeM Data Centre contains:

#### i. Patient Database

The Patient Database has vital information that includes name, ID, age, sex, blood group, past medical history, allergies to drugs, past ailments medical diagnosis and treatments administered. This database also contains the patient's general medical information including his normal blood pressure levels, blood sugar levels, and other necessary medical information to facilitate a more effective treatment. As soon as the patient has been picked up, his personal ID issued by the government, where the medical history is stored, is scanned on the ambulance and the computer retrieves his medical information from this database, giving the paramedics a better picture of the patient's condition. The specialists in the hospital are also linked to the cloud and have in hand the entire medical history of the patient so as to be able to provide the best first aid to be administered before the patient reaches the hospital.

#### ii. Hospital Database

The database of the hospitals will contain all the details about the specialists present at the different hospitals in the region, their working hours, the cases they have handled in the past, facilities provided by the hospital, statistics on number of patients at the different times of the day, number of patients in emergency and others. This database is used by the shortest path finding software module to find the closest hospital with the required facility and specialist at the given time for the patient. If patient's case is complicated the data of the past cases handled by the specialists comes into play to find the best specialist for the purpose.

The two databases together allow data to be filtered according to the need and guide the paramedics and specialists in taking the most appropriate actions. Though, time to time

updating of the database is a subject of matter and needs to be done every time a patient is administered for any treatment.

## 2. Software That Works on Raw Data from Life Monitoring System

The patient's instantaneous medical data is being monitored by the life support system which is connected to the computer on board. The raw data got from these equipments is worked upon by sophisticated software's on the cloud through SaaS. The software interprets data from the life monitoring system, works on it, and compares it with the standard results and the information from the patient database to give the required statistics and molded data to both the specialists at the hospital and the paramedics on board.

As this is high-performance software, it is better to be stored on the cloud rather than the computer on board and it can be accessed by multiple clients on various ambulances simultaneously.

## 3. Real-time Traffic Reporting System

A small delay in transferring the patient to the hospital due to clogged routes can be fatal. This Software updates the system with the traffic congestion on the different paths queried by the Shortest Path Finding Module giving the optimistic and pessimistic times to reach the hospital taking that path. The hardware to implement the following will include microwave sensors, traffic video cameras, E-ZPass readers at intersections and information from satellite to measure traffic volumes, congestion and record vehicle travel times [4]. The combined data from these sensors in the required path, received via 4G services or a city network are analyzed by the software to identify congestion choke points and give signals to the SPF Module to alter the path to the required hospital.

## 4. Shortest Path Finding Module

A delay in transmitting the patient to the nearest hospital due to traffic or ignorance of shortest possible route to closest hospital with required facilities can be hazardous to his life therefore giving rise to our Shortest Path finding Module. On inputting the set of required hospitals, got from the hospital database, this module computes the shortest traffic-less path by incorporating real-time data from the Real-time traffic reporting module and the GPS sensor on the ambulance. A stochastic time-dependent road networking model is constructed and a pre-processing algorithm which partitions the network is used. Now a sophisticated route planning algorithm is used to work up the shortest path.

A *pseudo code* for the SPF module has been described below.

1. Find all possible paths to the required hospital.
2. Find the current traffic at all sectors of the routes using the Real-Time traffic Reporting System.

3. Calculate the time for each route depending upon the traffic information, time between signals, and speed of the ambulance.

4. Choose path with least time.

5. Repeat step 1-4 periodically at regular intervals, till the hospital is reached.

The best algorithm for finding the shortest path has been mentioned in the thesis, Route planning algorithms for car navigation by Ingrid Flinsenberg[5].

Further real-time congestion information is got from the real time traffic reporting module and given to this module and the current position is got from the GPS sensor on board the ambulance.

## C. Specialist at the Hospital

Appointed specialists at the hospitals get the live transmission of the current scenario in the ambulance via 4G service and medical information of the patient is also available as mentioned before, from the cloud. The various statistics and data of the patient's instantaneous vitals can be got from the software that processes this information, also present on the cloud. The specialist interprets all the information got and gives instructions to the paramedics on board to administer the required treatment before the patient reaches the hospital. Further he also makes the necessary arrangements for the patient's arrival at the hospital so that immediate treatment can be provided. The specialist is also aware of the location of the ambulance and the time it will take to reach the hospital, and therefore having a wider perspective of the situation he can instruct the paramedics and the staff at the hospital to optimize the patient's treatment.

## IV. VEM DATAFLOW

1. When the patient enters the ambulance, his/her ID card is swiped and his entire medical history is got from the patient database on the cloud, by cross-referencing his/her ID card.

2. The GPS sensor on board along with the hardware for the Real time traffic reporting System provide the current location and traffic congestion to the SPF Module, which then calculates the shortest traffic-less path to the required hospital chosen from the hospital database by the paramedics.

3. The information from the life monitoring system that he is attached to is sent to the cloud via mobile 4G services and is processed by the software on the cloud.

4. The processed information and the medical history are made available to the specialist at the hospital from the cloud.

5. A video conference is set up between the paramedics on board and the specialist, through which the specialist can instruct the paramedics to take the required actions and monitor the treatment being administered to the patient.

## A. UML Sequence Diagram

Fig. 2 represents the UML [6, 7, 8] sequence diagram for the VeM.

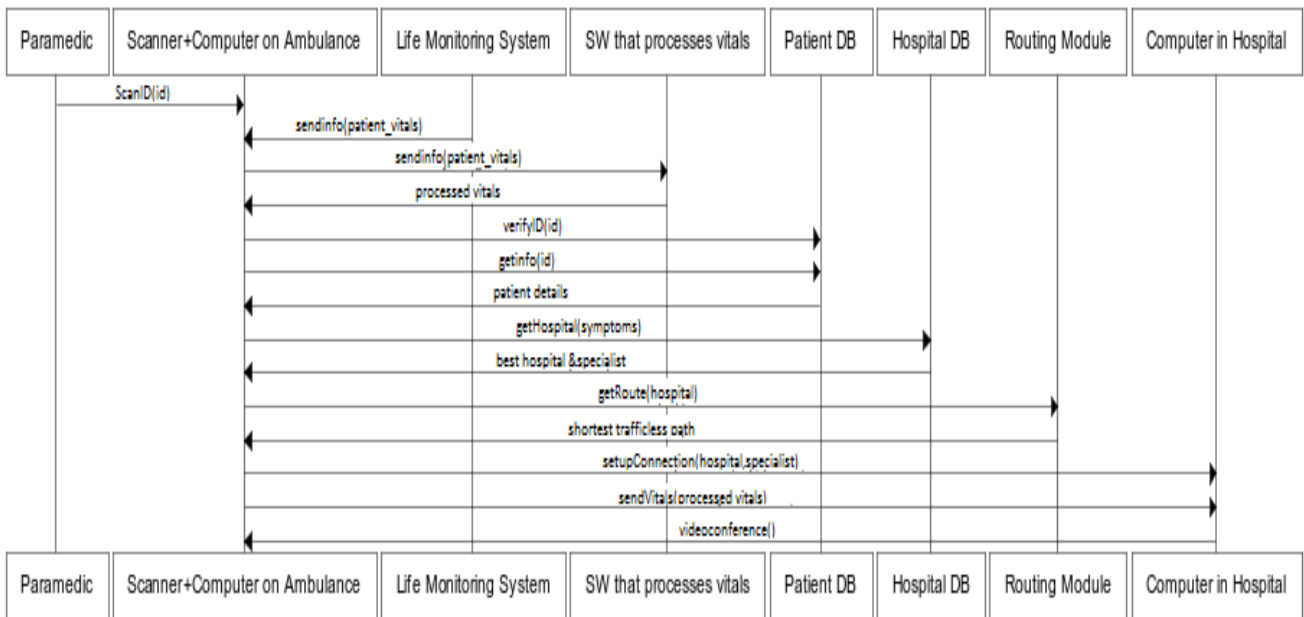


Fig. 2 UML Sequence Diagram for VeM

V. CONCLUSION

Many lives are lost while transporting patients to the hospitals for different reasons which include inadequate facilities on board, inappropriate medical treatment, and of course clogged, congested roads. Virtual e-Medic has therefore introduced a new perspective to health care on an ambulance. The sophisticated systems onboard and the VeM cloud provide the right information at the right time to provide the most effective treatment to the patient. With VeM, it's almost like the specialist is right there throughout the journey stabilizing the patient's condition on the fly.

With the drastic increase in population, the number of mobility vehicles has doubled and has imposed a threat of traffic congestion to an ambulance on the move. VeM's advanced routing algorithm compute the shortest traffic-less path to the closest hospital with the required facilities. Yes, the installation of this infrastructure comes with a big price tag but its boon to healthcare is limitless.



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REFERENCES

- [1] Metro Atlanta Ambulance service: [http://www.maas911.com/?page\\_id=76](http://www.maas911.com/?page_id=76)
- [2] Equipment for Ambulances: <http://www.facs.org/trauma/publications/ambulance.pdf>
- [3] Ang Li, Xiaowei Yang, Srikanth Kandula, Ming Zhang., Cloud Cmp: Shopping for a Cloud Made Easy.
- [4] News article on Mayor Bloomberg Announces New, Real-time Traffic Management System to reduce Congestion in Midtown Manhattan. PR-257- 11. Dated July 18, 2011.
- [5] Flinsenberg, Ingrid C.M. (2004). Route planning algorithms for car navigation. Thesis - ISBN 90-386-0902-7. Technische Universiteit Eindhoven.
- [6] [www.websequencediagram.com](http://www.websequencediagram.com)
- [7] Tewfik Ziadi, Marcos Aurélio Almeida da Silva Lom Messan Hillah, Mikal Ziane. 'A Fully Dynamic Approach to the Reverse Engineering of UML Sequence Diagrams' published in n "Engineering of Complex Computer Systems (ICECCS), 2011 16th IEEE International Conference on Las Vegas: US (2011).
- [8] AgroUML : <http://argouml.tigris.org/>
- [9] Massimo Cafaro, Giovanni Aloisio. Grids, Clouds and Virtualization. ISBN 1617-7975. Springer- Verlag London Limited 2011.



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