DESIGN AND DEVELOPMENT *SMART-IMBULANCE* FOR EFFICIENCY OF ROAD EMERGENCY PRIORITIES

Oleh
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Abstract

Medical emergency conditions required patients to be mobilized by ambulance quickly, precisely, and accurately. To save the patient, the ambulance acted as a helper and hope for the patient to survive until the patients reach the hospital. The ambulance has to go through the fastest and closest way to reach the hospital. However, problems arise when road conditions do not support the creation of the fastest and closest ambulance. Due to congested road conditions, it will be possible to delay the ambulance from reaching the hospital or other unwanted events. The road and traffic conditions that can be controlled for the smooth running of the ambulance need special attention. *Smart-iMbulance* framework modeling allows an ambulance to move quickly and precisely to reach the nearest hospital. This paper provides a transportation model for vehicles, an application model as an embedded program in an ambulance, and a traffic management plan as a solution offered for ambulances on the road.

Keywords: ambulance, emergency, smart traffic management.

INTRODUCTION

Ambulances have become the main transportation capital (*emergency medical services*) in the medical field to support mobile medical equipment by supporting patients in them. Generally, an ambulance is used in emergencies that require serious medical treatment [1]–[3]. More specifically an ambulance is a medical evacuation facility that quickly goes to health facilities [1], [4], [5]. It is not new regarding the role of the ambulance in dealing with emergency patients, especially in terms of time efficiency [6], [7].

Previous research that focused on ambulances both for medical treatment and regarding the efficiency of the ambulance reaching the hospital has become a special concern. Wajid et al. [8] reported their findings on optimizing the location of the ambulance for serious medical treatment managed to cut 22 minutes to 13 minutes for the ambulance to reach the scene. Fukushima and Moriya [6] use GPS to estimate the accuracy of an ambulance in handling emergency patients with congested road conditions in Japan. Chen et al. [9] using Dijkstra's algorithm for optimization of various route conditions in an emergency for the evacuation process.

The congested road conditions make it possible to disrupt the efficiency of the ambulance to get to the destination [6]. Besides, traffic that regulates vehicles also plays an important role in the smooth running of

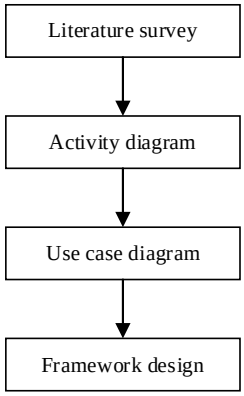
ambulances through congested roads. Huang et al. [10] develop a centralized traffic control mechanism with the *DSRC protocol* to overcome traffic congestion and route solutions for ambulances to pass through. Heavy traffic allowed ambulances to get stuck in many vehicles. In this case, the following traffic management and transportation research [11] trying to overcome traffic congestion for ambulances by implementing *intelligent transport systems* (ITS) that allow serious *vehicle-to-vehicle* (V2V) coordination.

Based on these studies, this paper tried to design a framework named "*Smart-iMbulance*" as an alternative to ambulances, especially an alternative solution for punctual patient handling. The framework is designed in such a way that a centrally integrated and embedded system can be accessed via *mobile app*, *smart traffic distribution management* (TDM), and IoT-based system as an intermediary for the two.

METHODS

The *Smart-iMbulance* framework system is based on the IoT system that integrates all road users, road signs, traffic lights to an emergency response system. In designing the *Smart-iMbulance* framework it imitates the *waterfall* system development life cycle (SDLC). This SDLC *waterfall* offers a simple framework development model and focuses on constant specifications [12]–[15]. It can be seen in Figure 1.

Figure 1. Research flowchart.



Source: Own studied.

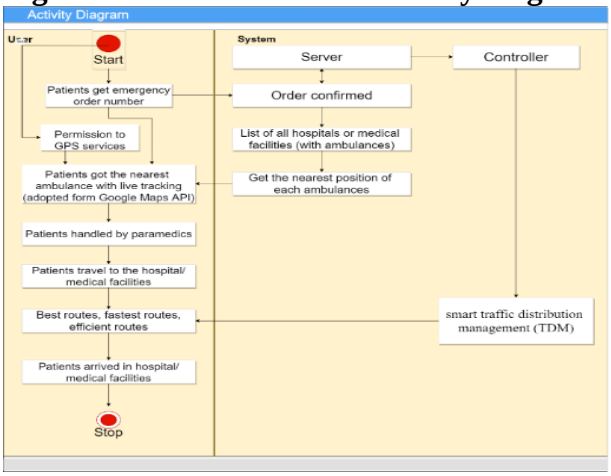
Figure 1 illustrates a research flow that begins with a literature study related to ongoing research from various journals: ScienceDirect (www.sciencedirect.com), Nature (www.nature.com), and Google Scholar (www.scholar.google.com), then proceed with modeling *activity diagrams* and *use case diagrams* that are tailored to the cases being reviewed. From the *activity diagram* model and *use case diagram*, a *Smart-iMbulance* framework can be built which will be developed as a mobile app that is integrated with IoT-based road infrastructure devices.

RESULTS AND DISCUSSION

Activity Diagrams and Use Case Diagrams

Figure 2 illustrates the activity diagram on the *Smart-iMbulance* which consists of the user and the system.

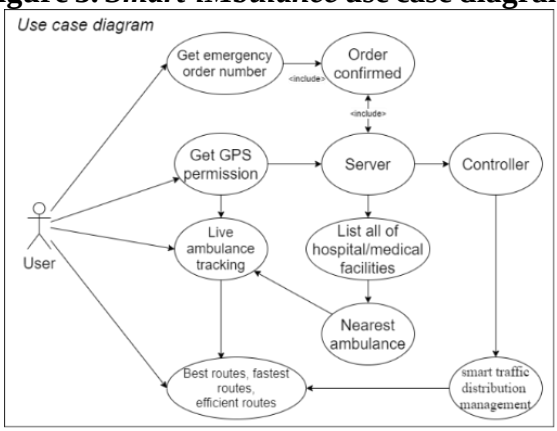
Figure 2. *Smart-iMbulance* activity diagram.



Source: Own studied.

Based on Figure 2, we know that the inter-user-system-controller integration will allow an integrated system device that is embedded in the ambulance. The use case diagram can be seen in Figure 3.

Figure 3. *Smart-iMbulance* use case diagram.



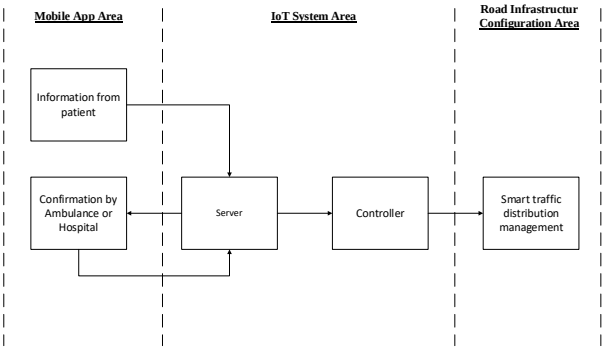
Source: Own studied.

Figure 3 describes in detail the features of the system that users get. This framework is prioritizing speed and accuracy for patients who need fast ambulance handling.

Smart-iMbulance Framework

Framework for the *Smart-iMbulace* system is prepared by integrating the mobile app and smart *Traffic Distribution Management* (TDM). By illustration can be seen in Figure 4.

Figure 4. *Smart-iMbulance* system framework.



Source: Data obtained.

Based on Figure 4, a framework of this system is divided into 3 parts, namely the mobile-app area as an area for sharing information between patients and ambulance providers, in this case, the hospital. Then the second part is the IoT system that regulates information management and controls the traffic simulation that will be run. The third part is smart *traffic distribution management* (TDM) as a configuration area for road infrastructure that runs simulations for emergencies for ambulances. Because the emergency condition requires that patients transported by ambulance must immediately enter the emergency room as soon as possible [16].

Mobile App Design

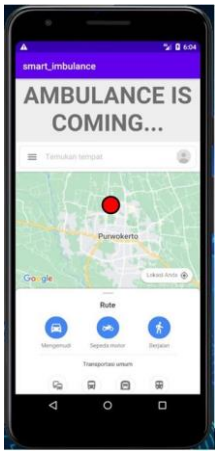
We design the mobile app for Android devices, it can be seen in Figure 5.

Figure 5. Homepage of mobile app in Smart-iMbulance.

Source: Own studied.

Figure 5 is a snapshot of the front page on the *Smart-iMbulance* mobile app operated on an Android device. Then the patient or user is expected to select the "*Order Ambulance Now!*" So, it will call the server which will then call a list of hospitals or health facilities with the availability of the closest ambulance, followed by a map display with live tracking location for ambulance trips to the patient or user location, can be seen in Figure 6.

Figure 6. The display after getting an ambulance is accompanied by a live tracking location.

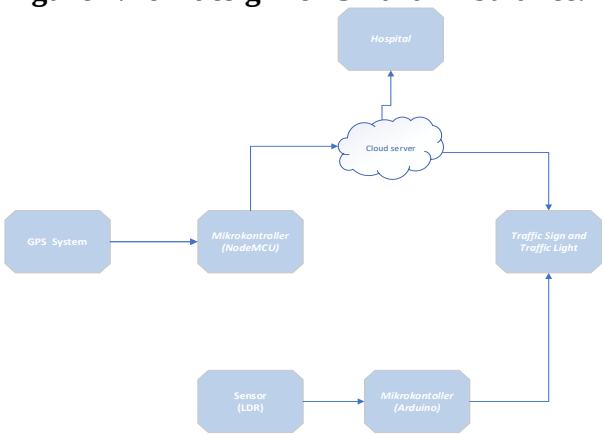


Source: Own studied.

IoT System Schematics

In this section, IoT is used to integrate the *Global Positioning System* (GPS) which is available on an Android-based mobile phone device with a *Smart Traffic Sign* and *Smart Traffic Light* as shown in Figure 7.

Figure 7. IoT design for Smart-iMbulance.



Source: Own studied.

The *server* uses a cloud server to function as database storage and is connected to a controller using the internet network. In the communication process using *NodeMCU* as a controller. Where the data obtained is sent through the cloud server as input to activate traffic signs and traffic lights.

In its use, the *LDR sensor* is used to determine the volume of vehicles on the road, so it can be seen how many vehicles were there at that time. So that it can make it easier in traffic engineering when there is a buildup of vehicles.

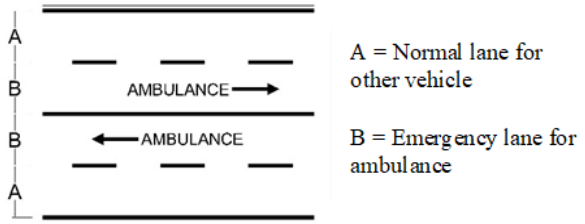
Smart TDM (Traffic Distribution Management)

We develop the smart TDM (Traffic Distribution Management) due to explain emergency lane simulation, smart traffic sign, and smart traffic light.

A. Emergency Lane Simulation

Emergency lane simulations are applied to roads having at least a 4/2 UD configuration for a 2-way flow function or a 2/1 UD configuration for a 1-way road flow function. Emergency lanes are on the inner side of the road or standby lanes. For countries that use right-hand steering rules, the emergency lane is in the right lane, and vice versa. This is intended to avoid side obstructions during an ambulance emergency. A simple application of emergency lane simulation can be seen in Figure 8.

Figure 8. Emergency lane simulation.



Source: Own studied.

Based on Figure 8, when an emergency occurs, road users will be notified via their cellphone and through a smart traffic sign, then road users are required to use the normal lane until the ambulance crosses the road.

B. Smart Traffic Sign and Smart Traffic Light

A *smart traffic sign* is a physical infrastructure that functions as a signal for emergencies or other conditions, the *smart traffic sign* has a screen system that can change according to the desired conditions, in this case, a special symbol for ambulance emergencies is used. A *smart traffic sign* can also be implanted with a sensor to determine the number of modes that are on the road area that the *smart traffic*

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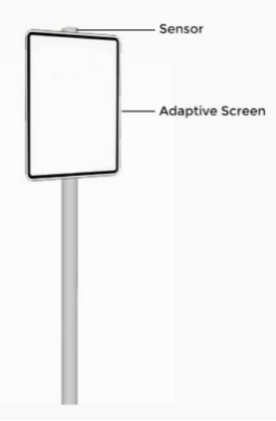
sign is placed on. The projection of it can be seen in Figure 9.

Figure 9. Smart traffic sign design.

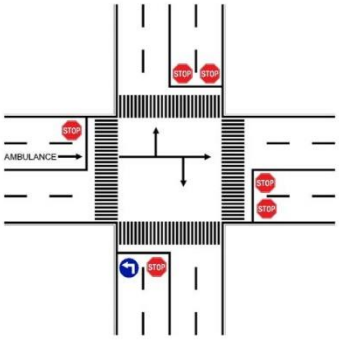


Source: Own studied.

A *smart traffic light* is another physical infrastructure required, placed at each intersection and it is recommended to have sensors to find out how many modes are on the road area. This *smart traffic light* has a traditional form like a normal traffic light in addition to having an additional screen to signal that an ambulance emergency or other condition has been imposed. The emergency siren allows other vehicles to budge [6].

Infrastructure devices in the form of traffic signs and traffic lights are required to manage intersection traffic. This infrastructure device is regulated by an IoT system that works automatically according to system calculations. To simplify the application of *smart traffic light* and *smart traffic sign* can be seen in Figure 10.

Figure 10. The intersection of emergency simulation.



Source: Own studied.

Based on Figure 10, when the work system is at an intersection, what happens is when the ambulance is at a certain distance from the intersection, the *smart traffic sign* will turn on the ambulance emergency signal and the driver is required to enter the normal lane and the *smart traffic light* will give a red signal in all directions and only the ambulance will pass the intersection, the *smart traffic light* will return to normal after the ambulance crosses the intersection.

CONCLUSION

This paper provides a *Smart-iMbulance* framework with integration between mobile-app, IoT features, and smart TDM (Traffic Distribution Management). *Smart-iMbulance* strives to provide the best alternative for ambulances to come to the scene quickly and precisely and accurately, then take the patient to the nearest hospital or health facility quickly and prioritize road safety with smart TDM (Traffic Distribution Management).

We suggest that hopefully this *Smart-iMbulance* framework can be implemented on every road in the future.

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