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Designing an IoT-Based Smart Ambulance Platform in Cimahi City

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The current ambulance service is managed via conventional methods that are inefficient in helping the people of Cimahi city. The ambulance service is governed by each village, so that if their ambulance is currently in use the queue cannot be transferred to another unused ambulance belonging to a nearby village. This is poor optimisation of a service which requires urgent deployment and maximum efficiency. This paper proposes an IoT-based smart ambulance platform which includes IoT devices, service-oriented architecture, and an Android-based interface to maximize ambulance service efficiency. It is expected that with this platform, the management of ambulance alerts can reach all people who need help without being limited by the limitations of their village.

Key words: *IoT, Health Management, Smart, Ambulance.*

Introduction

Smart Health is defined as providing health services using context-aware networks and infrastructure from Smart City (A. Solanas et al., 2014). In 2018, the City Government of Cimahi handed over one (1) official car unit to each village in Cimahi City to be used as a Standby Vehicle for public medical transportation needs in the Cimahi City area as the Alert Service Vehicle. This Standby Service Vehicle is a vehicle that is used to deliver, pick up and help with emergency needs, including emergencies relating to pregnant women, sickness, accidents, disasters, outbreaks or other conditions that require standby services at the scene until other health facilities are available. To use of the standby vehicle, a Standby Service Team is formed consisting of a Chair in charge of coordinating standby service activities with FKTP (First Level Health Facilities), Members who are tasked with assisting the team leader and accompanying the driver if needed, and the Vehicle Driver Service.

Each vehicle has three (3) drivers on rotating eight (8) hour shifts, so that the standby service vehicles can be used 24 hours a day. This service may be used by every citizen in the Cimahi City area as medical transportation from a house or patient's location to a hospital or FKTP and vice versa for free. Every citizen who needs a standby service vehicle is required to contact the Alert Service Team contact by either SMS or a telephone call. The contact will pass the necessary information to the driver of the standby service, who will then attend to the patient at the requested location within the community. Monitoring and evaluation of the standby service is carried out by the Camat and regularly reported to the Mayor at least every three months.

From those backgrounds, an IoT-Based Smart Ambulance Platform will be built to maximize the implementation of service, monitoring, and evaluation of standby service vehicles. With the presence of IoT-based Smart Ambulance, it is expected that when citizens need a standby service vehicle, they will be able to order the service through an application on Android and a driver will receive a corresponding service booking notification through the same application. This IoT-based Smart Ambulance Service will look for ready and available standby service vehicles who are proximate to the location of service orders so that the patient's pickup and delivery process will be expedited. Additionally, monitoring of standby service activities can be carried out in real time so that evaluations can be carried out more frequently than a three monthly basis. The data collected by the Smart Ambulance Platform can also be used to provide data on emergency events in each village with a holistic view to improve health services in Cimahi City.

The aim of this study are as follows:

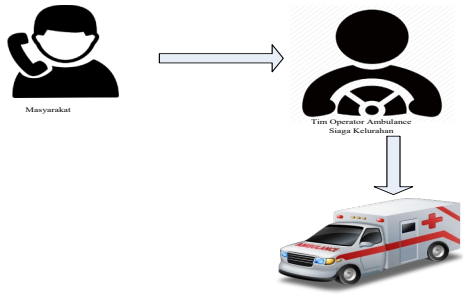
(1) To find out whether the standby vehicle service can be assessed as being in a ready and available state, and whether they are capable of sharing their respective known locations in real-time.
(2) To provide solutions for the community who require effective use of standby service vehicles so they can receive urgent care when needed.
(3) To allow the driver to find out the location of the patient and effectively route the driver to the location.
(4) To create an environment whereby stakeholders can monitor and evaluate efficiency on a more frequent basis than than three (3) months.

Emphasis is to be placed upon the two limitations in this study, these being the analysis of the nearest path search algorithm using Djikstra algorithm, and predictive analysis for the needs of service facilities at the village level in Cimahi City.

Analysis of the existing condition

Article 9 of the technical guidelines for the standby service vehicles in Cimahi City provides that each urban village is obliged to provide a contact number for the ambulance operator who can be contacted by the community if needed. The manual ambulance service procedure can be described in the following illustration:

Figure 1. Manual Procedure



The disadvantage of this manual procedure is that the community is only given access to contact one operator team in its urban area. So that if an ambulance is being used by someone else, the community cannot access the ambulance and must consider another solution such as hiring city transportation, borrow a neighbor car, or rent a taxi to get to the hospital. Of course, these vehicles are significantly limited and inappropriate for these purposes. The public is unable to know if there is an ambulance from another village that is not being used for emergency purposes. Therefore an IoT-based platform is needed to manage ambulances to make it easier for the community to efficiently access the an ambulance in an emergency situation.

Iot-based smart ambulance requirement engineering

From the background of the problem and the exposure of the existing condition to the management of the ambulance on standby above, an analysis of the requirements (engineering requirements) as follows:

Table 1: Functional Requirement

NO	FR Code	Fungsional Requirement
1	SRS-F-01	The system can provide functions that make it easy for users (communities) to call ambulances efficiently.
2	SRS-F-02	The system can provide a notification function that there is a user (community) who urgently needs an ambulance to the driver, and helps drivers steer with GPS to the location specified by the user.
3	SRS-F-03	The system can provide a function that replaces the car key to lock, unlock, turn on the engine, and turn on the siren with a QR code-based system. Moreover, able to record the maintenance logbook (workshop maintenance records).

4	SRS-F-04	The system can track the presence of ambulances in real time GPS-based.
5	SRS-F-05	The system can provide notifications to hospital staff so that proper and efficient handling can be prepared.

From these functional requirements, it can be developed into a more comprehensive system and it is needed to bring up various assumptions as follows:

Table 2: System Requirement

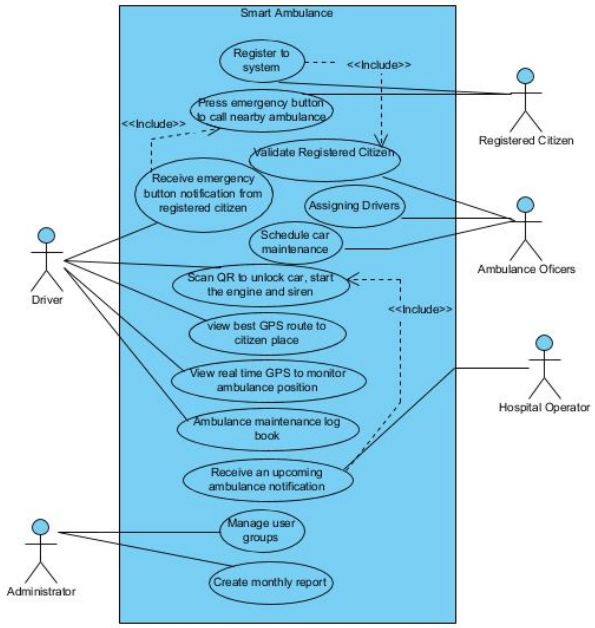
NO	FR Code	SR Code	System Requirement
1	SRS-F-01	F-01-FS-01	The system is equipped with an emergency button that can be accessed easily. Users must turn on the GPS feature and ensure the smartphone device is connected to the internet before using the emergency button.
		F-01-FS-02	The emergency button triggers the ambulance search function closest to the user's location, then sends a notification to the active driver on duty.
		F-01-FS-03	Real-time alert notifications in the form of pop-up displays and sounds that attract the attention of officers.
2	SRS-F-02	F-02-FS-01	The driver who gets the notification is the driver who is active on the shift.
		F-02-FS-02	Notifications contain information on the coordinates of the location to be addressed, the shortest route suggestion, and other supporting information.
3	SRS-F-03	F-03-FS-01	The driver can scan a QR code after they get a notification and or when they access vehicle maintenance features.
		F-03-FS-02	QR code-based validation can be used to open ambulance doors, turn on a car engine, turn on sirens, and various electronic devices in ambulances.
4	SRS-F-04	F-04-FS-01	The system uses google maps API to track the vehicle in real time.
		F-04-FS-02	The system can provide the fastest route to the user's location and the location of the hospital.
5	SRS-F-05	F-05-FS-01	Real-time alert notifications in the form of pop-up displays and sounds that attract the attention of officers.
		F-05-FS-02	The notification contains information about the patient's complaint or illness, count down ambulance travel time.

Table 3*:* Non-Functional Requirement

NO	NFR Code	Non-Fungsional Requirement	Type of Req
1	SRS-NF-01	The service server uses the Linux open source platform.	Organisational Requirement (implementation requirement)
2	SRS-NF-02	Service was developed using the Python programming language, and on the client side was developed using the android studio platform.	Organisational Requirement (implementation requirement)
3	SRS-NF-03	The system must be reliable in all conditions. The maximum loading time of 10 seconds.	Product Requirement (performance requirement)
4	SRS-NF-04	The system can run well on the Android version 4.1 or later	Product Requirement (portability requirement)
6	SRS-NF-05	The android application must be lightweight and can run with memory needs of less than 100MB. The installer has a maximum size of 20MB	Product Requirement (space requirement)

From the exposure of the above requirements, it can be described in the use case diagram as follows:

Figure 2. Use case Diagram



The following is an actor definition table and use case definition table to assist with understanding on Figure 2:

Table 4: Actor Definition

No	Actor	Description
1	Driver	Members of the smart ambulance operator team on duty on precise shifts. Each driver works 8 hours alternately (shift system).
2	Registered Citizen	People who register themselves as users of the smart ambulance system. They must fill out personal data in detail.
3	Hospital Operator	Hospital operators registered in the smart ambulance system
4	Ambulance Officer	The Chairman of the ambulance team that is on standby in the area of a particular village. Each village has one person charged with implementing the system.
5	Administrator	The ambulance coordinator of the Cimahi city. Entitled to appoint a smart ambulance team leader for each sub-district area, manage existing user groups, and generate monthly reports to relevant stakeholders.

Table 5: Usecase Definition

No	Use Case	Aktor	Deskripsi
1	Register to System	Registered Citizen	People register by filling out forms and uploading photos of legitimate self-identification.
2	Press the emergency button to call a nearby ambulance	Registered Citizen	The emergency button can be accessed directly when the user (registered citizen) opens the application. The user must press the button three times; then a map display appears to determine the pickup point. Then the user is required to verify using a fingerprint sensor or a six-digit input PIN to ensure that an unauthorized person does not misuse the application.
3	Validate Registered Citizen	Ambulance Officer	Ambulance officer verifies the completeness and validity of the contents of the form and conformity with documents uploaded to the system. Then determine whether it is approved or rejected.
4	Assigning Drivers	Ambulance	The ambulance officer assigns and schedules

		Officer	drivers shifts. He or she can also assign other drivers outside his schedule if there are drivers who are unable to carry out their duties due to illness/permission.
5	Schedule car maintenance	Ambulance Officer	The ambulance officer is responsible for the maintenance of the ambulance vehicle unit. Including scheduling when the car must go to the workshop for service, oil change, tire change, and so on. So that the vehicle remains fit to carry out its duties. Moreover, assign the driver to go to the workshop.
6	Receive emergency button notification from registered citizen	Driver	Drivers receive notifications and voice alerts if a registered citizen is pressing the emergency button.
7	Scan QR to unlock the car, start the engine, & siren	Driver	The driver performs a QR scanning that is taped to the windshield or on the car door using an android application on his smartphone to open the car door. Then the driver presses the physical button, the engine start and start a siren, which is affixed to the dashboard of the car to start the engine and ambulance siren.
8	View best GPS route to citizen place	Driver	After the QR scan, the display of the Android application goes directly into drive mode where the main display is a map (maps) and the route to a place determined by a registered citizen. Then the application can also display the fastest route to the desired hospital.
9	View real-time GPS to monitor ambulance position	Driver	Display the current real-time ambulance position, use the Google maps API or Waze API to display the latest road conditions in real time.
10	Ambulance maintenance log book	Driver	Drivers who are assigned to go to the workshop can fill out the car maintenance form.
11	Receive an upcoming ambulance notification	Hospital Operator	Hospital staff receive notifications containing ambulances on their way to the ER, so the medical team in the hospital can prepare emergency actions quickly and efficiently
12	Manage user groups	Administrator	Administrators can manage user groups with full access.
13	Create a monthly	Administrator	Administrators can make monthly reports on the

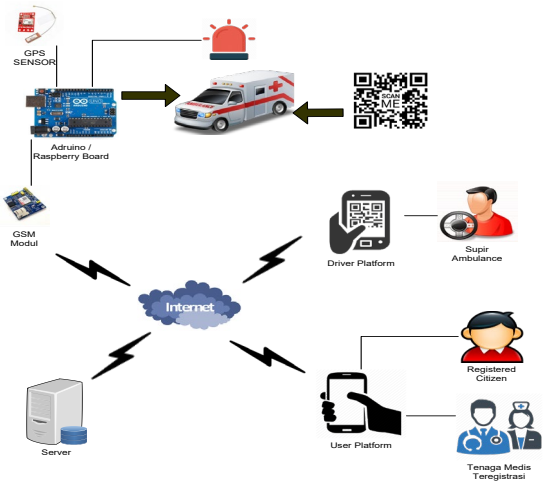
	report		use of ambulance standby to report to related stakeholders (head of the health office, and mayor)

Iot-Based Smart Ambulance System Design

The architecture of IoT-based Smart Ambulance Platform

The overall architecture of the IoT-based smart ambulance platform as follows:

Figure 3. IoT-Based Smart Ambulance Architecture



The proposed platform is intelligent integration of several systems, including IoT-based controller systems installed inside ambulance vehicle, data processing systems on servers (provided an API connected to IoT and Android devices), and an Android-based system installed on a user's smartphone.

Sequence Diagram

Due to the limitations of the page, the sequence diagram design shown in this publication is just some of its features [11,12]. Among others:

Figure 4. Sequence Diagram for Citizen Registration

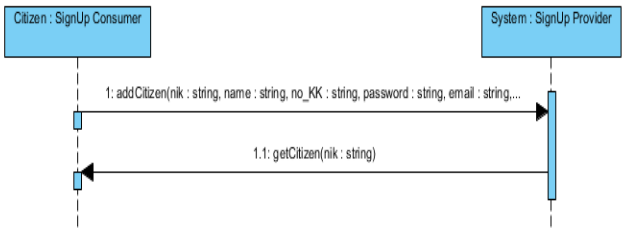


Figure 2. Sequence Diagram for the emergency button
Service Interface Diagram

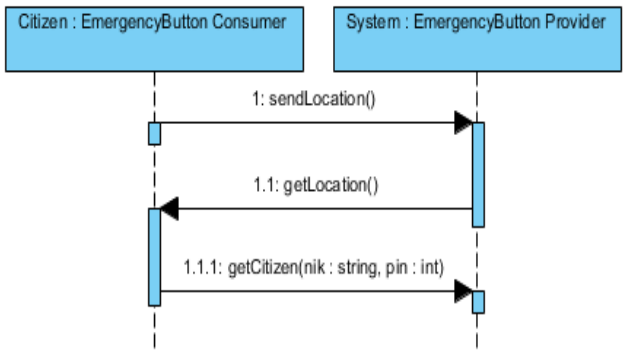


Figure 3. Service interface for citizen registration

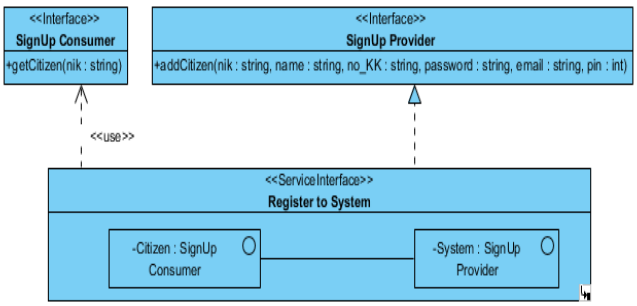


Figure 4. Service interface for the emergency button

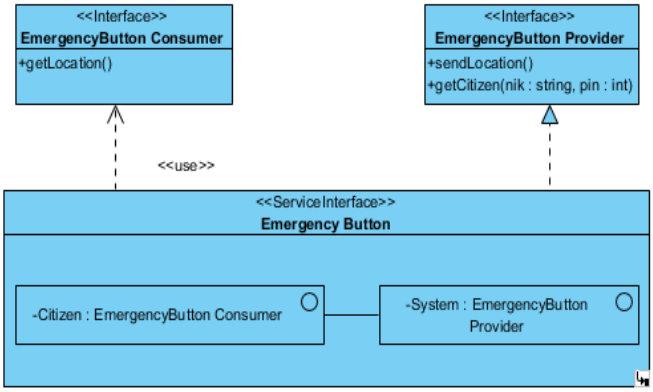


Figure 5. Service interface for driver notification

Service Contract Diagram

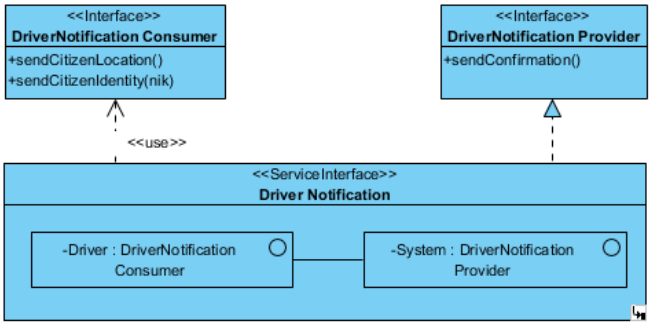


Figure 6. Service Contract for Citizen Registration

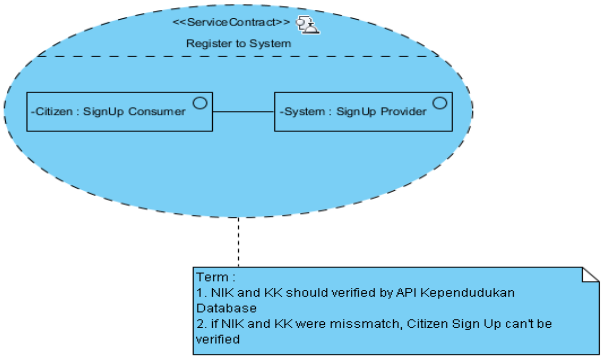


Figure 11. Service contract for the emergency button

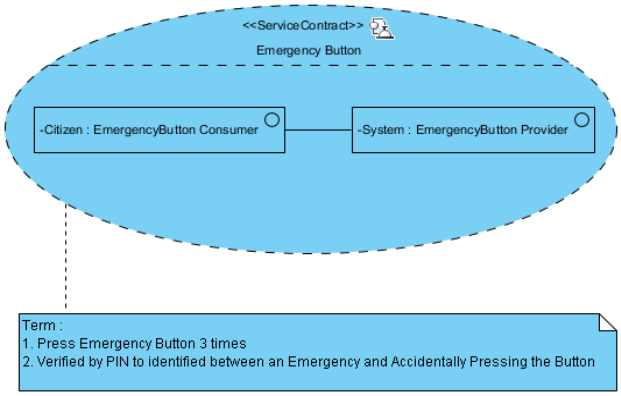
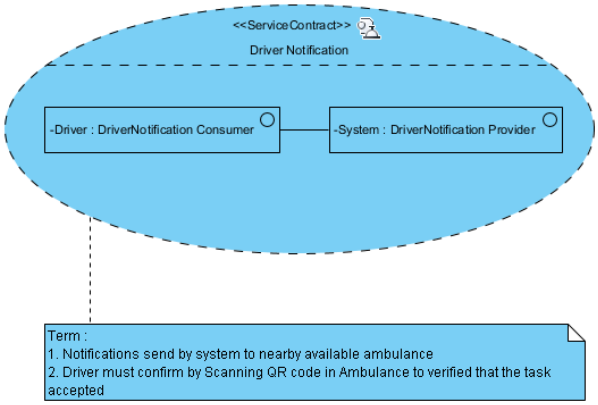


Figure 12. Service contract for driver Notification



Conclusion

The conclusion of this study can be described as follows [13,14]:

1. Management of ambulance can be maximized by using the use of service-oriented technology (SOA). By utilizing smartphones as devices used by users, and IoT installed in ambulance vehicles.
2. Implementation of the smart ambulance platform needs to be supported by revisions to the mayor's regulation [10] as a legal law in the Cimahi city.

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