Development of Routing Decision Support System for Emergency Medical Service

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ABSTRACT

The emergency medical system in Thailand has been developed since then together with the development of tools and life saving appliances in the emergency rooms of each hospital, both public and private sectors. However, evaluation of EMS is limited due to the lack of knowledge and experience in the route. Moreover, in the various traffic condition, the driver might got stuck or can not go as fast as possible. This problem has resulted in delayed delivery the patient to the hospital.

In this research we have demonstrate possible application scenario for medical emergencies that, not only requires dynamic data of road conditions but also the destination point (Available bed, Existing of Doctor, etc) and suitable car has considered to support the situation of the patient. In the case of road networks, the arcs in a directed graph correspond to street segments (edge E) whereas the nodes correspond to street segment intersections (node vertex V). Each arc has a weight associated with it, representing the impedance (cost) of traversing it. The Dijkstra algorithm is used in this routing applications. The routing system has deployed through the web map application using FOSS4G and OCG standard.

***Keywords**: Emergency Medical service, Web Map Application, Dynamic Routing, Decision Support System*

1. INTRODUCTION

National Institute for Emergency Medicine (NIEM) has been established to be responsible for the administrative management and coordination between relevant agencies, both public and private sectors, including the promotion of local governments to play a role in the management of emergency medical services. The aim of the establishment is to support patients to access the emergency medical service equally and thoroughly with qualified standard (NIEM, 2556 B.E.). Emergency sickness is an individual crisis. Whenever an accident or immediate sickness happens, it can result in death or disability if the treatment is not done in time. Also, it may result in unnecessary serious injury or sickness, or even premature death. It was found that the higher rate of emergency patients' death according to emergency sickness in Thailand has been resulted from the late treatment. These situations have been occurred because the emergency medical service does not cover and access in a wider area; as well as the emergency section and emergency treatment in hospitals do not achieve the standard yet.

Due to the fact that there are not enough Emergency Physicians, the treatment sometimes cannot be processed immediately. (NIEM, 2553 B.E.). As a result, the Manual of Medical Triage and Treatments has been processed. The manual introduces the criteria for the medical triage and treatments at the Emergency Unit according to 25 groups of symptoms. The criteria for medical triage are based on the 5-scale Emergency Severity Index (ESI) Version 4. The manual is supposed to be the central standard for medical institutes, units and operators to apply into the triage and treatments based on the patients' symptoms. (NIEM, 2556 B.E.)

The problem of unable to reach the patient in may be time because of the misplaced identification or misrouted driving. The patient will, therefore, be unable to be treated in time causing death or disabilities. Also, some patients may be at risk of unnecessarily having more serious symptoms. So, the research team will develop the system for tracking the routes to reach the patients within the area of Muang District, Phitsanulok Province. When people face immediate accident or sickness, if they are not treated in time, it may cause them death, disabilities, or complications. On the other hand, if they are treated in time, the rates of death and disabilities can be reduced.

This research aims to design and develop the online tracking system for the most appropriate and fastest routes to reach the patients.

2. THE SYSTEM DESING

The system development is based on network of 1669 and apply the system's resources for the highest efficiency. The development and experiment are classified into 2 phrases: 1) map development system based on NIEM's major operation e.g. ECART MAP API in which is online information service system and the major routing system (appropriate routing system) is based on this operation; and 2) development based on pgRouting algorithm. The host and database of the system which have been developed by the research team by connecting with database through the Apache, PHP, MapServer, Geoserver , jQuery Mobile, JavaScript, Java MapScript, etc. The routing system has deigned based on the real works situation, EMSs in each area differ from each other. As in Phitsanulok, the operation is classified by the sides of Nan River and odd and even dates in a month. For instance, in even dates, EMS A operates in the west side while EMS B operates in the east side of Nan River; or in add dates, EMS A operates in the east side while the other EMS operates in the west side of Nan River. Zoning operation has been therefore the case study of routing system to develop other areas in the future. In the process of zoning operation, a user must select either using zoning to track the EMS or not, then select the type of EMS in order to track the location of the desire one. The EMS will be tracked based on the odd-and-even dates. Figure 1, there are 6 conditions for tracking an EMS. **Condition 1**: The case of zoning is off and no selecting types of EMS: the system will track every EMS within 50 km around the area. **Condition 2**: The case of zoning is off but the type of EMS is selected: the system will track the selected type of EMS within 50 km around the area. **Condition 3**: The case of zoning is on and selecting even date, but no type of EMS selected: the system will tract all the EMS based on the selected options. On even dates, the EMS on the east side of Nan River will be tracked. **Condition 4**: The case of zoning is on

and selecting odd date: the system will tract all the EMS based on the selected options. On odd dates, the EMS on the west side of Nan River will be tracked. **Condition 5**: The case of zoning is on and selecting even date; and the type of EMS is selected: the system will track all the EMS based on the selected options. On even dates, the EMS on the east side of Nan River will be tracked. **Condition 6**: The case of zoning is on, selecting odd date, and selecting the type of EMS: the system will track the EMS based on the selected options. On odd dates, the EMS on the west side of Nan River will be tracked. These conditions are shown in Figure 3.2.

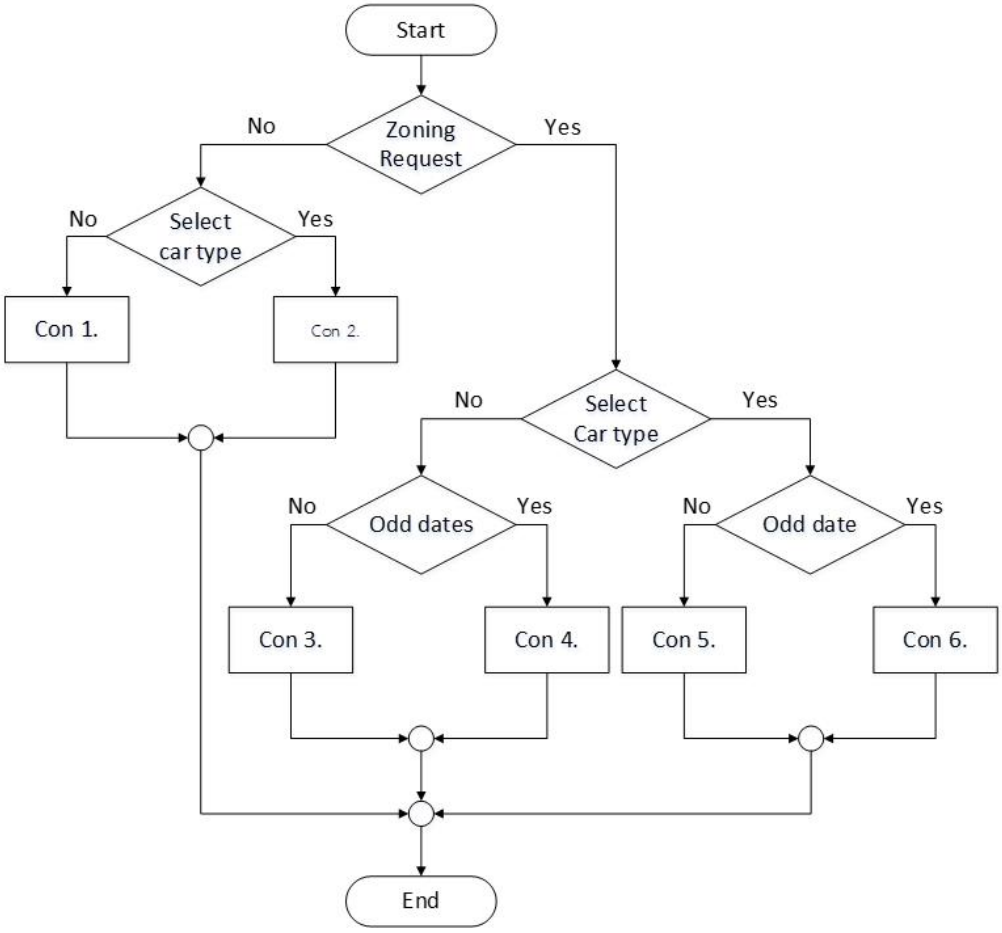


Figure 1. the system design for 6 conditions of EMS tracking

3. RESULT OF ERDP SERVICE THROUGH ECART API

3.1 Operation of ERDP through ECART API

The system designed to be a user-friendly interface that the user can choose the desired location (for example, accident point) and select the conditions. The system will verify the condition and send back the result as a web map to the user. The result of this process shown as the sample identification following the sample location and condition identification so that the system can show the calculated results. The situation can be identified as follows:

3.2 Routing result between no conditions and added conditions in Phitsanulok

Sittichai *et al*., 2014 has developed Emergency Routing Decision Planning (ERDP) system. In this system, ERDP had used through ECART API and one was added the efficiency of zoning selection of EMS in each area. This study has identified service areas of Phitsanulok as the case study only. The Figure 2 (a) shows the system operation to track an EMS and hospital as well as to find the best route without zoning condition. Comparing to zoning condition service, in the case of a patient was in Tathong Sub-district, Route 177, the selected EMS was Kaw-Phab Rescue for the no condition service. This EMS could reach to the location within 5-6 minutes and take the patient to Naresuan University Hospital which takes only 6 minutes. On the other hand, when applying zoning condition service in Phitsanulok (see Figure 2 (b), the system operation has been set that the odd dates will take the EMS on the east side of Nan River which the EMS on the west side of Nan River will be taken on the even dates. When it comes to this condition, at the same location, the system will verify the date first whether it is the even or odd date. Therefore, the system filtered the EMS on the west side of Nan River and it was found that the nearest EMS was at Inter Vejchakan Hospital, which was 14-15 minutes far from the location and 6 minutes to Naresuan University Hospital.

(a) (b)

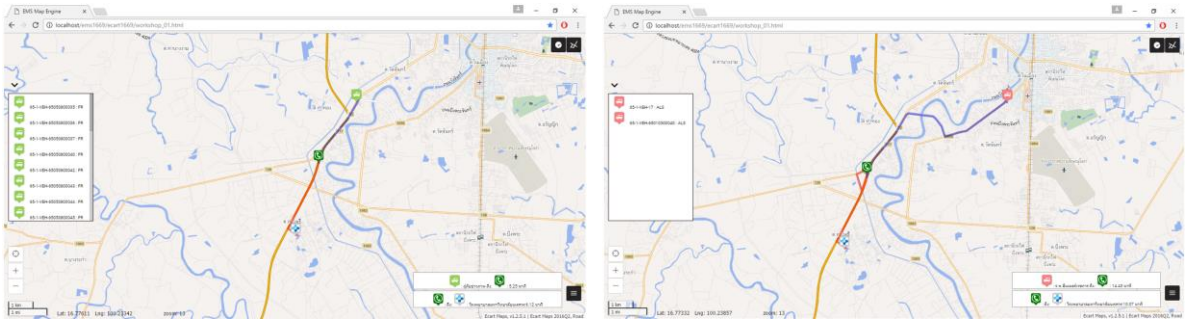


Figure 2 The results of location and route in the cases of zoning condition is requested (b) and not request (a)

3.3 The use of ERDP Service through ECART API

Apart from interactive usage which shows the information and map in the website screen, in order to respond to the application development in the future, the research team also prepared the service system called ERDP Service in which the user can get the nearest EMS and hospital as well as the best route via Web Service. This means that the user can use the service by identifying the latitude and longitude and other conditions through the URL for the similar results but showing in JSON format. This format is the specified dataset which can be transferred or exchanged on the GIS webpage or application in order to manifest the geographical information in point, line, or polygon. This section will demonstrate the operation sample of ERDP Service by identifying the example location as follow, to show the result as in JSON format. This operation sample applied ERDP Service through webpage to track the best route by identifying the location in an area of Bangkok as 13.866942, 100.592697 as shown in the Figure. The condition was to track for the ALS type only, without zoning service.

1) Tracking of the location and name of the EMS in the database through URL

```
http://www.geo-nred.nu.ac.th/NuEMS/ems1669/json-car-location.php?lat=13.866942&lon=100.592697&vehicleslevel=ALS&zone=fa
```

After receiving the location of the patient that was 13.866942, 100.592697, the system would track the nearest EMS based on algorithm. The system would filter the fastest EMS based on the identified condition (the result showed was json encode showing the location of EMS, BLS type, Koobdaeng Rescue), the data would then be sent back as JSON format as


```
[{"lat":"13.889909089000302","lon":"100.60534208471677","vname":"ALS\u0e23.\u0e1e.\u0e40\u0e0b\u0e47\u0e19\u0e17\u0e23\u0e31\u0e25\u0e40\u0e22\u0e19\u0e40\u0e19\u0e2d\u0e23\u0e31\u0e25"}]
```


2) Calculating and showing the dataset of the fastest route between the EMS and patient through URL

```
http://www.geo-nred.nu.ac.th/NuEMS/ems1669/json-car-route.php?lat=13.866942&lon=100.592697&vehicleslevel=ALS&zone=false
```

After receiving the command set and calculating route, the information of the best route and the nearest EMS type ALS would be sent back as JSON format. The information which was sent back consisted of the line format of the location of 13.866942, 100.592697, time period of transportation in second units (1,333 seconds) and the distance in meter units (7,966 meters) as shown below.


```
[{"line":[{"x":13.86768,"y":100.59376},{"x":13.86744,"y":100.59417},{"x":13.86806,"y":100.59451},{"x":13.86784,"y":100.59492},{"x":13.86752,"y":100.59555},{"x":13.86649,"y":100.59734},{"x":13.86383,"y":100.59574},{"x":13.85972,"y":100.59333},{"x":13.85849,"y":100.59259},{"x":13.85984,"y":100.59017},{"x":13.85829,"y":100.58929},{"x":13.8742,"y":100.59598{"x":13.87869,"y":100.59841},{"x":13.87935,"y":100.59882},{"x":13.88125,"y":100.59995},{"x":13.8818,"y":100.6003},{"x":13.88315,"y":100.60108},{"x":13.88467,"y":100.60198},{"x":13.88476,"y":100.60204},{"x":13.88564,"y":100.60254},{"x":13.88651,"y":100.60307},{"x":13.88888,"y":100.60445},{"x":13.89003,"y":100.60514},{"x":13.88996,"y":100.60525}],"dur":1333,"dis":7966}]
```


The operation sample of pgRouting API has been examined as shown in Figure 3..

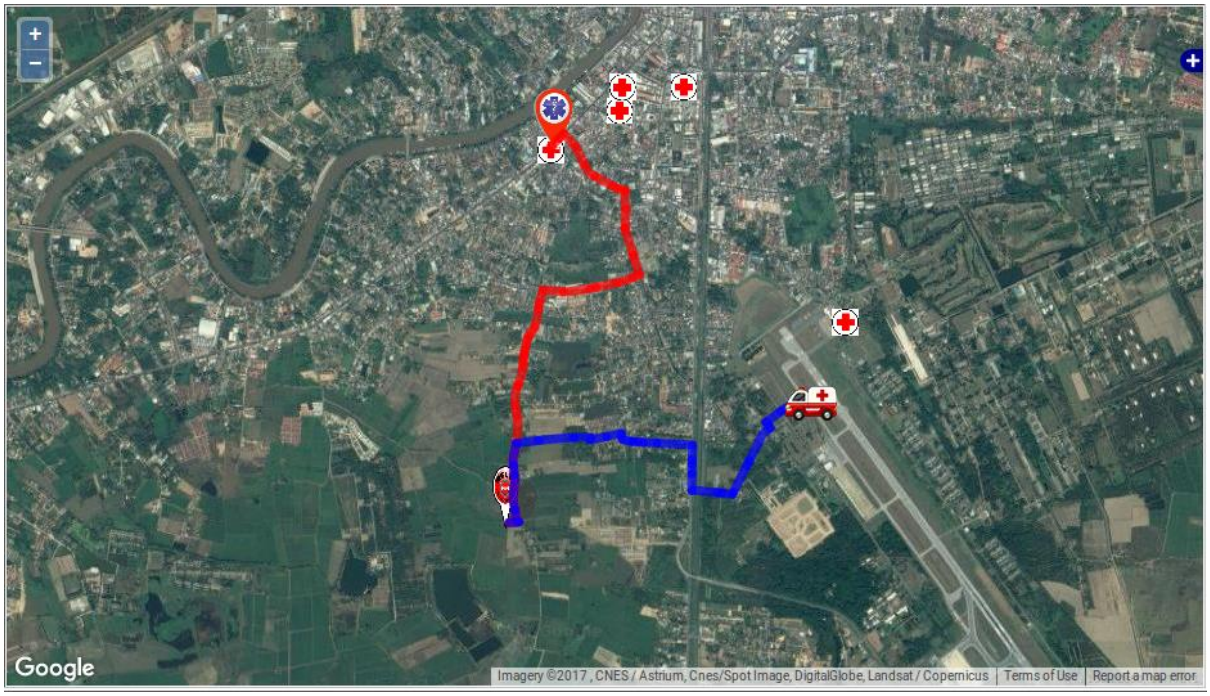
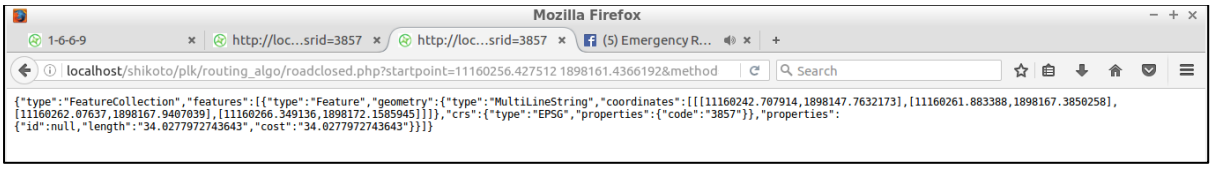


Figure 3 The system could analyze dynamic data when the user identified tracking condition with Dynamic Routing

5) Examine the improvement in cast that there are changing of the road such as car crash, closed route or flooding. The user can add more information of the location into the system such as closed route or flooding. Then, the system will automatically improve the data. After the road data improvement, the system will re-route in order to avoid the accident area.

Road Blocked



Road open (normal condition)

(a) (b)

Figure 4 the routing result between road block (b) and road in normal condition (a)

4. SUMMARY

On the diversified road where there is a lot of limitation e.g. do not turn, one-way road, do not enter, etc., the calculation of the most appropriate and accurate route is the key factor (Sittichai *et al*., 2017). Considering the distance and time period may not be enough in the case of EMS that is in need to take the patient to the medical center as fast as possible. Therefore, applying dynamic data analysis is important to analyze the most appropriate and accurate route. The dynamic data are such as traffic condition or an unexpected situation on the road including closed road, etc. As a result, updating these data is as necessary as data analysis. The summary of this development of the system can be concluded as follows:

- Ecart API and pgRouting can calculate the route by using the location of EMS and hospital information from NIEM database.
- Ecart API can examine the system all over the country while pgRouting API can only examine the area where data must have been prepared or taken from other organizations.
- When the database has been updated, the system will re-route by avoiding the closed road.
- The development of ERDP system with the database of hospital and EMS from NIEM can analyze the dynamic data based on the condition and situation of each route in each time.
- Both systems that have been developed can be further developed with other systems of NIEM because its software is the opened-code.

A project of "Development of Decision Support System for Emergency Routing Service" has designed the database and developed the system of decision making to reach to the emergency patient for the Emergency Medical Call Center to dispatch for the best route via internet networking. This system can show the location of the patient on the online map, track the most appropriate EMS for the patient's condition, and find the nearest the medical center. The transportation from place to place must be the safest in order to help the patient in time.

5. DISCUSSION AND CONCLUSION

This system can support the basic decision making of Emergency Medical Call Center to dispatch for the appropriate EMS to the patient's symptom and the fastest and safest route to reach the patient. This system differs from Google Map because it can analyze the dynamic data whereas Google Map does not allow the user to edit the road information and route self-analysis.

According to the system examination, the results follow the conditions identified by the system. It can be explained that when the user added the geographical data (latitude and longitude) of the accident area into the system, the system showed the results of the most accurate location of the patient, the appropriate EMS type, and the nearest hospital. The system can analyze and calculate the route from the EMS parking area to the patient location; and the patient location to the nearest and most appropriate hospital (Sittichai et al., 2017). It can also analyze the dynamic data in the case of zoning service regarding even and odd dates. Moreover, the system can analyze the dynamic data when there is changing of the transportation on the road such as bad traffic, flooding and closed road; and avoid those routes.

The system of decision making support has been developed by employing PHP language with PostgreSQL/PostGIS database and JavaScript command set (Humhong *et al.*, 2016). The system examination was classified into 2 phrases including 1) system development with the collaboration of Ecart Map API; and 2) system development via pgRouting API opened-software. The results of the study, the development, and the experiment lead to the differences of both systems as shown in Table 5.1.

6. ACKNOWLEDGEMENTS

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