International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 11
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 November 2023*

An Approach for Reducing the Emergency Vehicle’s Travel Time by Routing

[1]**Jadhav Prafulla Balshiram**

[1]Research Scholar, Department of Computer Science, Eklavya University, Damoh, M.P.

[2]**Dr. Shailendra Jain**

[2]Supervisor, Department of Computer Science, Eklavya University, Damoh, M.P.

ABSTRACT

In order to improve the effectiveness of the routing of an emergency vehicle, it is recommended to combine traffic signal preemption with dynamic path planning processes. We construct a graph version of the D*Lite informed search algorithm in order to design ideal routes for the emergency vehicle in a manner that is both efficient and dynamic. This is accomplished by taking into account real-time updates of congestion levels and other delays to travel time. The findings demonstrate that dynamic path planning has the ability to enhance travel time in situations of unpredictable congestion. Furthermore, the incorporation of an appropriate traffic signal preemption mechanism has the potential to further enhance travel time for emergency vehicles, which might possibly save lives.

Keywords: Congestion, Travel time, Dynamic path, Routing, Static

I.INTRODUCTION

It is common for the timely and effective arrival of emergency vehicles to be the deciding factor in urban emergency response systems. Every second counts since the public's safety and welfare are at stake if we are late in reaching our goal. Since decreasing the journey time of emergency vehicles is of the utmost significance, experts in the industry have been vigorously seeking new ways to improve the routing tactics used by these life-saving vehicles. Emergency response systems are facing more and more difficulties as a result of the rising complexity of metropolitan surroundings and the concentrations of human populations. Making sure emergency vehicles can respond quickly is no easy feat, what with navigating through crowded metropolitan streets, following traffic laws, and factoring in unpredictable events like road closures or accidents. The ever-changing nature of emergencies can overwhelm traditional routing algorithms, causing them to choose less-than-ideal routes and cause delays. To overcome these obstacles, the suggested method incorporates advanced routing algorithms, real-time data, and predictive analytics to build a system that is more responsive and flexible.

The use of state-of-the-art technology, including data from Global Positioning Systems (GPS), traffic monitoring systems, and machine learning algorithms, is fundamental to this method. Using real-time data, emergency vehicles may learn about the current traffic conditions in real-time, so they can change their routes on the fly to avoid heavy traffic and take the quickest routes possible. Further, by analyzing past data, machine learning algorithms can foretell how traffic will flow, enabling proactive route design that lessens the effect of any delays. This data-driven method improves the emergency response system's overall efficiency while also optimizing trip time. The flexibility of the suggested method to accommodate the unique qualities of various urban environments is a critical component. The road networks, traffic patterns, and possible hazards of different urban settings are very different. Hence, it is not feasible to have a solution that works for everyone. To address the specific issues faced by each community, the strategy instead makes use of a flexible framework. The routing strategy's versatility guarantees its effectiveness in a wide range of settings, from expansive suburban regions to highly congested city centers. The method also accounts for the ever-changing character of cities by permitting revisions and upgrades as cityscapes change through time.

In addition to technical considerations, this strategy relies on cooperation between different players in the urban emergency response ecosystem. The suggested routing approach requires close collaboration between emergency service providers, municipal planners, and IT developers. Working together, we will share data, coordinate response protocols, and optimize the system in real-time using user input. This method promotes the creation of an integrated system where data flows freely, guaranteeing that first

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 11
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 November 2023*

responders' vehicles are both technologically advanced and in sync with one another and the larger system of emergency response. Both the creation and the execution of this strategy are heavily influenced by ethical concerns. It is critical to prioritize the safety of the community and individuals while also ensuring a prompt response to emergencies. Strong protections are needed to preserve people's privacy rights when data is used, particularly when location-based information is included. The ethical underpinning for this approach's adoption includes transparent policies, informed consent methods, and secure data processing standards. Successful integration of such technologies into urban fabric depends on public trust and support, which this method seeks to cultivate by proactively addressing these ethical issues.

II.REVIEW OF LITERATURE

Zeng, Ziling et al., (2021) Emergency medical services (EMS) have a significant issue in the form of insufficient multistakeholder coordination. In the ambulance routing procedure, the lack of coordination from idle traffic operators results in a failure to prioritize the ambulance. Additionally, disregarding the selection of hospitals will inevitably result in the need to transfer patients between hospitals. This paper focuses on optimizing daily ambulance routing problems in an EMS network with high spatial resolution. It introduces two advanced technologies: prehospital screening, which diagnoses patient injuries, and lane preclearing, which ensures that ambulances can travel at a predefined driving speed. Three distinct categories of ambulances are utilized for the purpose of transporting and providing first medical assistance to patients, depending on the evaluated outcomes. A mixed-integer linear programming (MIP) model is suggested as a means to effectively manage the ambulance fleet. This model aims to allocate vehicles to injured individuals and devise routes that minimize trip time. A flexible time limit is included to account for the penalty incurred when arriving late at the site or hospitals. To verify the computational performance of a commercial solution called the general algebraic modeling system (GAMS), a real-world scenario in Shenzhen, China is provided. This instance involves high-quality EMS that answers to the call within seconds. Within the case study, we conducted a more in-depth examination of the impact of various stakeholders' engagement, such as hospitals and traffic operators. This data substantiates the effectiveness of involving several stakeholders in the process of determining ambulance routes.

Shaaban, Khaled et al., (2019) By generating a green wave as they approach the incident site through a system of signalized junctions, emergency vehicles (EVP) are intended to be granted right of way. First, EVP systems are designed to minimize the negative impact of preemption on general traffic; second, they are designed to eliminate any obstruction to the movement of electric vehicles (EVs) along the road and at crossings. By carefully choosing a preemption technique, the detrimental effects of EVP on regular traffic can be reduced. Prior EVP systems neglected or failed to address the detrimental effects of EVP on conventional traffic in their pursuit of reducing EV travel times. Optimal path selection and EV preemption are combined in this study's technique. In order to ensure that each junction is cleared before the EV arrives, the suggested strategy chooses the best route for the EV before it leaves its starting point and then triggers the preemption at the correct moment. At both the path selection and preemption phases, the suggested EVP method seeks to reduce the effect of EVP on regular traffic. To clear the entire road or the oncoming lane, other cars can get emergency information through vehicle-to-vehicle and vehicle-to-infrastructure communication along the EV path, which is a big benefit of the suggested way. A small simulation environment was used to evaluate the technique on a real-life traffic network. Results showed that EV travel times were significantly reduced with little disruption to regular traffic caused by preemption. Corresponding agencies and practitioners might find the suggested technique and evaluation procedure useful for gauging the effects of preemption on current or future arterials.

Humagain, Subash et al., (2019) Improving vital services like fire, police, and ambulance can be achieved by reducing the trip time of emergency vehicles (EVs). Efficient methods for reducing EV travel time include route optimization and pre-emption. Optimisation and pre-emption strategies for electric vehicle routing are reviewed in this paper's comprehensive literature analysis. In addition to a critical analysis and debate, a comprehensive categorization of current methodologies is provided. The study highlights the shortcomings of current routing systems and the absence of practical use cases for the suggested pre-emption systems. As a result, there are several intriguing and crucial gaps in our understanding and areas that need to be addressed via more research. Optimizations utilizing real-time dynamic traffic data, optimizing algorithms that take travel time into account, evaluating and minimizing the impact of electric vehicle routing on other types of traffic, and resolving safety issues in traffic networks with multiple EVs simultaneously are all examples of what is lacking.

Rathore, Nikki et al., (2018) There are a number of emergency medical services (EMS) that are partially run by the government in India. One of these services is called 108, and it is present in a number of the country's states. The effectiveness of the Emergency Management System (EMS) is contingent upon its prompt response to the demand as well as the incorporation of real-time travel and traffic data into the model that is used for scheduling and positioning vehicles. Using the Google Maps Distance Matrix API, the emphasis of this work is on the process of constructing routes for emergency vehicles. This is accomplished by developing an optimization model that is based on the knowledge that is currently available regarding real-time traffic statistics. The formulation of the vehicle routing issue as an integer programming model and the optimization of that model through integration with the Google API are both components of the heuristic method. The most important aspects of the model are the location of incidents, the tracking of vehicles, the identification of the shortest path, and the optimization of dispatch. The validity of this simulation technique is demonstrated by a comprehensive set of tests and a variety of samples.

Zhao, Jiandong et al., (2017) The challenge of dynamic path planning for emergency vehicles is typically hampered by a number of criteria, including the reliance on the road network, the amount of resources that are required, and the efficiency with which time is spent. In light of this, a two-stage model of dynamic routes planning for emergency vehicles is constructed with the objective of achieving the lowest possible journey time while simultaneously minimizing the amount of traffic congestion. To begin, a polyline-shaped speed function is created in accordance with the dynamic features of the traffic on the road network. Then, in order to forecast the amount of time it will take to travel, a new kernel clustering technique that is based on the shuffling frog jumping algorithm is developed. This algorithm analyses both real-time and historical data about travel speed. In the second place, and in conjunction with the anticipated amount of time spent traveling, the traffic congestion index is defined in order to evaluate the dependability of the route. Thirdly, in order to solve the challenge of solving a two-stage target model, a two-stage shortest path method is presented. This algorithm is made up of two different algorithms: the K-paths algorithm and the shuffling frog jumping algorithm. In conclusion, a simulated example is utilized to validate the aforementioned methodologies. This instance is based on the data of floating automobiles located on the highway in Beijing. It is clear from the findings that the optimization route algorithm is capable of satisfying the requirements of the numerous restrictions.

Djahel, Soufiene et al., (2015) In the present day, the extraordinary growth in road traffic congestion has resulted in serious implications for individuals, the economy, and the environment, particularly in metropolitan regions in the majority of the world's largest cities. The delay of emergency vehicles, such as ambulances and police cars, constitutes the most significant of the aforementioned repercussions. This delay results in an increase in the number of fatalities that occur on the roads as well as significant financial losses. In order to mitigate the effects of this issue, we have developed a sophisticated adaptive traffic control system. This system makes it possible for emergency services to respond more quickly in smart cities, while simultaneously ensuring that there is only a slight increase in the amount of congestion that occurs along the path of the emergency vehicle. This is something that may be accomplished with the help of a Traffic Management System (TMS) that is able to apply changes to the control and driving regulations of the road network in accordance with an adaptation strategy that is suitable and effectively calibrated. The latter is decided by taking into account the severity of the emergency situation as well as the present traffic circumstances, which are evaluated using a technique that is based on fuzzy logic. Using a set of typical road networks, the simulation results that were obtained demonstrated the effectiveness of our approach in terms of the significant reduction in response time for emergency vehicles and the negligible disruption caused to vehicles that were not involved in an emergency while they were traveling on the same road network.

Yu, Joseph et al., (2014) Studies of urban transportation networks that are based on simulation have been increasingly used to the process of evacuation planning. The amount of information that is supplied inside a traffic simulation model makes it possible to devise methods for emergency response and evacuation when an emergency occurs. The purpose of this study is to build a simulation model of the transportation network in downtown San Jose, California, in order to evaluate the effectiveness of the evacuation procedure under hypothetical situations. The scenarios that have been reviewed in this article are not complete; nonetheless, they do highlight the potential of the simulation technique for controlling the traffic engineering components of the emergency response. Among the possibilities that are detailed in this article are the utilization

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 11
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 November 2023*

of contraflow lanes, traffic accidents on the network, and evacuees switching to transit as their mode of transportation. From the several scenarios that were examined, it was discovered that the most effective strategy would be to reduce the number of vehicles on the road by increasing the number of people who utilize public transportation. This would be done in conjunction with rerouting vehicles and conducting contraflow operations on major routes. The capacity of this study to investigate not only the travel durations for evacuees but also the mobility and accessibility of emergency vehicles might be considered the most significant contribution of this research. The amount of time it takes to reach the location(s) that are in danger while simultaneously ensuring that evacuation operations are carried out effectively is essential for minimizing losses throughout the course of a disaster that was caused by humans.

Musolino, Giuseppe et al., (2013) Within the context of a road network, a framework is described that allows for the dynamic planning of routes for emergency vehicles, taking into account fluctuations in link travel times that occur within a single day. Two different modeling components are incorporated into the framework. The first is a dynamic assignment model that operates within a single day and simulates the interaction between the time-varying network and travel demand. The second is a dynamic vehicle routing model that is responsible for designing the most efficient routes for emergency vehicles. It is possible to create routes for emergency vehicles based on anticipatory knowledge of traffic dynamics on the road network, which is made possible by the short-term anticipated trip time, which serves as the connecting variable between the two modeling components. In an experimental evacuation test site, certain procedures of the proposed framework are calibrated and tested in order to ensure their viability.

Barrachina, J. et al., (2013) In contemporary times, the issue of traffic congestion in metropolitan regions has escalated steadily each year due to the ongoing rise in the quantity of automobiles within our cities. Vehicle accidents are a prevalent source of traffic congestion. Furthermore, road congestion may cause a delay in the arrival time of emergency services. Intelligent Transportation Systems (ITS) play a crucial role in reducing or mitigating this problem. This study presents four distinct methodologies aimed at resolving the issue of traffic congestion, with a comparative analysis conducted to determine the most optimal option. By utilizing V2I communications, we can precisely gauge the level of traffic congestion in a specific region. This information is crucial for effectively redirecting traffic, resulting in shorter response times for emergency services and preventing traffic congestion in the event of an accident. More precisely, we suggest two methodologies utilizing the Dijkstra algorithm, as well as two methodologies employing Evolution Strategies. It is important to note that in the event of an accident, time is of utmost importance, and the tactics shown here help you choose the best option quickly.

III.PROPOSED METHOD

Two primary components make up the suggested solution: preemption and dynamic path planning. By analyzing data from the GPS monitoring device, we may ascertain the emergency vehicle's destination and present position. Graphs are used to depict the traffic network between the origin and destination, with nodes representing junctions and edges representing the routes in between. Edges are then given corresponding charges. The time required to go down an edge is translated into its cost, as reducing the emergency vehicle's trip time is the overall purpose of the solution. The projected edge travel time, which includes both traversal and congestion relief, is scheduled to be this amount of time. After edges have their prices assigned, the graph may be sent into D* Lite, the algorithm for dynamic path planning. The algorithm is constantly updated with the latest information on the emergency vehicle's location through GPS data and the current edge costs through the assumed congestion detection system. It then produces the optimal route that is accessible at any given moment. Depending on when the vehicle is predicted to reach crossings along the identified path, the preemption procedure can begin early after path identification. At last, the traffic lights at each intersection that was preempted go through a recovery phase so that they work normally again when the emergency vehicle has passed.

IV.RESULTS AND DISCUSSION

The evaluation is carried out using our D*Lite implementation, which is based on graphs. In this implementation, nodes are charged for signal delay and edges are charged for Queuing Delay caused by congestion, in addition to distance. We employed two graphs in the initial test instances, as shown in Figure 1. There is just one choice point between point A and point D in the first, basic case. On the other hand, there is a more intricate graph with several possible paths connecting points A and M. In km, the numbers along the margins represent the length of the network roadways. It is believed that the maximum speed of the emergency vehicle is 120 km/hr. Nodes, or junctions, between the origin and the destination were given a 3-

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 11
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 November 2023*

minute cost to examine the relationship between cost and intersection delay in the absence of preemption. It is presumed that queuing delay is zero in the absence of congestion. As a measure of the queuing delay that may occur at some network edges due to congestion, an estimated cost of 7 minutes is assigned to these edges. Assuming preemption is executed flawlessly, with no congestion along the vehicle's route, serves as a lower bound for delay.

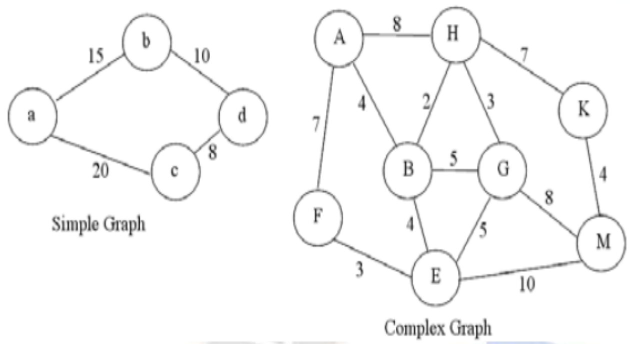

Figure 1: Road Networks Used in Testing

The findings reveal that dynamic path planning is far better than static path planning. You can see this in the figures below. In the case involving complicated graphs, the difference becomes more apparent. The results of static and dynamic route design for trip time are same when there is no congestion. When traffic is heavy, though, dynamic path planning significantly reduces travel times. With no preemption and heavy congestion, the difficult example shows the most noticeable performance difference. Based on these first findings, dynamic routing alone can have a significant impact in places where preemption is not an option. Dynamic and static routing both see significant reductions in journey time with the addition of preemption, but dynamic path planning achieves even greater time savings due to its ability to preempt the least cost path.

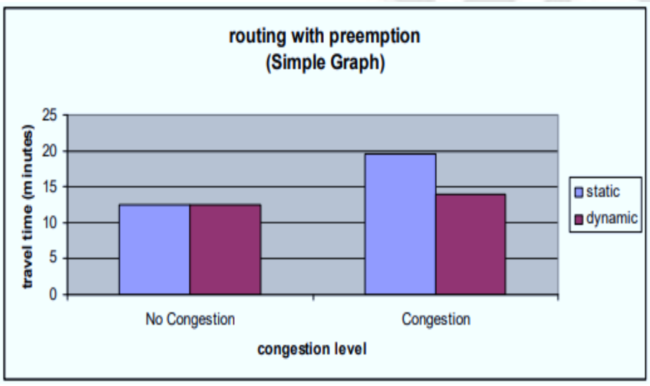

Figure 2: Simple graph showing results of congestion level routing with preemption

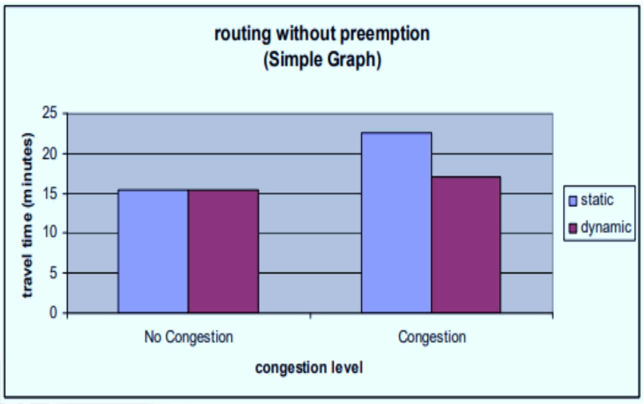

Figure 3: Simple graph showing results of congestion level routing without preemption

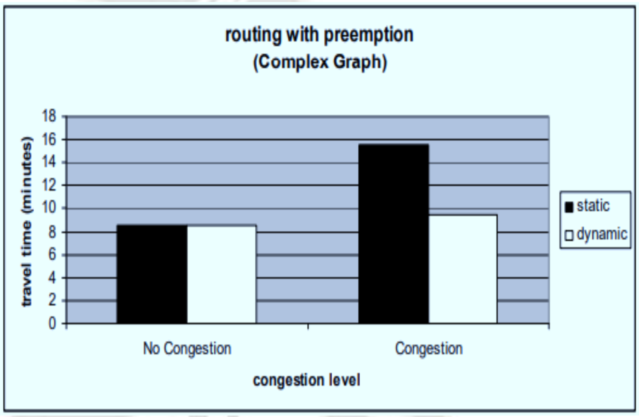

Figure 4: Complex graph showing results of congestion level routing with preemption

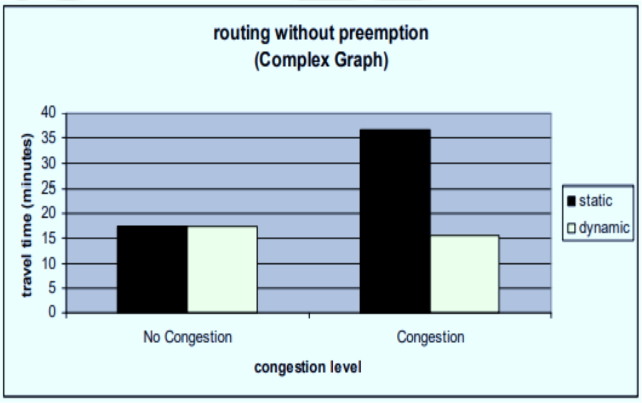

Figure 5: Complex graph showing results of congestion level routing without preemption

V.CONCLUSION

The utilization of optimal routing to decrease trip time for emergency vehicles exemplifies the capacity of multidisciplinary solutions in tackling intricate societal problems. It is crucial to continuously improve and put into action these tactics, promoting a culture of innovation and cooperation that eventually results in safer and more resilient urban settings. Our data clearly show that implementing dynamic path planning has effectively decreased the journey time of emergency vehicles. Dynamic path planning demonstrates substantial enhancement over static path planning, even without being integrated with preemption.

REFERENCES: -

1. Kamble, Shridevi & Kounte, Manjunath R. (2022). A Survey on Emergency Vehicle Preemption Methods Based on Routing and Scheduling. International Journal of Computer Networks And Applications. 9. 60-71. 10.22247/ijcna/2022/211623.
2. Zeng, Ziling & Yi, Wen & Wang, Shuaian & Qu, Xiaobo. (2021). Emergency Vehicle Routing in Urban Road Networks with Multistakeholder Cooperation. Journal of Transportation Engineering Part A Systems. 147. 10.1061/JTEPBS.0000577.
3. Shaaban, Khaled & Khan, Muhammad Asif & Ridha, Hamila & Ghanim, Mohammad. (2019). A Strategy for Emergency Vehicle Preemption and Route Selection. Arabian Journal for Science and Engineering. 44. 10.1007/s13369-019-03913-8.
4. Humagain, Subash & Sinha, Roopak & Lai, Edmund & Ranjitkar, Prakash. (2019). A systematic review of route optimisation and pre-emption methods for emergency vehicles. Transport Reviews. 40. 1-19. 10.1080/01441647.2019.1649319.
5. Ogunwolu, Ladi & Sosimi, A & Jagun, O & Onyedikam, Chidi. (2019). Optimal routing for automated emergency vehicle response for incident intervention in a traffic network. Journal of Applied Sciences and Environmental Management. 22. 1941. 10.4314/jasem.v22i12.12.
6. Rajak, Biru & Mallick, Shrabani & Kushwaha, Dharmender. (2019). An Efficient Congestion Avoiding Approach for Optimal Path Finding for Emergency Vehicle. Recent Advances in Computer Science and Communications. 13. 10.2174/2666255813666191227144637.
7. Rathore, Nikki & Jain, Pramod & Parida, Manoranjan. (2018). A ROUTING MODEL FOR EMERGENCY VEHICLES USING THE REAL TIME TRAFFIC DATA. 175-179. 10.1109/SOLI.2018.8476771.
8. Katsuma, Ryo & Yoshida, Shin. (2018). Dynamic Routing for Emergency Vehicle by Collecting Real-Time Road Conditions. International Journal of Communications, Network and System Sciences. 11. 27-44. 10.4236/ijcns.2018.112003.
9. Zhao, Jiandong & Guo, Yujie & Duan, Xiaohong. (2017). Dynamic Path Planning of Emergency Vehicles Based on Travel Time Prediction. Journal of Advanced Transportation. 2017. 1-14. 10.1155/2017/9184891.
10. Djahel, Soufiene & Smith, Nicolas & Wang, Shen & Murphy, John. (2015). Reducing Emergency Services Response Time in Smart Cities: An Advanced Adaptive and Fuzzy Approach. 10.1109/ISC2.2015.7366151.
11. Yu, Joseph & Pande, Anurag & Nezamuddin, N. & Dixit, Vinayak & Edwards, Frances. (2014). Routing Strategies for Emergency Management Decision Support Systems During Evacuation. Journal of Transportation Safety & Security. 6. 10.1080/19439962.2013.863258.
12. Musolino, Giuseppe & Rindone, Corrado & Polimeni, Antonio & vitetta, antonino. (2013). Travel Time Forecasting and Dynamic Routes Design for Emergency Vehicles. Procedia - Social and Behavioral Sciences. 87. 193-202. 10.1016/j.sbspro.2013.10.603.
13. Barrachina, J. & Garrido, Piedad & Fogue, Manuel & Martinez, Francisco & Cano, Juan-Carlos & Calafate, Carlos & Manzoni, Pietro. (2013). Reducing Emergency Services Arrival Time by Using Vehicular Communications and Evolution Strategies. Expert Systems with Applications. 41. 10.1016/j.eswa.2013.08.004.
14. Wang, Jiawen & Yun, Meiping & Ma, Wanjing & Yang, Xiaoguang. (2013). Travel Time Estimation Model for Emergency Vehicles under Preemption Control. Procedia - Social and Behavioral Sciences. 96. 10.1016/j.sbspro.2013.08.242.
15. Polimeni, Antonio & Quattrone, Agata & Vitetta, A.. (2010). An approach to designing vehicle routes in evacuation conditions. WIT Transactions on Information and Communication Technologies. 43. 469-480. 10.2495/RISK100401.