RAPIDEMS

A Novel, Systematic Signal-to-Vehicle Communications Strategy

01. Introduction

Contemporary emergency medical services (EMS) response times in reaction to life-threatening events play a critical role in determining the mortality rate of a patient. Prior empirical research has provided evidence that largely supports the importance of reducing response time. Additionally, the idea that quicker response times lead to improved outcomes for patients is a widely accepted and established principle within the EMS field. Introducing systems to EMS that decrease the response time of its vehicles is has a significant correlation with the likelihood of saving a patient.

EMS systems inevitably interact with stop-lights, road blockages, and vehicles. Previous research has shown that seemingly arbitrary variables such as the arrival frequency of buses and taxis to their stops slow down travel time. Additionally, the effects of ambulance diversion (i.e. "a patient not being transported to their initially intended hospital because the hospital is unable to accept patients because of temporary emergency department overcrowding or closure") and clinical handover communication (i.e. "communication between staff in healthcare"), can effect the success rate of EMS systems.

This project details our research on a communications strategy to decrease response times to save lives.

02. Research Question

How can we **decrease** emergency service response time by **increasing** the efficiency of routing through the development of a **universal framework** of communication between EMS, traffic lights, hospitals, and vehicles?

03. Framework

The creation of RapidEMS took into account various factors, such as the level of traffic on the road, the calculated route of all potentially obstructive vehicles, currently obstructive vehicles, and more.

The strategy we have created will be referred to as RapidEMS. The phrase "with RapidEMS" specifies that the strategy has been implemented.

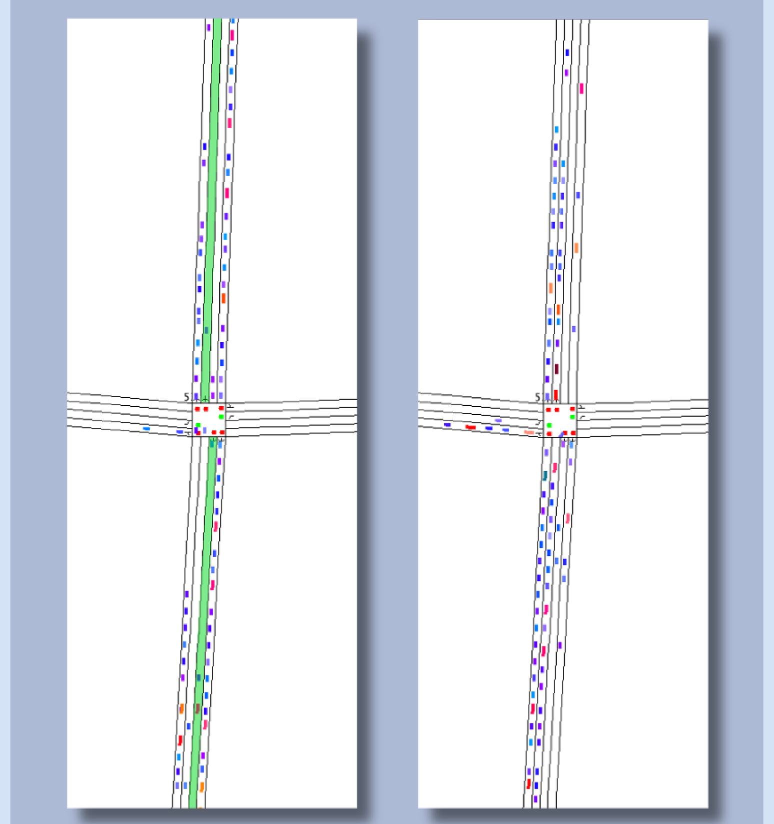

Figure 3. RapidGLD with and without RapidEMS.

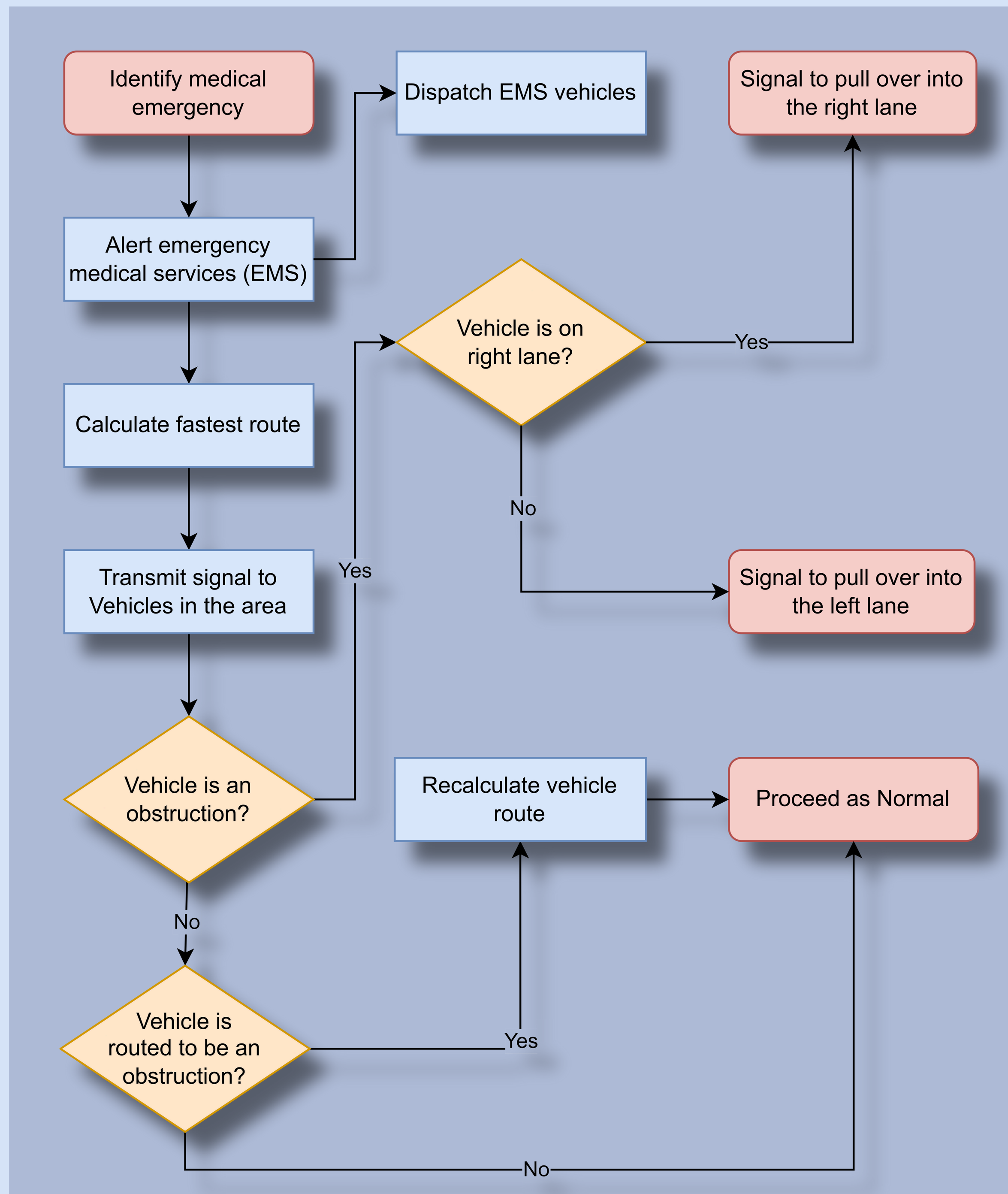

Figure 1. a process flowchart of the RapidEMS communications strategy.

A hardware implementation of RapidEMS would likely utilize a similar process to the one laid out in Figure 2. Refer to section 06. for more information about a hardware implementation.

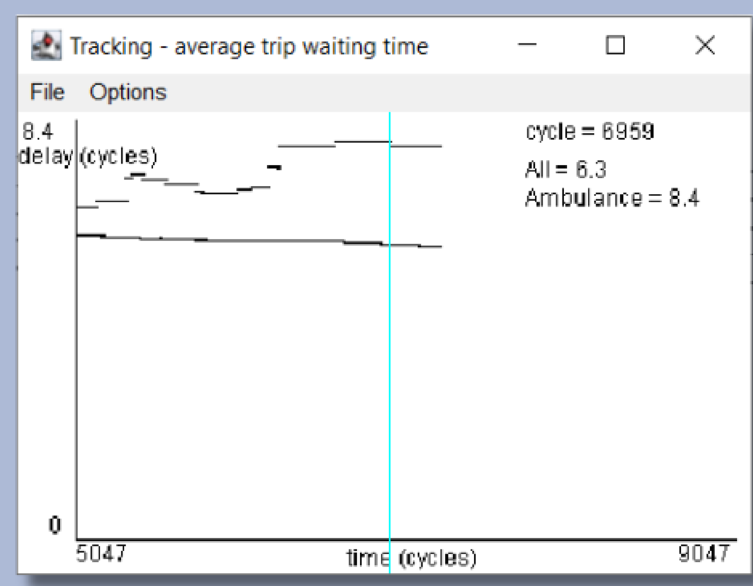

Figure 2. a module within RapidGLD tracking average trip waiting time (i.e. the amount of time an EMS vehicle is not moving)

- Simulation of our strategy was conducted using RapidGLD, which we developed. RapidGLD is a derivative of Green Light District (GLD) Simulator, a traffic simulator designed to test the performance of reinforcement learning (RL) traffic light controllers. RapidGLD enables us to test our strategy across varying levels of traffic density in a fully operational traffic infrastructure.
- The map used to attain our results was created based on a location in Bronx, New York, which was a randomly chosen urban environment.
- In GLD (and RapidGLD), the unit of time used is known as **cycles**. One cycle represents one "step" of the simulation, in which every decision is made.
- Vehicle spawn chance represents the likelihood of a vehicle "spawning" on an edge node within the simulation. In other words, it represents the level of traffic on the road.
- Waiting times were tested via RapidGLD (as seen in Figure 2) to test our strategy's effectiveness.

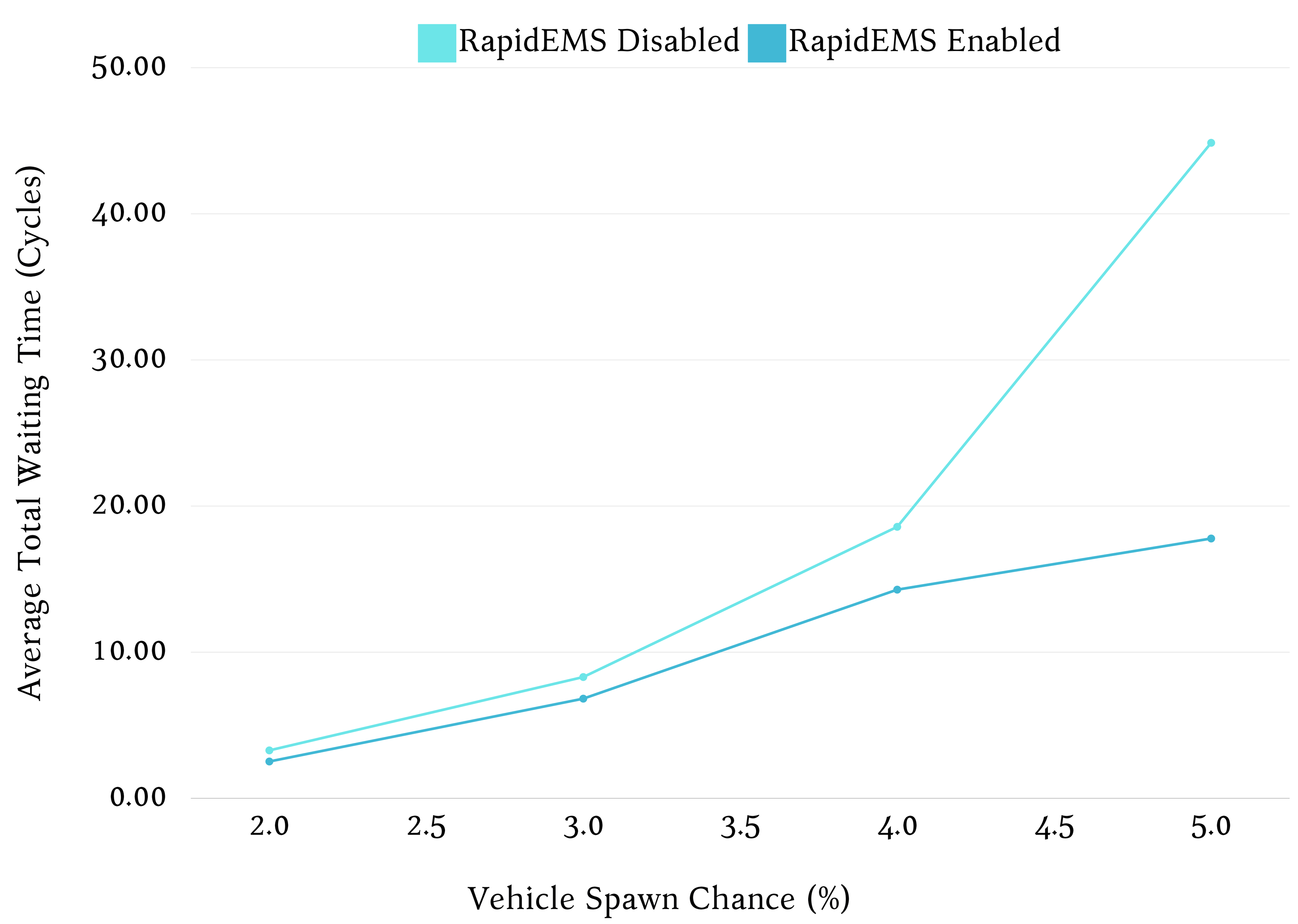

Figure 4. Average total waiting times produced in RapidGLD with and without the implementation of RapidEMS.

04. Analysis

The employment of the RapidEMS strategy significantly decreases average EMS vehicle waiting times by ~23.17%, ~17.83%, ~23.14%, and ~60.37% at a spawn chance of 2, 3, 4, and 5 percent, respectively. RapidEMS, as tested in RapidGLD, becomes increasingly effective at reducing total waiting times (and therefore reducing the total response times) of EMS vehicles.

Spawn Chance	Total Waiting Time (Cycles)					
	Trial					Mean
	1	2	3	4	5	
2%	2.4	2.4	2.4	2.6	2.8	2.52
3%	6.9	6.8	6.8	6.7	6.9	6.82
4%	13.2	14.9	15.2	14.1	14	14.28
5%	17.7	17.7	17.2	18.4	17.9	17.78

Table 1. Total waiting times of ambulances at various traffic levels with RapidEMS

Spawn Chance	Total Waiting Time (Cycles)					
	Trial					Mean
	1	2	3	4	5	
2%	3.4	3.2	3.2	3.3	3.3	3.28
3%	8.4	8.5	8.2	8.1	8.3	8.30
4%	19.3	18.9	18.7	18.3	17.7	18.58
5%	45.5	48.5	45.1	43.2	42.0	44.86

Table 2. Total waiting times of ambulances at various traffic levels without RapidEMS

05. Conclusion

The utilization of a communications strategy similar to RapidEMS is likely to be effective at reducing emergency service response times. As expected, higher levels of traffic lead to greater levels of obstruction on the road, thereby increasing the effectiveness of proper communication.

06. Limitations

- Only one map was used
- Focused only on urban areas
- Waiting time may not be the best indicator of response times
- The strategy was only tested using a simulator which may behave differently from real scenarios

07. Future Plans

- Build a hardware prototype to showcase how an implementation of RapidEMS would function in a vehicle
- Utilizes GPS Modules and Raspberry Pi's that would represent an ambulance and a civilian vehicle to demonstrate the lane routing and alerting

08. Key References

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