Traffic-Light Control for Emergency Vehicles

Rodrigo Gonçalves de Branco
Prof. Edson Norberto Cáceres - Advisor
Prof. Ronaldo Alves Ferreira

June 26, 2020

College of Computing
Federal University of Mato Grosso do Sul - UFMS

Motivation

Ambulance stuck in traffic, five-year-old boy dies on way to hospital in Bhubaneswar

The minor boy, Pratik was being rushed to the private hospital at P... deteriorated.

Published: 12th February 2020 01:23 AM | Last Updated: 12th February 2020 09:38

Ambulance waiting times soared in March as calls hit record high

By Alison Moore | 9 April 2020

- National average for category two calls 32:06 minutes in March, against a target of 18 minutes
- Average category two response in London more than an hour in March
- Ambulances responded to a record 866,575 answered calls last month

The response time for the commonest ambulance call out rose 45 per cent in March nationally and almost trebled in London, the centre of the coronavirus pandemic.

Patient Dies After Ambulance Crashes Head-On With Car

Want to Beat Traffic in Tehran? Hire an Ambulance—Just Remember, It's Illegal

Iran's capital city is seeing a rise in wealthy citizens using emergency vehicles to shorten their

Patients die as Manila traffic jams block ambulances and motorists don't yield

Ambulances delayed by traffic light

By Syam Manohar, Gulf News Reader www.gulfnews.com

I would like to bring to *Gulf News'* attention, a very important situation that might sometimes be a matter of life and death.

I live near Rashid Hospital roundabout, next to the Dubai Metro station, which is currently under construction.

Because of the hospital, ambulances arrive at the junction at all times of the day. However, they often get delayed while approaching the hospital from 10th Street – the road near the football stadium and school zone.

For some reason, the duration of the wait at the traffic signal on this road is twice as long as the others. Only after other signals turn green twice does this signal turn green once.

Motivation

20 per cent of emergency patient deaths blamed on traffic jam delays

Jan 16. 2017

By The Nation

MORE THAN 20 per cent of patients needing emergency treatment have died on their way to hospital because of delays due to traffic jams and uncooperative motorists, National Institute of Emergency Medicine (NIEM) secretary-general Anucha Setthasathian said.

Thailand - 20% of death due to traffic jam - Jan 2017!

Problems and Goals

Big picture - Mobility and Public Transportation

Problems and Goals

Reduce the delay (time loss) of the EV in traffic

Using traffic light (TL) preemption

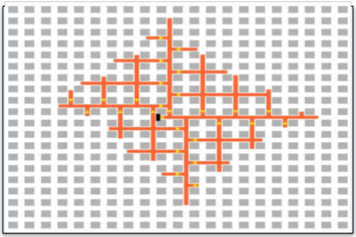
Do not impact (too much) other vehicles!

Problems and Goals

Research challenges

- Does green light mean vehicles passing through?
- Is it an optimization problem?
- Is it NP-Hard?
- Can we use probabilistic modeling?

Related Work

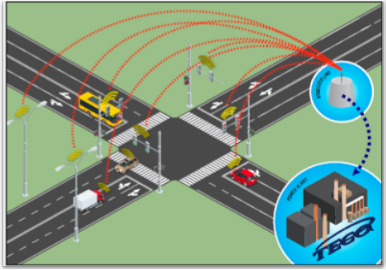


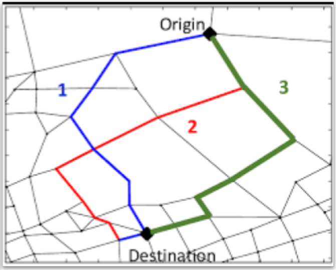
Proximity sensors ✗

Focus on intersection ✗

Unrealistic scenarios ✗

Related Work





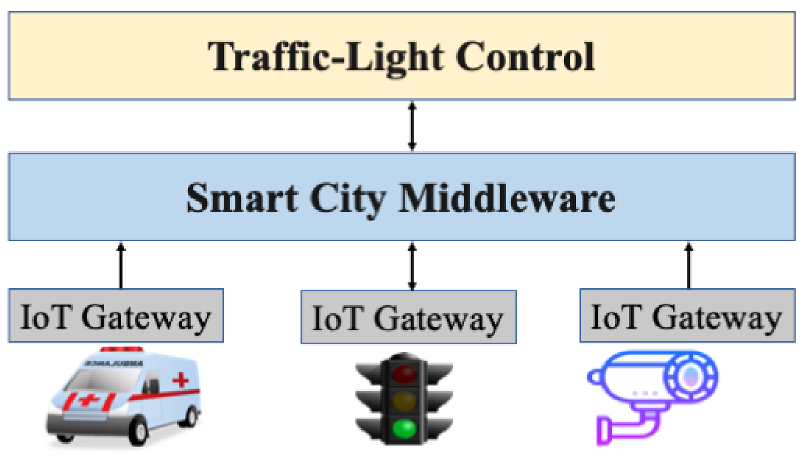
Different EVs, with different routes ✗

Hard-to-deploy infrastructure ✗

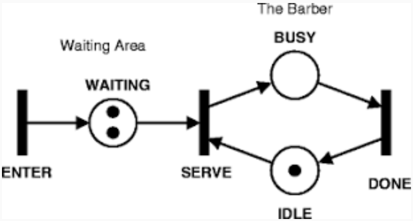
Lack of formal properties of safety for the entire EV route ✗

Data Gathering - Smart City Middleware

Focus on solution!!!



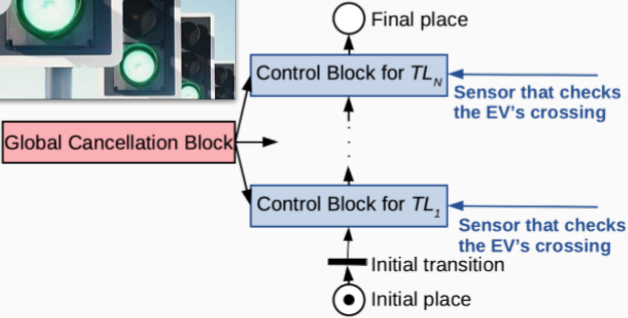
Proposed Solution - TPN



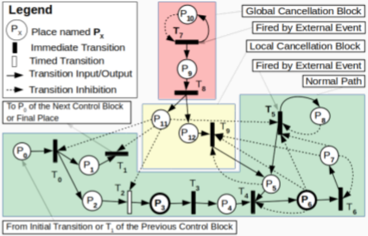
Directed Graph

- Useful to model distributed, parallel and concurrent systems
- Places, transitions, and directed edges
- Transitions can be fired when tokens are present in their input places
- Timed Petri Net - minimum time to fire a transition

Control of all TLs in the EV route



Individual control of a TL



$$T_{2_i} = \begin{cases} 0, \text{if } \frac{d_{TL_i}}{ASLpath_i} \leq \epsilon \text{ or } ASpath_i \leq \delta \\ \max\{(\frac{d_{TL_i}}{ASLpath_i} - t_{flush_i}) \times (1 - Opath_i), 0\} \end{cases} \quad (1)$$

Why is it safe?

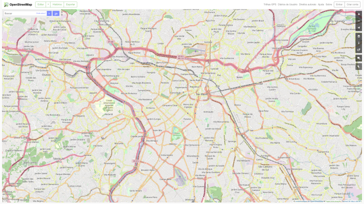
i It executes at most one preemption action

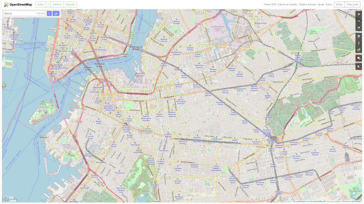
ii It does not restore the state of any TL_i before its preemption

iii It executes at most one restore action

The token that gets to P_3 arrives only via P_0, which receives a token only once from the *Initial Transition* for TL_1 or from T_1 of TL_{i-1} for all TL_i, $2 \leq i \leq N$. Because the preemption action happens when the token gets to P_3, a control block executes at most one preemption.
For properties *(ii)* and *(iii)*, the token must get to P_6 via T_4. As T_4 depends on P_4 and P_3, a control block does not restore the state of a TL_i before P_3 triggered the preemption. Likewise, because P_4 gets only one token, the restore action happens at most once.

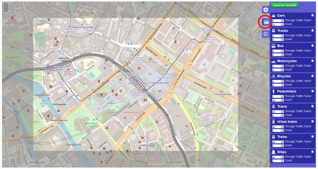
Performance Evaluation





- SUMO Simulator
- SP and NY
- All routes were generated using the OSMWebWizard tool
- Cars, trucks and motorcycles

Performance Evaluation



Scenario	Car	Truck	Moto	Total
1	3494	1167	2355	7016
2	5826	2322	4694	12842
3	8136	3509	5855	17500
4	10457	4656	7041	22154
5	12258	5624	8000	25882

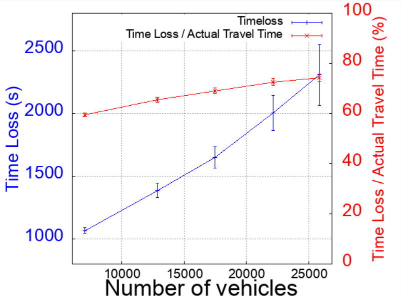
(a) Sao Paulo

Scenario	Car	Truck	Moto	Total
1	2128	706	1431	4265
2	3544	1412	2833	7789
3	5009	2151	3639	10799
4	6422	2847	4353	13622
5	7830	3579	5045	16454

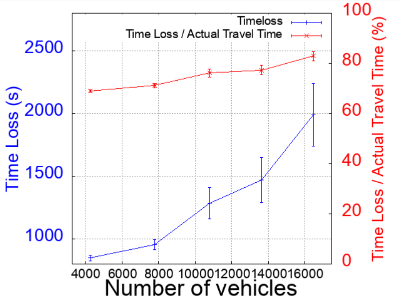
(b) New York

- A vehicle was chosen to be the EV in each city (crossing 65 TLs)
- Routes
  - EV: fixed
  - Other: dynamic
- Two other algorithms: RFID and Fuzzy
- 60 independent simulation runs

Simulation Results - Time Loss - No Preemption

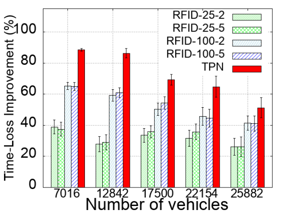


(e) SP

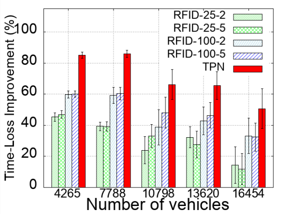


(f) NY

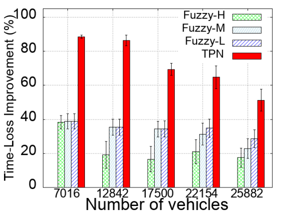
Simulation Results - Time Loss Improvement - TPN × RFID And Fuzzy



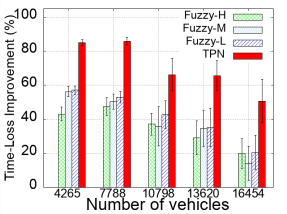
(g) SP



(h) NY

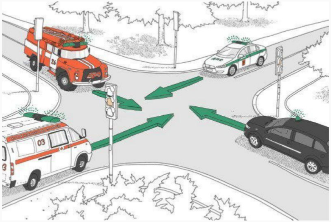


(i) SP



(j) NY

Limitations and Future Work



- Use more than one EV (conflict policies)
- Allow improvement beyond 100%
  - by allowing that the EV speed be greater than the maximum speed limit of the streets
- Integrate our solution with the InterSCity middleware
  - real *versus* simulated time
- Go deep on Research challenges

Final Considerations

- Source code at `https://github.com/smartcity-tpn-preemption/tpn-preemption`
- Comparision example
    - SP-1 `https://youtu.be/_AgZ3HyDgCs`
    - SP-5 `https://youtu.be/7r_lyiemsE0`

My e-mail: `rodrigo.g.branco@gmail.com`