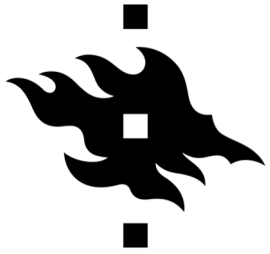
ERL: Edge based Reinforcement Learning for optimized urban Traffic light control

Pengyuan Zhou, Tristan Braud, Ahmad Alhilal,

Pan Hui, Jussi Kangasharju



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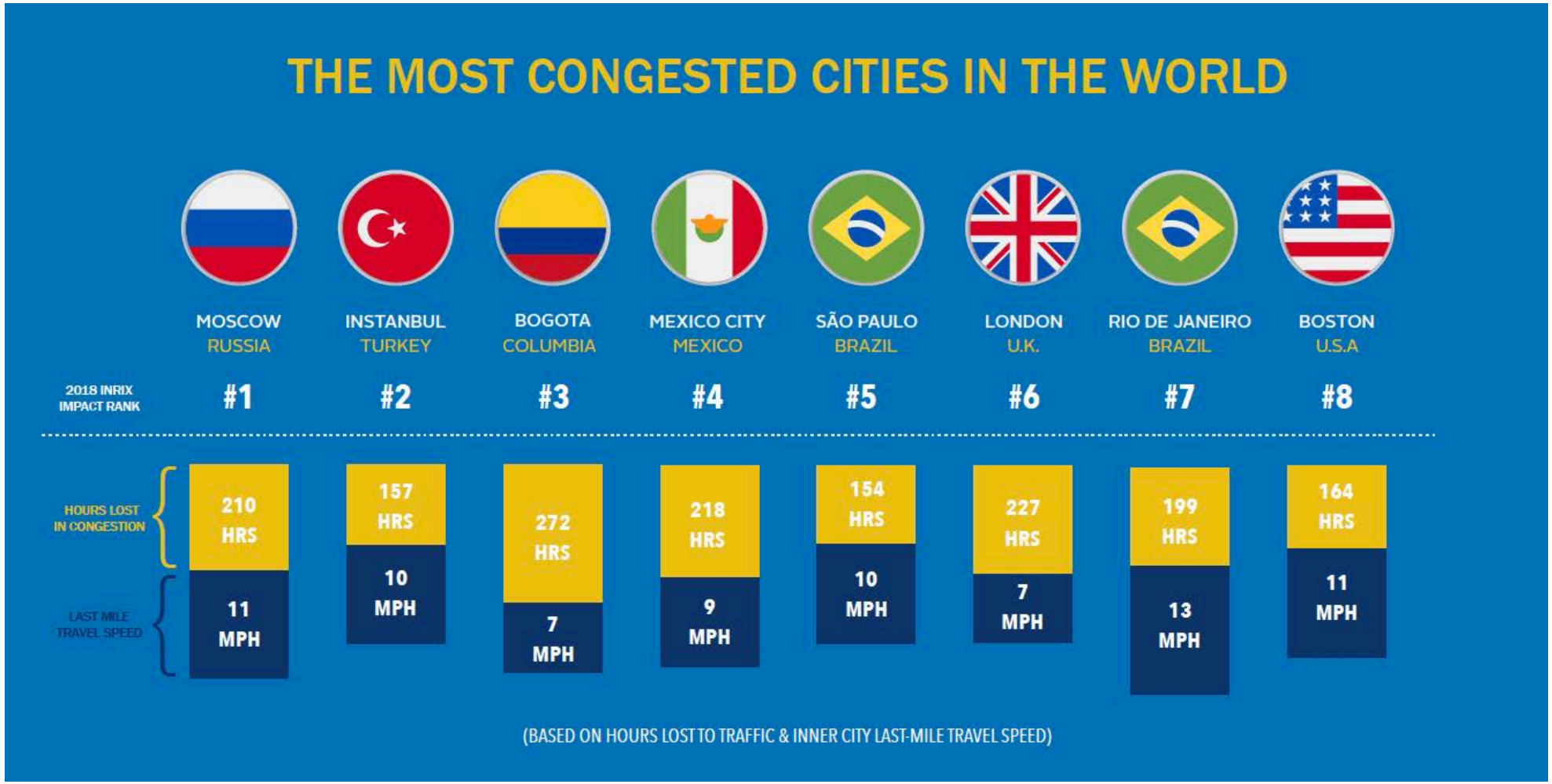
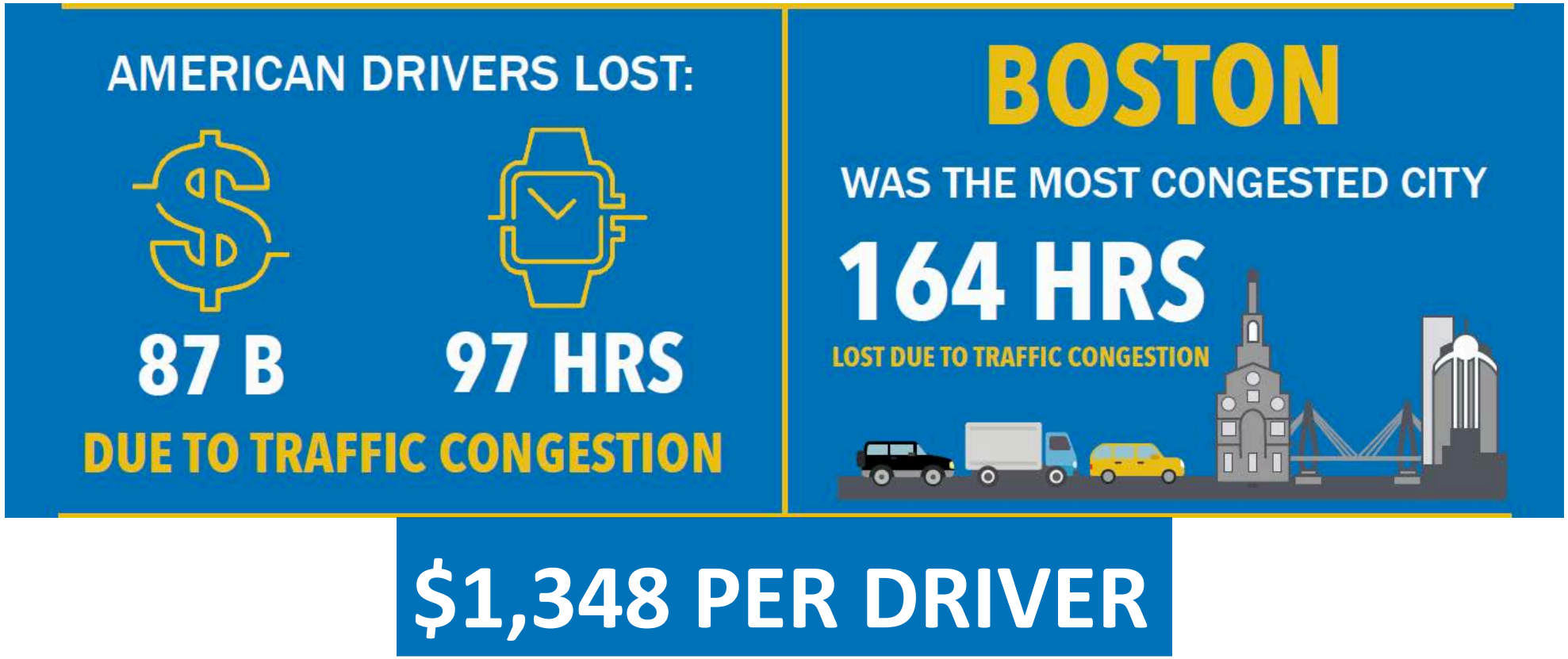
Traffic Congestion



INRIX Research, 2018

Traffic Congestion



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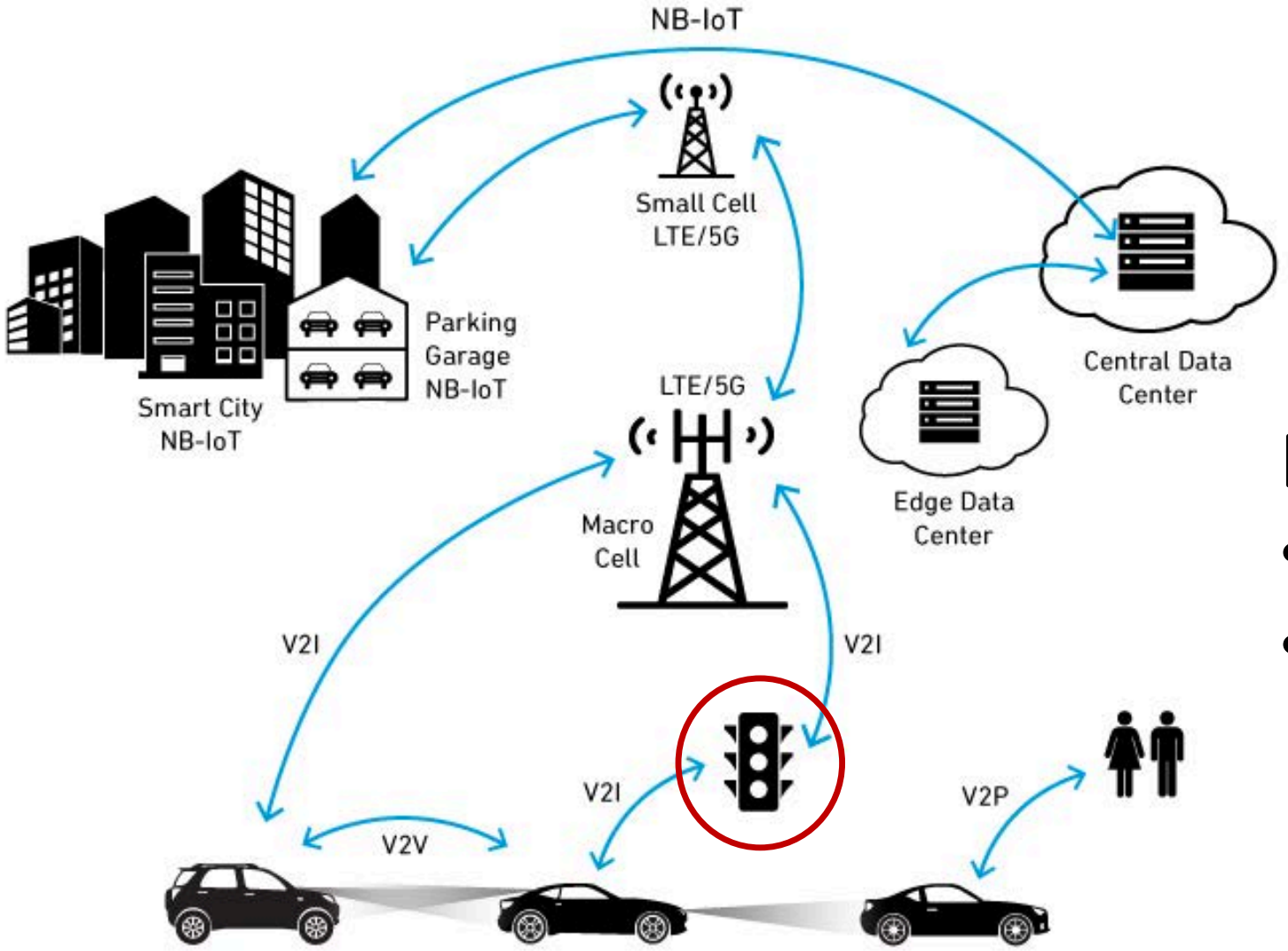
Vehicular Network, a way out?



Better data provision

- Fast network (5G)
- More connections (V2X)

Challenges

Information → Gather

Information → Share

Information → Feedback

Fast

Options

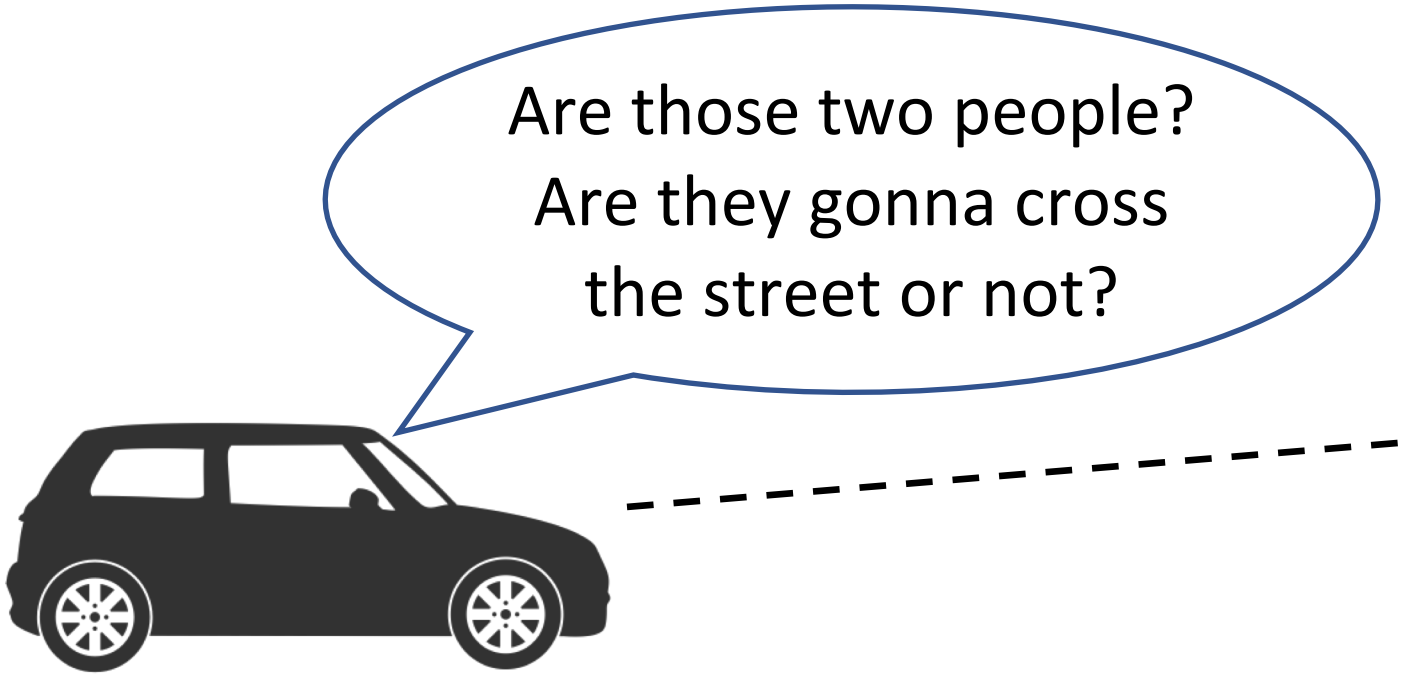
Cloud?

Automotive?

Or

EDGE

Hazards of self-driving



Hazards of self-driving

BIZ & TECH // BUSINESS

After Uber accident, fewer people want self-driving cars

David R. Baker | Aug. 16, 2018 | Updated: Aug. 16, 2018 4 a.m.

1 of 3

A Cruise self-driving car is tested last year on 11th Street in San Francisco.

Photo: Paul Chinn / The Chronicle 2017

Most Popular

- It's no laughing matter — SF forming Poop Patrol to keep sidewalks clean
- Carr Fire's horrendous tornado captured in newly released videos
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- Whatever happened to the Giants' Joe Panik?
- Massive Carr Fire tornado trapped, killed Redding firefighter, report says
- Report finds 'worrisome' levels of lead, arsenic in some baby foods
- Millionaire tech mogul Gurbaksh Chahal faces jail

Pros and Cons

Solution	Pros	Cons
Cloud	Global collection	Large delay
Smart Vehicle	Fast computation	Limited view
Edge	1. Extended view 2. Small delay	Deployment cost

Why Edge?

Delay:
as small as possible

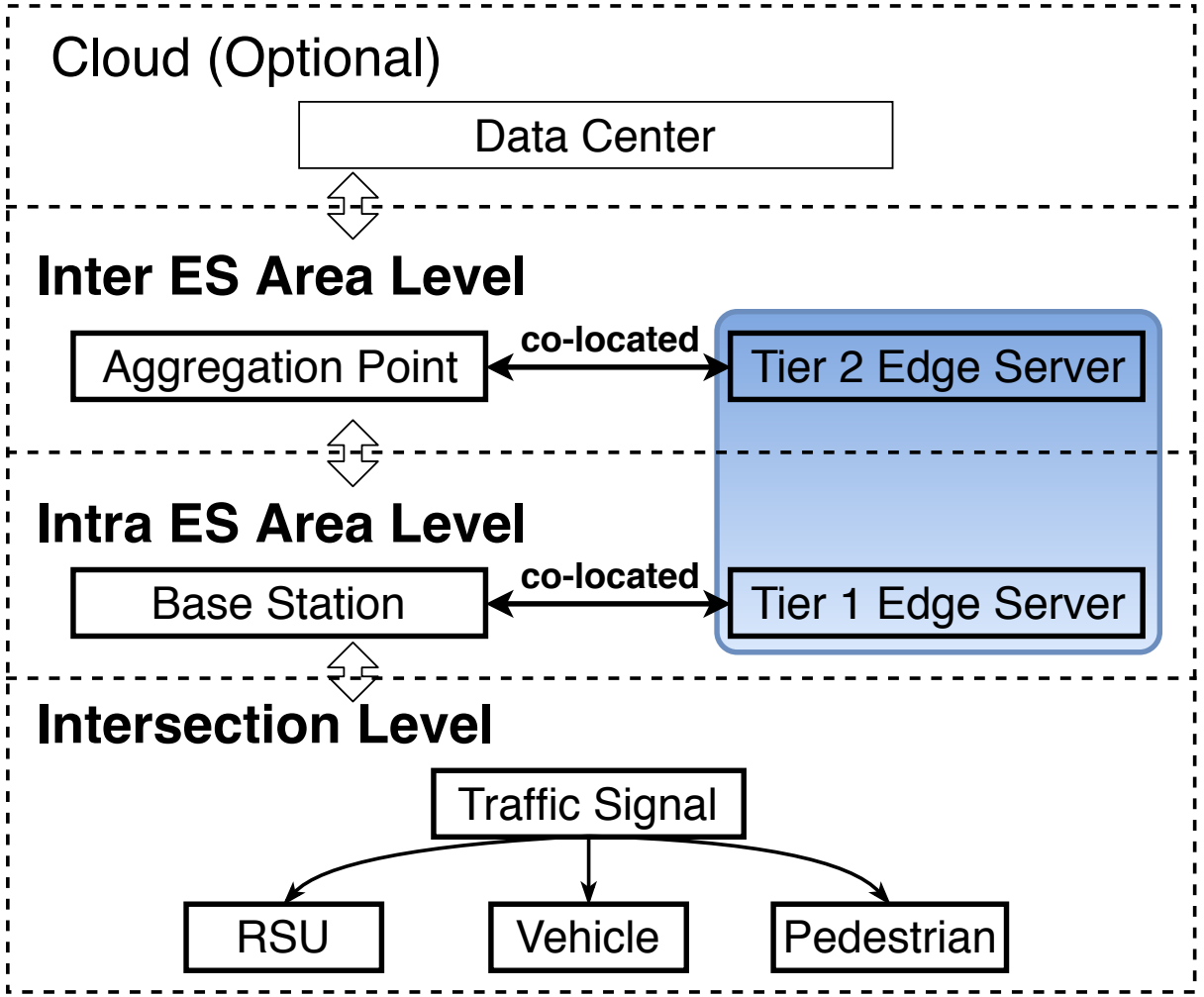
View:
large enough

Processing:
sufficient

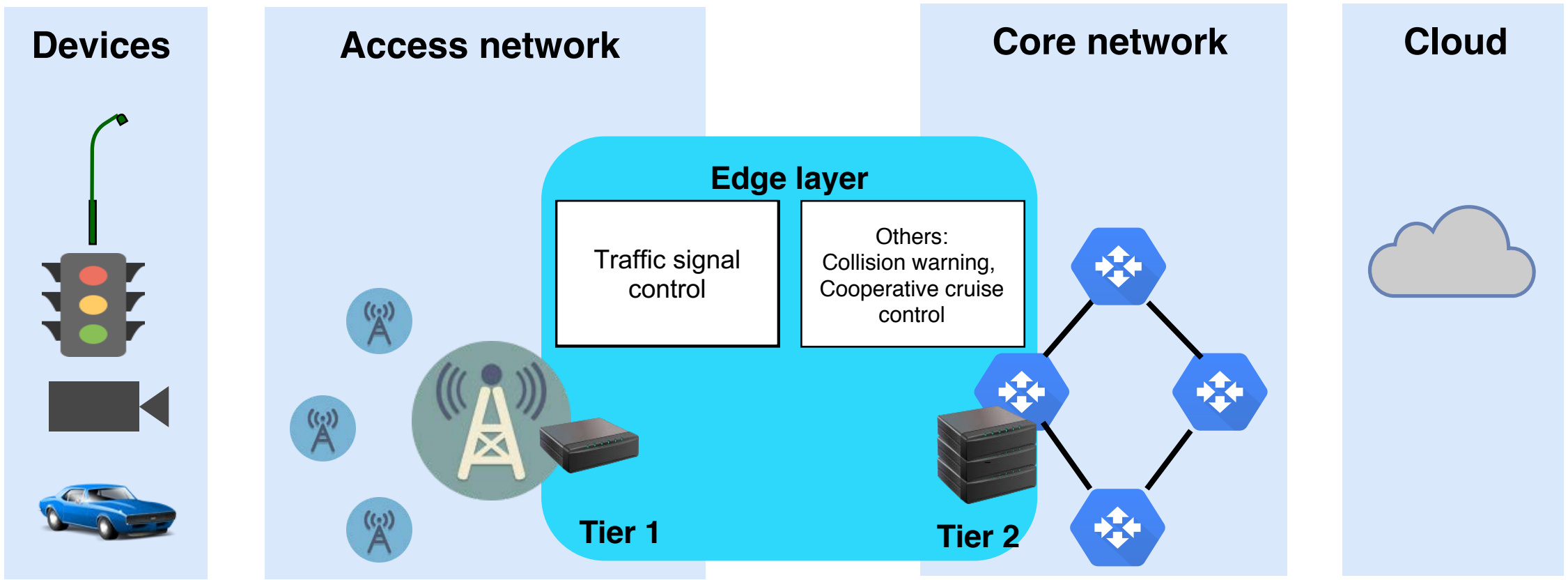
ERL (Edge based Reinforcement Learning)

- System Architecture
- Reinforcement Learning
- Preliminary Evaluation

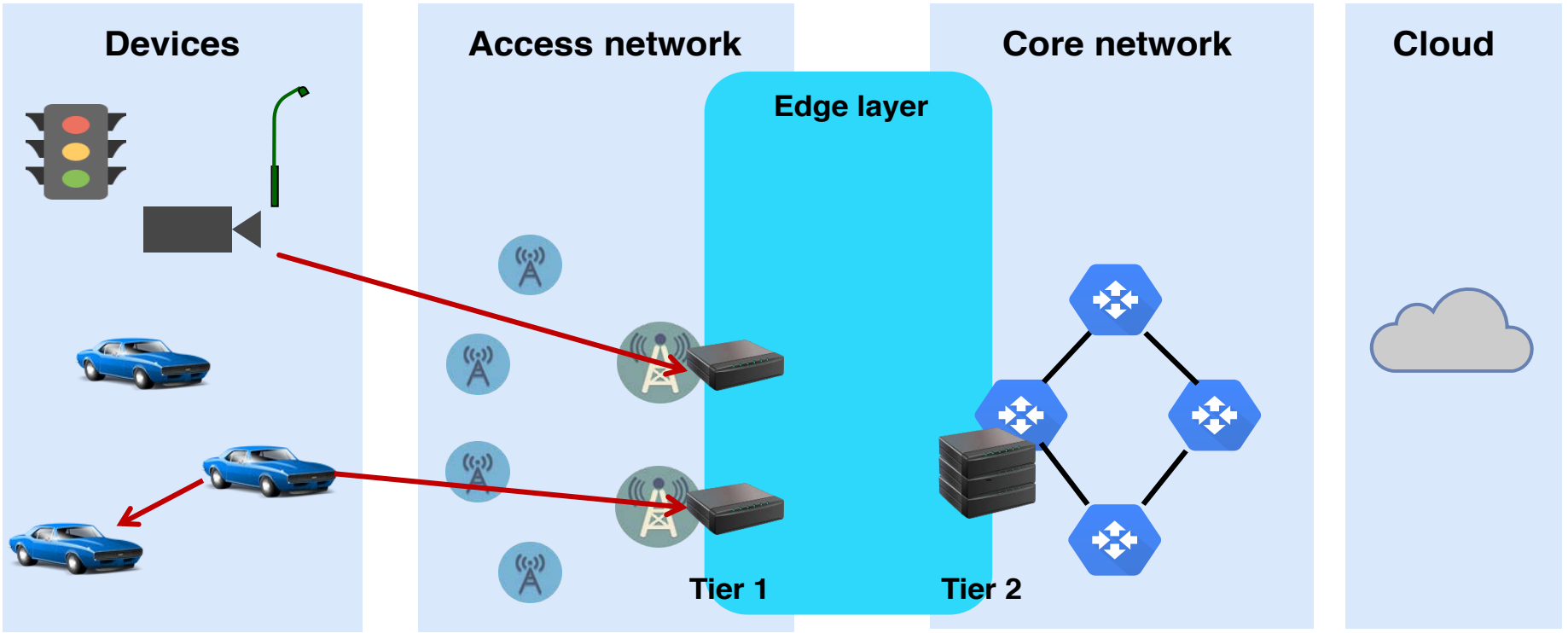
System Architecture



System Architecture

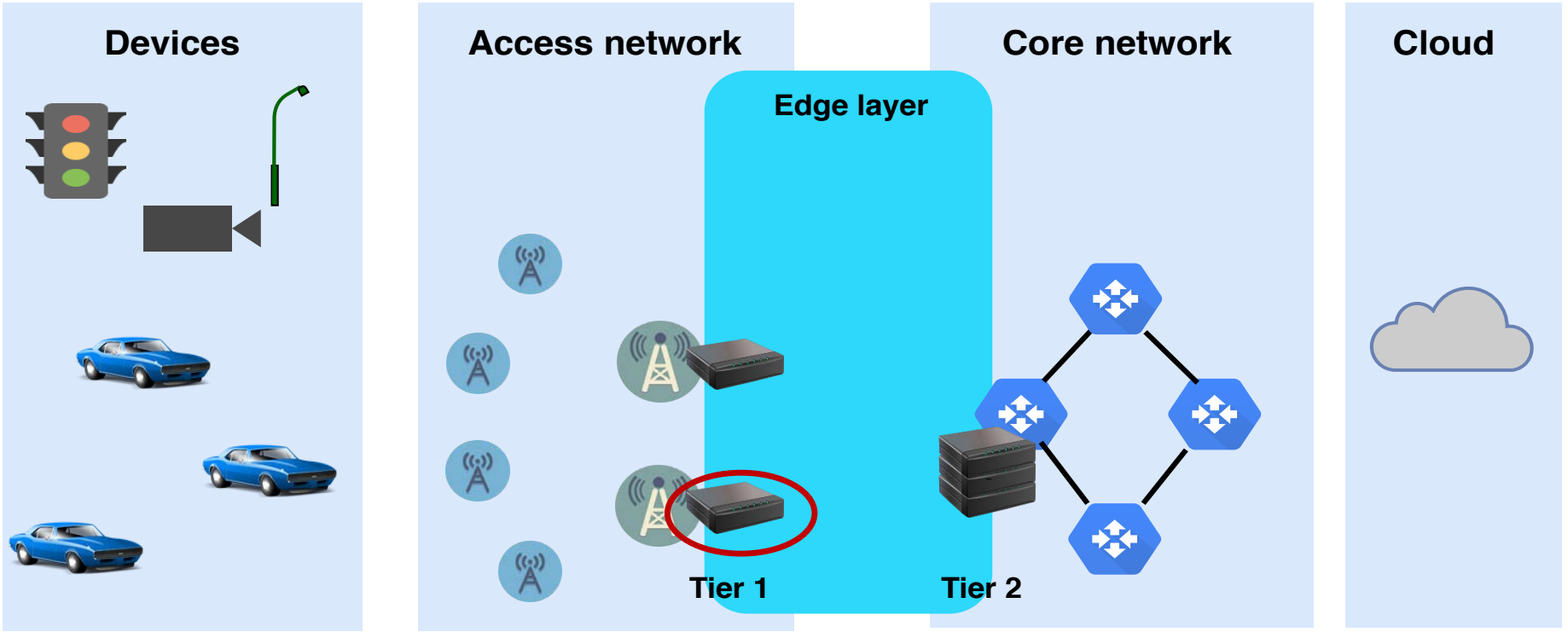


Communication Model



Neighbor notification
Data processing
Data transmission
Data dissemination
Data aggregation
Data upload

Communication Model



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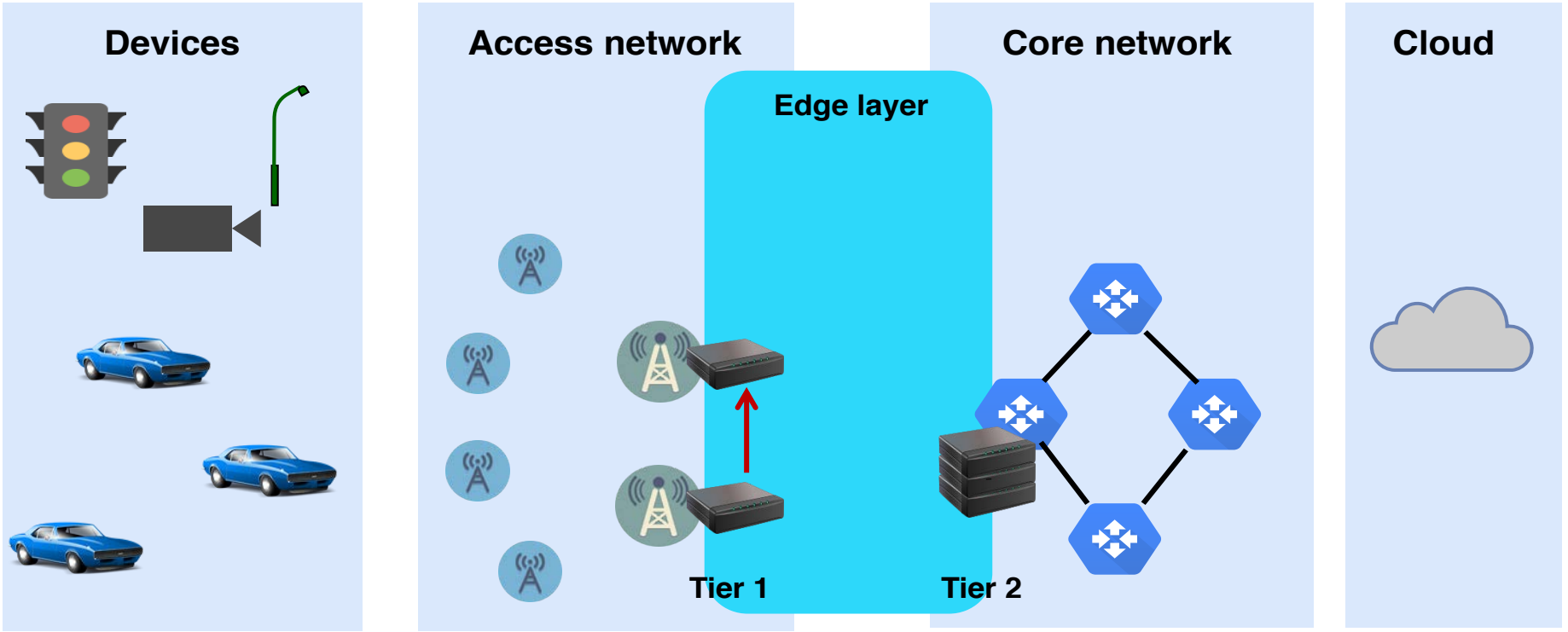

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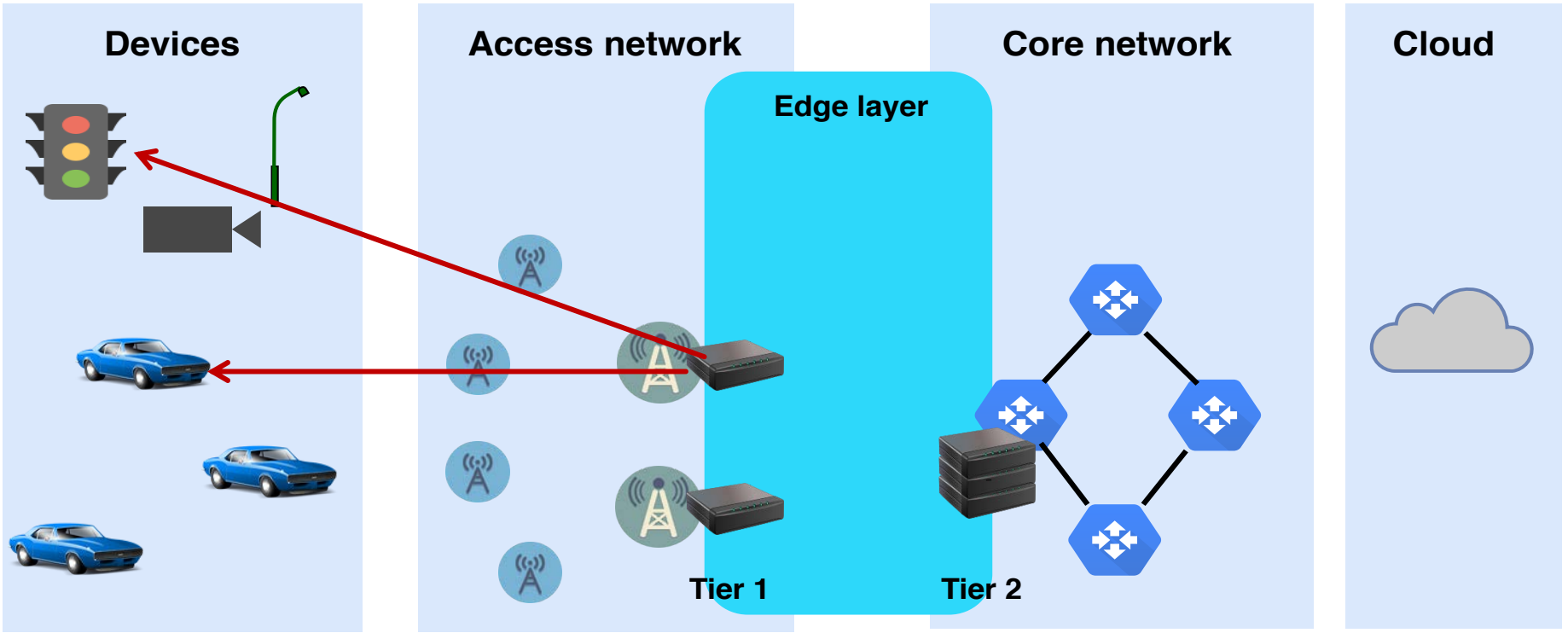

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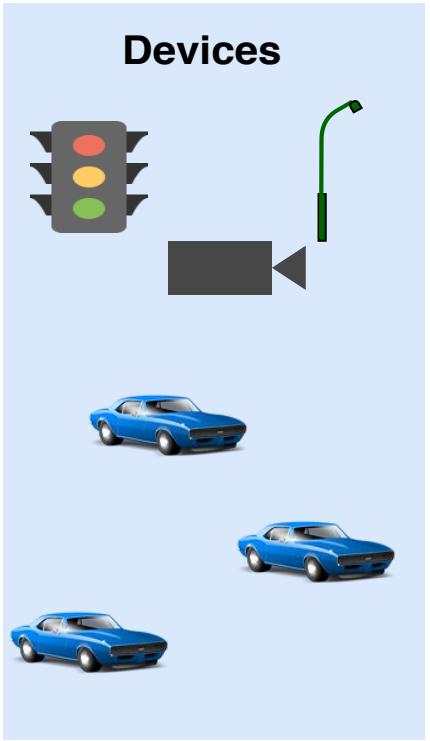

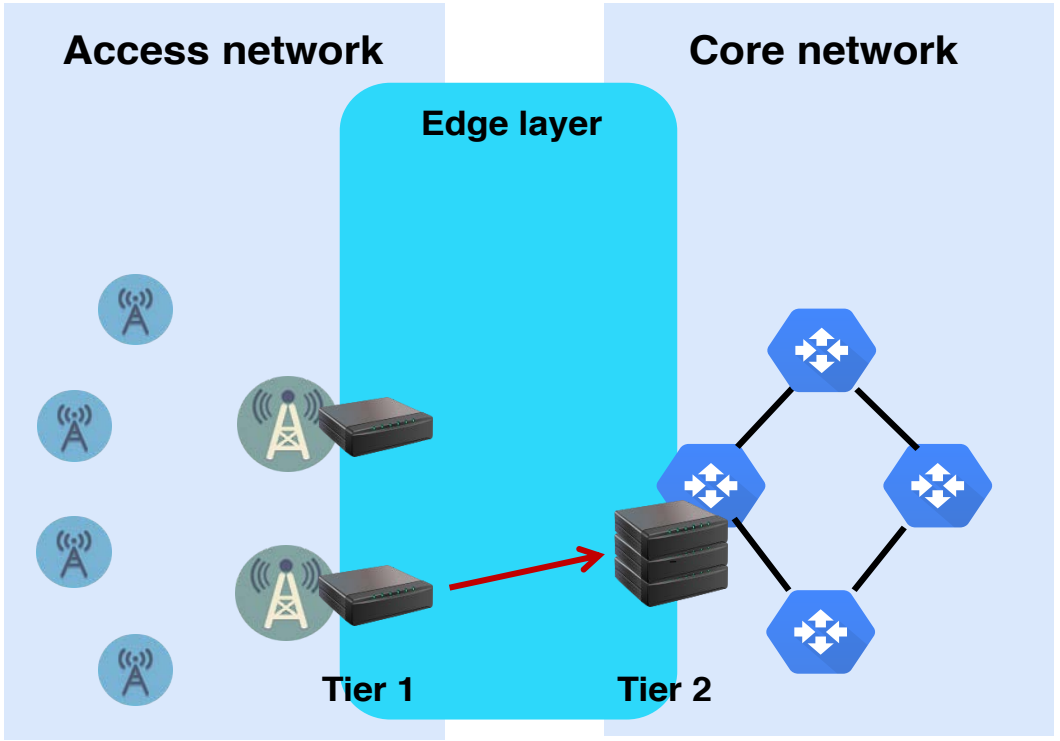

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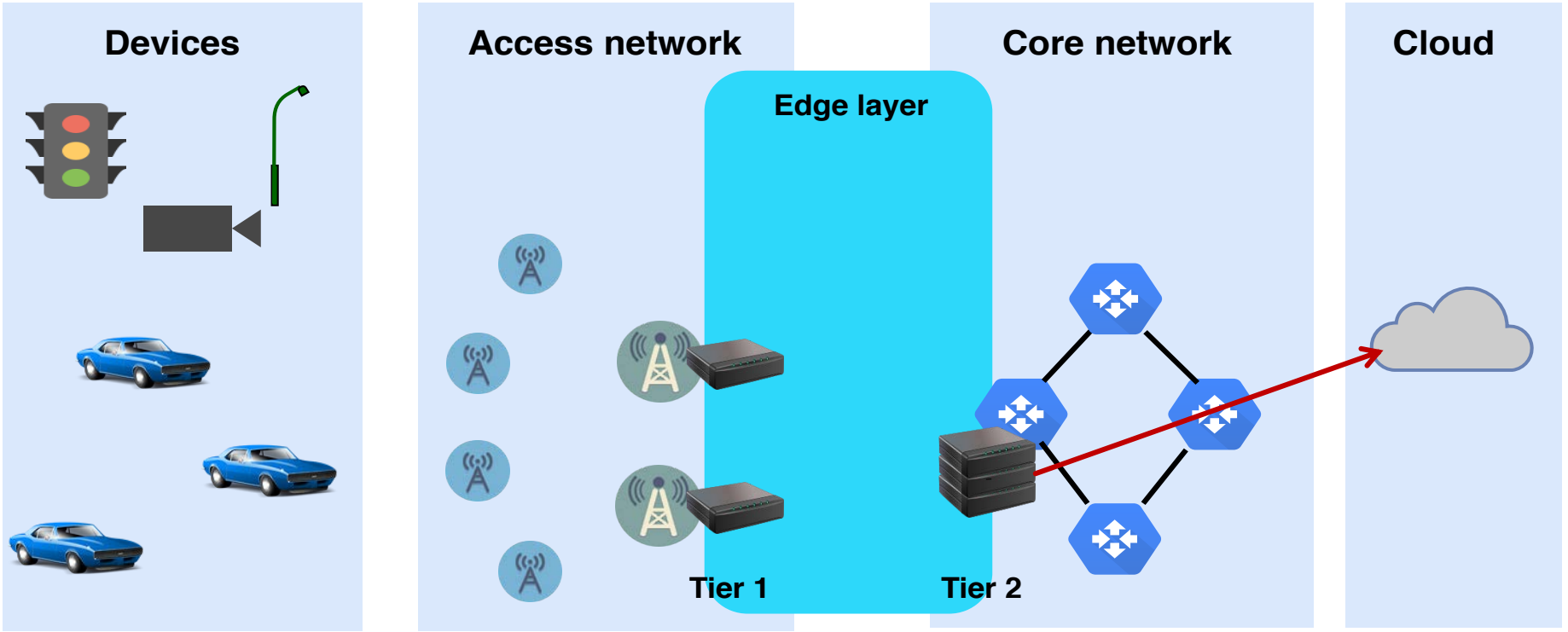

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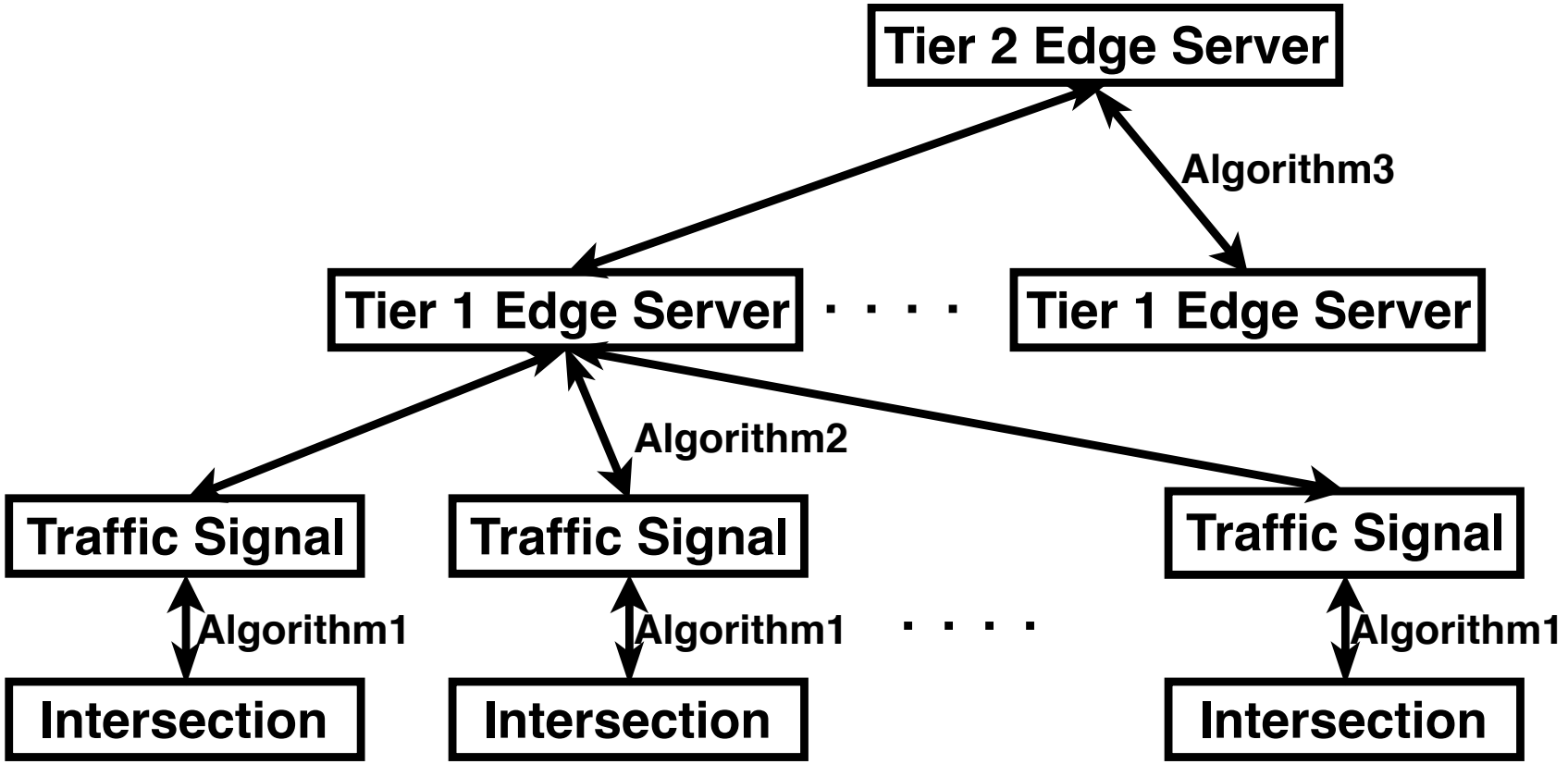
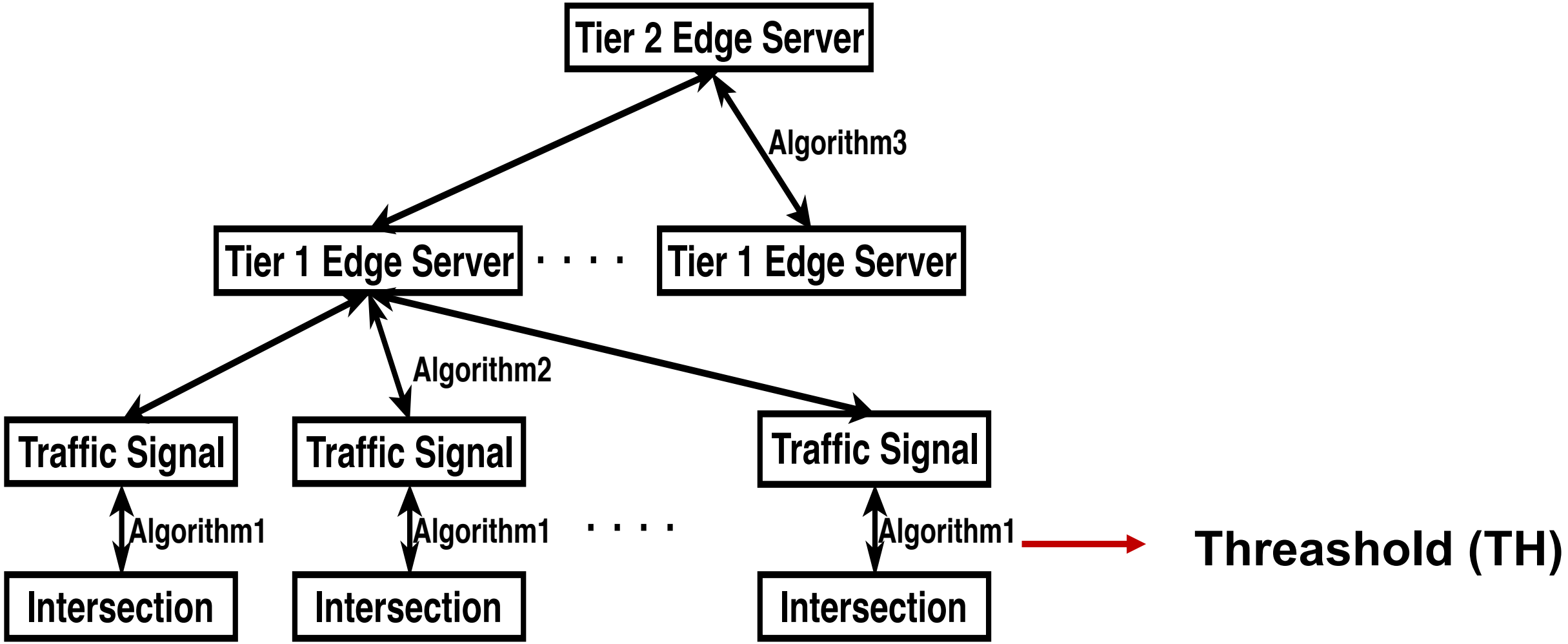
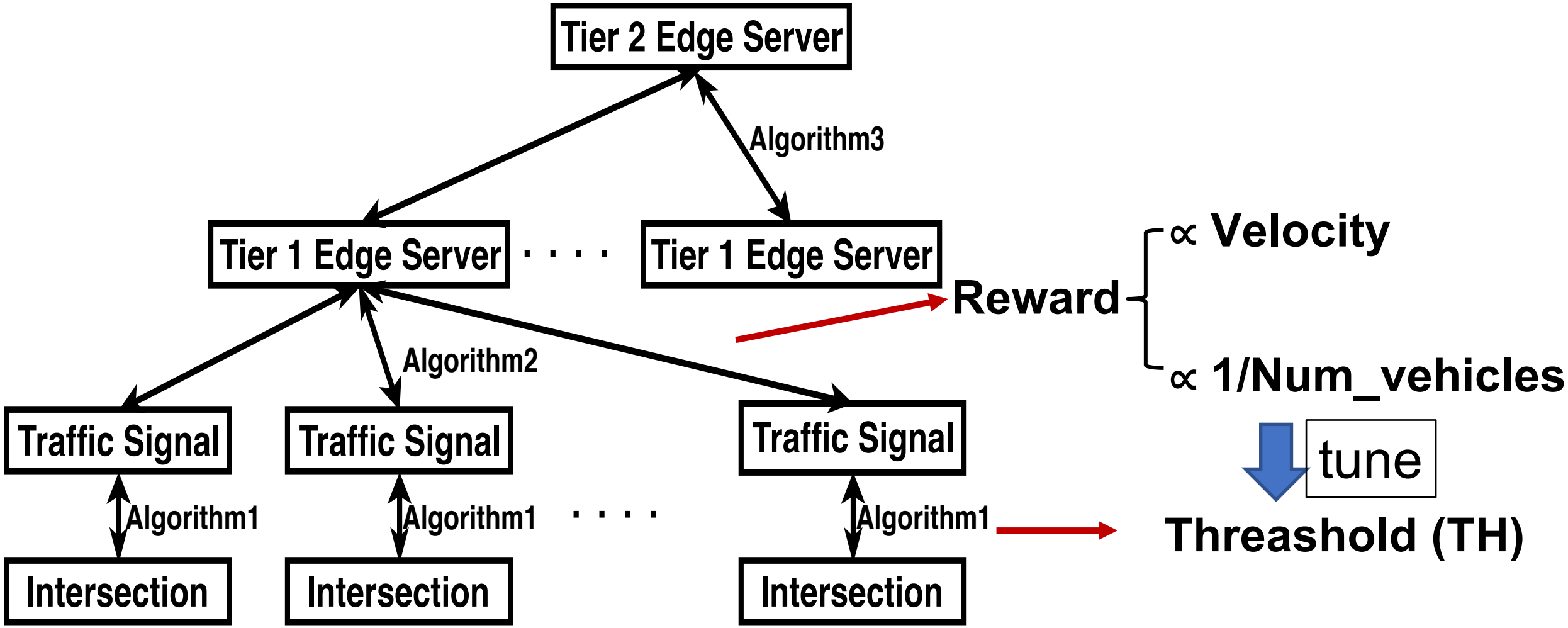
Layered Algorithm



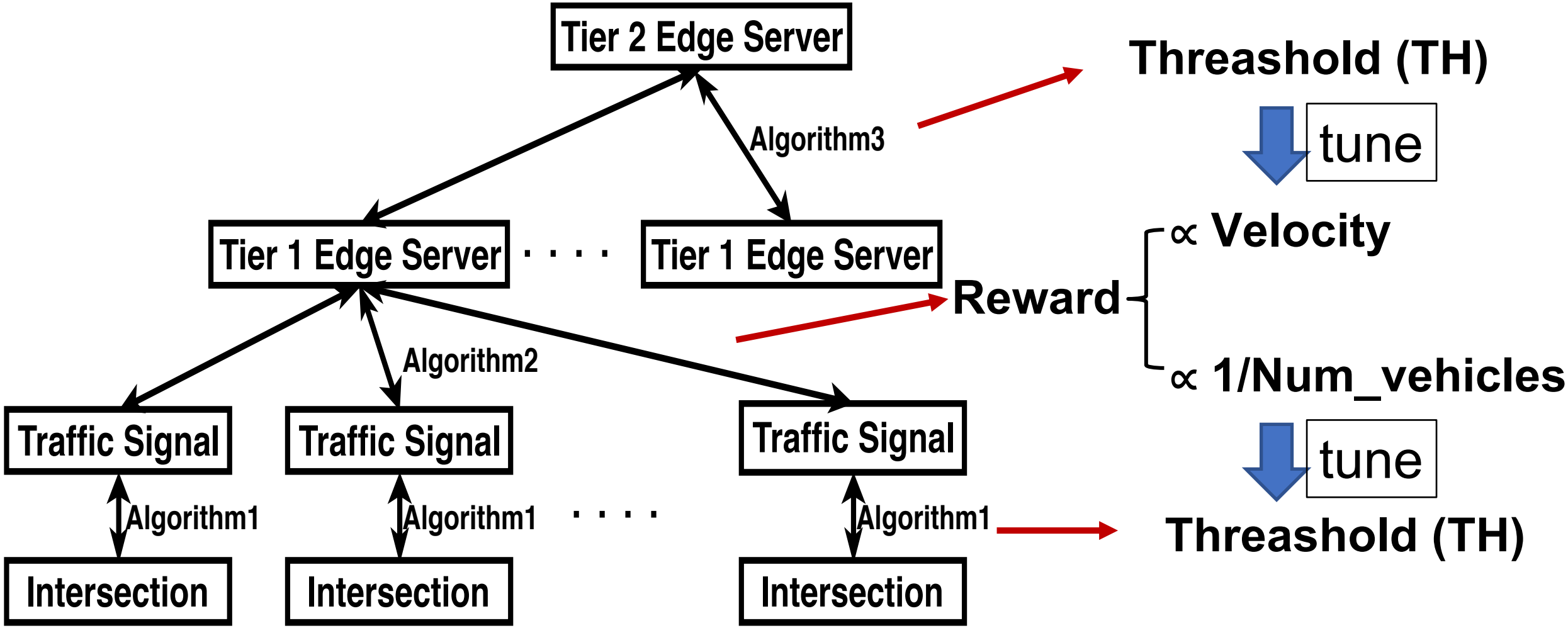
Intersection Level



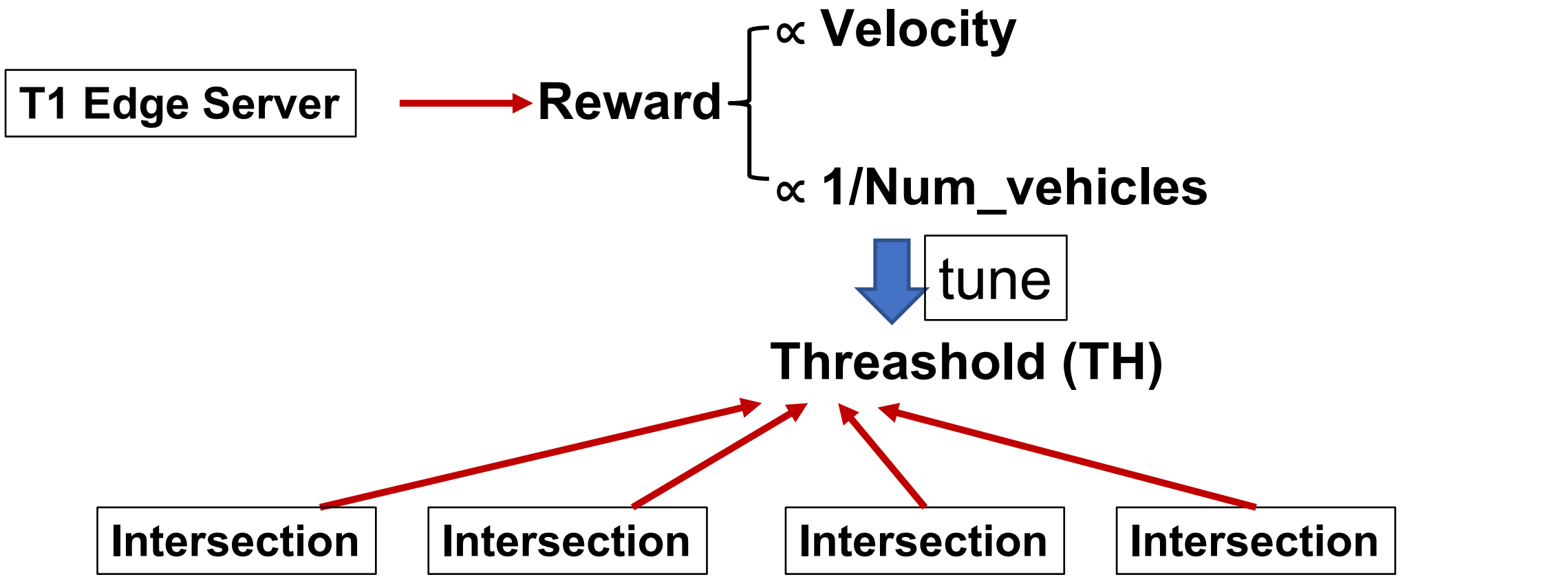
Intra ES-area Level



Inter ES-area Level



Scalability

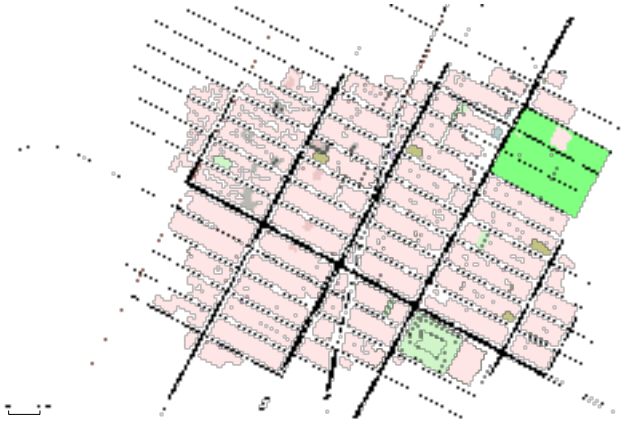


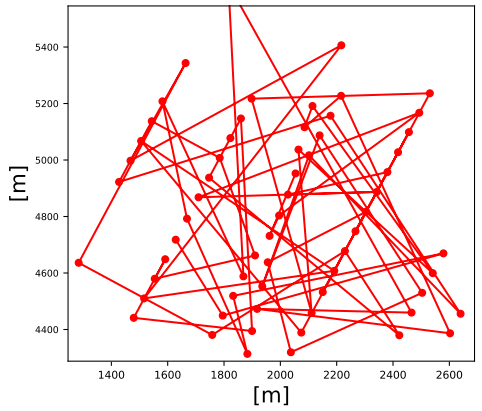
A normal algorithm demands huge capcity,
e.g., 470 Gigabytes for 15 traffic lights (6-phase each, addup to 6^{15})

Preliminary Evaluation

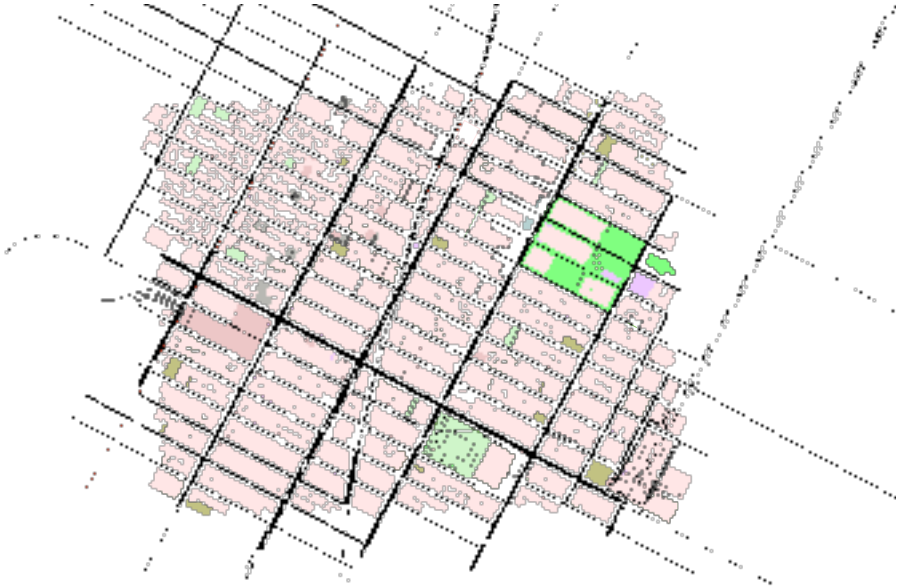
- Map: Central New York City maps with different scales
- Adapted algorithm: Algorithm 2 (intra ES-area level)
- Metrics:
  - Adaption period
  - Adaption unit
  - Monitoring metric: *vehicle speed* or *waiting queue length*

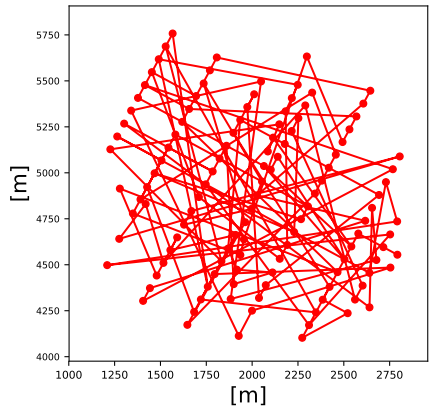
Map





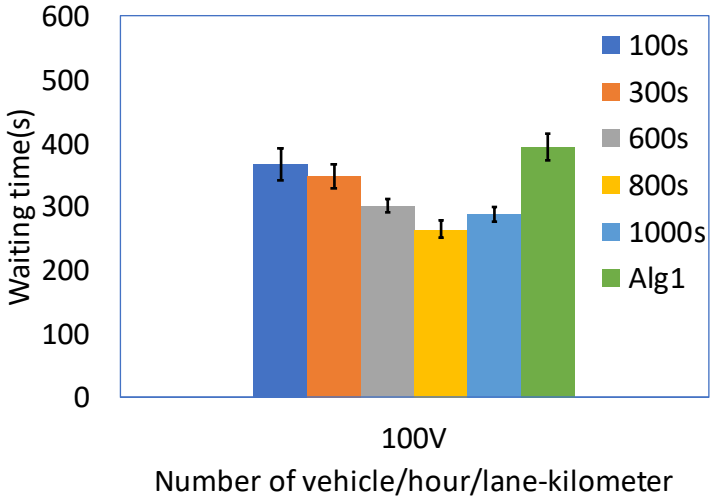
67 lights

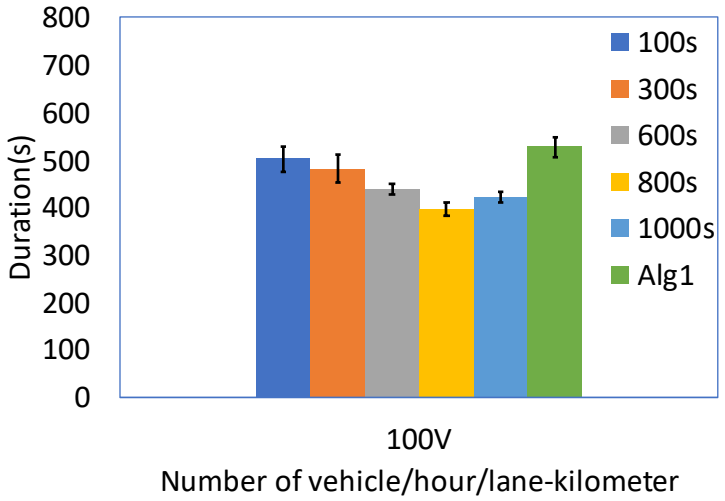


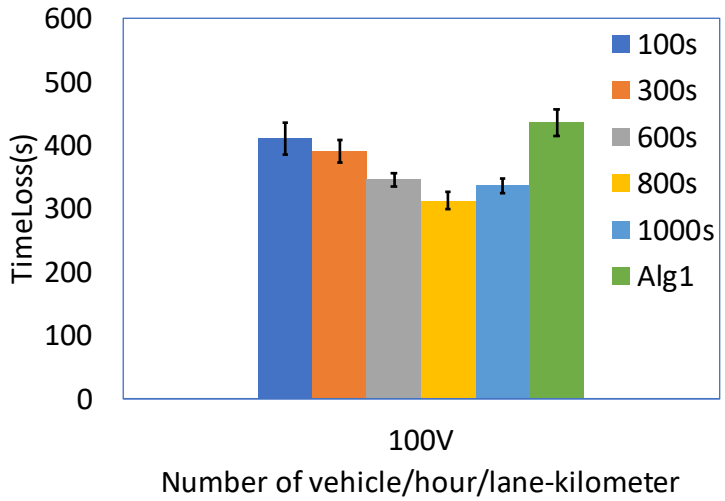


127 lights

Results


600
500
400
300
200
100
0
Waiting time(s)
100s
300s
600s
800s
1000s
Alg1
100V
Number of vehicle/hour/lane-kilometer


800
700
600
500
400
300
200
100
0
Duration(s)
100s
300s
600s
800s
1000s
Alg1
100V
Number of vehicle/hour/lane-kilometer


600
500
400
300
200
100
0
TimeLoss(s)
100s
300s
600s
800s
1000s
Alg1
100V
Number of vehicle/hour/lane-kilometer

Conclusion

- Our system exploits the low latency of Edge servers to provide fast DNN training and control feedback.
- ERL runs optimization at intersection, neighborhood and city level that allow for different fine-grained and scale of traffic control.
- We enable the coupling of neighboring lights adaptation and decrease the dimension of action space, allowing ERL to scale to city block size with fast training and control feedback.
- The preliminary results show that ERL improves traffic light control in some scenarios, e.g., smaller scale of map.

Thank You!
Q & A

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