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PALM: Platoons Based Adaptive Traffic Light Control System for Mixed Vehicular Traffic

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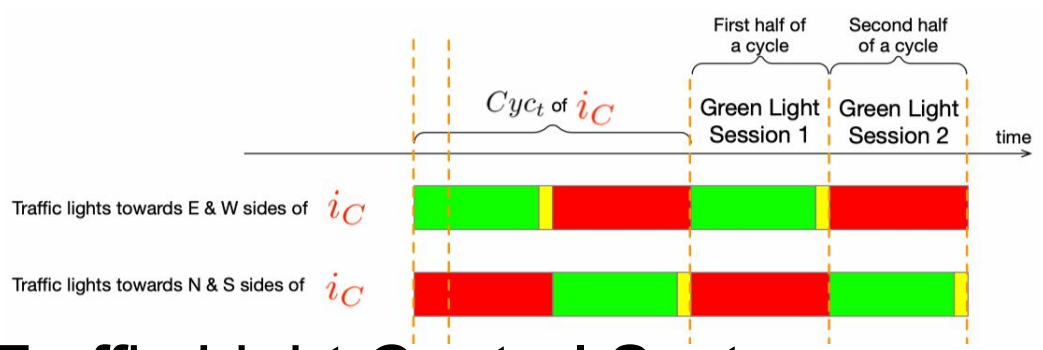
Background

- Autonomous Vehicles (AVs) and Human-Driven Vehicles (HVs) will co-exist in near future
- The coexistence will make the traffic management even harder
- Traffic lights continue to be a major contributor to reducing congestion

Technical Gap

- TLCS for HVs
  - Many in human history
- TLCS for AVs
  - Emerging a lots in recent years
- TLCS for mixed vehicular traffic
  - Few

Contributions



- Propose an efficiency Traffic Light Control System (TLCS) for AVs and HVs mixed traffic
  - Consider mixed traffic
  - Consider traffic flow at nearby intersections
  - Consider platoons of CAV
- Adjust for each green light session instead of cycle

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PALM: Platoon based Adaptive traffic Light control system for Mixed vehicular traffic

- Traffic Flow Watcher (TFW): observes the traffic at each intersection and collects measurements.

- Traffic Light Controller (TLC): schedules the next green light sessions based on the TFW measurements.

- Green Light Extender (GLE): grows current green duration if there barely are vehicles in orthogonal directions while there is continuous traffic flow coming in current directions.

- Platoon Coordinator (PC): adjusts the schedule for near future made by TLC when there are platoons existed.

TFW

If exceeds one, it means the throughput of that flow grows, and congestion is unlikely to happen.

$$\gamma_{PV} = \frac{PV_t\left(F\left(sou,\ tgt\right)\right)}{PV_{t-1}\left(F\left(sou,\ tgt\right)\right)}$$

When the ratio exceeds one, the load is getting larger with growing possibility of congestion.

$$\gamma_{DV} = \frac{DV_t\left(F\left(sou,\ tgt\right)\right)}{DV_{t-1}\left(F\left(sou,\ tgt\right)\right)}$$

A value bigger than one means that the vehicles have to wait for longer time to pass the intersection and consequently the probability of congestion is growing.

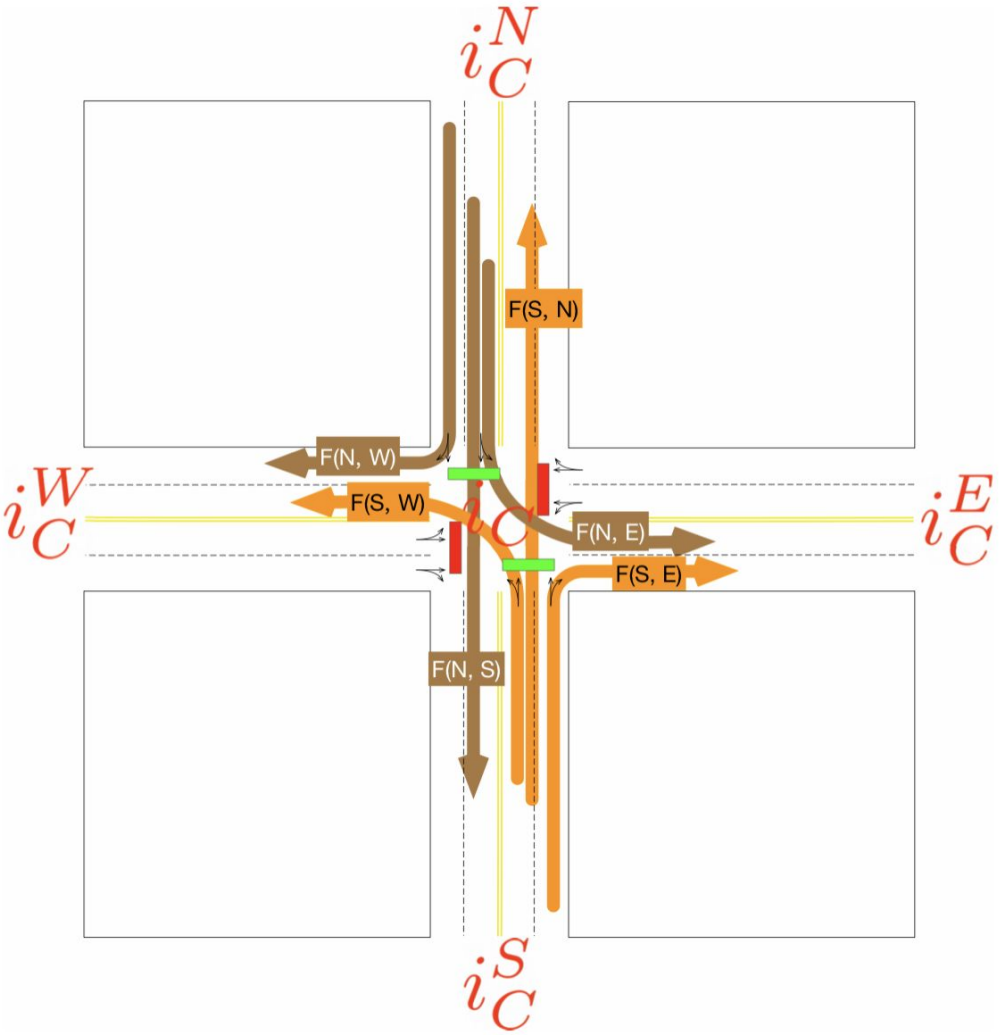
$$\gamma_{AWT} = \frac{AWT_t\left(F\left(sou,\ tgt\right)\right)}{AWT_{t-1}\left(F\left(sou,\ tgt\right)\right)}$$

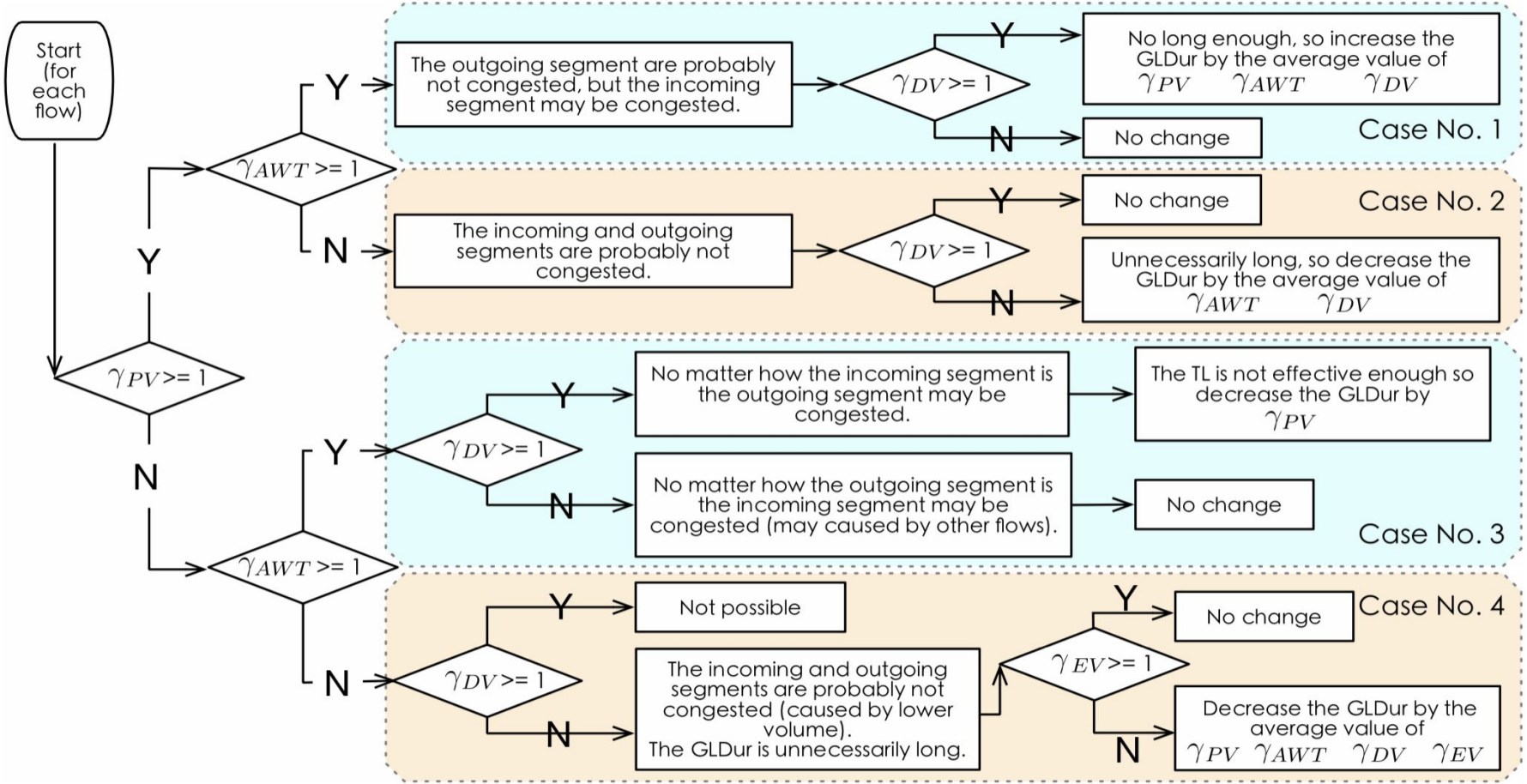
It denotes the ratio of the numbers of expected vehicles of flow F (sou, tgt) during the previous two cycles. If it surpasses one, the load during Cyc(t+1) is expected to rise.

$$\gamma_{EV} = \frac{EV_t\left(F\left(sou,\ tgt\right)\right)}{EV_{t-1}\left(F\left(sou,\ tgt\right)\right)}$$

TLC

- Case 1 Sufficient remaining capacity:
  - let all vehicles pass
- Case 2 Insufficient remaining capacity:
  - TLC dynamically adjusts phase duration
  - Consider Four ratios provided by TFW
  - Cooperate with PC when necessary (explained later)


i_C^N
F(S, N)
F(N, W)
i_C^W
F(S, W)
i_C
F(N, E)
i_C^E
F(S, E)
F(N, S)
i_C^S


Start (for each flow)
γ_{PV}>= 1
Y
N
γ_{AWT} >= 1
Y
N
The outgoing segment are probably not congested, but the incoming segment may be congested.
γ_{DV}>= 1
Y
N
No long enough, so increase the GLDur by the average value of γ_{PV} γ_{AWT} γ_{DV}
No change
Case No. 1
The incoming and outgoing segments are probably not congested.
γ_{DV}>= 1
Y
N
No change
Unnecessarily long, so decrease the GLDur by the average value of γ_{AWT} γ_{DV}
Case No. 2
γ_{DV}>= 1
Y
N
No matter how the incoming segment is the outgoing segment may be congested.
The TL is not effective enough so decrease the GLDur by γ_{PV}
No matter how the outgoing segment is the incoming segment may be congested (may caused by other flows).
No change
Case No. 3
γ_{DV}>= 1
Y
N
Not possible
The incoming and outgoing segments are probably not congested (caused by lower volume).
The GLDur is unnecessarily long.
γ_{EV}>= 1
Y
N
No change
Decrease the GLDur by the average value of γ_{PV} γ_{AWT} γ_{DV} γ_{EV}
Case No. 4

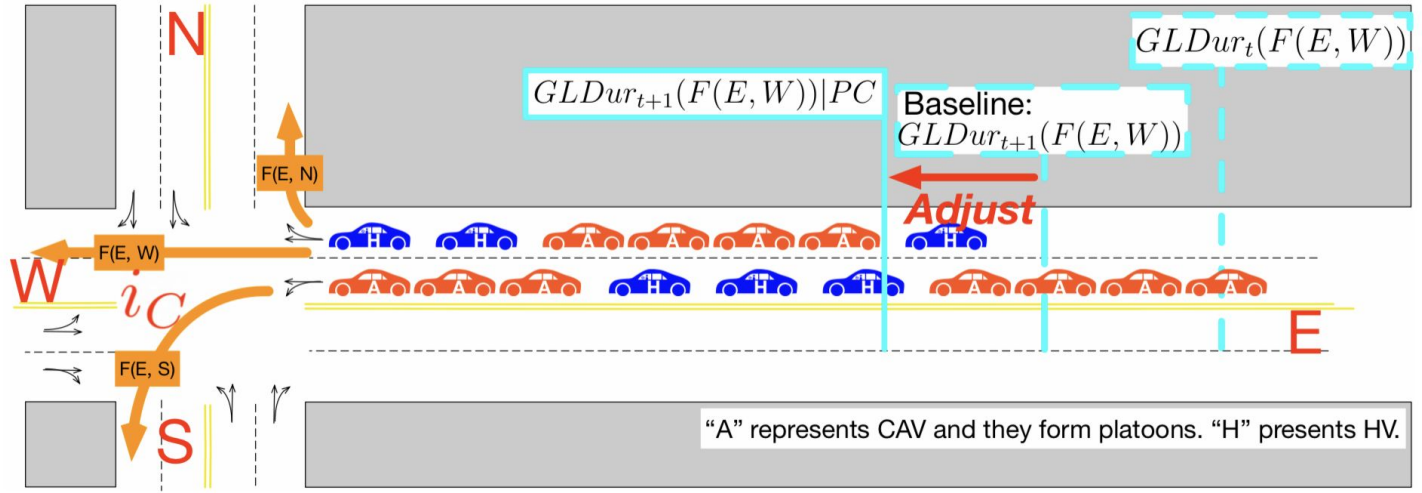
GLE

At the end of current green light, if there are no vehicles in orthogonal directions within a certain proximity to the intersection and meanwhile there are continuous uninterrupted vehicle flow coming, GLE extends the current green light:

When there is a platoon, extend until last vehicle of the platoon

When no platoon, extend by three seconds

PC



Principle of the PC is to favor longer platoons and tries to keep them intact because platoon has better performance.

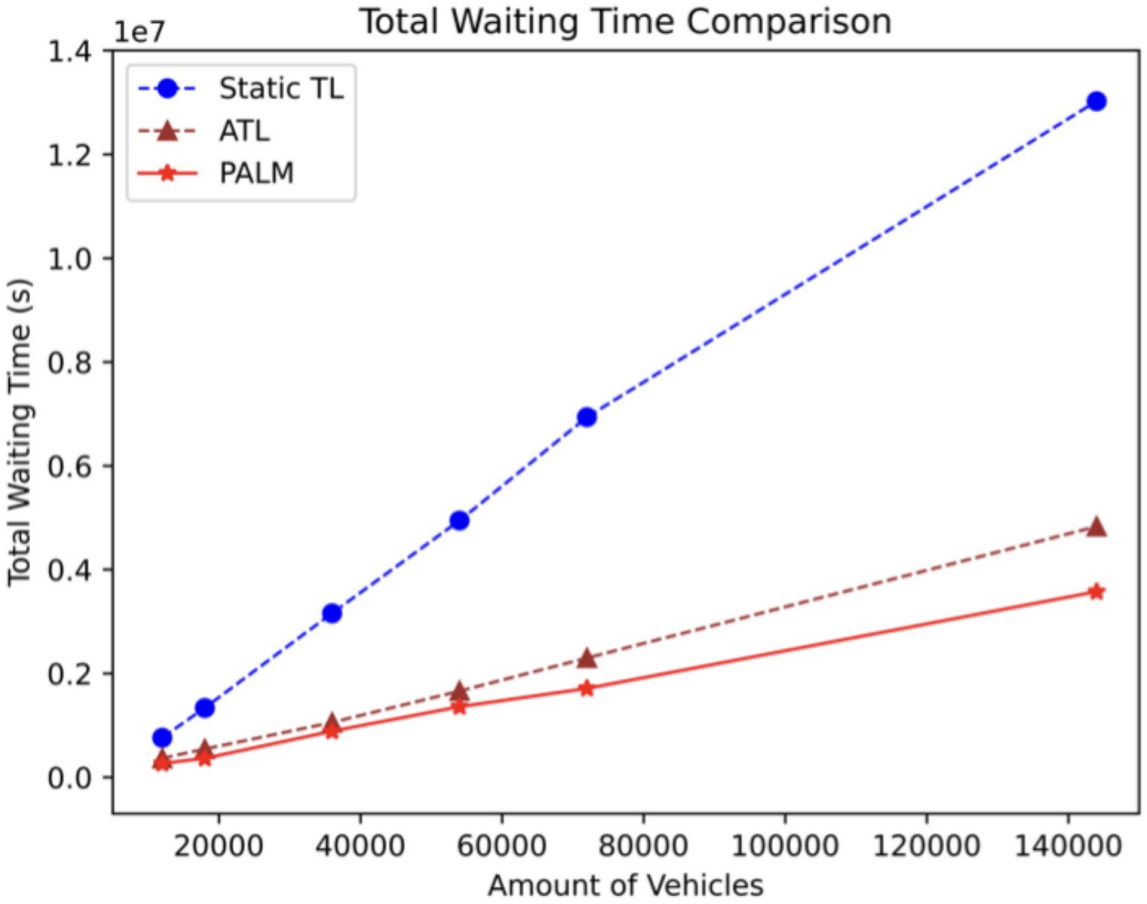
When TLC plan for next green light session,

If the initial TLC doesn't cut any platoon then no action needed.

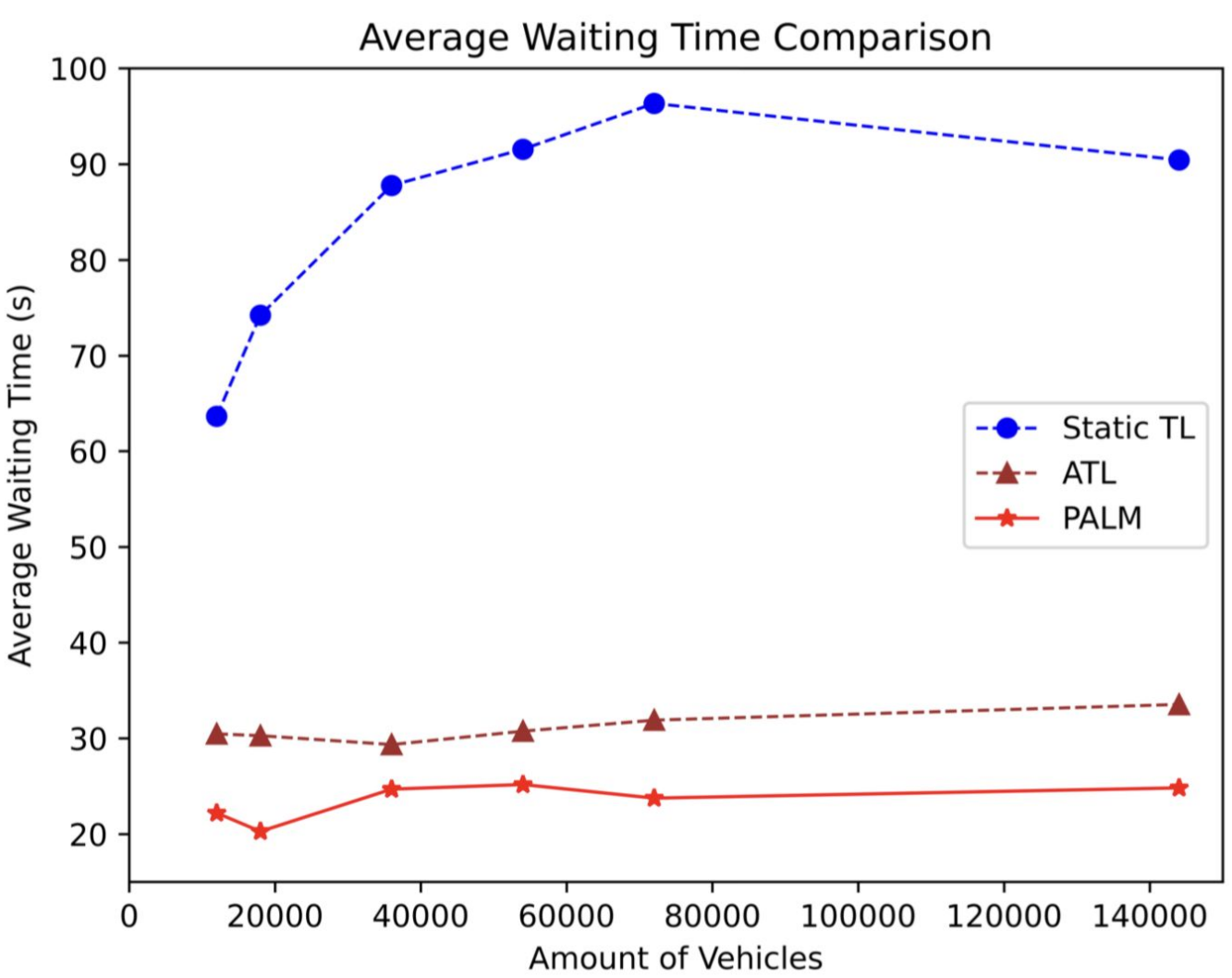
Else, then PC will adjust it to minimum platoon cuttings.

VALIDATION EXPERIMENTS

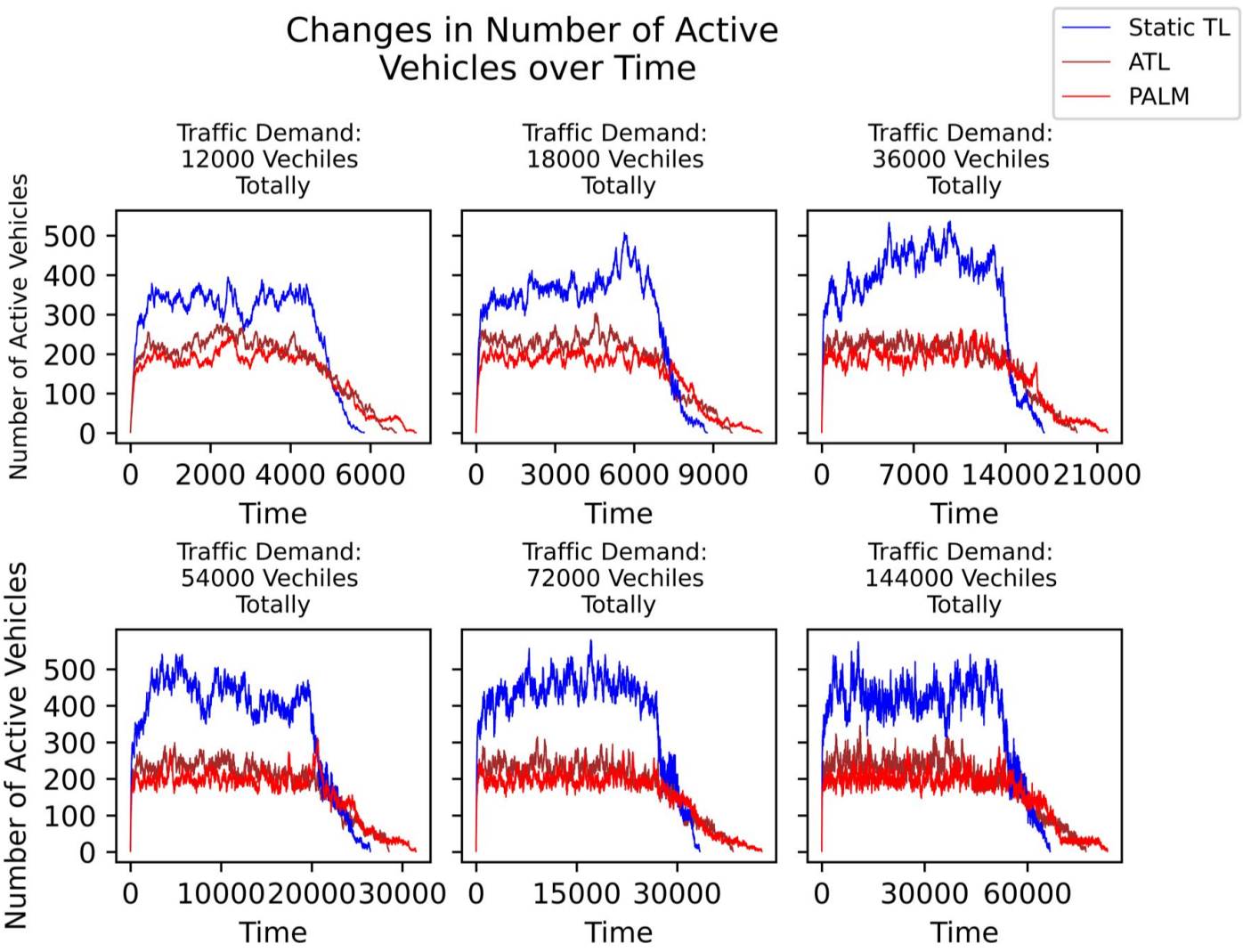
The STL ATL, the waiting time increases at a high rate as the demand leaps



PALM reduces the average waiting time by as large as 75.34% and 33.02% compared to the static and actuated TLCS, respectively. In addition, it has a much more stable performance for different traffic flow demands.



PALM consistently reduces the number of active vehicles



Open source

Everything will be open source at
https://github.com/DayuanTan/OpenSourceAcademicResearch

(Currently it’s not yet because our another ongoing project is also using this code.)

Thank you!

Any questions, comments, suggestions, concerns?

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