Smart Interaction – Pedestrians and vehicles in a CAV environment

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Motivation

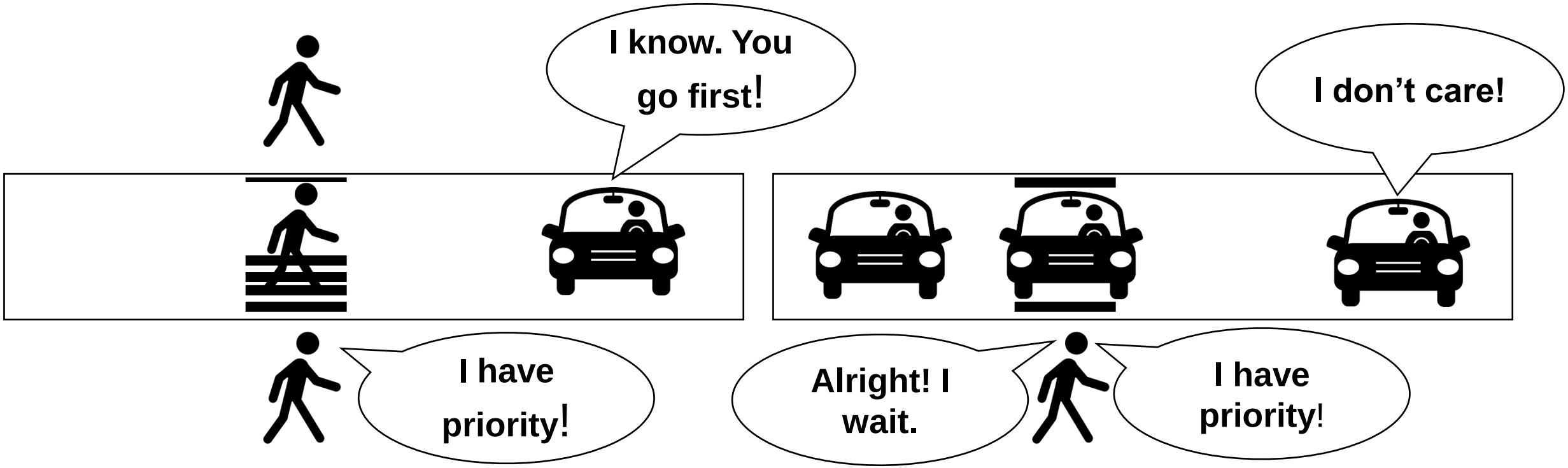
- At unsignalized crossings, pedestrians and motorists often engage in a non-verbal “negotiation” to determine who should proceed first [Fricker and Zhang, 2019].
- Quantifying the pedestrian-motorist negotiation is important for understanding the interaction behaviors of real pedestrians and real motorists and providing a basis for implementation of self-driving vehicles (SDVs).

- The self-driving vehicle in Arizona highlights safety concerns and calls for regulating the testing SDVs [National Transportation Safety Board, 2018].
- Current literature focuses on the interaction between human- operated vehicles and SDVs.

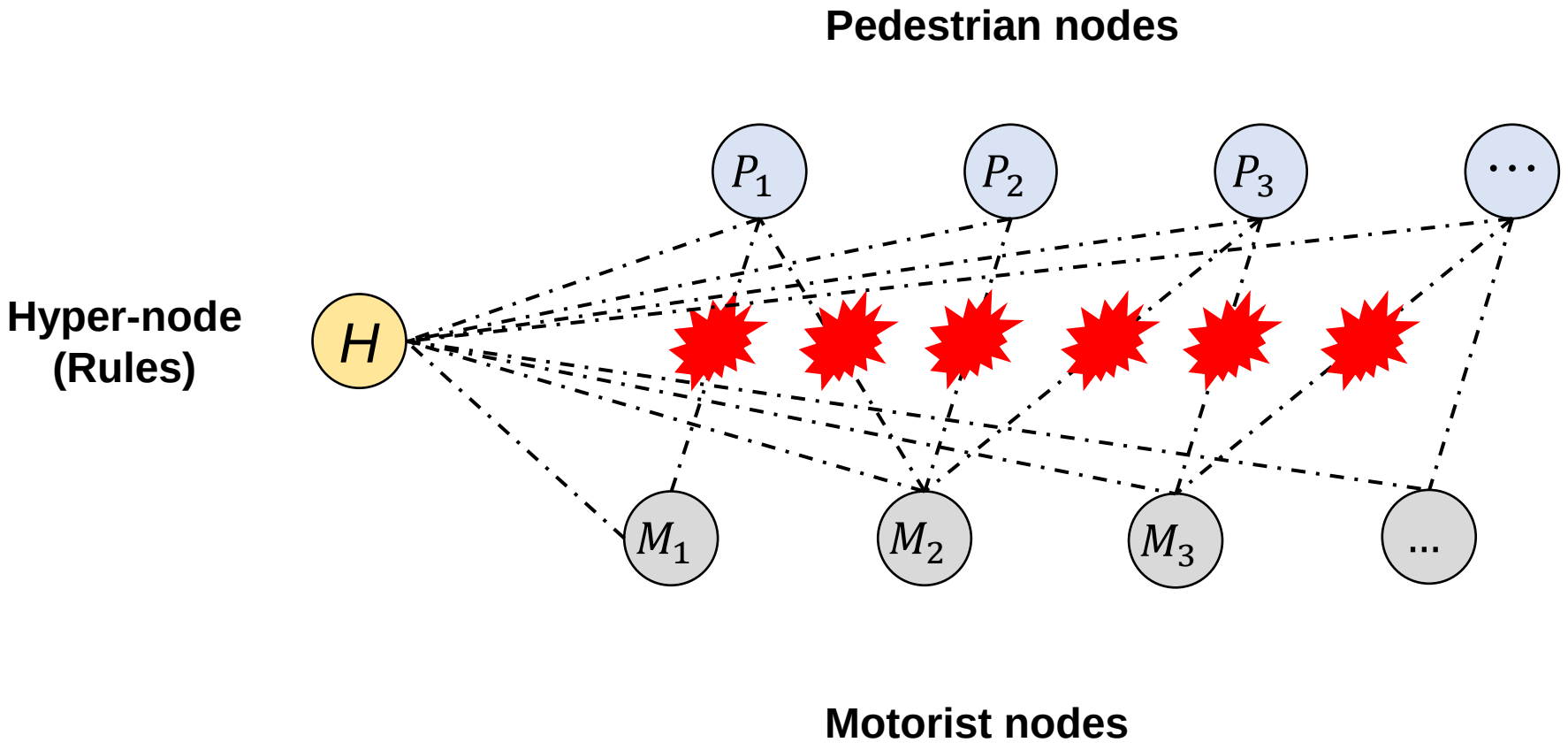
- However, how about vulnerable road users (*pedestrians*, *cyclists*)?

Recap of previous studies

Objective: to understanding the interaction behaviors of real pedestrians and real motorists



A graph representation - dynamic bipartite network



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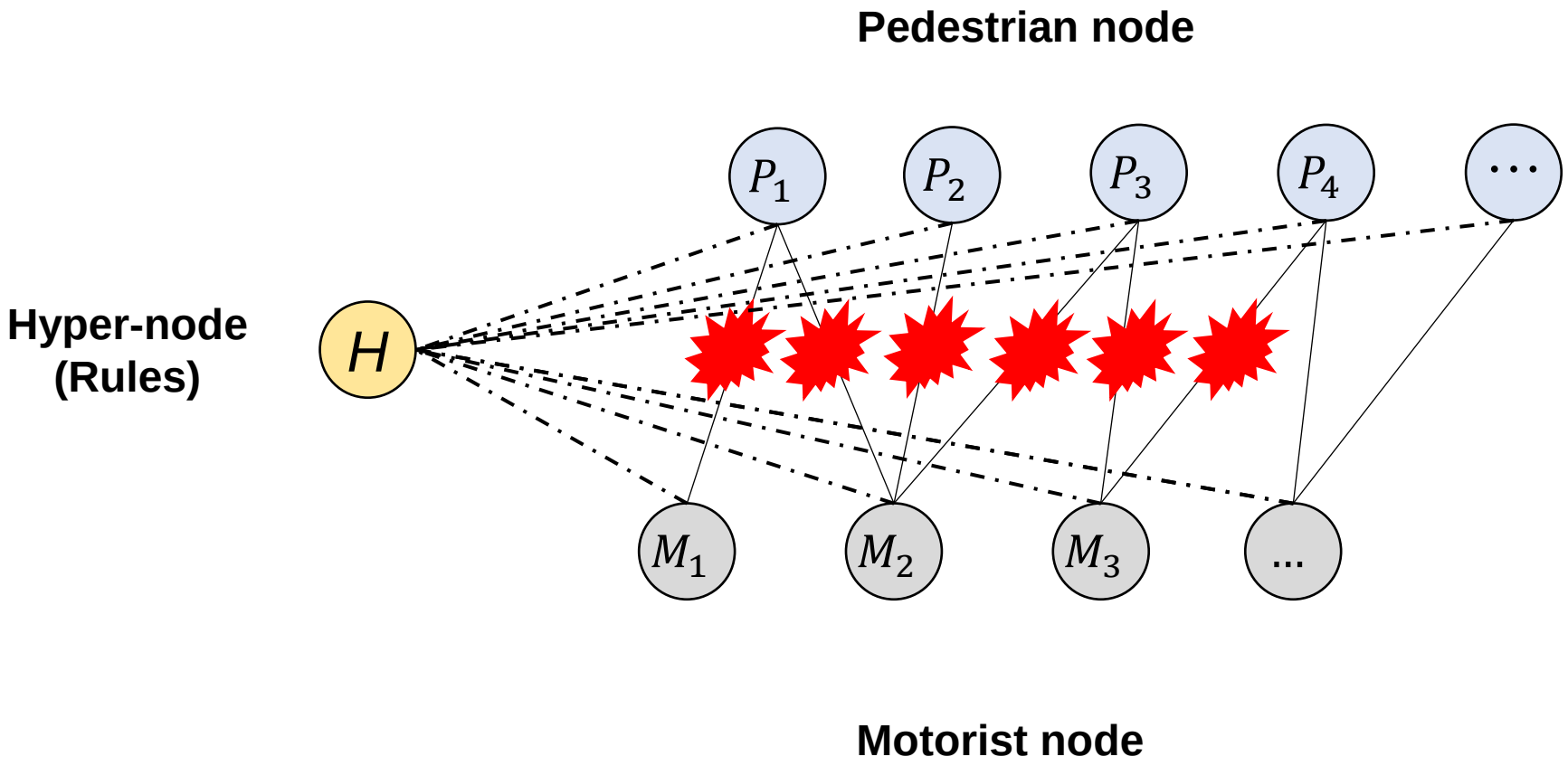
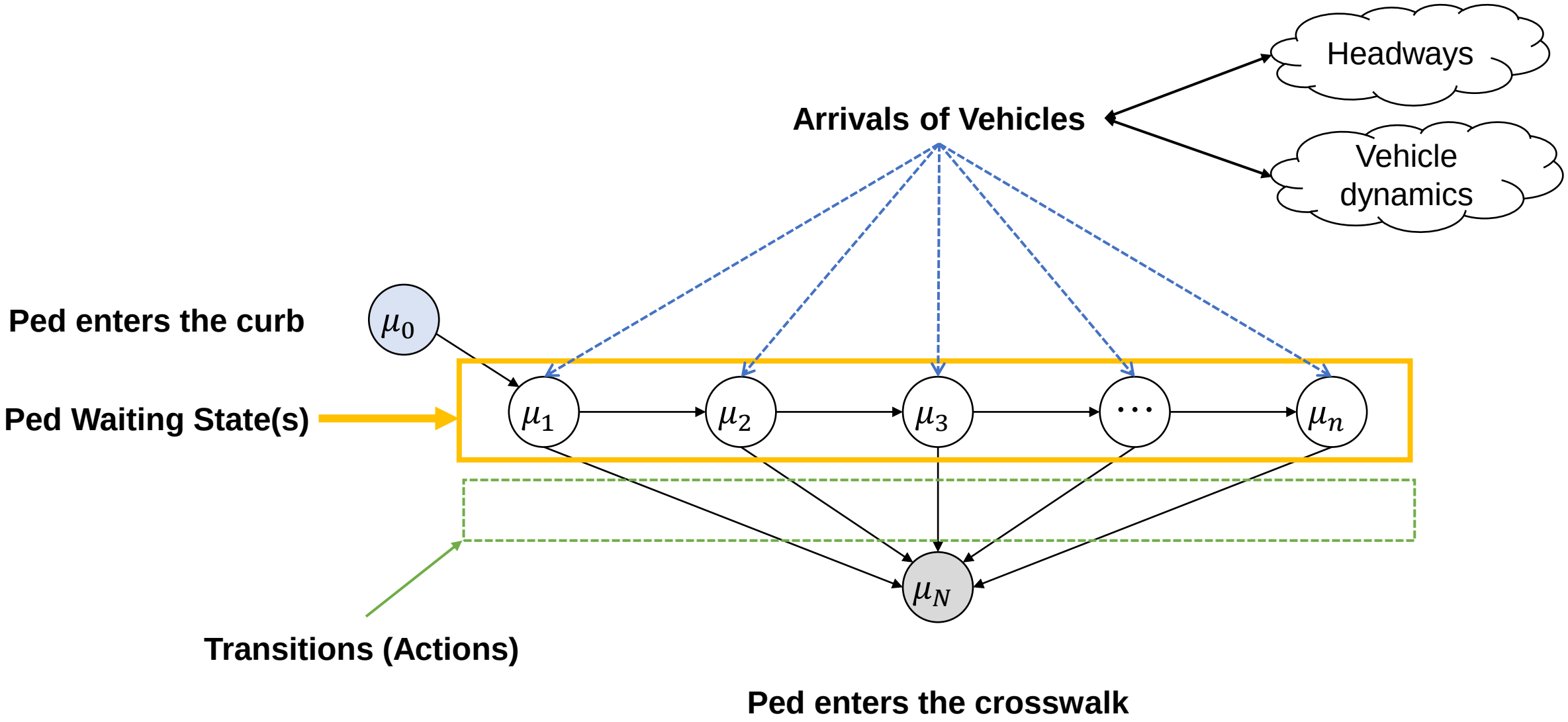


Big Idea: *Let's simplify it and focus on HUMAN!*

Visualization of Pedestrian Crossing Behavior



Methods

■Renewal process:

- The state of art method estimating the pedestrian waiting behavior with the consideration of vehicle interactions [Zheng and Elefteriadou, 2017].
- Limitations:
  - ✓ The vehicle-pedestrian interactions may be correlated.
  - ✓ The driver yielding possibility is only dependent on the distance between the approaching vehicle. (No generalizations)

■Semi-Markov approach:

- The problem of correlated vehicle-pedestrian interactions may be solved by using the technique of Markov Chains [Zhang 2019; Zhang et al., 2020] ;
- Any probabilistic driver yielding functions can be incorporated into the semi-Markov framework.

Highlights

- **Either Monte Carlo sampling or rejection sampling can be applied to generate the sample distribution.**

- **One trick can be applied to compute the expectation of Equation (23) by considering the grand expectation of pedestrian delay as a finite mixture distribution.**

Expected Results

- Previous studies indicated that large proportion of pedestrians consider the tradeoff between risk costs and delay costs before making a decision due to the ***non-verbal communications*** with drivers [Zhang et al., 2020].
  - ✓ Conduct experiments on the ***impacts*** of distributions of vehicle headways and vehicle dynamics on pedestrian delay or vehicle delay.
  - ✓ Assume a ***better communication*** between pedestrians and motorists and simulate the interaction behaviors.
  - ✓ We hope to build a robust computing and simulation framework to model crowd behaviors such as "*cooperators*" versus "*defectors*" with the consideration of a variety of control strategies.

References

- Chen, P., Wu, C., & Zhu, S. (2016). Interaction between vehicles and pedestrians at uncontrolled mid-block crosswalks. Safety science, 82, 68-76.
- Fricker, J. D., & Zhang, Y. (2019). Modeling pedestrian and motorist interaction at semi-controlled crosswalks: the effects of a change from one-way to two-way street operation. *Transportation research record*, *2673*(11), 433-446.
- National Transportation Safety Board (2018). Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian.
- Zhang, Y., Qiao, Y., & Fricker, J. D. (2020). Investigating pedestrian waiting time at semi-controlled crossing locations: Application of multi-state models for recurrent events analysis. *Accident Analysis & Prevention*, *137*, 105437.
- Zheng, Y., & Elefteriadou, L. (2017). A model of pedestrian delay at unsignalized intersections in urban networks. *Transportation research part B: methodological*, *100*, 138-155.