



Transit Priority Strategies for Multiple Routes under Headway-based Operations

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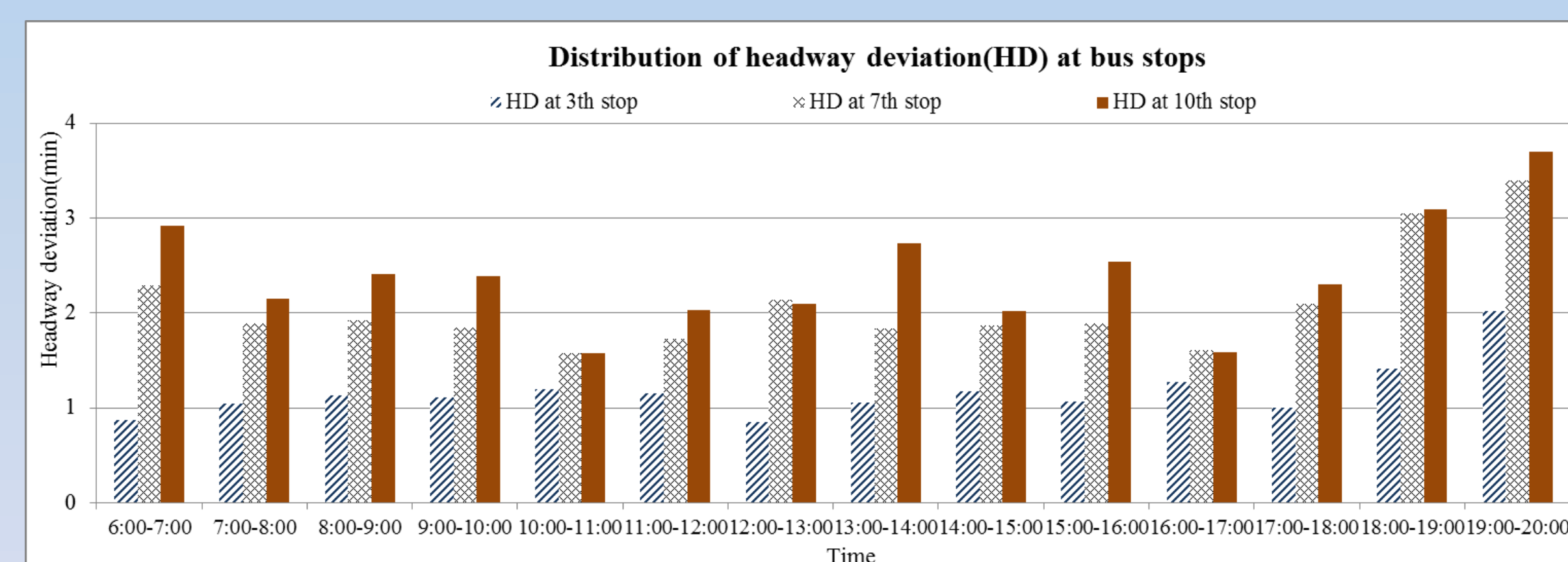


Abstract

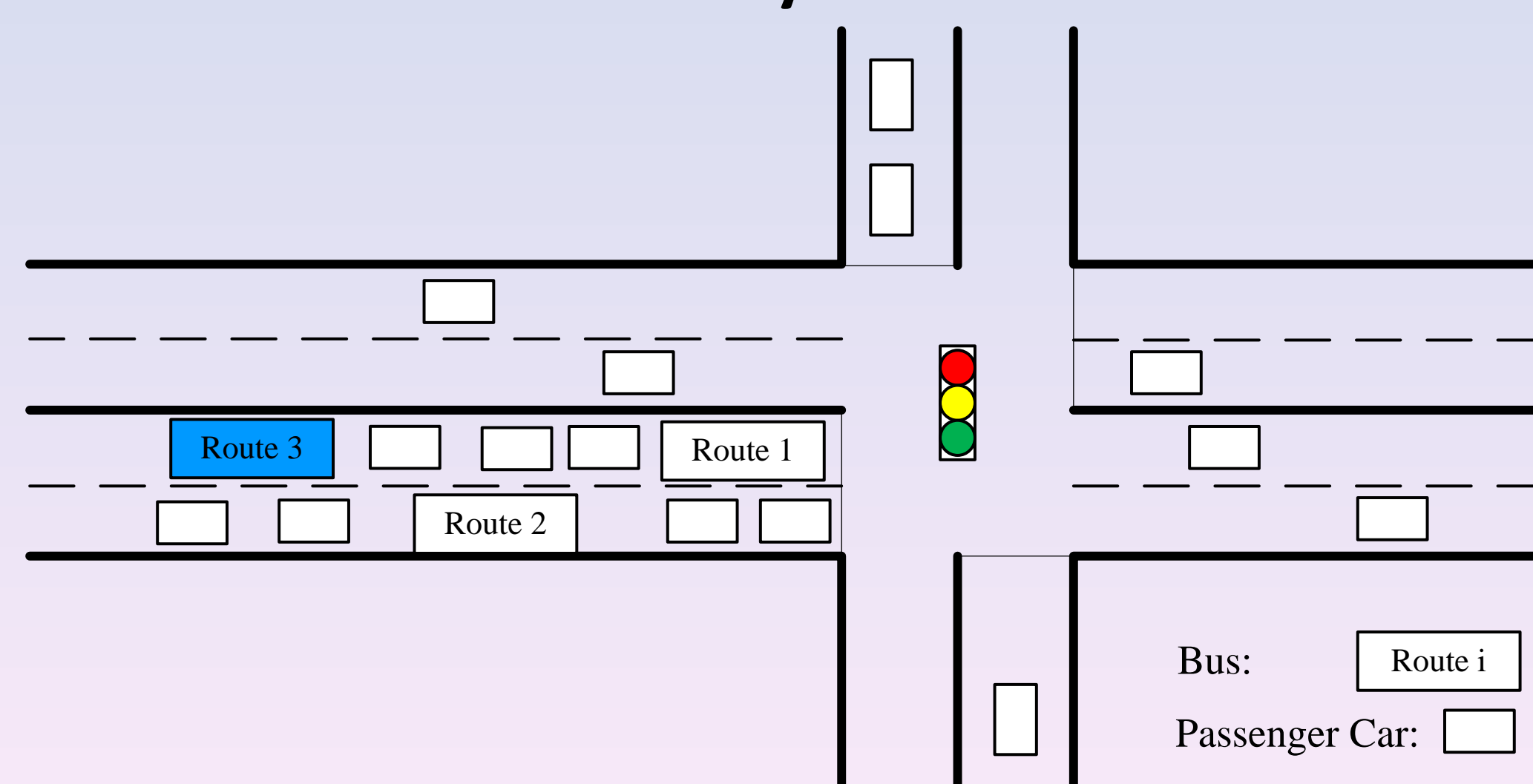
- This paper presents a transit signal priority (TSP) model designed to consider the benefits of **both bus riders and all intersection passenger car users**.
- The proposed strategy, mainly for **headway-based bus operations**, offers the responsible agency a reliable way to determine the optimal green extension or red truncation duration in response to **multiple bus priority requests from different routes**.
- The **control objective** is to minimize bus passenger waiting time at the downstream bus stop while ensuring that the delays for all passengers are not increased.

Research Background

- The conventional “first-come-first-served” strategy may improve the schedule reliability of some buses but at the cost of others, that is, to reduce the headway between some buses which are either on their scheduled headways or even ahead of the required arrival time at the next stop.
- More specifically, the objectives of this study are to: 1) Design a control system to **handle multiple priority requests** of buses from different routes, based on various measures of effectiveness, and 2) **Identify critical factors or relations** that may impact the TSP’s efficiency under different traffic conditions.

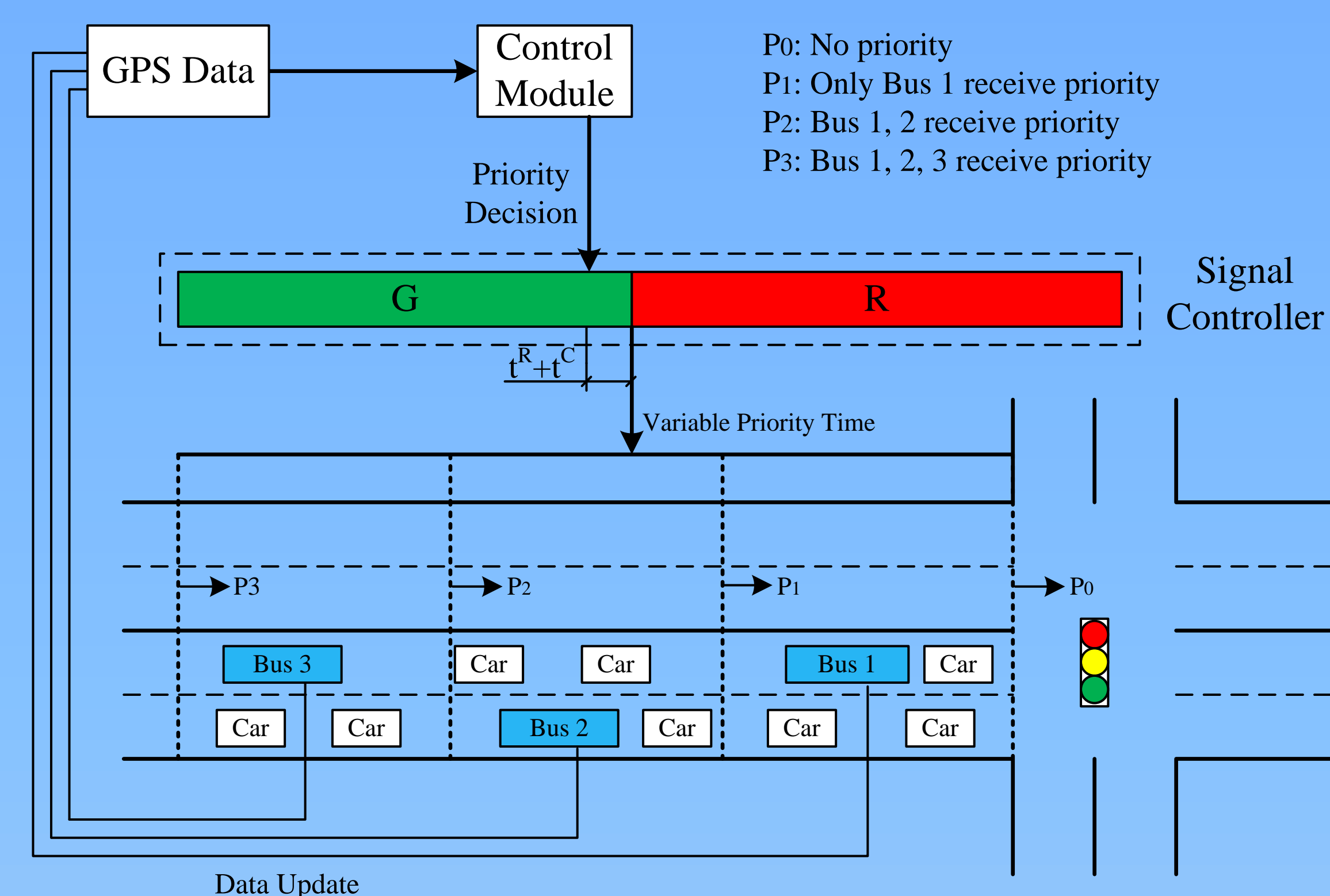


Distribution of absolute headway deviation of route 35 in Jinan, China



Impacts of bus sequences over different routes at the intersection

Model Development



Signal control logic of the proposed TSP system

The entire decision-making process for TSP in response to multiple requests includes the following steps:

- Step 1:** Collect bus location data and current signal settings from the available communication system.
- Step 2:** Estimate the maximal allowable duration for green extension or red truncation in terms of traffic conditions.
- Step 3:** Detect the approaching buses and their current locations a few seconds (the sum of communication time and reaction time plus the maximal allowable duration) prior to the end of a green phase.
- Step 4:** Estimate the potential benefits if granting the priority to a different number of detected buses.
 - Step 4.1:** Calculate the headway of each detected buses under an intended green extension or red truncation.
 - Step 4.2:** Estimate the average passenger waiting time at bus stops.
 - Step 4.3:** Compute the delay reduction for bus passengers and passenger-car drivers in the target arterial segment.
 - Step 4.4:** Estimate the increased delay for passenger-car riders on the crossing street.
- Step 5:** Determine the priority strategies and the optimized green duration for the priority requests.
- Step 6:** Execute the TSP control strategy.

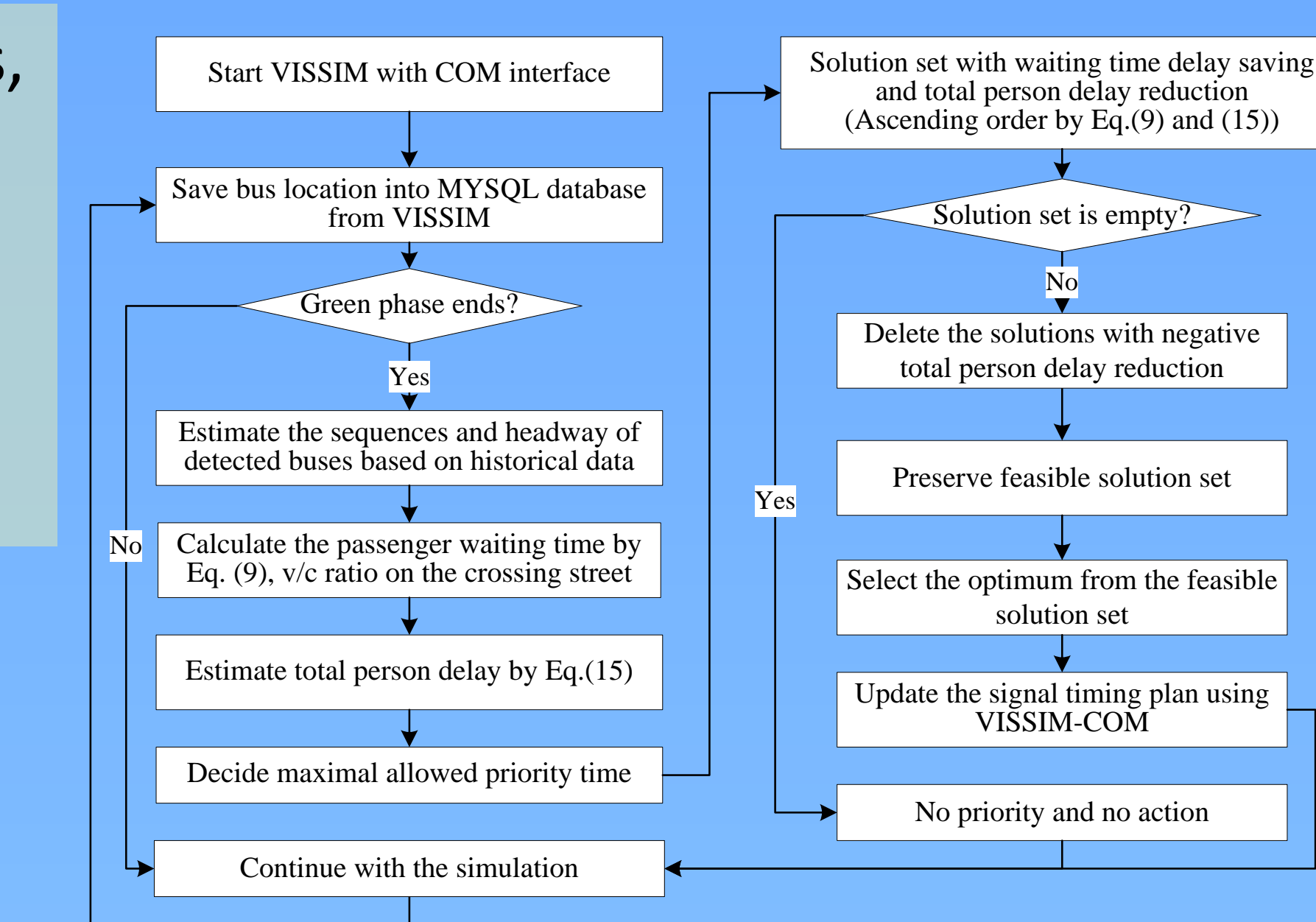
This system will grant a bus priority to major road with the extended green seconds, caused by green extension or red truncation, if the following criteria are satisfied:

- To **limit traffic disruptions** on the cross street, a red truncation and green extension cannot be taken simultaneously in one signal cycle;
- The total bus passenger waiting time will be reduced;
- The total person delay will not be increased by a TSP execution.

The total passenger waiting time at the next stop:
$$c(k) = \sum_{r \in R_{p,q}} \beta_r \sum_{i \in I_{r,p,q}} c_{r,i,k} \alpha_{r,i}(k)$$

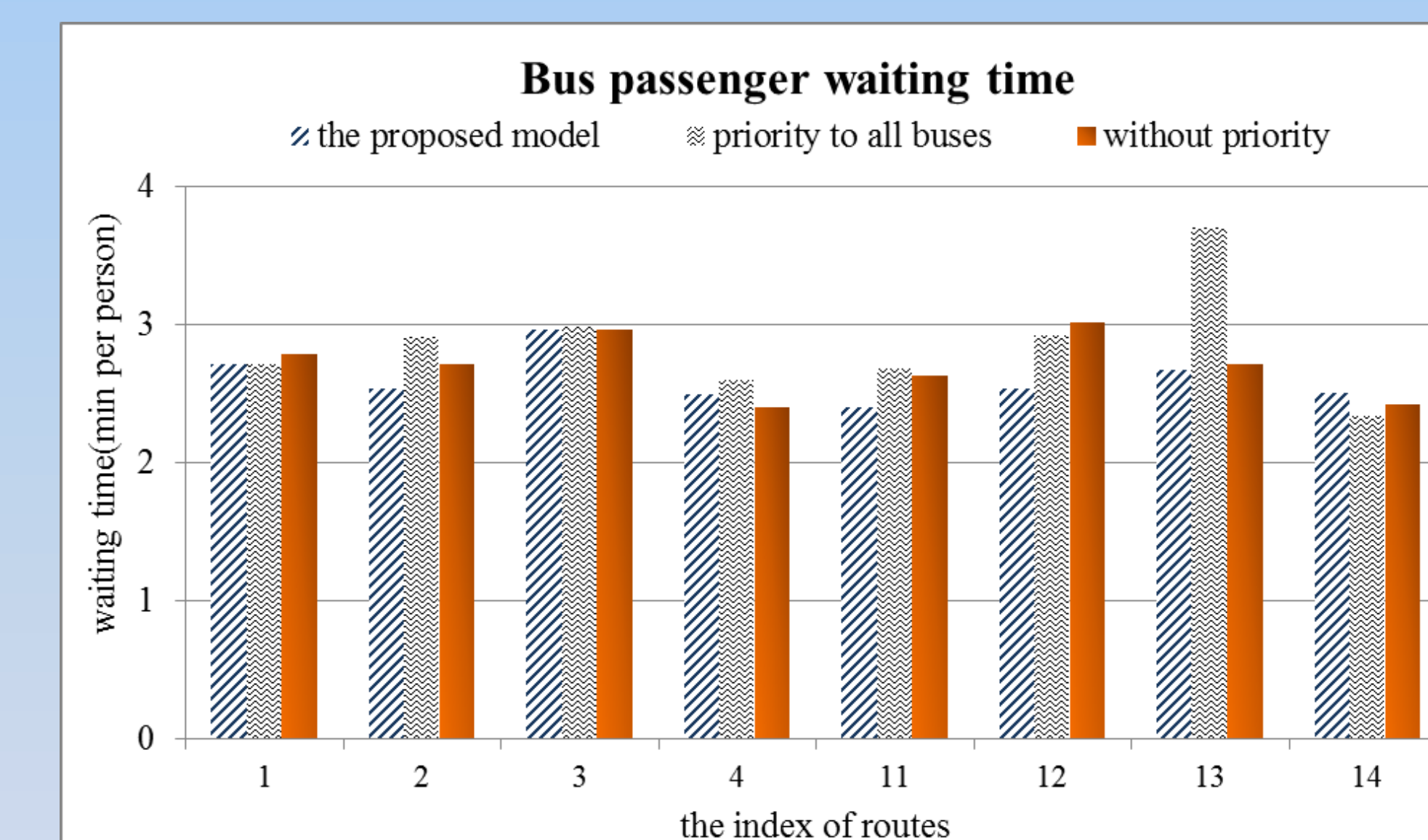
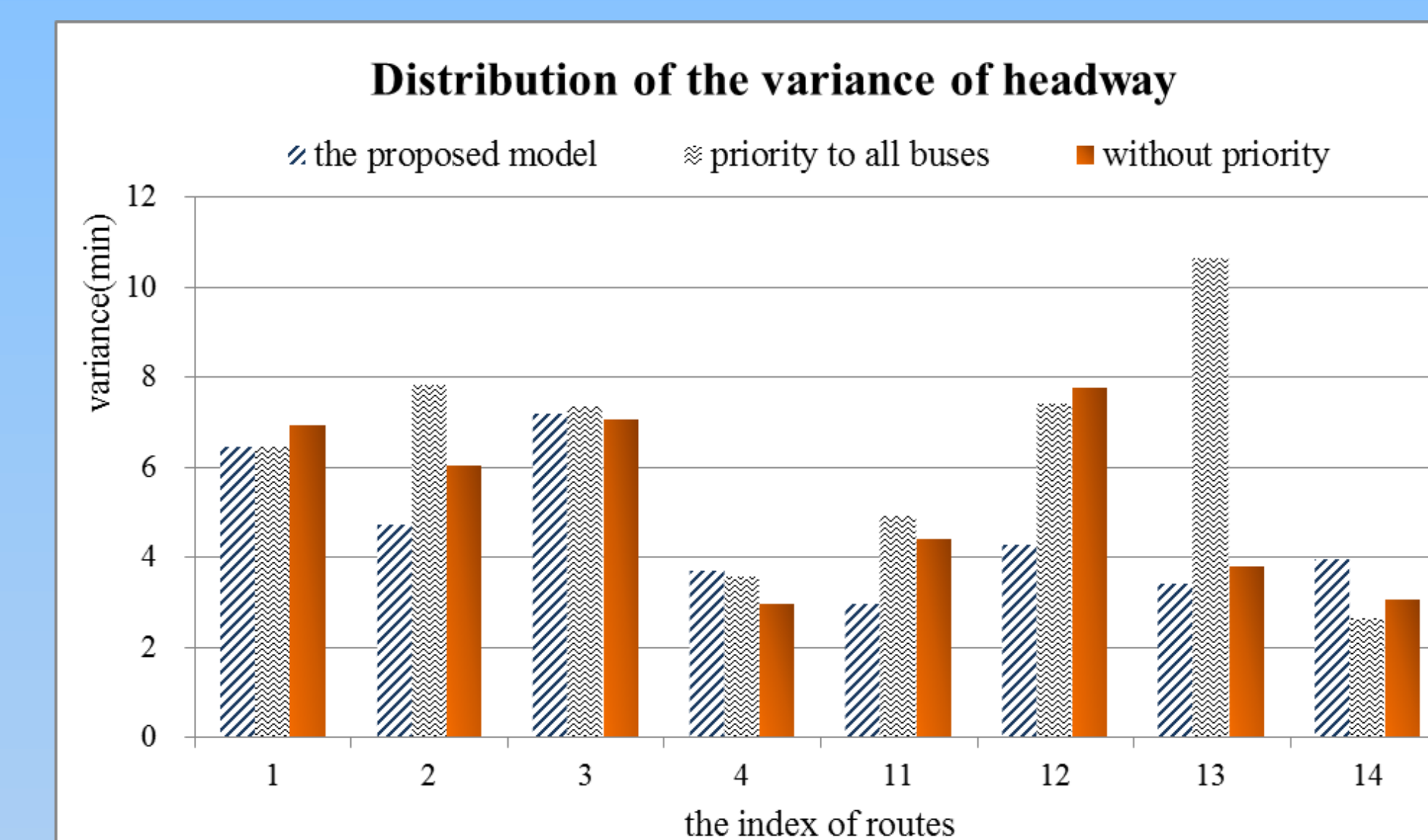
The total person delay reduction during the TSP execution period:

$$D = d_R^{PC} - d_I^{PC} + d_R^B + c(k) - c^{NON}(k)$$



Flow chart of simulation evaluation using VISSIM

Case Study



Conclusions

- The proposed model **utilizes the variable priority time technique**, which is capable to perform a more precise control so as to give partial priority to detected buses. To **minimize the negative impact** to the entire intersection, the proposed TSP strategy also computes **the total person delay** to ensure its efficiency.
- Using **the field data** from Jinan, the performance evaluation under a simulated platform clearly shows that the proposed TSP control can significantly reduce the passenger waiting time in the scenario of having multiple priority requests from multiple transit routes.
- An extensive sensitivity analysis has also revealed that the proposed TSP can yield significant benefits to both bus passengers and all users in the system if the ratio between bus and traffic volumes exceeds 2 percent. Such benefits are generally expected to increase with total intersection volume.

Scenario description:

The total travel distance of bus routes is about 6.0-6.8km;
The length of the arterial is about 3km with two-way 6 lanes;
The mean headway is about 4 min, the variance observed on the target arterial ranges from 2 to 6 minutes;
There are 8 bus routes in two directions;
No bus exclusive lane is available on the arterial;
There are 6 intersections along the arterial, and only 2 have the function to offer the bus priority function;
The duration of simulation time is about 3600 seconds.

