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公交信号优先控制系统原型设计
Prototype of Transit Signal Priority Control System

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•智能交通系统(ITS)研究中心

报告大纲 Outline

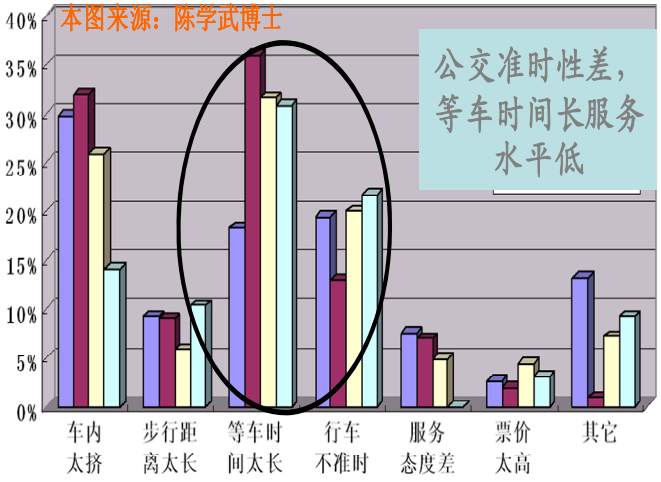
- 研究背景 **Background**
- 系统原型 **System Prototype**
- 核心模型 **Critical Models**
- 结　　论 **Conclusions**

Background

Traffic Congestion

Transit Congestion

Implementation of Exclusive Bus Lane



- BRT with related ITS systems were built in Beijing, Hangzhou and other cities.
- Level of service of bus system should be enhanced to attract more passengers

Limitations of current works

1. Most of researches concentrate on active/real-time transit signal priority strategies.
2. Most conventional bus priority strategies give absolute priority to buses (Meenakshy Vasudevan, 2005).
3. The objective of “Minimize person-delay for given demand” is just seems fair (Peter G. Furth, 2004).
4. In most implementations, detection occurs no further from the stopline than the closest upstream stop or signalized intersection (TCRP Project A-16, 1998).
5. The coordination of priority strategies between adjacent intersections is seldom considered.
6. Strategies for “late” bus are proposed, but strategies for “early” bus are neglected.

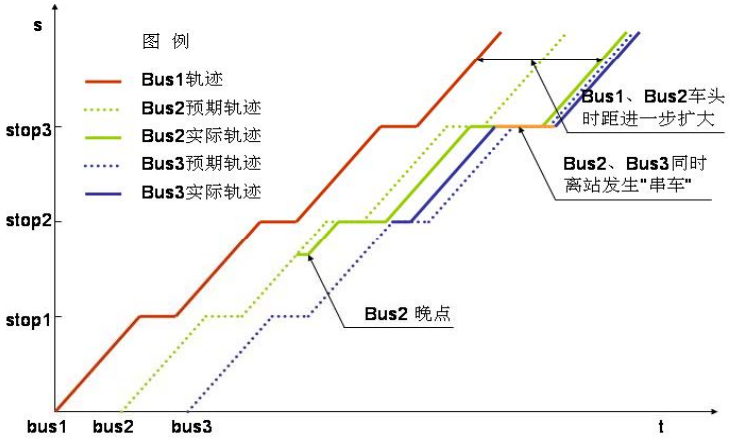
Characteristics of Bus System

Travel Time

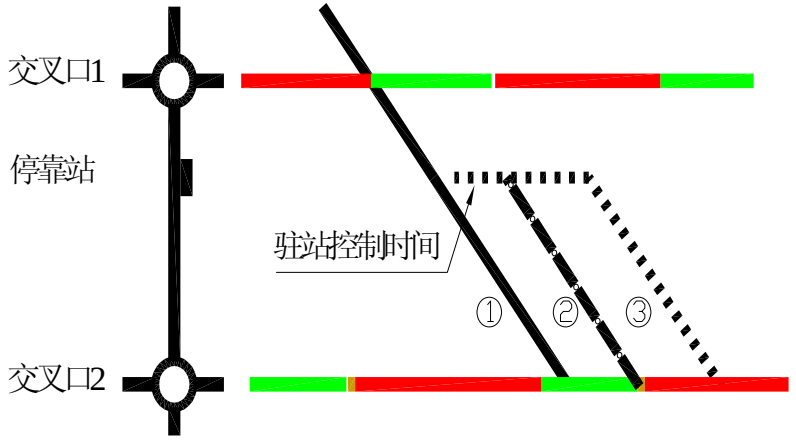
$$T_t = \frac{L}{V} + \sum_{k=1}^{N} d_{jk} + \sum_{k=1}^{N} d_{sk}$$

Link signal Bus stop

Interaction of Buses



Impact of signals and bus stops



Multi-Objectives

- Traffic

TRAFFIC MANAGER

One Bus, One Route, One Trip

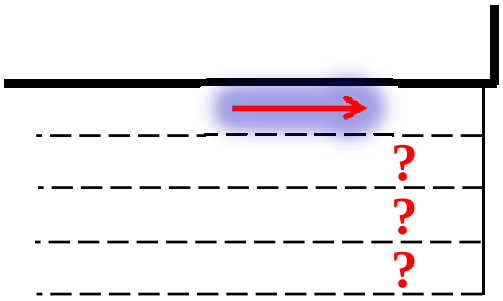
- Transit

TRANSIT MANAGER

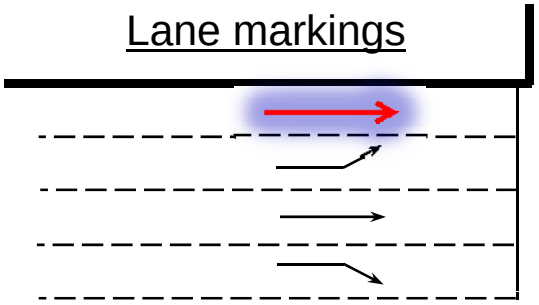
Multiple Buses, Multiple Routes, Multiple Trips

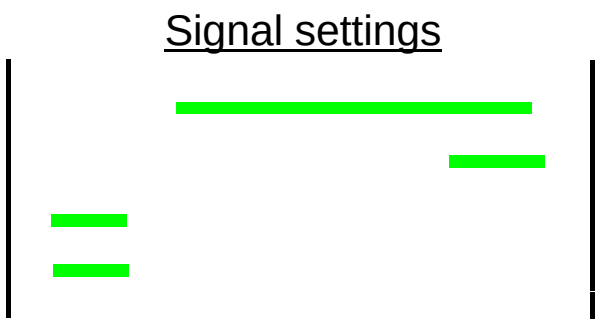
Offline Optimization:
Basic concept of L-TSP

Lane-based control variables



What are the optimal lane markings and signal settings with fixed exclusive bus lane?





Exclusive Bus lane ⇨ Simultaneous determination of optimal lane markings and signal settings

A multi-objective model for intersection

Objectives

$$\min F_1 = [D_b, D_v]$$

$$D_b = f_1(X, L); \quad D_v = f_2(X, L)$$

Constrains

$$l_k + l_{k+5} + \delta_k \le L_i \quad k = 1,3; i = 1,3$$

$$l_k + l_{k+3} + \delta_k \le L_i \quad k = 2,4; i = 2,4$$

$$l_i + \delta_i \le l_i^o \quad \forall i = 1,\ldots, N_T$$

Number of lanes constrains

$$C_{\min} \le C \le C_{\max}$$

$$x_i \ge 0, \quad \forall i = 1,2,3,4,5,6$$

$$x_1 \ge x_2$$

$$x_2 - x_i \ge 0, \quad \forall i = 3,5;$$

$$x_1 - x_2 - x_i \ge 0, \quad \forall i = 4,6$$

Duration of signal timings constrains

$$g_i^{\min} \le x_2 - x_{3+(i-1)/2} \le g_i^{\max}, \quad i = 1,5;$$

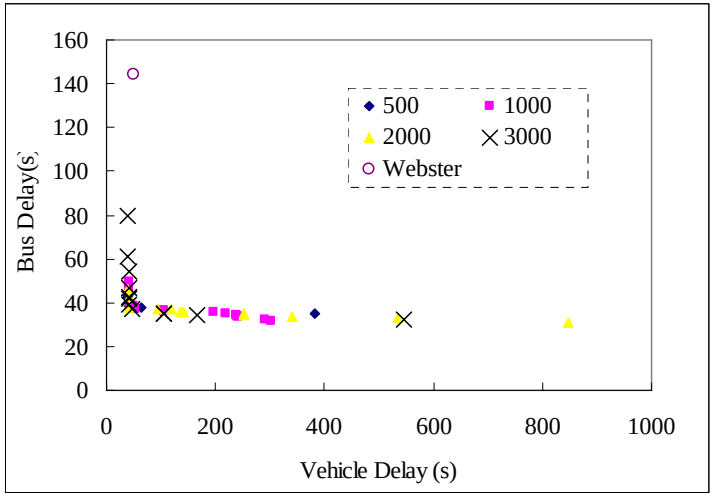
$$g_i^{\min} \le x_1 - x_2 - x_{3+(i-1)/2} \le g_i^{\max} \quad i = 3,7$$

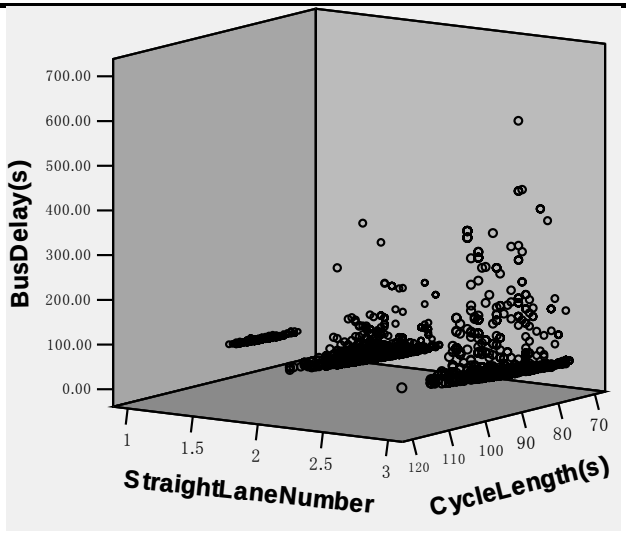
$$Max(\sum_{i=1}^{2} g_i^{\min}, \sum_{i=5}^{6} g_i^{\min}) \le x_2 \le Min(\sum_{i=1}^{2} g_i^{\max}, \sum_{i=5}^{6} g_i^{\max})$$

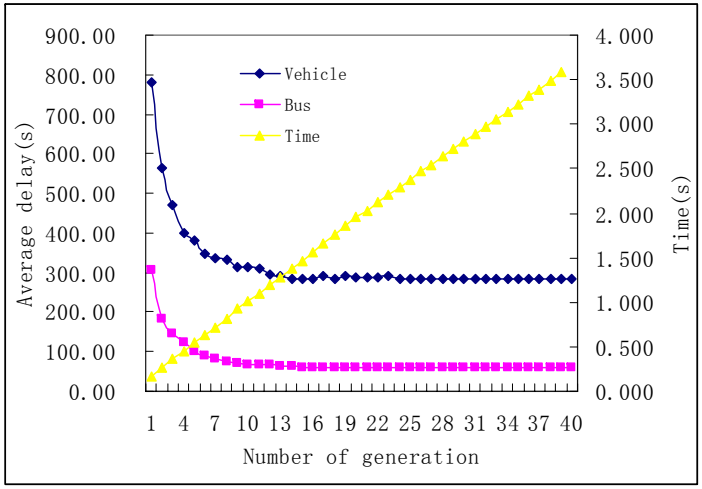
$$Max(\sum_{i=3}^{4} g_i^{\min}, \sum_{i=7}^{8} g_i^{\min}) \le x_1 - x_2 \le Min(\sum_{i=3}^{4} g_i^{\max}, \sum_{i=7}^{8} g_i^{\max})$$

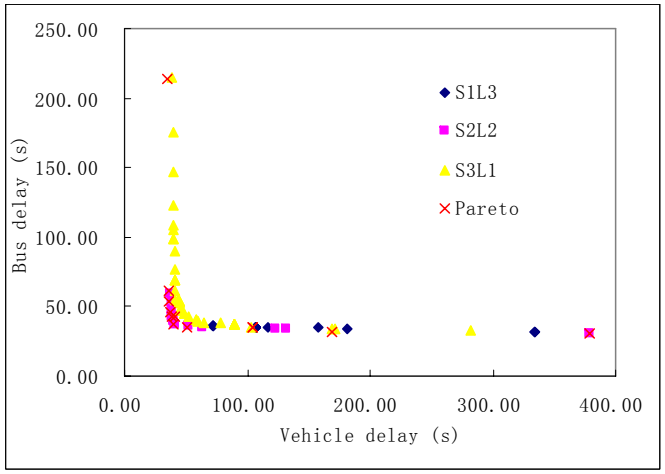
$$g_j^{\min} \le x_i \le g_j^{\max}, \quad i = \forall 3,4,5,6, \quad j = \forall 2,4,6,8$$

A case study and results





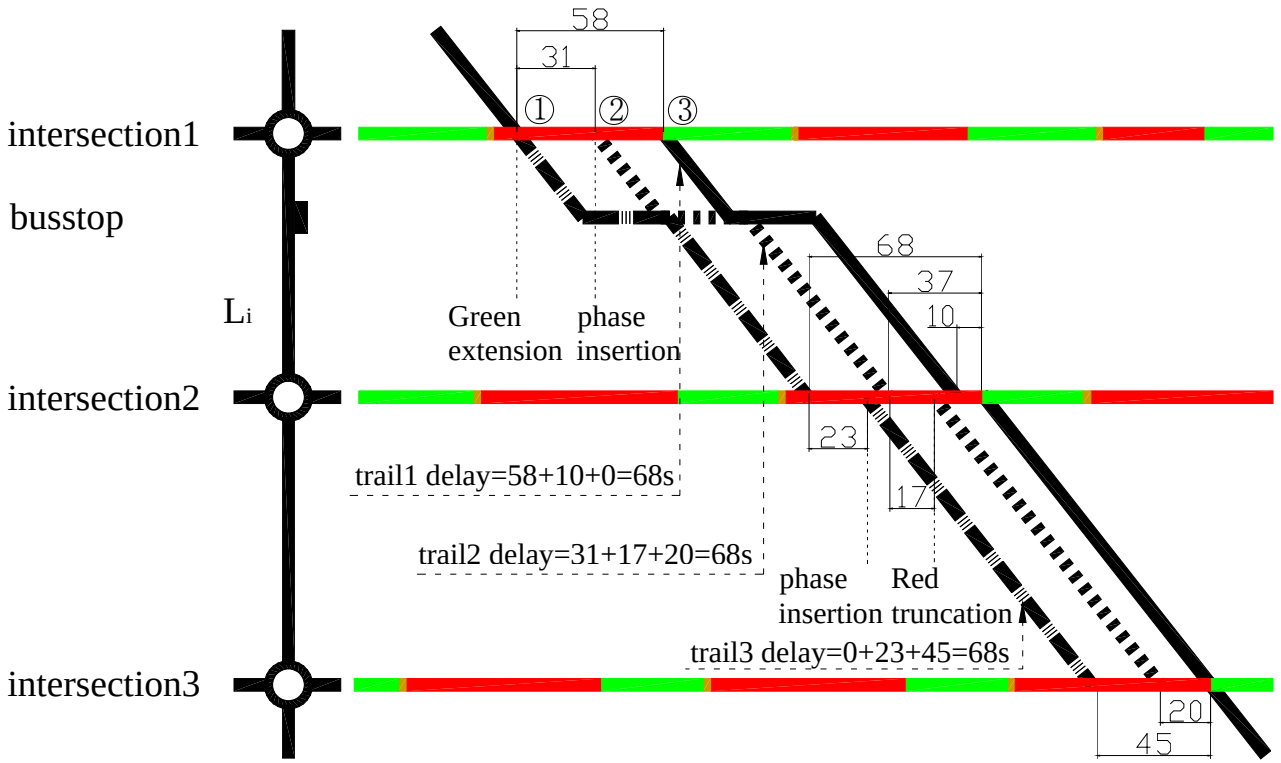




Pareto frontier of L-TSP are composed by Pareto frontier of all fixed lane markings model

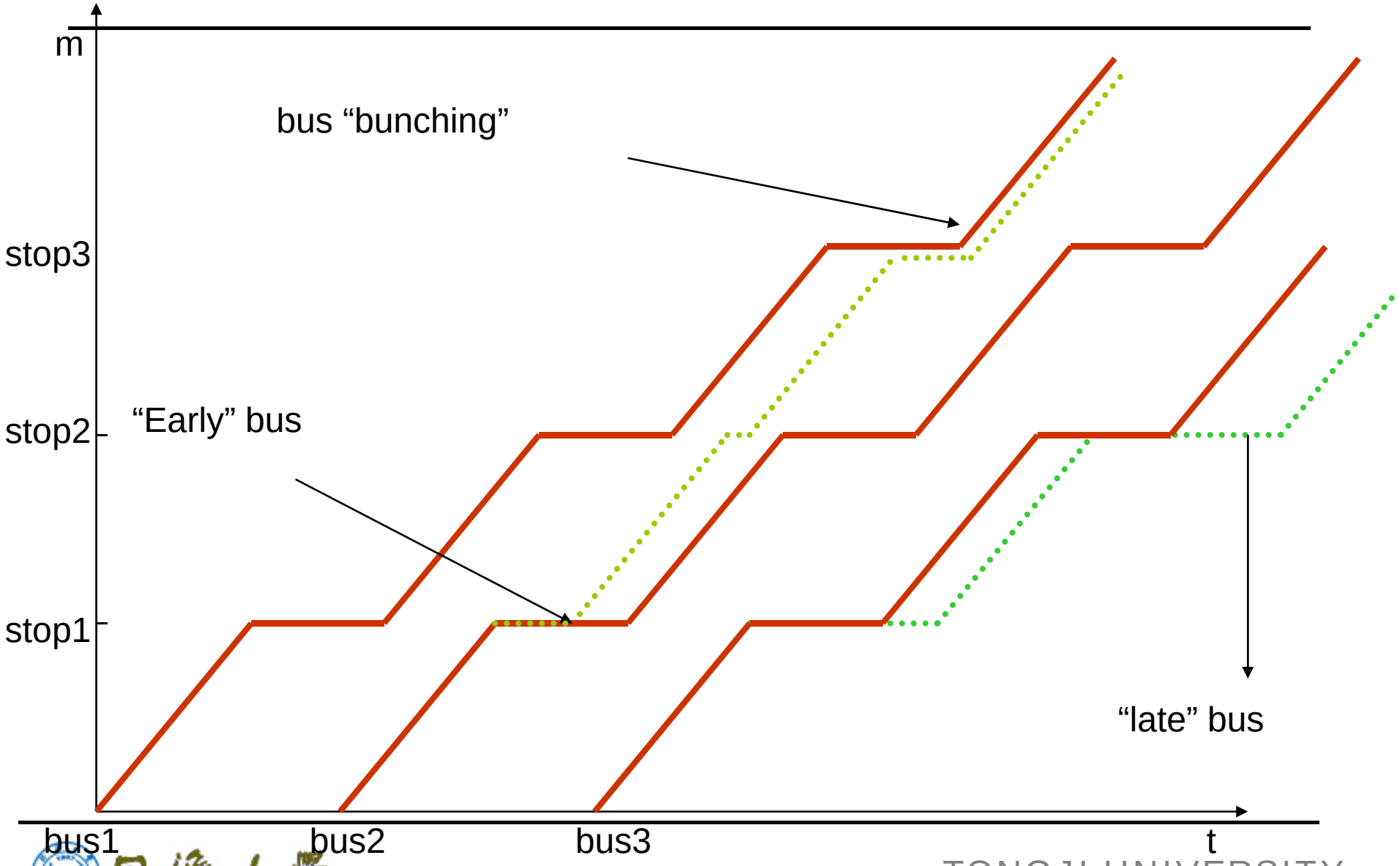
Online Optimization (1):
Coordinated and conditional Bus signal Priority

Different strategies, same delay



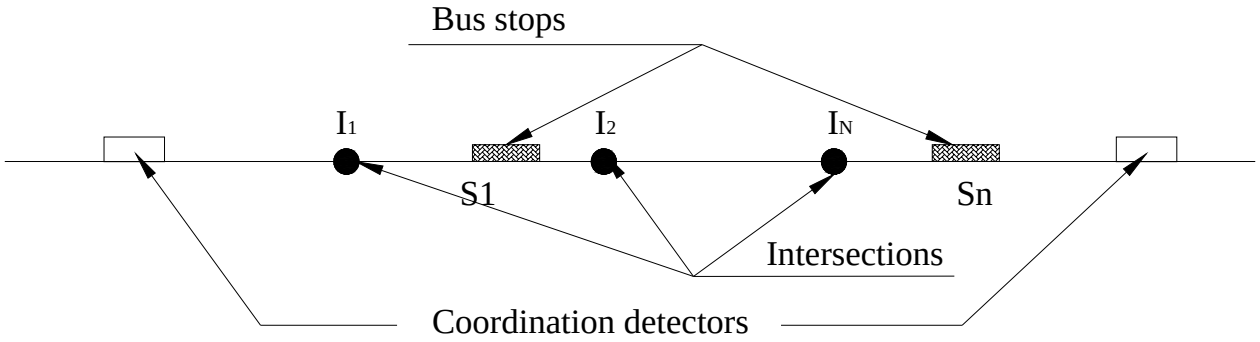
1. Trajectory1: green extension + phase insertion + no priority
2. Trajectory2: phase insertion + red truncation + no priority
3. ~~Trajectory3: no priority + priority + no priority~~

Impacts of “early” bus and “late” bus

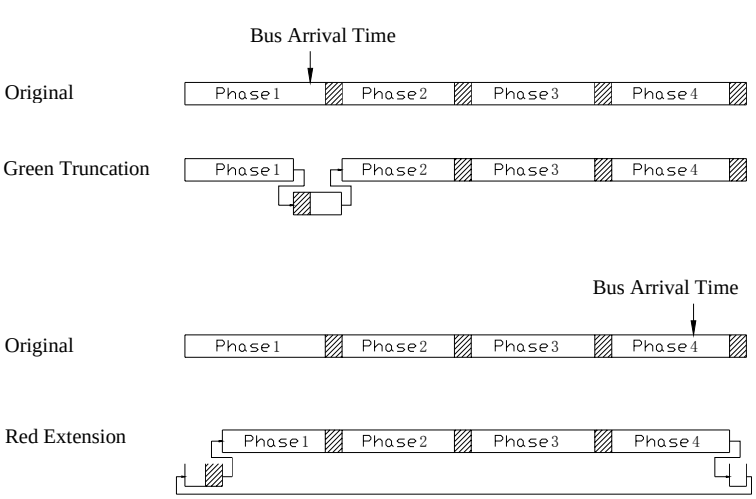


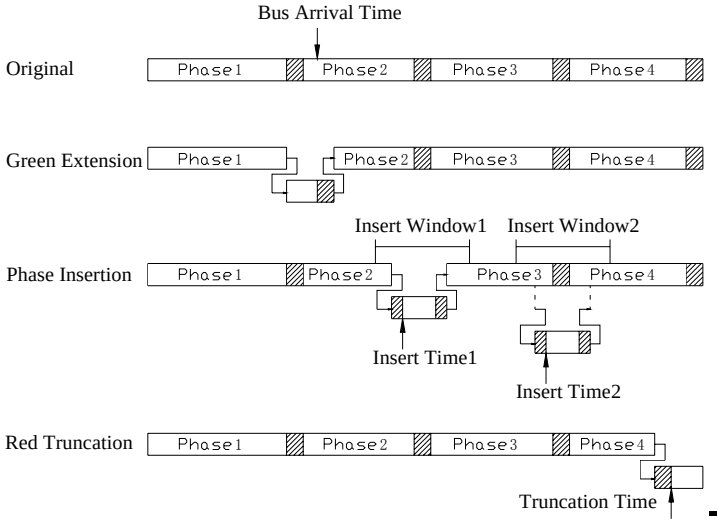
Basic concept of CCBSP

Intersection group

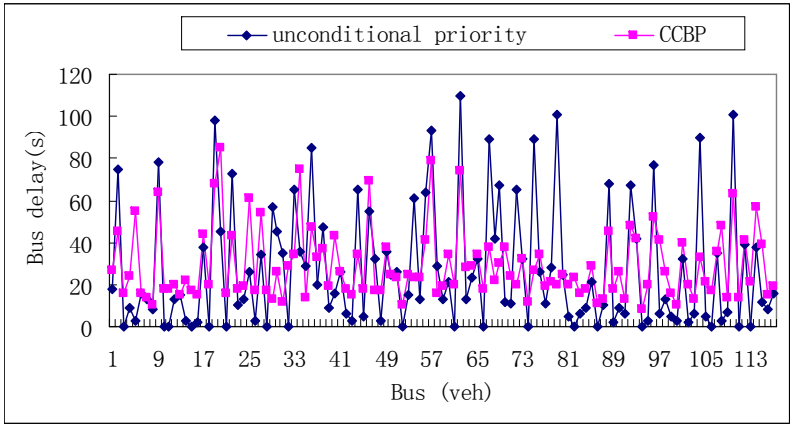


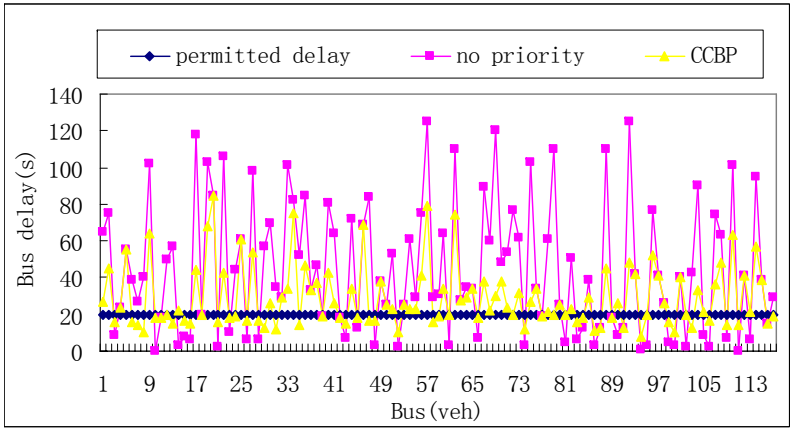
Frequency and schedule

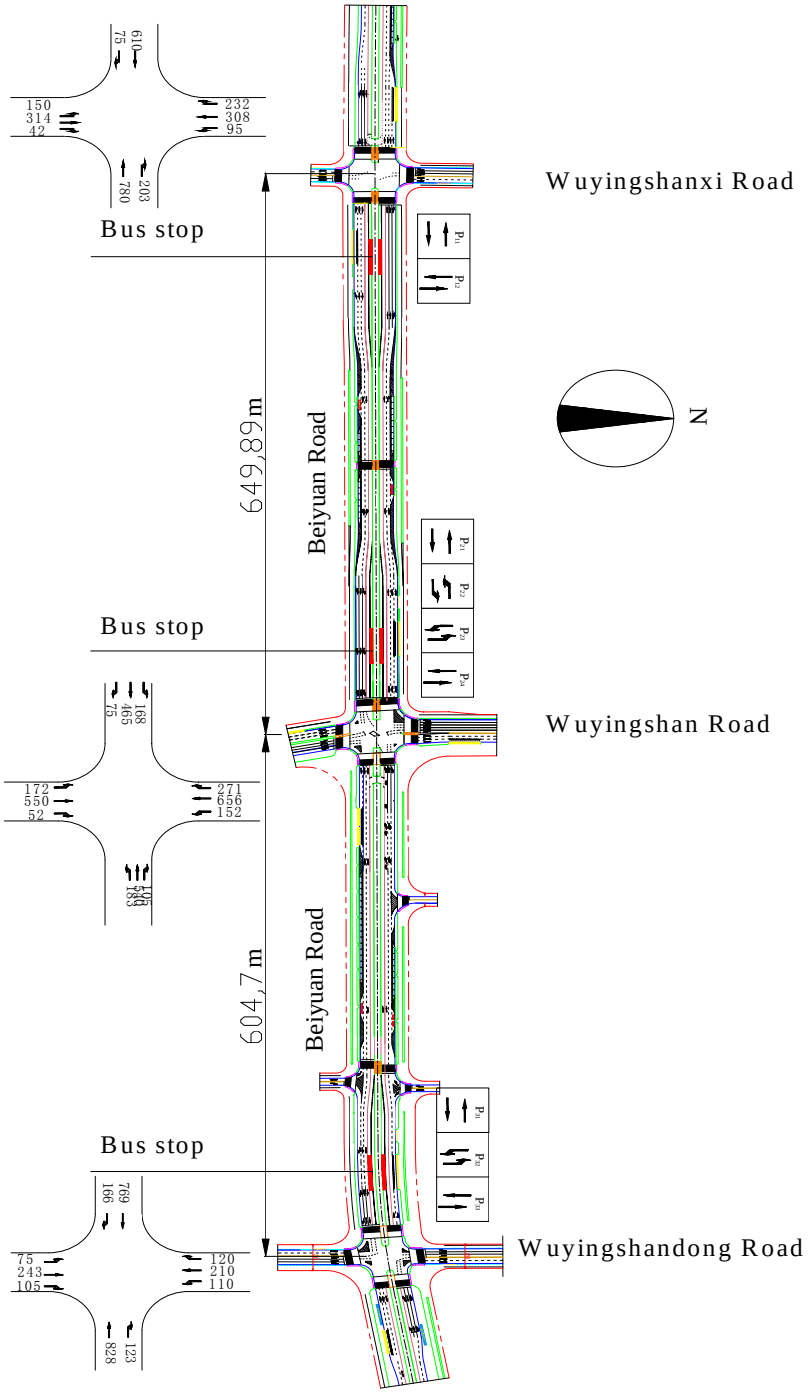




A case study of Ji'nan







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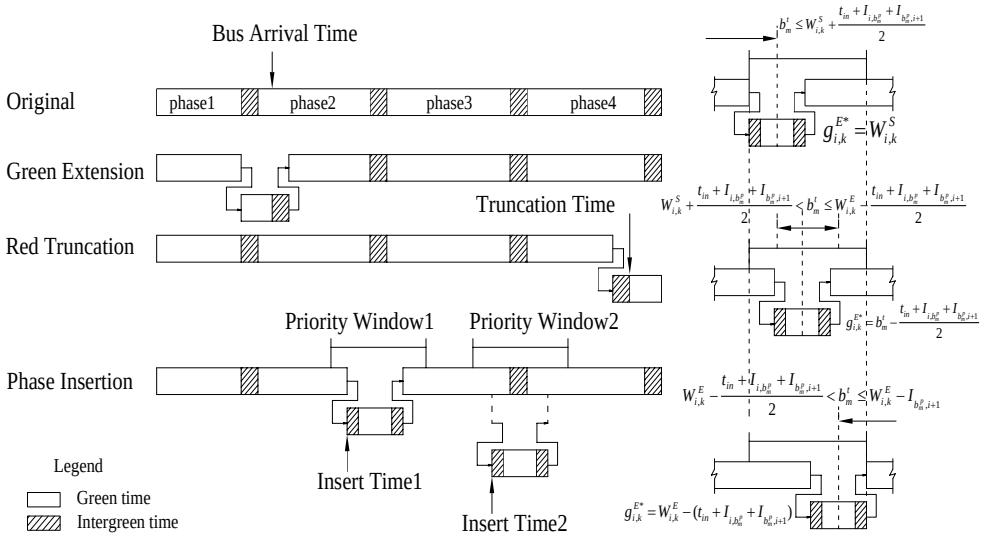
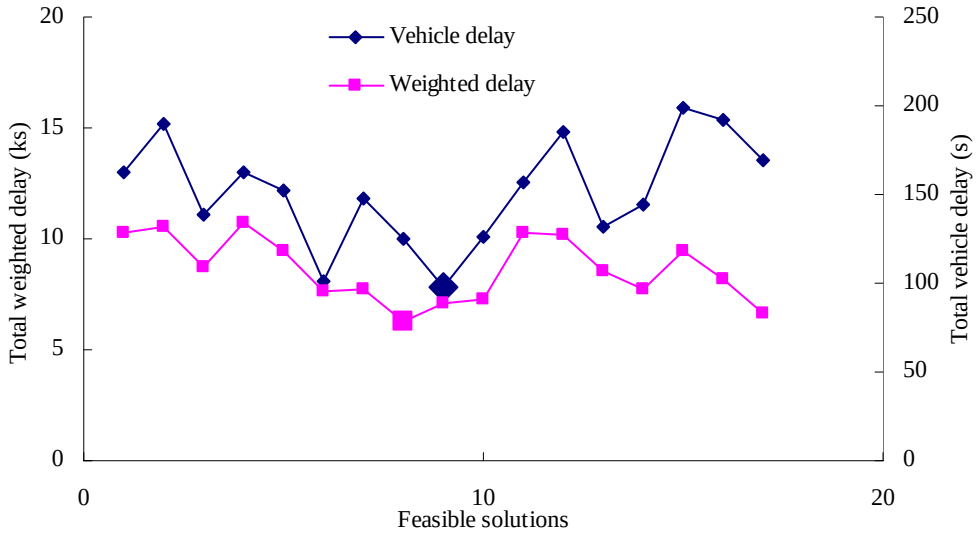
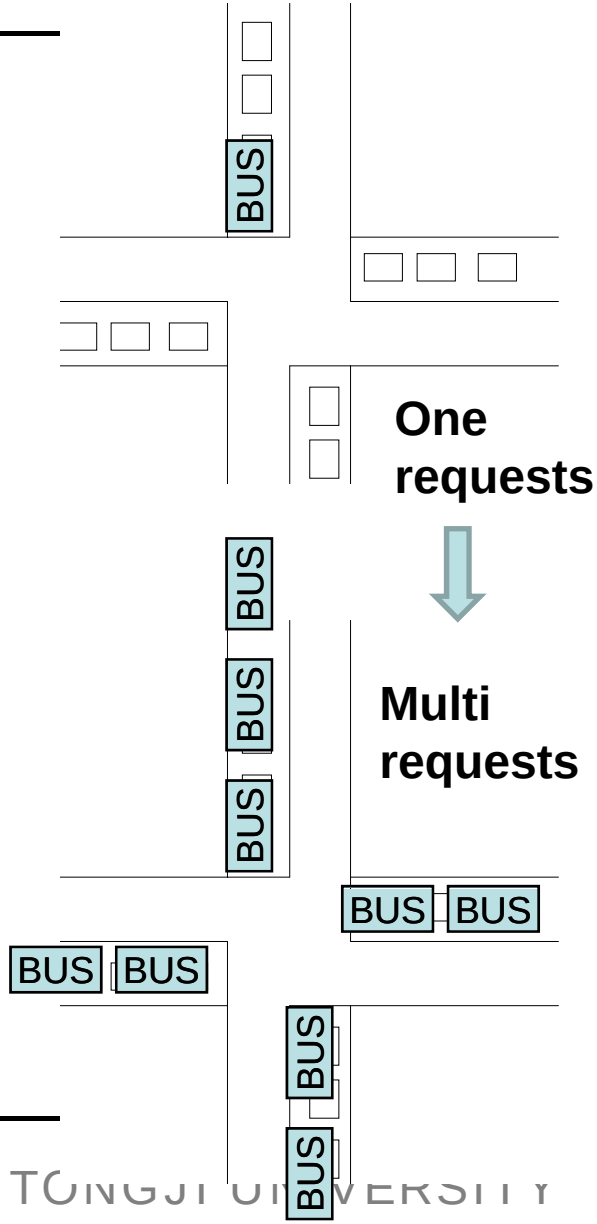
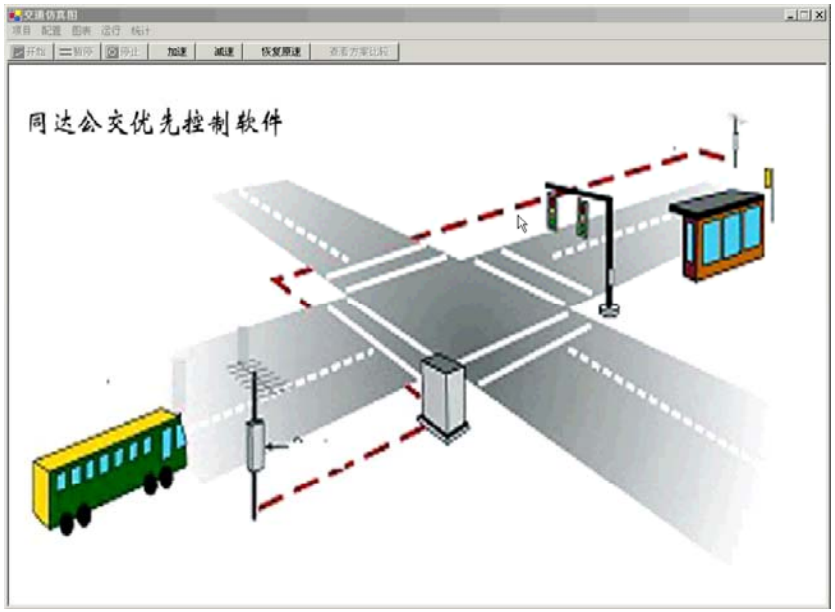
Online Optimization (2): DP model for Multi Priority Request

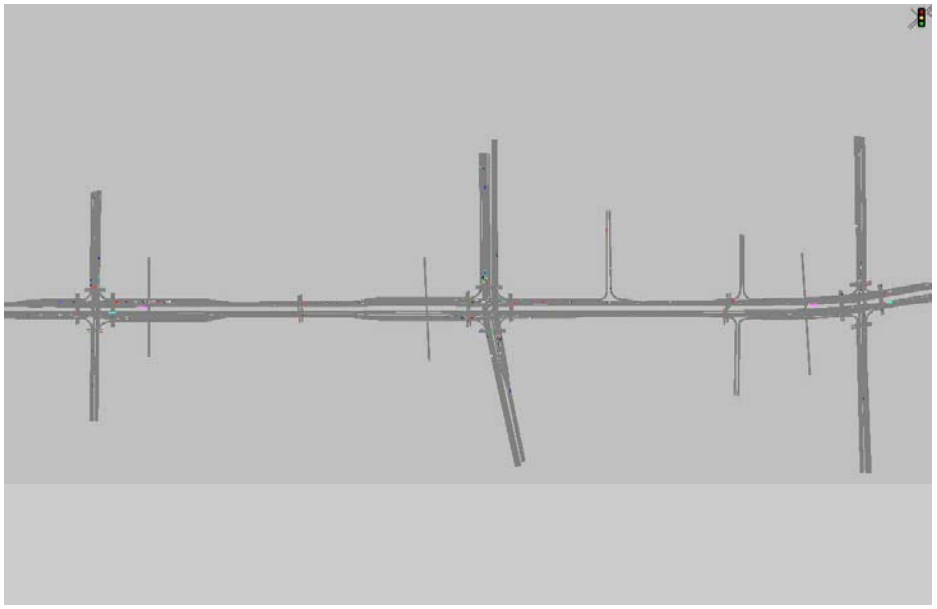






Demonstration Version





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Conclusion

- Transit signal priority is one of low cost and promising solutions to relive traffic congestion. However, a systematic strategies including traffic /transit system planning, management and design should be implemented to provide better transit service and better foundation for TSP

- A prototype of TSP was proposed and fundamental models were developed

- The performance of the proposed system applied to examples under different demand levels appears to be promising.

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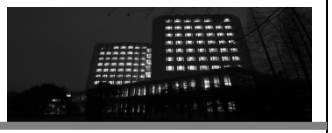
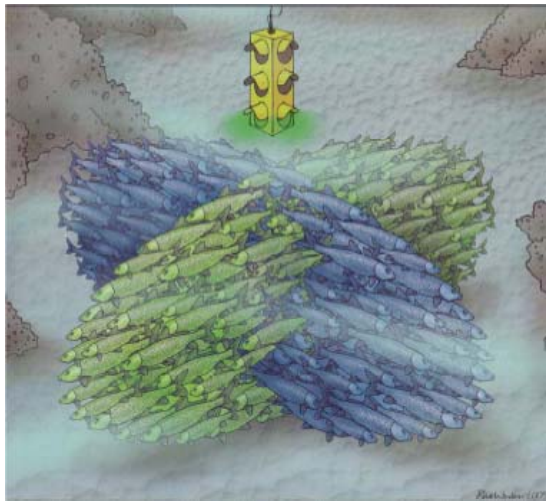


With a good model comes discovery,
with discovery comes understanding,
*with understanding comes **control**!*



Thanks for your attention!