Planning and Management Analytics for Next-generation Transit

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UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING
Transportation Research Institute

iCity-CATTS' Transit R&D Vision

- Facilitate and accelerate the transition to next-generation transit systems through
  - Understanding the impacts of new automated and shared mobility technologies
  - Developing and demonstrating new solutions and service concepts
  - Transforming the service planning, scheduling and operational management processes
  - Developing new data-driven, AI-based analytical tools and platforms for decision support

iCity-CATTS Transit R&D Program

Service Planning

- Definition & allocation of service areas by type of service/technology
- High frequency bus network design
- First/Last mile planning
- Joint fixed route and DRT services
- Bus platooning in busy corridors
- Other

Scheduling

- Bus fleet size & mix determination
- Optimal scheduling of automated bus networks
- Optimal transfer schedule design
- Dynamic scheduling of DRT and ridesharing services
- Other

Operations

- Route management
- Connection management
- Major disruption Management
- Other

Adaptive TSP for Improved Reliability and Speed

(ORF, Trapeze, OCE, NSERC and SOSCIP)

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Motivation

Reliability and speed are performance indicators important for both transit agencies and passengers

Transit services are vulnerable to variability and delays, especially in busy networks

Conventional TSP aims at reducing delays only

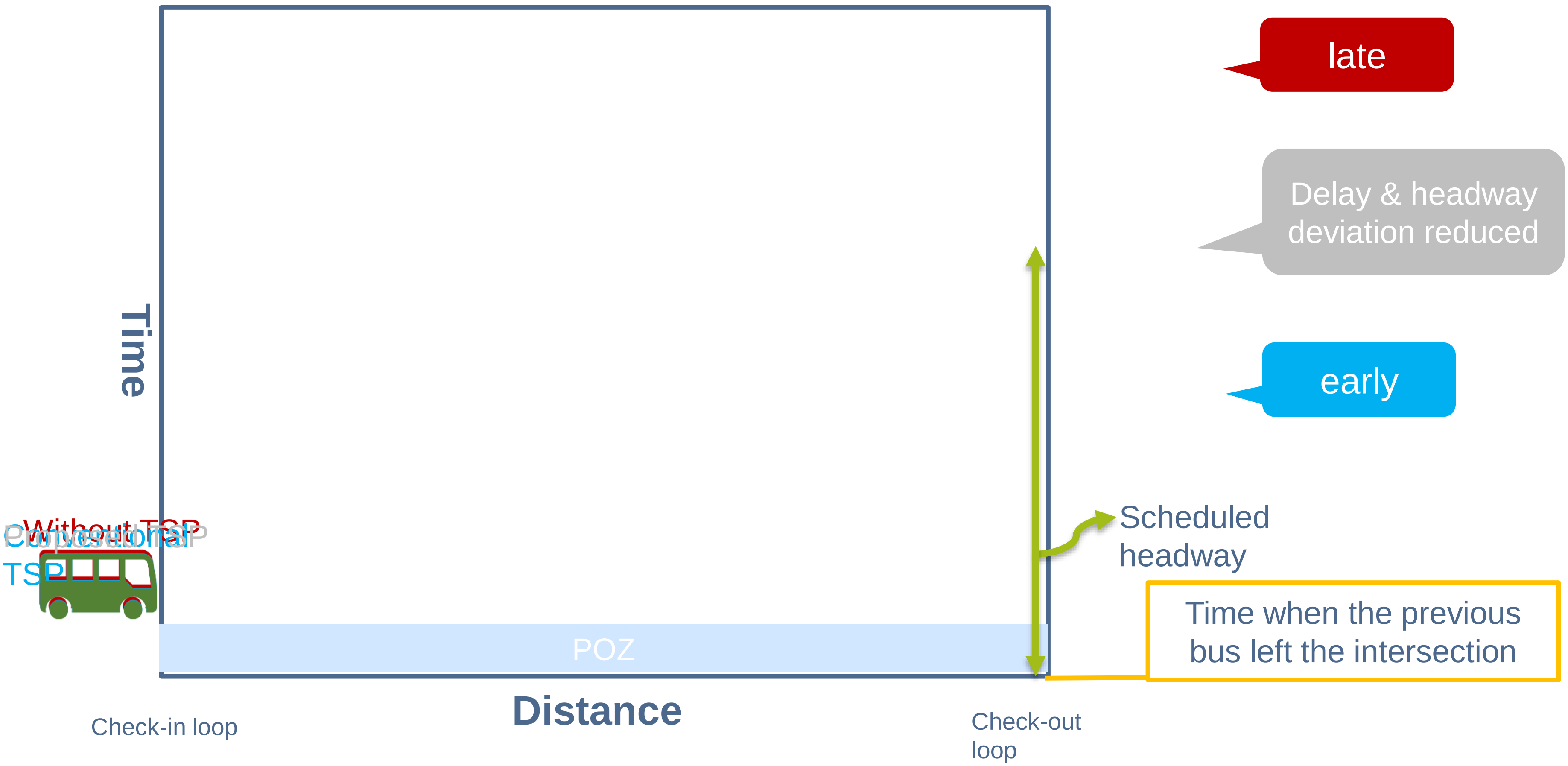
No strategies can adaptively improve headway regularity and reduce signal delays simultaneously

Goals

Develop adaptive TSP for improved reliability (regular headways) and speed

Validate the proposed TSP algorithm in a micro-simulation model of one intersection in Toronto as a case study

Goals



late
Delay & headway deviation reduced
early
Time
Scheduled headway
Time when the previous bus left the intersection
POZ
Distance
Check-in loop
Check-out loop

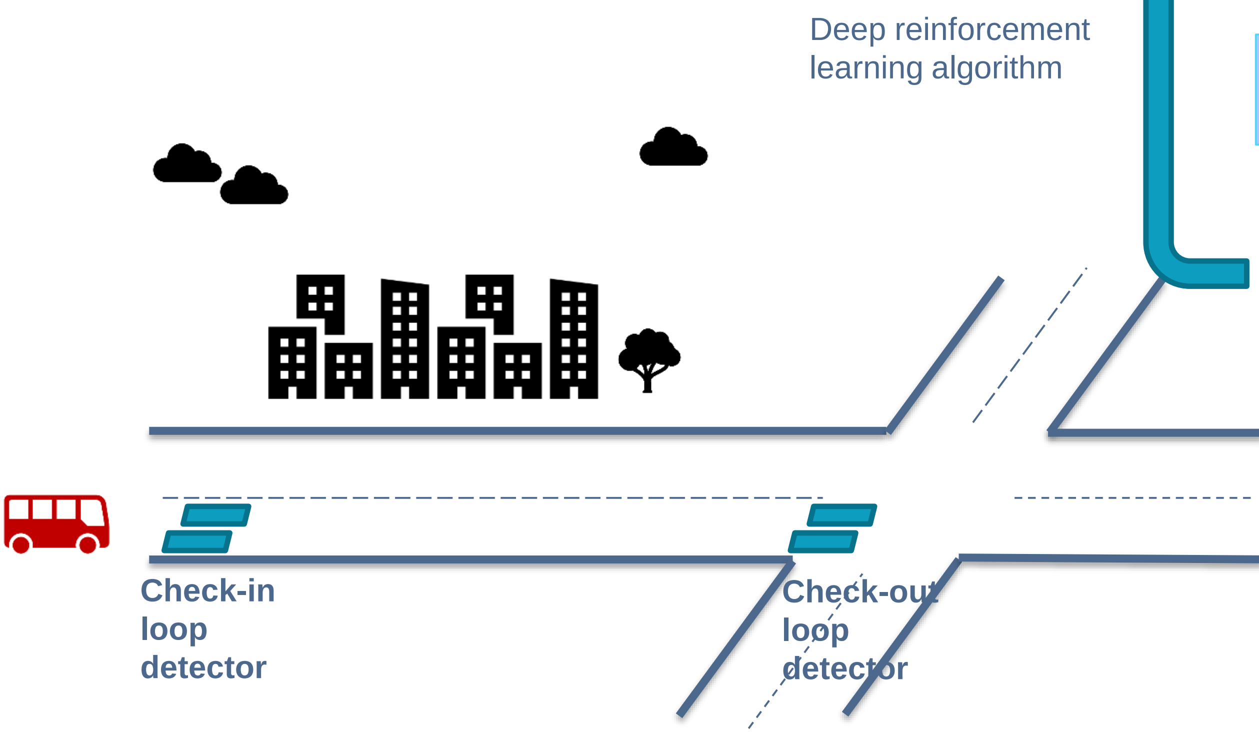
Deep Learning Method

Bus t checks in: collect data of the environment state (St), including traffic flow, target travel time (a function of headways), and elapsed time of current signal phase

Take an action (At): extend the green, or truncate the red phase

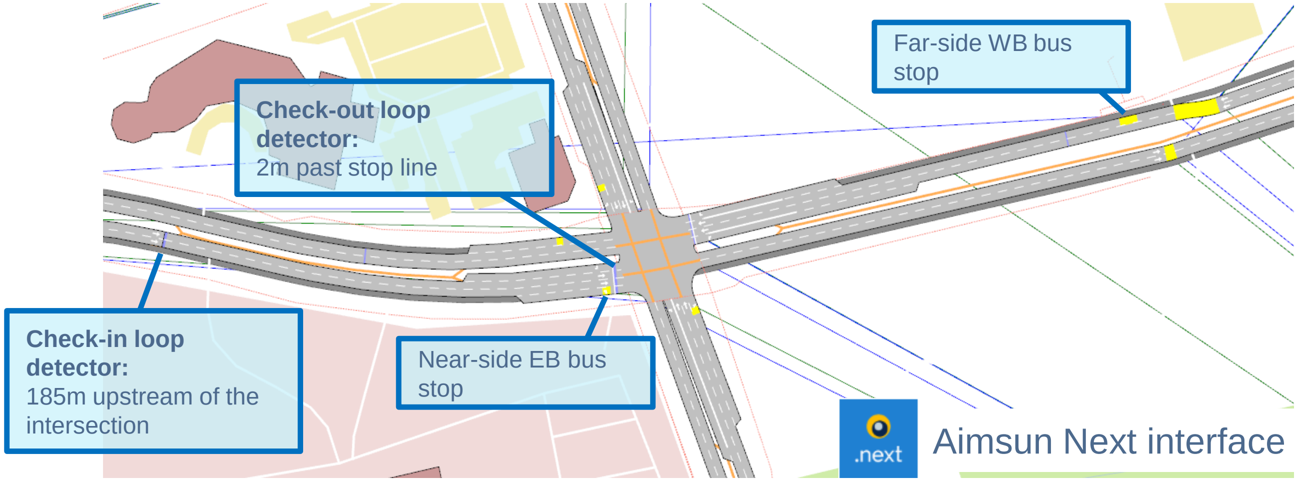
Bus t checks out: collect data of headway to Bus (t-1)

Bus (t+1) checks in: collect data of the state (St+1), calculate reward of action At, update the action-value function



Case Study

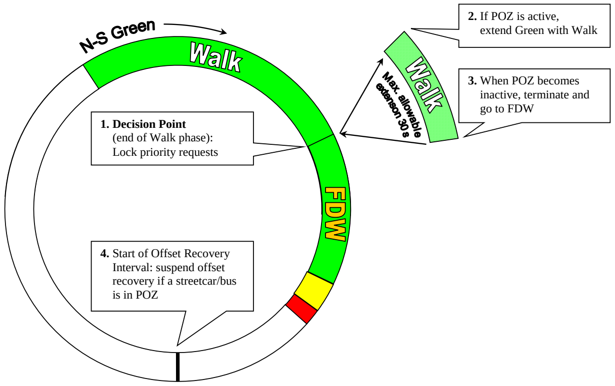
- Finch Ave West & Kipling Ave
  - TSP installed
- Bus line: 36 Finch West
  - poor reliability



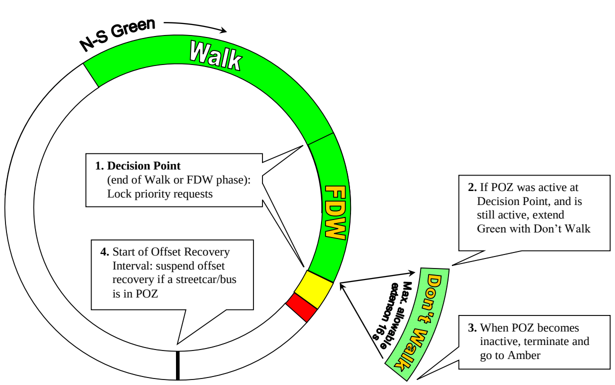
Case Study

- Base cases
  - No TSP
  - Existing TSP algorithms
    - Algorithms A and B
- Simulation shows
  - no improvement in headway regularity
  - Time spent in POZ
    - Algorithm A: 65 sec (34% shorter than No TSP)
    - Algorithm B: 68 sec (31% shorter than No TSP)

Example A. Standard Algorithm:
Extensions during Walk (up to 30 s)

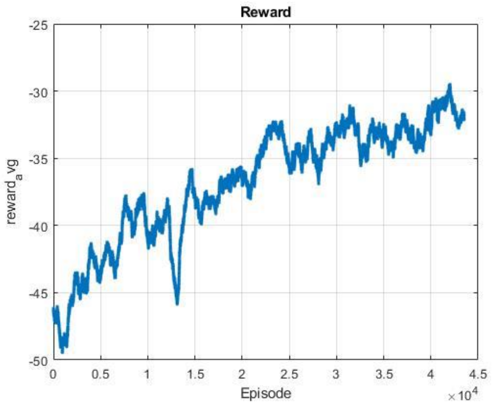


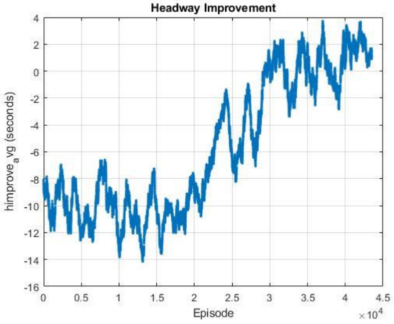
Example B. Standard Algorithm:
Extensions during Solid Don't Walk (up to 16 s)

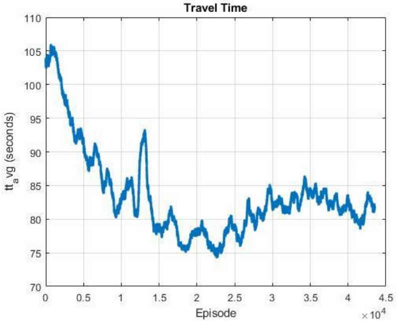


Case Study

- Proposed adaptive TSP (still in training)
  - Reward
    - Maximize $r = w_1(|h_{in} - h_{sc}| - |h_{out} - h_{sc}|) - w_2 tt$
    - 1st term: headway improvement, absolute value of check-in headway deviation minus check-out deviation
    - 2nd term: time spent in the POZ (tt)
    - Ws: weights







Summary

	No TSP	TSP Algm. A	TSP Algm. B	Proposed TSP
Average headway improvement per bus	/	/	/	10s
Average time in POZ per bus	99s	65s	68s	78s
Average extension	0	11.9s	5.4s	4.4s

- Algorithm A and B provide green extension to buses when the POZ is active at predetermined decision point(s) regardless of the headway
- No headway/reliability improvement using algorithm A or B
- The proposed TSP
  - improves headway
  - Time spent in POZ is comparable to algorithm A
  - Less overall modification to the length of green >>> effect on side street traffic

Other Transit Research at iCity-CATTS

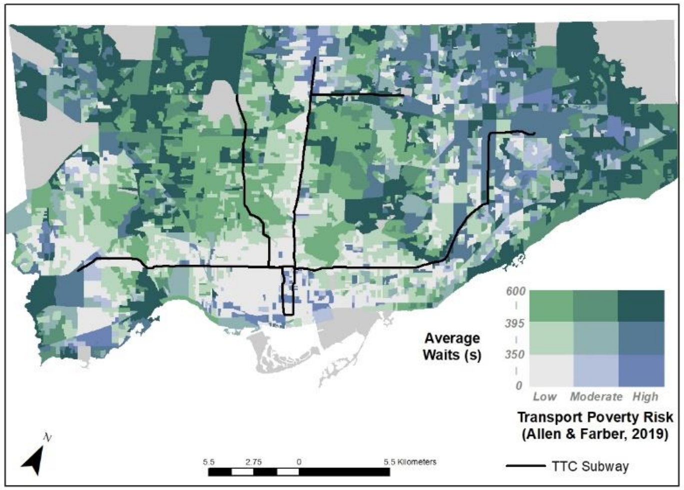
Smart Shuttles and Transport Equity

- Evaluation of smart shuttle performance and user perception/experience

  (City of Toronto, CUTRIC and MITACS)

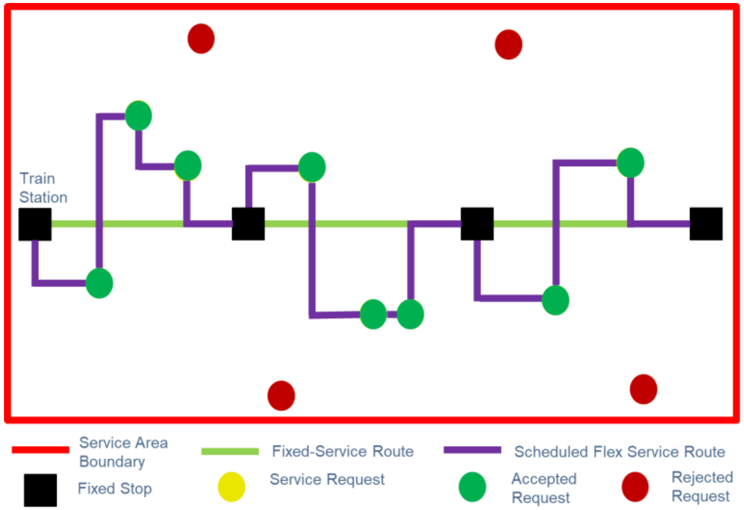
- Transport equity/justice in the era of automated and shared mobility

  (XSeed)



DRT/Microtransit Planning & Management

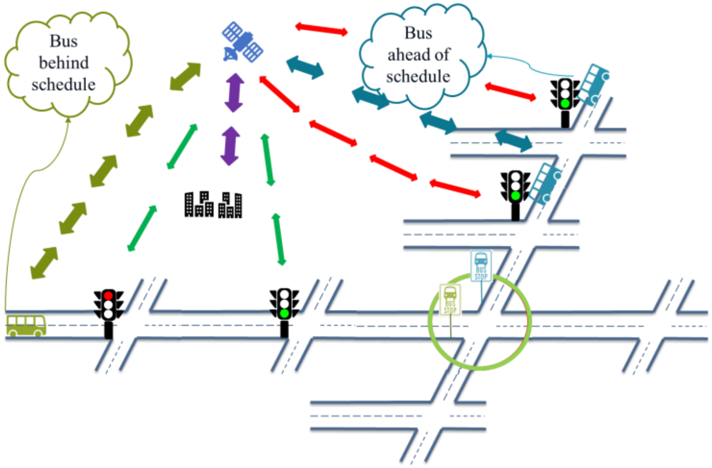
- Smart DRT/Microtransit
  - Guidelines/standards for scheduling, planning and operations
  - Demand prediction
  - Modelling tools for scenario testing



(City of Toronto, York Region)

Connected Transit

- Connection Protection
  - Analytics to enable Connected Bus operations
  - Application in a simulation model for evaluation

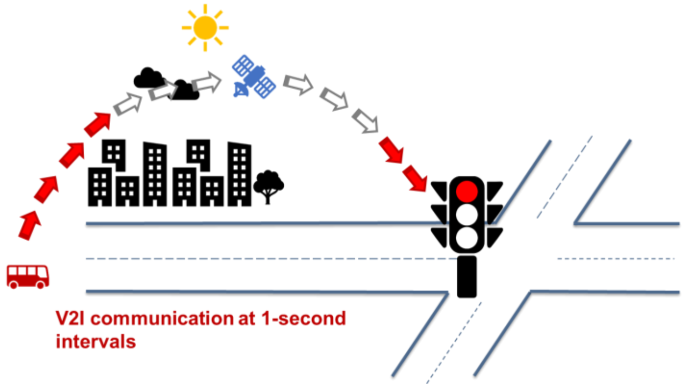


(City of Toronto, York Region)

Advanced TSP

- TSP under V2I
- Route level TSP
  - Integrated with schedule and route elements
  - Single and multiple lines
- Network level TSP

(Huawei)



TRANSIT DATA
TORONTO 2020
6TH INTERNATIONAL WORKSHOP AND SYMPOSIUM

Thank You!