Coping with Real-World Challenges in Real-Time Urban Traffic Control

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Challenges

- Uncertainty and disturbances can significantly degrade the accuracy of real-time flow predictions
- Optimization of vehicle flows requires active attention to bus and pedestrian flows

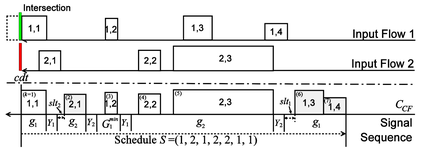
Our Work

- Investigate real-word challenges in the context of SURTRAC, a **live, urban adaptive signal system testbed**
- Propose strategies for strengthening SURTRAC to better deal with real-world uncertainties and multi-modal traffic demands
- Evaluate the effectiveness and impacts of these strategies using both simulations and analysis based on field data

SURTRAC (Scalable URban TRAffic Control) System

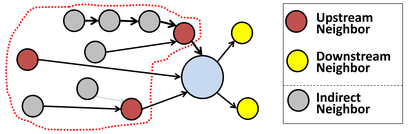
Schedule-Driven Intersection Control

– Treat each intersection as a single machine scheduling problem
– Use aggregate representation of traffic flows (as sequences of queues and platoons) to identify input jobs
– Use schedule to decide whether to extend or switch phase



Neighbor Coordination Mechanisms

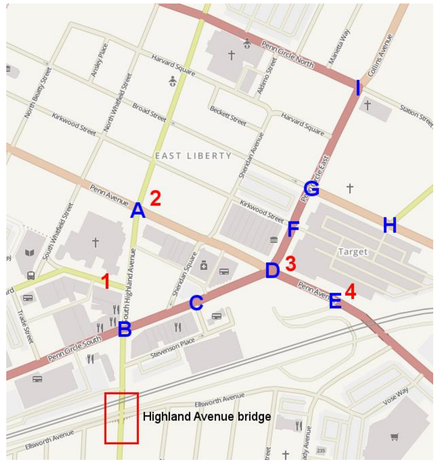
– Communicate schedules to downstream neighbors to give visibility of future input jobs
– Layer mechanisms for coping with mis-coordinated situations (e.g., spillback) to account for fact that schedules might change



The East Liberty Adaptive Signal Testbed

Network Characteristics

– Grid-like character in contrast to arterial settings
– Tightly coupled intersections impose a challenge for coordination in decentralized control
– A range of uncertainties and disruptions



System Performance and Robustness

– Pilot tests: 26% lower travel time, 41% lower wait time
– Inherent robustness for handling significant changes in traffic flow patterns over time
➢ e.g., flow changes caused by the closing of the Highland Avenue bridge between Mar 4 - Oct 23, 2013

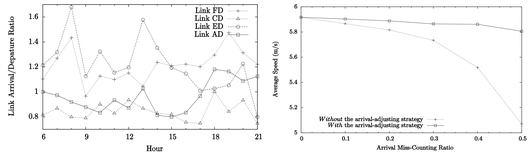
Percentage increase in vehicle counts at **D** after the bridge closing

	EDF	EDA	EDC	FDC	FDE	ADE	ADF	CDE	CDF	Total
Mon	23.6%	23.0%	29.8%	1.4%	14.7%	24.2%	-4.6%	45.5%	-5.9%	**20.0%**
Tue	14.4%	24.4%	32.0%	-5.7%	17.6%	23.2%	-6.9%	49.5%	-4.6%	**18.9%**
Wed	18.9%	27.1%	30.1%	-2.5%	14.8%	18.3%	-4.1%	46.8%	-8.2%	**18.6%**
Thu	15.7%	22.4%	27.3%	-0.6%	17.9%	21.4%	-5.3%	50.1%	-4.5%	**19.1%**
Fri	22.3%	25.1%	32.8%	-4.7%	13.9%	19.1%	-10.3%	42.9%	-11.8%	**17.8%**
Sat	20.7%	23.9%	25.1%	-2.1%	14.6%	26.2%	-6.0%	49.6%	-4.8%	**20.4%**
Sun	20.2%	22.6%	32.9%	-4.4%	10.3%	27.8%	-2.1%	52.8%	-5.5%	**20.7%**
avg	**19.3%**	**24.1%**	**29.9%**	**-2.7%**	**14.9%**	**22.6%**	**-5.7%**	**48.0%**	**-6.6%**	**19.3%**

Strengthening Strategies

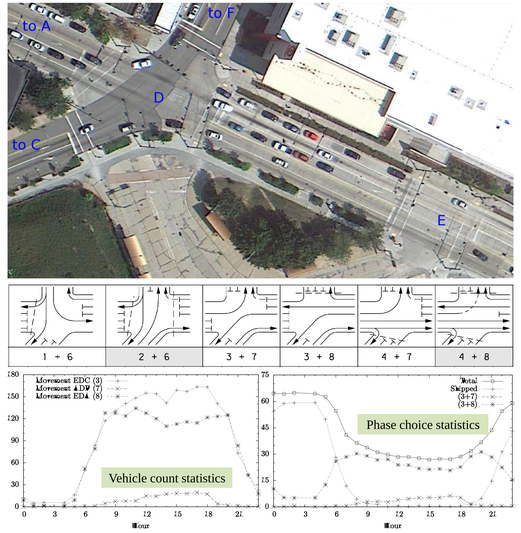
1. Queue Management

– **Problem**: Handle various forms of sensing uncertainty (e.g., detection errors, hidden flows from/to mid-block side streets)
– **Approach**: (1) Define states using detection information; (2) Adjust arrival counts dynamically based on arrival/departure ratio
– **Result**: Restore the performance to near optimal



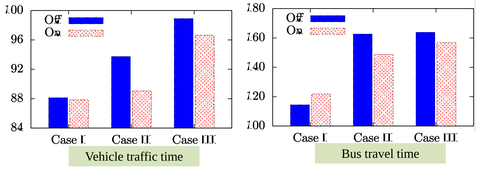
3. Minor Flow Management

– **Problem**: How to service minor flows more intelligently
– **Approach** (Hybrid control): major flows by the local scheduler, minor flows by an actuated mode with history-based prediction
– **Result**: Balance system adaptivity and robustness; keep efficiency for major flows; and ensure stability from minor flows



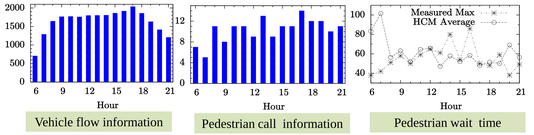
2. Disruption Management

– **Problem**: The flow on a road might be temporarily blocked during the green period (e.g., caused by bus stops, or spillback)
– **Approach**: Treat disruption as a job delay in scheduling problem
– **Result**: (1) Optimize the efficiency for both vehicle and bus flows; (2) No need to define a number of heuristic decision rules



4. Pedestrian Flow Management

– **Problem**: Pedestrians are often ignored in vehicle-centric systems
– **Approach**: Vehicle-pedestrian mixed coordination protocol
– **Result**: Reduce pedestrian wait time and ensure coordination



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