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Adaptive Truck Priority Signal System

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Motivation

Differences between Passenger Cars and Trucks

Acceleration Rates of Cars and Trucks

Speed Range (mph)	Acceleration Rates (ft/sec²)	
	Passenger Car	*Typical Truck*
0 – 20	7.5	1.6
20 – 30	6.5	1.3
30 – 40	5.9	0.7
40 – 50	5.2	0.7
50 – 60	4.6	0.3

Avg. Emission Rates of Cars and Trucks

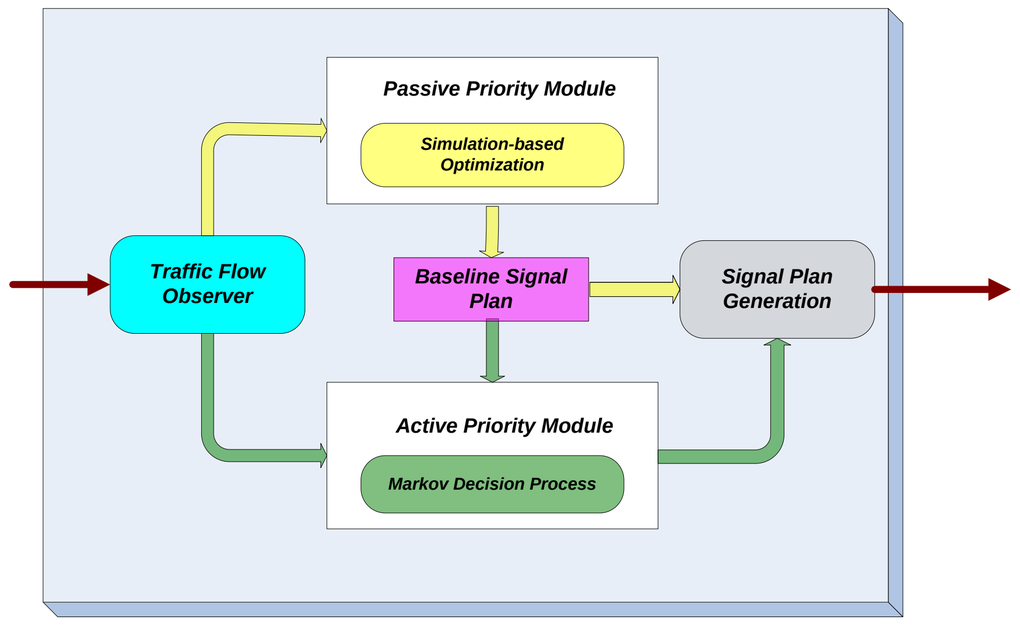
Pollutant	Emission Rates (g/h)	
	Passenger Car	*Typical Truck*
VOC	2.683	6.495
THC	3.163	7.260
CO	71.225	151.900
NOx	3.515	5.330

Two Vehicle Queues Before Traffic Signal

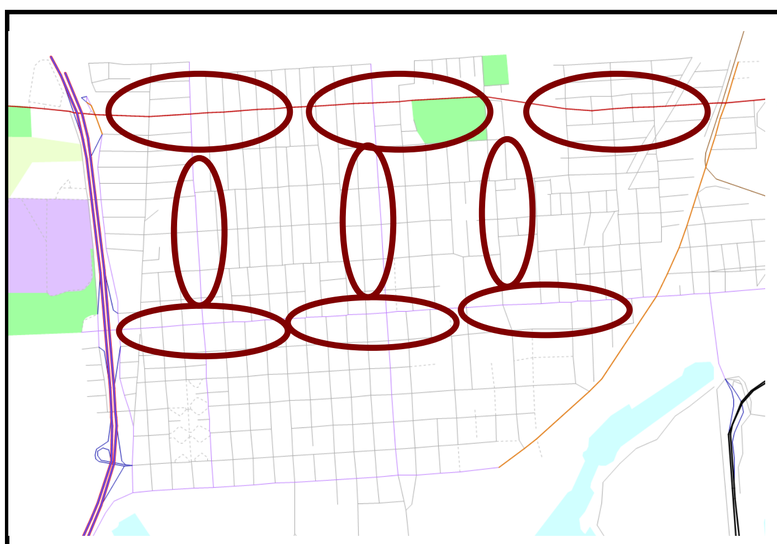
Queue with All Cars | Queue with A Truck

- ❑ Increasing total traffic delay
- ❑ Increasing total pollutant emissions

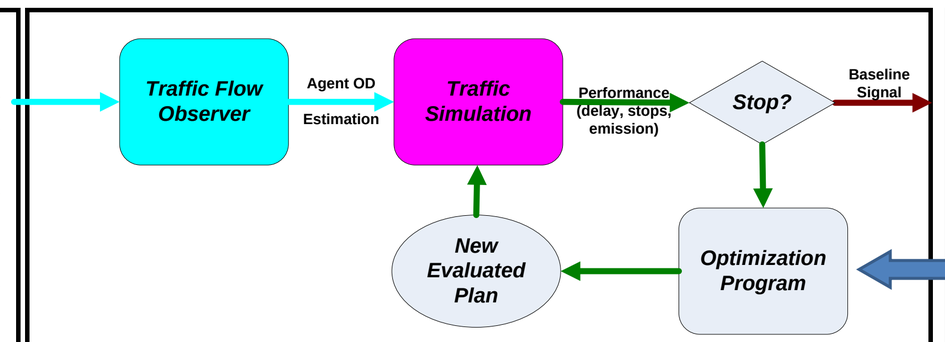
Solution



Simulation-based Passive Priority Module



Multi-Agent Signal Control



$$\min_{c,g,o} \quad J(x) = TD(c,g,o) + \beta ST(c,g,o) + \gamma EM(c,g,o)$$

$$s.t. \quad c \in [c_{\min}, c_{\max}]$$
$$g_i \in [g_{i\min}, g_{i\max}]$$
$$o_i \in [o_{i\min}, o_{i\max}]$$
$$\forall i \in 1,\ldots,m$$

Initialization at $k = 0$:

1) For each phase , initialize its green length and offset, then obtain an initial solution x_0;
2) Select search direction vector $d = (d_1, d_2, .., d_n)$;
3) Select algorithm parameters: $\lambda \in [1, \infty)$, $\theta \in (0,1)$, and ε.

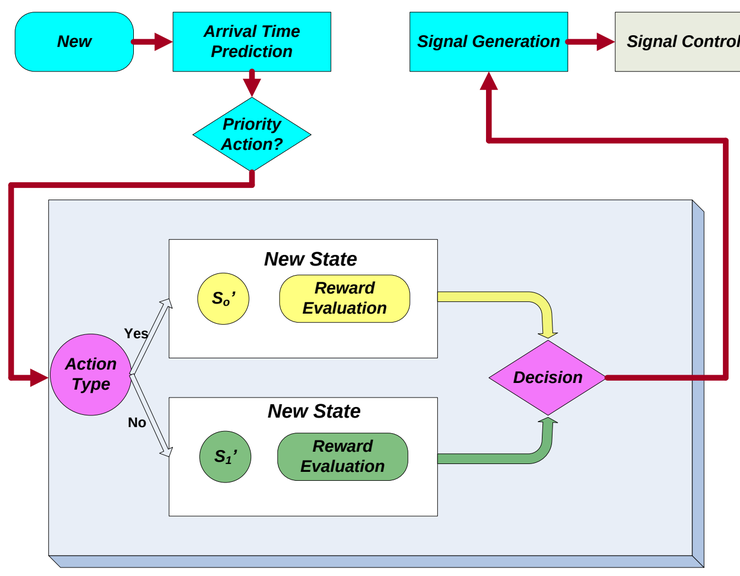
For each time step k, do:

1) Evaluate the value of objective cost function with simulation, get $J(x_k)$;
2) For each search direction $i = 1, 2, ..., n$:
   Compute directional search step s_k^i;
   Evaluate $J(x_k + s_k^i)$ if $x_k + s_k^i$ is a feasible solution;
   End for
3) Select $s_k = \arg\min_{s_k^i} f(x_k + s_k^i)$;
4) If $f(x_k + s_k) \geq f(x_k)$
   Update step size $\Delta_{k+1} = \theta \Delta_k$ and $x_{k+1} = x_k$
   Else
   Update $\Delta_{k+1} = \lambda \Delta_k$ and $x_{k+1} = x_k + s_k$;
5) If $\Delta_{k+1} \leq \varepsilon$, stop algorithm and return x_{k+1};

End for

Active Priority Module

Priority Request and Response



- ❑ No Action
- ❑ Green Extension
- ❑ Early Green
- ❑ Phase Insertion

Optimal Decision Iteration

$$a = \{a_1, a_2, a_3, ..., a_r\} \qquad a_i = \begin{cases} 1, & \text{give the priority} \\ 0, & \text{refuse the priority} \end{cases}$$

$$\left(\dot{\theta}_1(t), \dot{\theta}_2(t), ..., \dot{\theta}_n(t)\right) = f_{in}(t \mid s) - f_{out}(t \mid s, a)$$

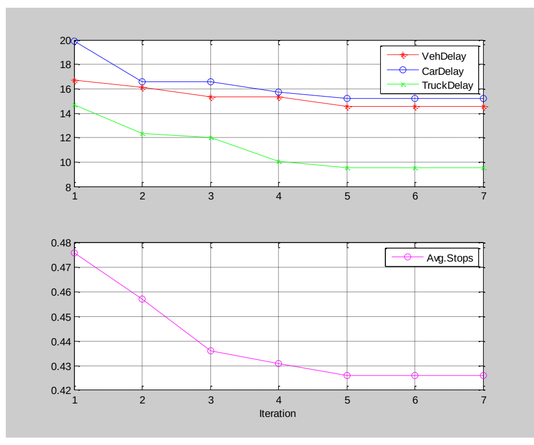
$$R_a(s, s') = -\frac{1}{T} \sum_i \int_t^{t+T} w_i \theta_i(\tau) d\tau$$

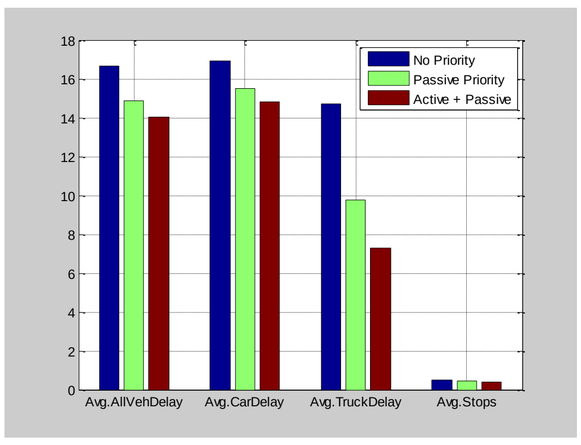
$$\pi(s) := \arg\max_a \left\{ \sum_{s'} P_a(s, s') \left(R_a(s, s') + \gamma V(s') \right) \right\}$$

$$V(s) := \sum_{s'} P_{\pi(s)}(s, s') \left(R_{\pi(s)}(s, s') + \gamma V(s') \right)$$

Measurements

Fixed OD Input





Dynamic OD Input

	No Priority	Passive Priority		Active + Passive Priority	
		Value	*Improved Percent*	*Value*	*Improved Percent*
Avg. Delay/Veh (sec)	15.767	15.216	3.49%	14.391	8.73%
Avg. Delay/Car (sec)	15.993	15.498	3.10%	14.871	7.02%
Avg. Delay/Truck (sec)	12.697	11.383	10.35%	7.861	38.09%
Avg. Stops/Veh	0.463	0.471	-1.73%	0.440	4.97%
Avg. Stops/Car	0.466	0.477	-2.36%	0.456	2.15%
Avg. Stops/Truck	0.418	0.399	4.55%	0.229	45.22%
Avg. Speed/Veh (mph)	28.631	28.760	0.45%	28.956	1.14%

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