Signal Control with Realistic Cycle-length (SCRC) for Managing Transportation Networks

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Dynamic Traffic Assignment (DTA)

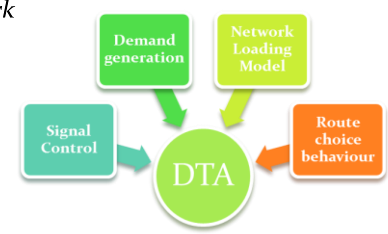
"DTA describes time-varying network and demand interaction using a behaviourally sound approach"-TRB

What is DTA?

- *Is a model to understand road network performance*
- *Input → demand, network topology*
- *Output → optimal solution to the problem*
- *Solution types: System Optimal (SO), User Equilibrium (UE), bi-level*

Applications:

- Network modeling and analysis
- Inter-zonal travel cost
- Identify congested link → Network Design Problem (NDP)



The theme of the research

To propose realistic traffic signal control models for the Dynamic Traffic Assignment (DTA) problem

Objectives:

- DTA framework with embedded signal control
- Demand responsive control
- Linear formulation

Traffic Signal Control (SC)

- ***Controls the traffic movements at the intersection***
- **Control schemes:**
  - a) **Fixed-SC:** green splits are fixed or pre-timed
  - b) **Traffic actuated:** decision variables determines green splits
- **Most important property for DTA-SC: linearity**

1. Less complexity and easy to solve
2. Can be applied to realistic size network

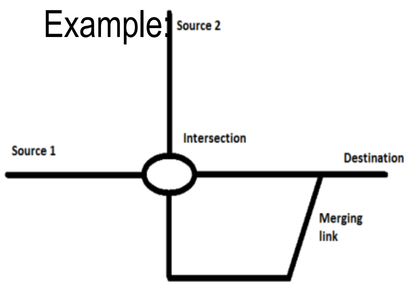
- **Existing DTA frameworks with SC**
  - *a)* ***Mixed integer or non-linear:*** very high complexity and computationally intractable
  - *b)* ***Continuous (Ukkusuri et al. 2010):*** Cycle time = discrete time interval of the Network Loading Model. **So, unrealistic cycle length**

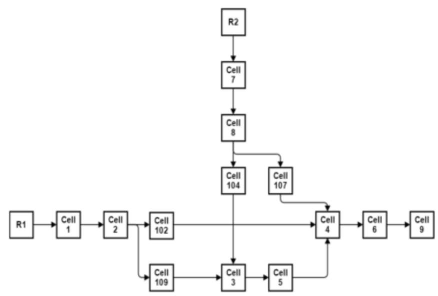
How the roads are modeled?

Network Loading Model of DTA: Cell Transmission Model (CTM)→Roads are divided into number of homogeneous segments called cells

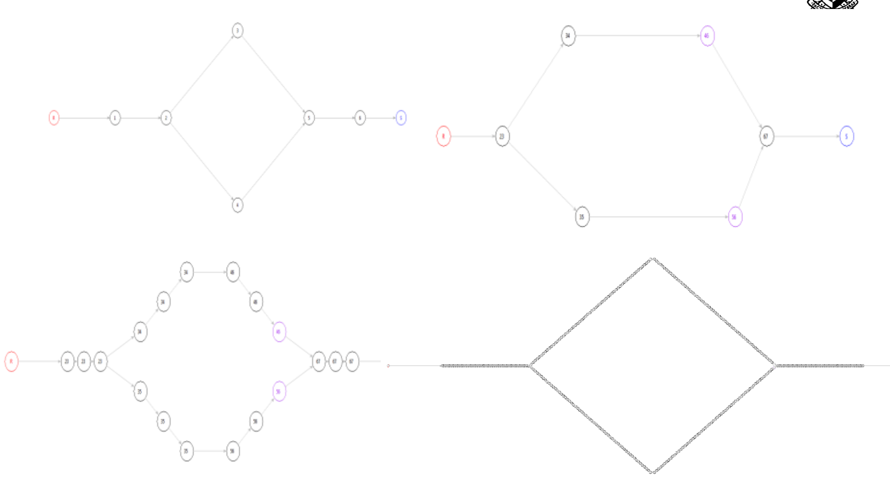
Cell length = free flow speed x discrete time interval

Example:



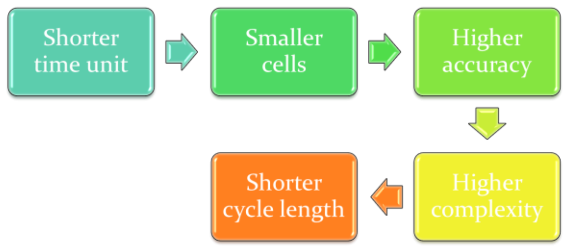


Impact of discrete time interval



Where is the problem?

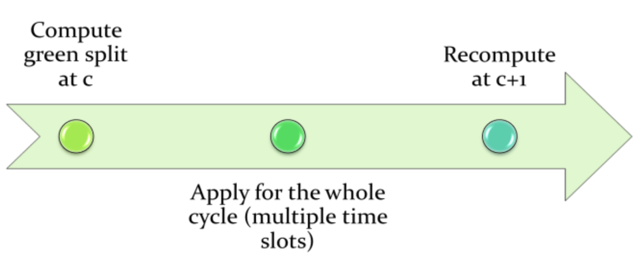
The only linear-continuous model by Ukkusuri (Ukkusuri et al. 2010):



- 60s CTM = 1km cell length !
- 1s CTM would have 1s cycle length ! Not realistic !
- We need a realistic signal control cycle length for reasonably short discrete time slots for maintaining the accuracy and usability of the solution

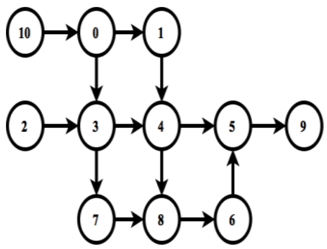
Solution: our approach

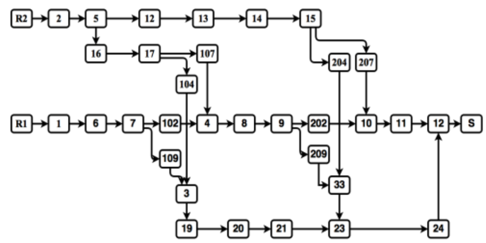
t = time slot index, c = cycle start index $c = \left\lfloor \frac{t-1}{m} + 1 \right\rfloor$,
m = cycle length (multiple of time slots)



- Strikes balance between accuracy and complexity
- Enables us to set realistic cycle-length
- Linear, continuous, and computationally tractable

Results: the network





The road network

Cell representation

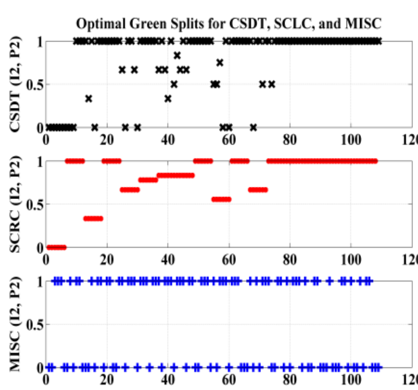
Cells	1,6,7,2,5,11	All other cells	R1, R2	S
Q_i	12	6	12	∞
N_i	36	18	∞	∞
δ_i	0.5	0.5	--	--
v	15.24 ms-1	15.24 ms-1	--	--

Structure of optimal green splits

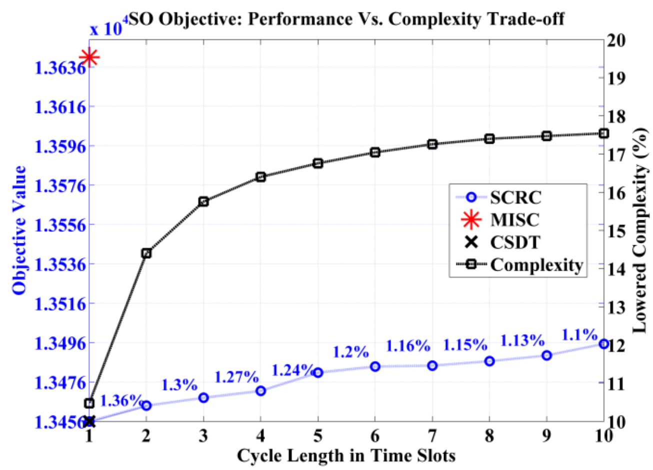
Ukkusuri's Approach→ CSDT: Cycle-length Same as Discrete Time

Our method→SCRC: Signal Control with Realistic Cycle

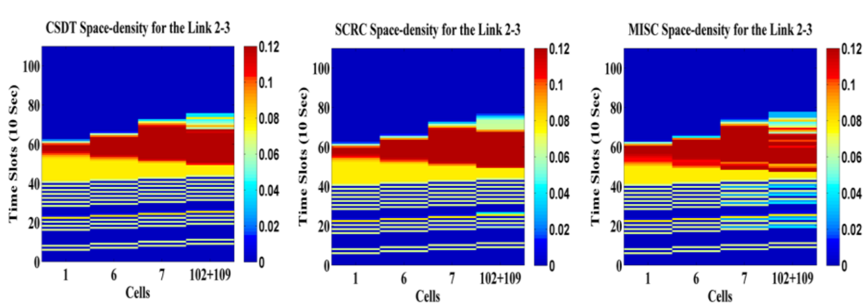
MISC: Mixed-integer Signal Control



Performance Vs. complexity



Congestion and adaptation



Conclusion

- SCRC→a novel realistic traffic signal control model
- Linear model and attains solution faster
- Resolves the trade-off → cell-length and signal control cycle-length
- Attains comparable performance to CSDT model
- Adaptive to varying traffic conditions
- Reduces the complexity of the problem substantially

Questions

CAIA Seminar http://caia.swin.edu.au tislam@swin.edu.au 19/11/2015