Organic Traffic Control Collaborative (OTC^2)

7th colloquium of the DFG SPP Organic Computing, Zurich, Switzerland
September 17th/18th, 2008

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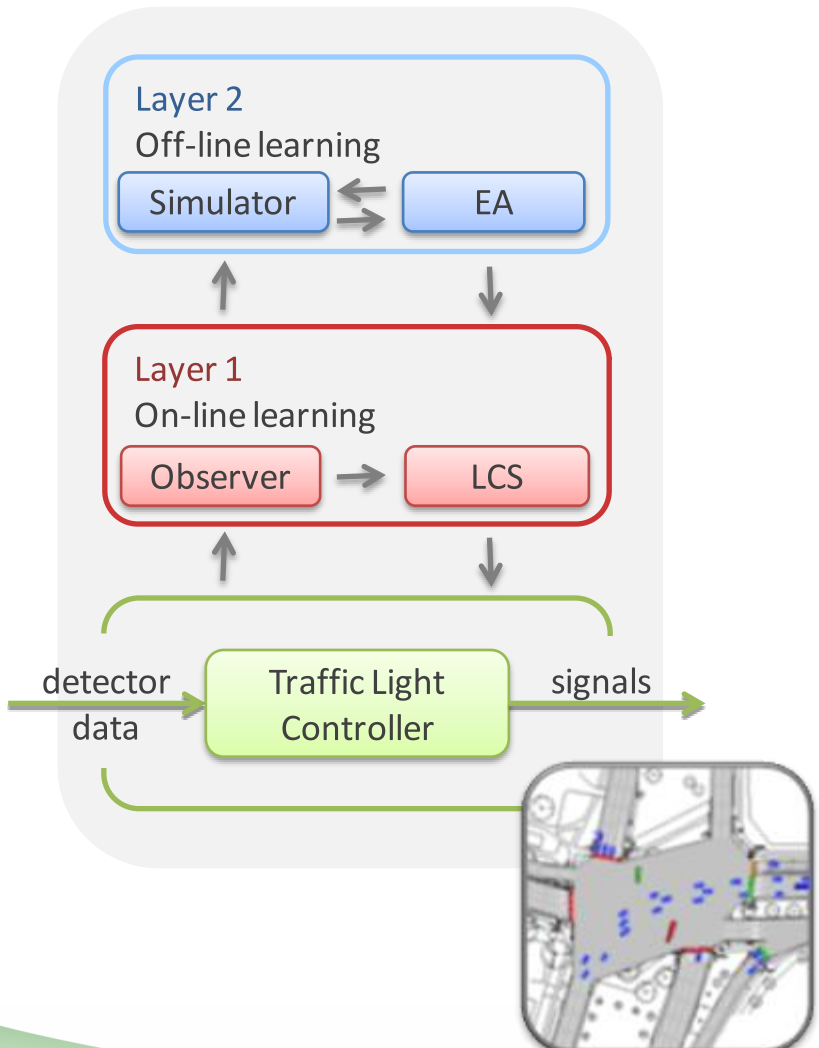
Motivation

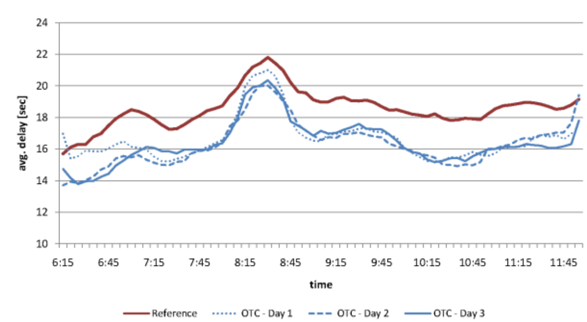
Organic Traffic Control



OTC architecture

- *adapts autonomously* to its changing environment,
- *learns new control strategies* when necessary, and thereby
- *limits manual intervention* and effort for setup and maintenance.

Evaluation in a *realistic scenario* showed *promising results.*



Motivation

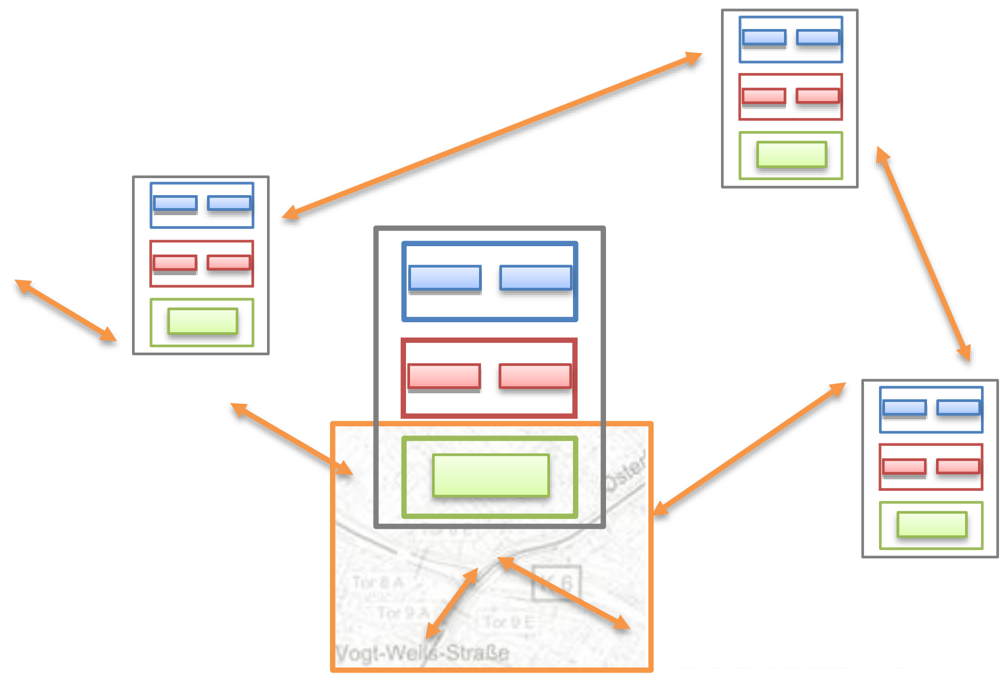
Organic Traffic Control Collaborative

Goals

- Investigate possibilities for collaboration
- Study different architectural variants

Current focus

- *Traffic-responsive* creation of Progressive Signal Systems (PSS)
- *Decentralised* operation



Outline

- Decentralised Progressive Signal Systems
  - Determine collaborating nodes
  - Determine cycle time
  - Determine offsets
- Experimental results
  - Arterial road
  - Manhattan network
- Conclusion

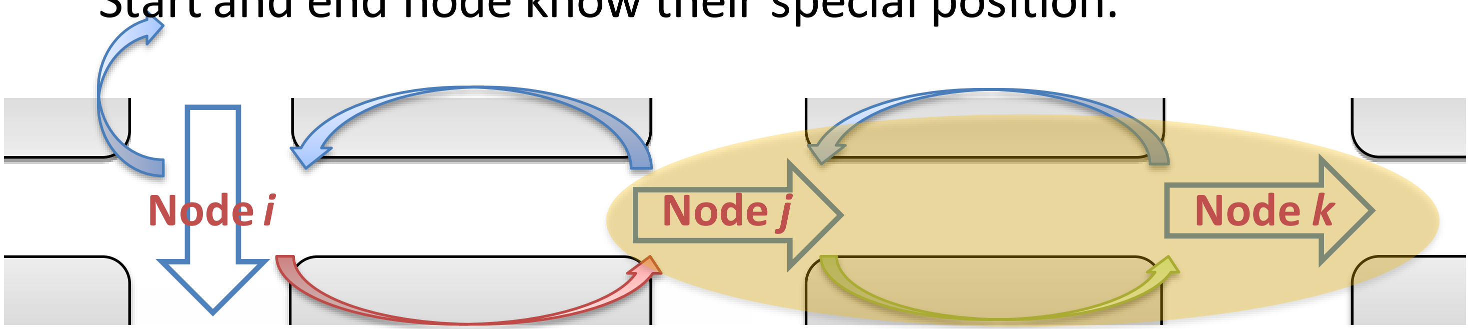
1. Determine collaborating nodes

Traffic-dependent selection of suitable partners for a PSS

Algorithm running locally at each node *j:*

1. Node *j* locally determines its strongest turning "*i* → *k*".
2. Node *j* informs its desired predecessor *i*.
3. Local matching: Is *j* the desired predecessor of *k*?
   - Yes → Acknowledge partnership.
   - No → Reject partnership.

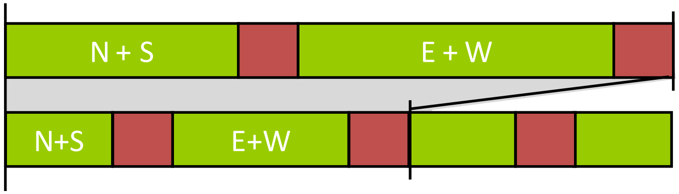
Result Nodes in PSS know their predecessor and successor.
Start and end node know their special position.



2. Determine cycle time

Common cycle time as a prerequisite for coordination

- Shorter cycles decrease the node capacity (due to clearance times)



- Longer cycles increase delays in undersaturated traffic conditions

→ Provide *sufficient capacity* while *keeping short delays*

How can this trade-off be realised?

Each node keeps track of

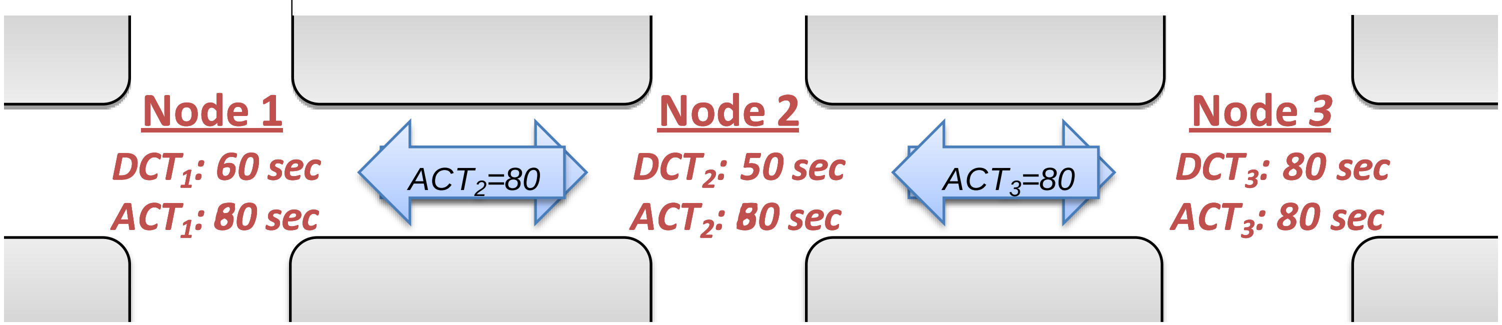
- its own desired cycle time (DCT) (determined by LCS invocation, tends to be short due to delay optimisation)
- an agreed cycle time (ACT) (maximum of other DCTs).

Decentralised Progressive Signal Systems

2. Determine cycle time

Echo algorithm for cycle time determination

1. Each node *i* determines DCT_i and sets $ACT_i := DCT_i$.
2. Node 1 sends ACT_1 to its successor.
3. Node *i* receiving ACT_{i-1}
   - sets $ACT_i := \max \{DCT_i, ACT_{i-1}\}$, and
   - sends ACT_i to node i+1.
4. ACT is propagated back to node 1 when the last node was reached.

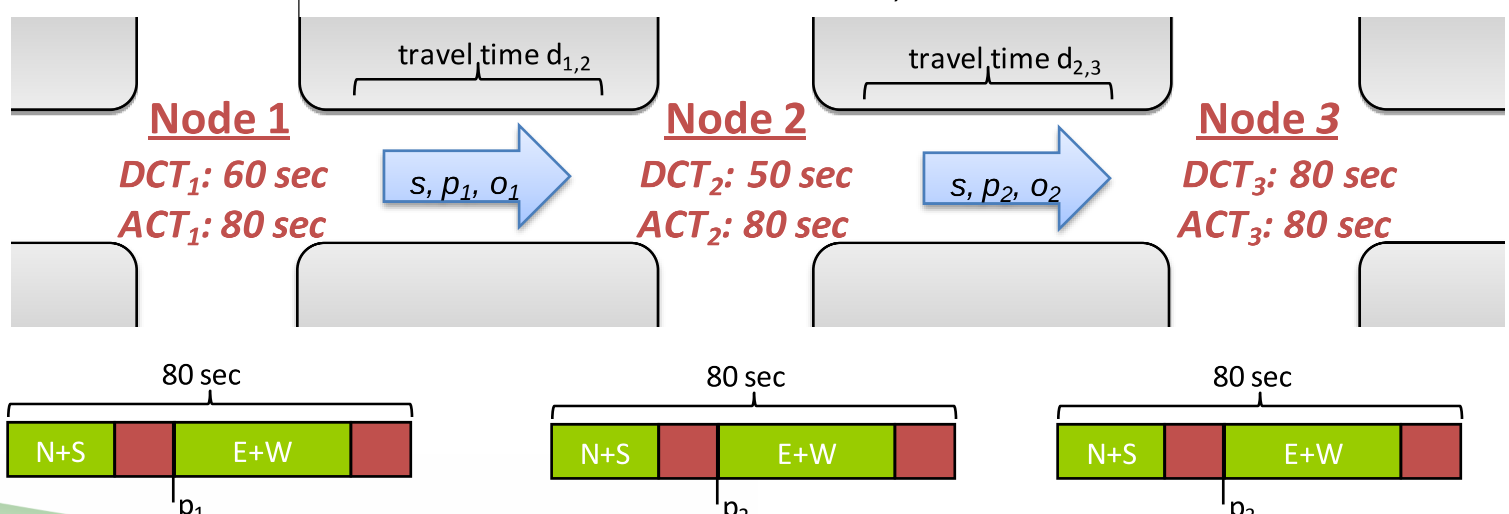


Decentralised Progressive Signal Systems

3. Determine offsets

Starting at the first node, the nodes successively

- select TLCs (by LCS invocation with respect to ACT),
- determine/ communicate
  - the absolute start time *s* of the PSS at the first node,
  - the relative start p_i of their synchronised phase,
  - the travel time $d_{i-1,i}$, and
  - their relative offset $o_i = o_{i-1} + p_{i-1} + d_{i-1,l} - p_{i.}$



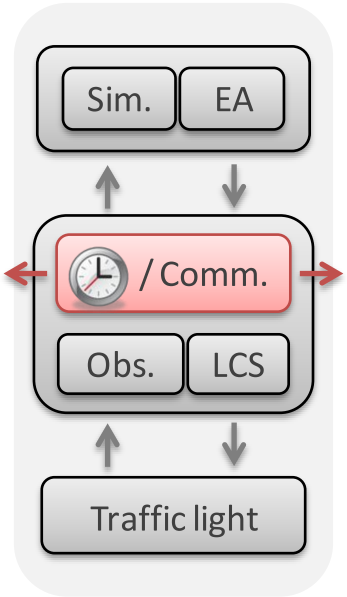
Establish synchronisation

Establishing a PSS

Intermediate traffic light controllers to implement offsets

Technical requirements

- Synchronised clocks at collaborating traffic nodes
- (Local) communication capability



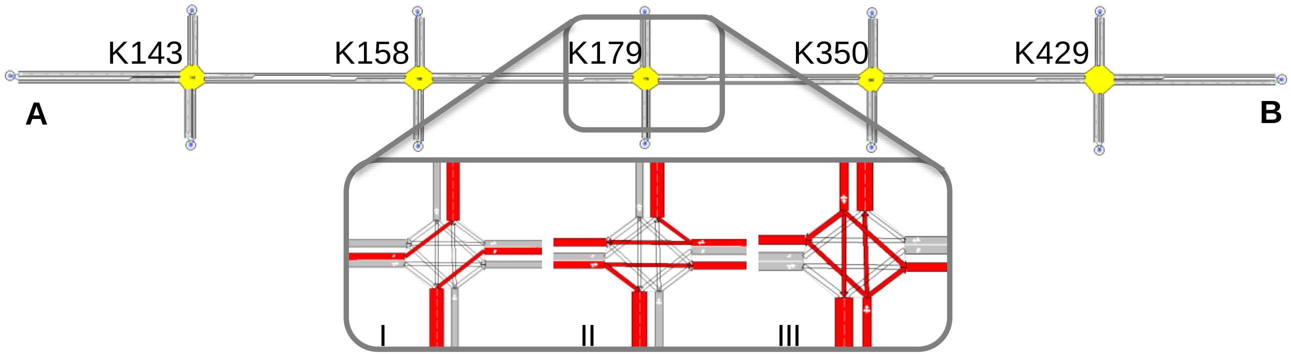
Necessary extensions of the OTC architecture

- Cycle time constraint for LCS and EA
- Cycle time modification for existing traffic light controllers

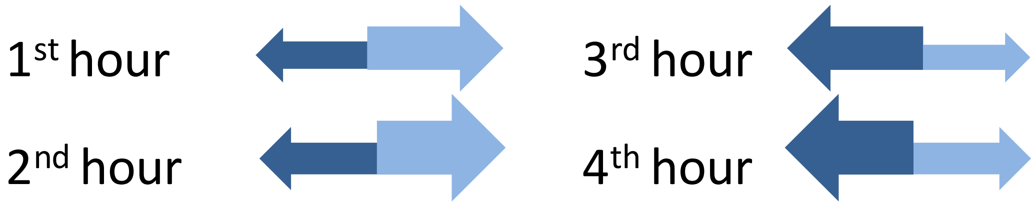
Experimental results

Arterial road

Arterial road with 3-phased intersections



Traffic demands



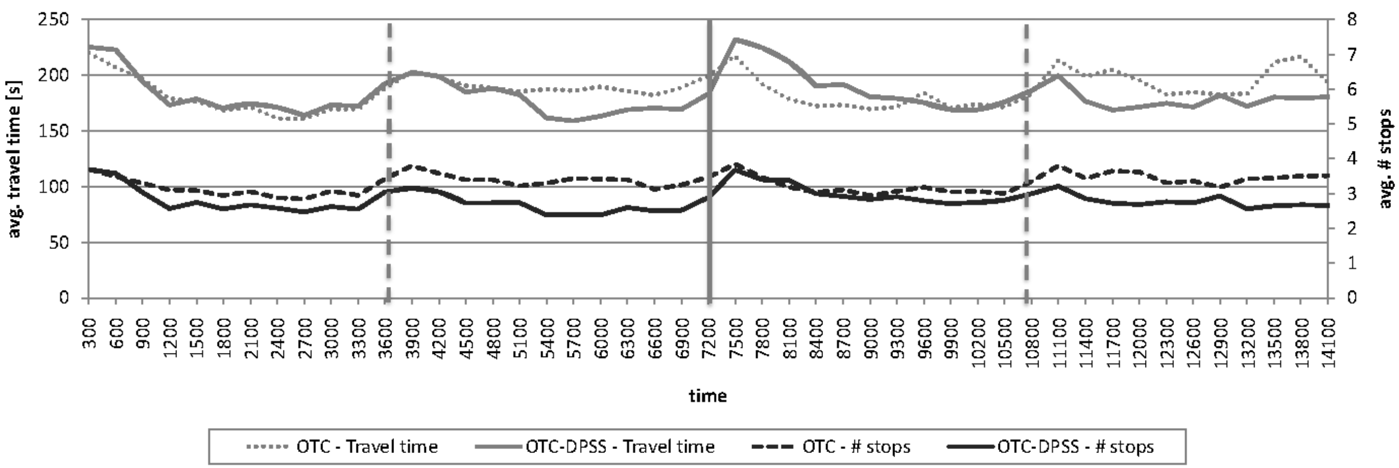
Comparison OTC nodes (Phase I) vs. collaborating OTC-DPSS nodes (Phase II)

Criteria

- Network-wide travel time and number of stops
- Local delay times at nodes

Experimental results
Arterial road

Network-wide results



Number of stops

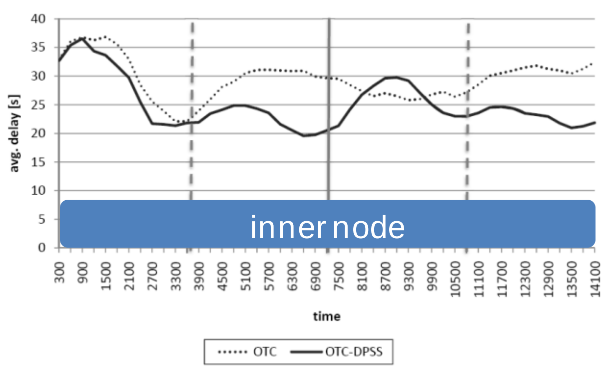
15% reduction

Travel times

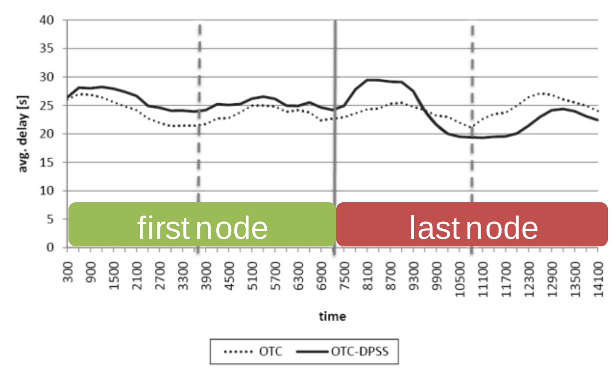
Slightly reduced

Local delays

K 350



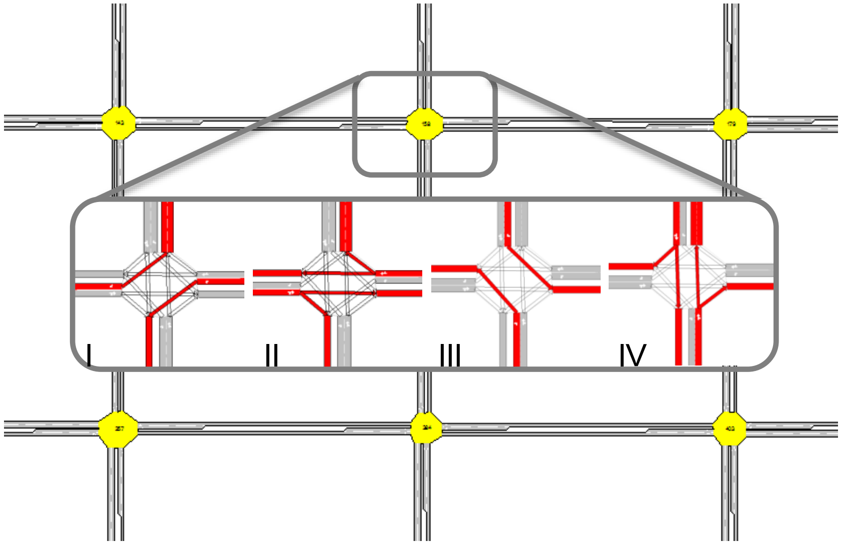
K 429



Experimental results

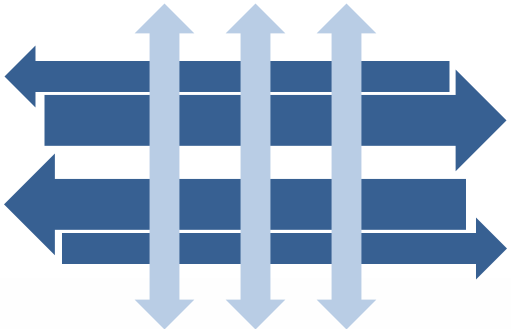
Manhattan network

Manhattan network with 4-phased intersections

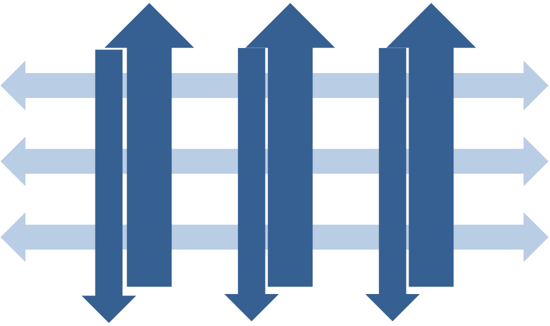


Traffic demands

1st half

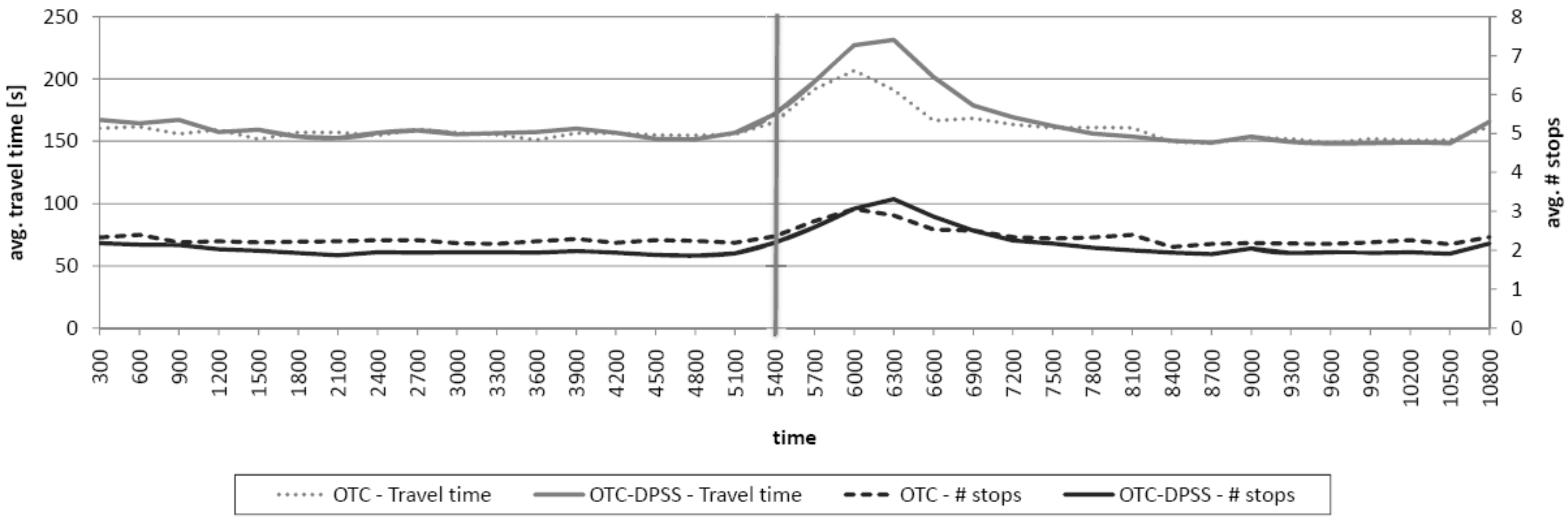


2nd half



Experimental results

Manhattan network



Number of stops

7% reduction

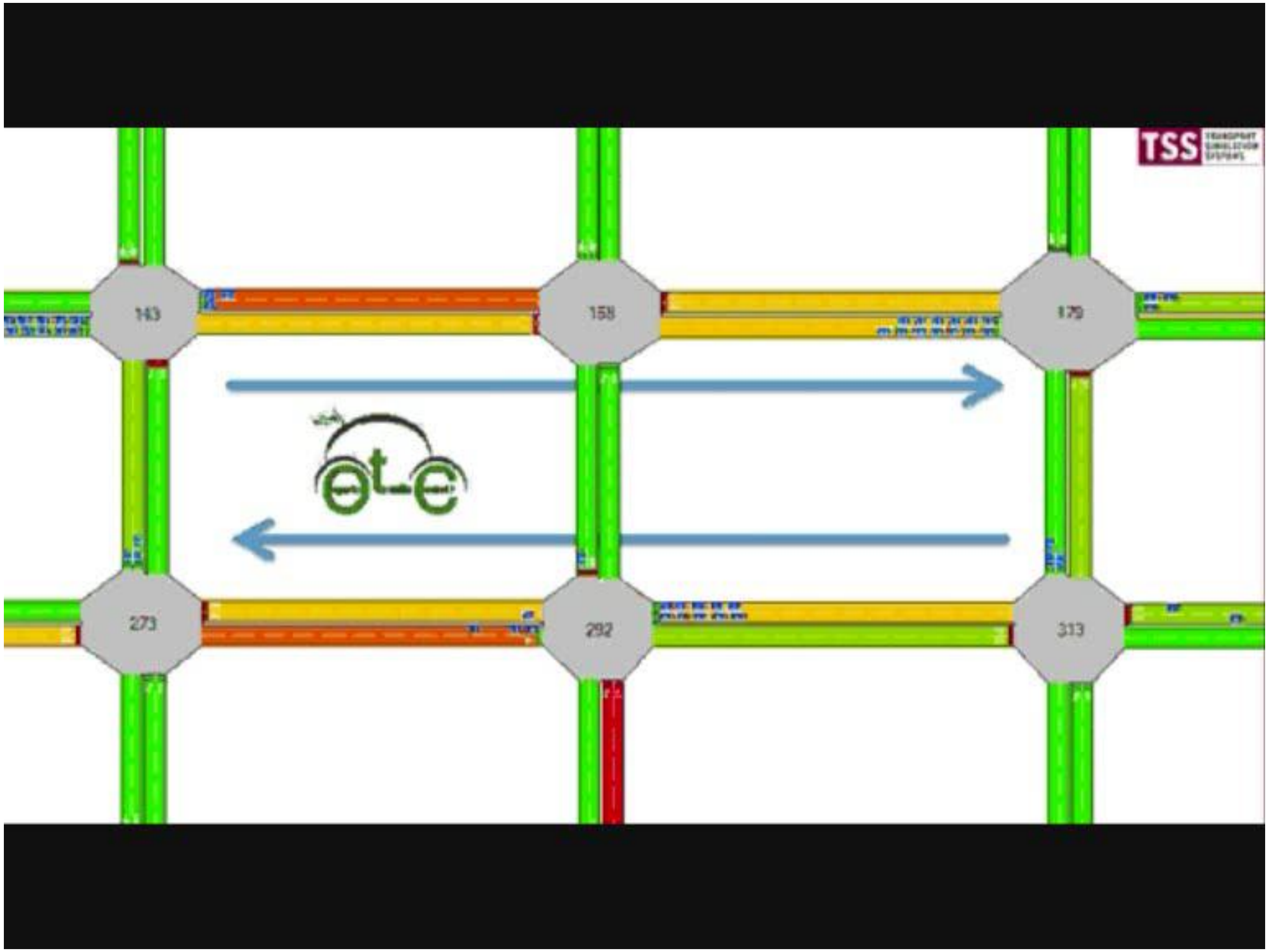
Travel times

Mostly unaffected, but increased after abrupt traffic change

→ Improve traffic observation

Experimental results

Manhattan network



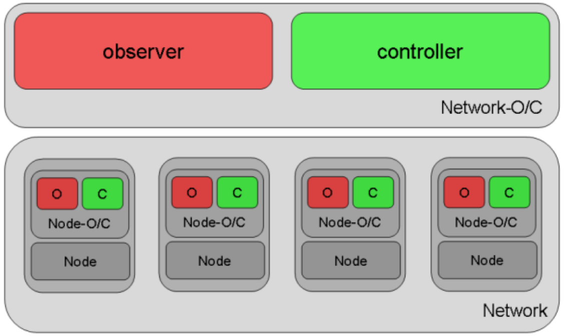
Conclusion

Extension of the OTC architecture

- *Traffic-responsive* Progressive Signal Systems
- *Decentralised operation*
- *Promising results* for test networks

Remainder of Phase II

- Refinement and further evalution of presented approach
- Development of hierarchical architecture



Recent publications

2008

H. Prothmann, F. Rochner, S. Tomforde, J. Branke, C. Müller-Schloer, and H. Schmeck. Organic control of traffic lights. In *Proc. of the 5th International Conference on Autonomic and Trusted Computing (ATC-08)*, volume 5060 of LNCS, pages 219–233. Springer, 2008. *ATC08 BEST PAPER AWARD*

S. Tomforde, H. Prothmann, F. Rochner, J. Branke, J. Hähner, C. Müller-Schloer, and H. Schmeck. Decentralised progressive signal systems for organic traffic control. In *Proc. of the 2nd IEEE International Conference on Self-Adaption and Self-Organization (SASO 2008)*, 2008. *Accepted for publication.*

U. Richter, H. Prothmann, and H. Schmeck. Improving XCS performance by distribution. In *Proc. of the 7th International Conference on Simulated Evolution And Learning (SEAL'08)*, 2008. *Accepted for publication.*

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J. Branke, P. Goldate, and H. Prothmann. Actuated traffic signal optimization using evolutionary algorithms. In *Proc. of the 6th European Congress and Exhibition on Intelligent Transport Systems and Services (ITS07)*, 2007.

H. Schmeck. Optimierungstechniken des Organic Computing in der Verkehrstechnik. In *Informatik bewegt! Informationstechnik in Verkehr und Logistik*, pages 11-38. Fraunhofer-IRB-Verlag, 2007.

2006

F. Rochner, H. Prothmann, J. Branke, C. Müller-Schloer, and H. Schmeck. An organic architecture for traffic light controllers. In *Informatik 2006 – Informatik für Menschen*, volume P-93 of LNI, pages 120-127. Köllen Verlag, 2006.

J. Branke, M. Mnif, C. Müller-Schloer, H. Prothmann, U. Richter, F. Rochner, and H. Schmeck. Organic Computing – Addressing complexity by controlled self-organization. In *Post-Conference Proce. of the 2nd International Symposium on Leveraging Applications of Formal Methods, Verification and Validation (ISoLA 2006)*, pages 185–191. IEEE, 2006.


Grüne Welle
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