Organic Traffic Control (OTC³)
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Munich | October 7th/8th, 2010
Project overview
Phases I & II

Adaptive learning node controller

Collaborative control of traffic signals in urban road networks

- Decentralised coordination
- Hierarchical coordination
Project overview
Phase III

Route guidance and driver information
• Communicating traffic lights
• Variable Message Signs
• Decentralised routing

→ Minimise travel times
→ Prevent congestions
→ Improve robustness wrt incidents
Agenda

1. Decentralised routing
   – Distance vector routing
   – Link state routing

2. Test scenarios and results

3. Observer/controller refinements

4. Summary and outlook
1. Decentralised Routing
Routing components

- Located at intersections
- Estimate turning delays (based on current flow / green time)
- Manage routing tables (for incoming sections)
- Communicate routing data
  - Distance vectors
  - Link states
Distance vector routing (DVR)

Routing components
• Process local destinations (◆)
• Compute turning delays
• Create routing entries
• Advertise destinations and distances
• Receive routing data
  – Add new routes to advertised destinations
  – Update distances if advertised distance is shorter
Link state routing (LST)

Routing components
- Determine turning delays
- Communicate delay changes
  - Link state advertisement
  - Network flooding
- Create weighted network graph from received link states
- Compute shortest paths using Dijkstra’s algorithm
Routing in road networks Compared to Internets

- Road networks limited in size
- Intersections
  Separate queues / routing tables for incoming links
- Turnings
  - Capacity influenced by traffic lights
  - Non-linear cost relations
- Separate networks for road traffic and routing traffic
- Routing protocols differ in
  - Computational effort
  - Communication cost
  More important for Internets
2. TEST SCENARIOS AND RESULTS
Experimental evaluation
Scenario

Manhattan network
- 25 intersections (●)
- 20 destinations (◆)
- 120 road segments (—)

Signalised intersections
- Variable Message Signs (VMS)
- 4-phased signal plans
- Organic traffic lights

Traffic demand
3800-7600 veh/h (equally distributed among destinations)
Experimental evaluation
Test case I

- 75% compliance rate
- Undersaturated demand
- No incidents

Reductions

<table>
<thead>
<tr>
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<th>DVR</th>
<th>LST</th>
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<tbody>
<tr>
<td>Travel time</td>
<td>5.0%</td>
<td>3.4%</td>
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<tr>
<td>Stops</td>
<td>3.1%</td>
<td>2.6%</td>
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<tr>
<td>Fuel/CO₂</td>
<td>5.8%</td>
<td>4.6%</td>
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Experimental evaluation
Test case II

- 75% compliance rate
- Highly saturated demand
- No incidents

Reductions:

DVR | LST

Travel time > 50%
Stops > 30%
Fuel CO₂ > 35%

Routing avoids gridlocks!

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Experimental evaluation
Test case III

- 75% compliance rate
- Undersaturated demand
- 3 blocked roads

![Graph showing travel time and stops reduction]

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<tr>
<td>Travel time</td>
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<td>Stops</td>
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<td>Fuel/CO₂</td>
<td>19%</td>
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3. OBSERVER/CONTROLLER REFINEMENTS

In cooperation with ecos
Observer/controller refinements

Level 1: On-line learning

XCS-RC
- Improved discovery component
- Rule generalisation by inference
  → Improved learning rate
  → Reduced population size

Level 2: Evolutionary optimisation

Handling of noisy, simulation-based fitness estimations, e.g.:
- Simulated duration vs. estimation quality
- Distribution of simulation time

Cross-project publication
- N. Fredivianus, H. Prothmann, and H. Schmeck. XCS Revisited: A Novel Discovery Component for XCS. Accepted for 8th Int. Conf. on Simulated Evolution And Learning, 2010.
- Presented at SPP-miniworkshop on Learning Classifier Systems
Organic Network Control

Reliable broadcast protocol for MANETs

- Increasing network load
- Dynamic environments: Static protocol configuration works well on average
- Better performance due to:
  - On-line adaptation
  - Context-aware protocol settings

Cross-project publication
4. SUMMARY AND OUTLOOK
Summary and outlook

Decentralised routing

• Extension of organic traffic lights
  – Variable Message Signs
  – No car-to-x communication
• Adapted Internet protocols
  – Local communication
  – Local traffic data
• Routing improves robustness
  – Highly saturated demands
  – Road works
  – Accidents
  – …

Outlook

1. Regional routing
   → Reduce communication effort and computational cost

2. Hierarchical routing
   • Network-wide traffic prediction
   • Incorporate external goals
   • System vs. user optimum
Selected publications


Summary and outlook

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