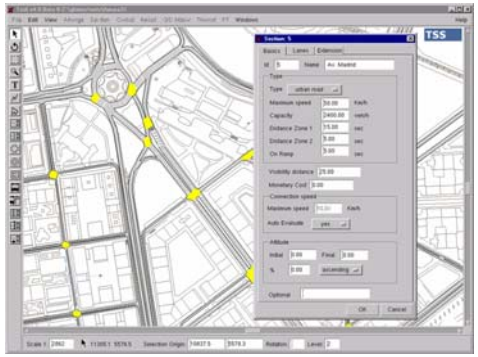
Organic Traffic Control

A joint research project
of Karlsruhe and Hannover Universities
SPP 1183
Organic Computing



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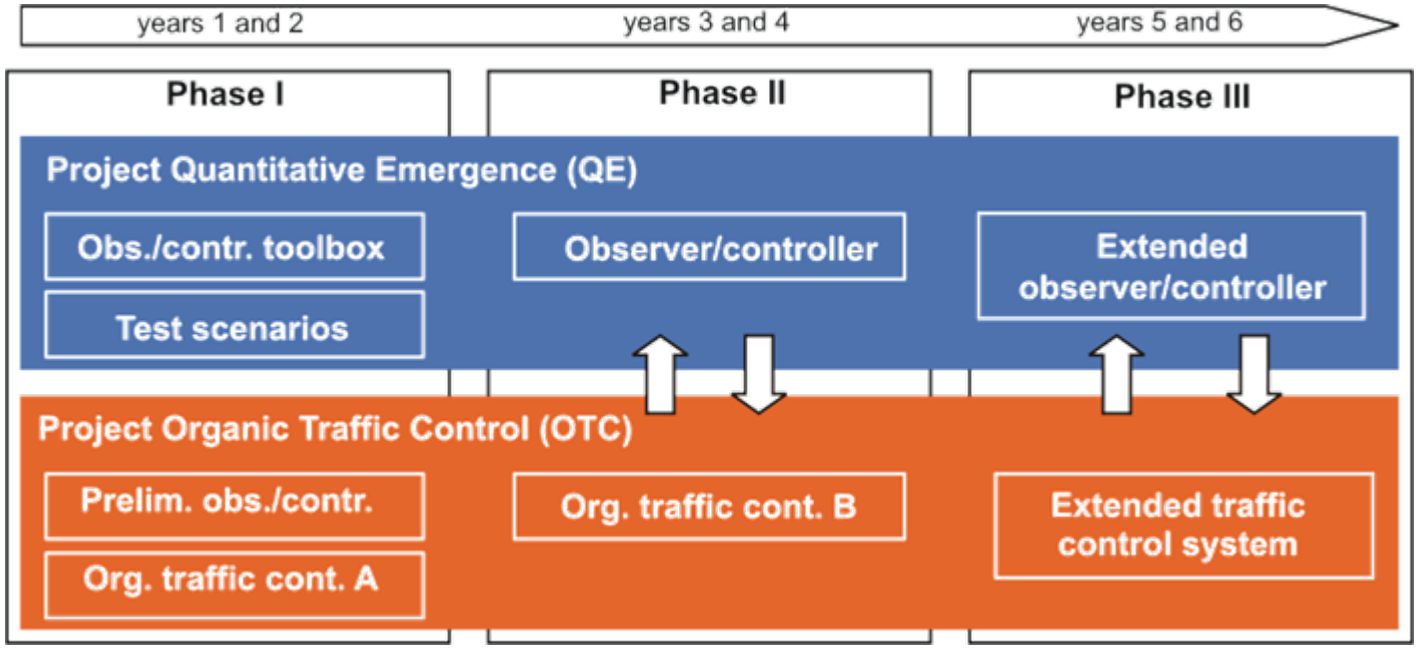
Outline

- Relationship QE↔OTC
- Motivation and requirements
- Local learning with classifier systems
- Offline learning
- Architecture
- Status

Two related projects: OTC and QE

- QE: Generic tools to detect and control emergent behaviour
- OTC: Traffic control system well suited as a test case for QE
- Use of QE tools within OTC will improve control system's performance
- Coordinated research, exchange of components in phase II



Motivation

Traffic Networks

- Congestion due to high utilization
- Intersections often bottlenecks
- Current approach: Centralized optimization
  - High complexity
  - High effort (computing power)
  - Inflexible
- OTC approach: Decentralized control
  - Scales with complexity of task
  - Generic system, easily transferable
  - Adaptive and flexible

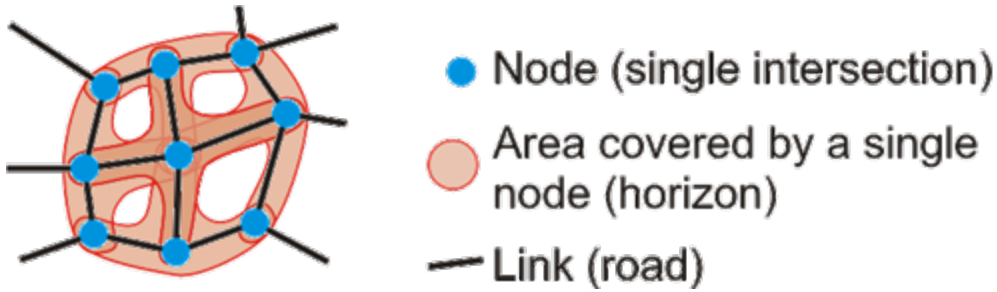
Requirements for decentralized traffic control

- Capable of global optimization
- Adapts automatically to different environments — **Self-configuring**
- Reacts quickly to changing traffic situations — **Context-aware**
- Behaves robustly — **Self-healing, Self-protecting**

Self-X → Organic System

Decentralization

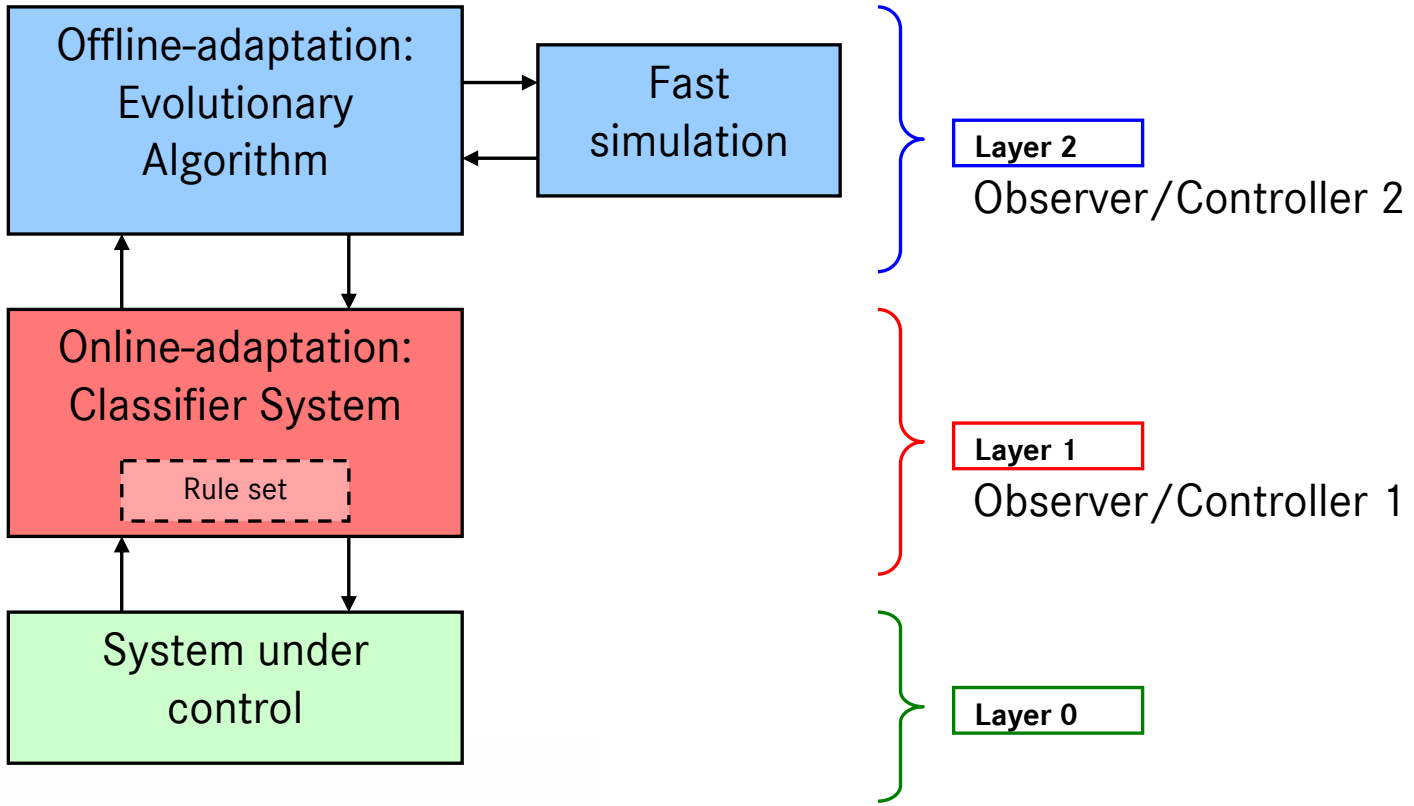
- Learning node controller at every intersection
- Controller gets additional data from neighbour nodes



- Challenges:
  - Local learning
  - Cooperation ▶ Global optimization ▶ Stability

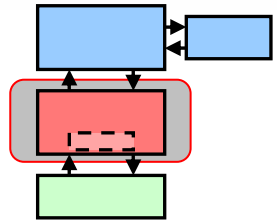
Challenge: Adaptation speed

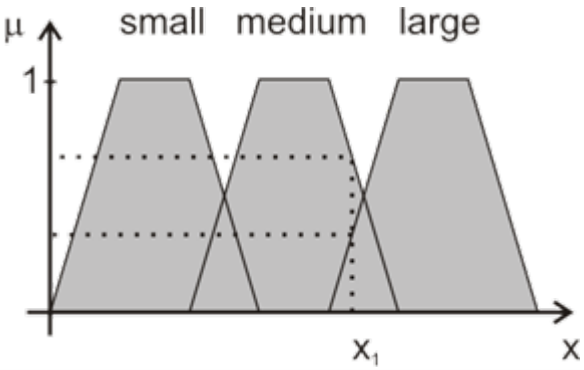
- Reasonable operation from the start mandatory ▶No learning from scratch
- Search space is huge ▶Pure online-adaptation takes too long
- Initial rule set is generated and updated offline



Learning classifier system

- Basis: XCS (Wilson, 1994)
- Classifier: If-then-rule
  - Condition (if): Match against input
  - Action (then): Triggered if condition matches
  - Value: Probability of selecting this rule, changes according to success
  - Coding: Ternary (binary + wildcard)
- GA to generate new classifiers ▶ Adaptation
- Fuzzy classifier: Input mapping using fuzzy sets
- Problem: Classifiers are stateless (Markovian)

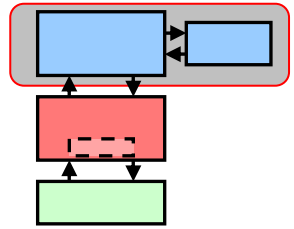


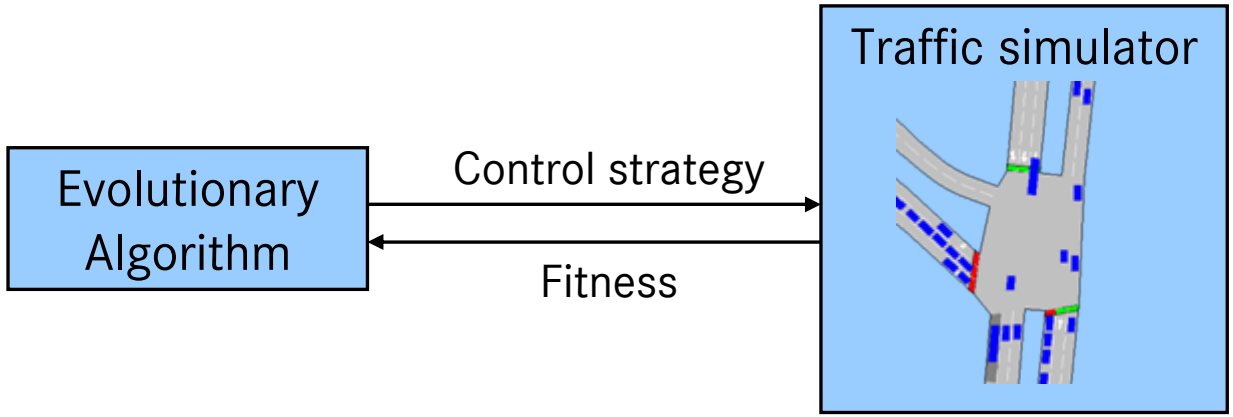


	if	then	value
→	10100	10010100	0.95
	01101	01100101	0.22
→	10001	10111010	0.40
	10101	01001011	0.79
	01000	00101010	0.50
→	10111	01010101	0.47

Evolutionary Algorithm

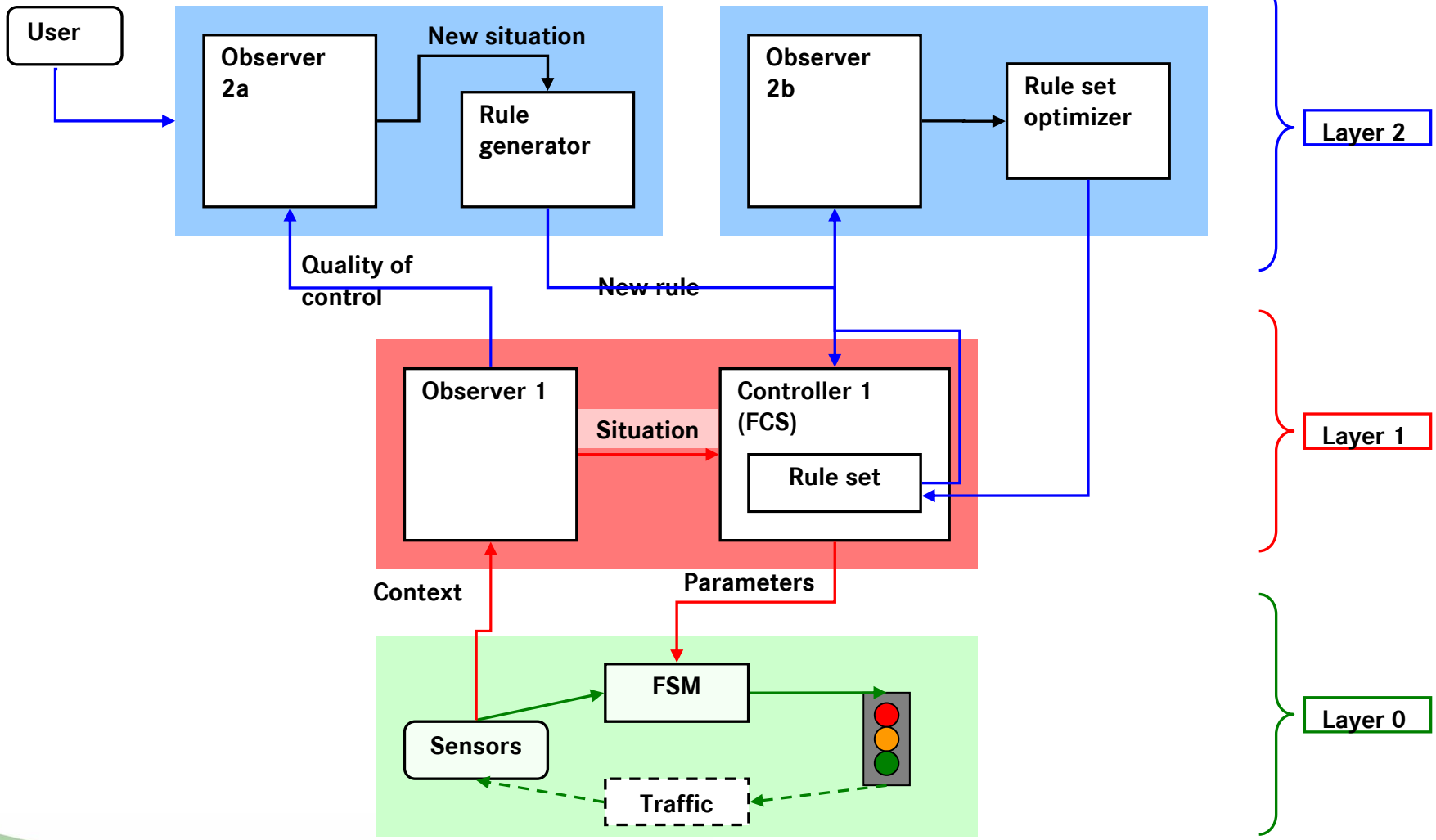
- Generates control strategies for traffic signals
- Quality of strategy is tested using a traffic simulator
- Fitness measures:
  - Mean travel time
  - Average number of stops
  - ...





- Strategies are evaluated under different traffic conditions
- Optimized if-then-rule (condition + strategy) is added to rule set of LCS

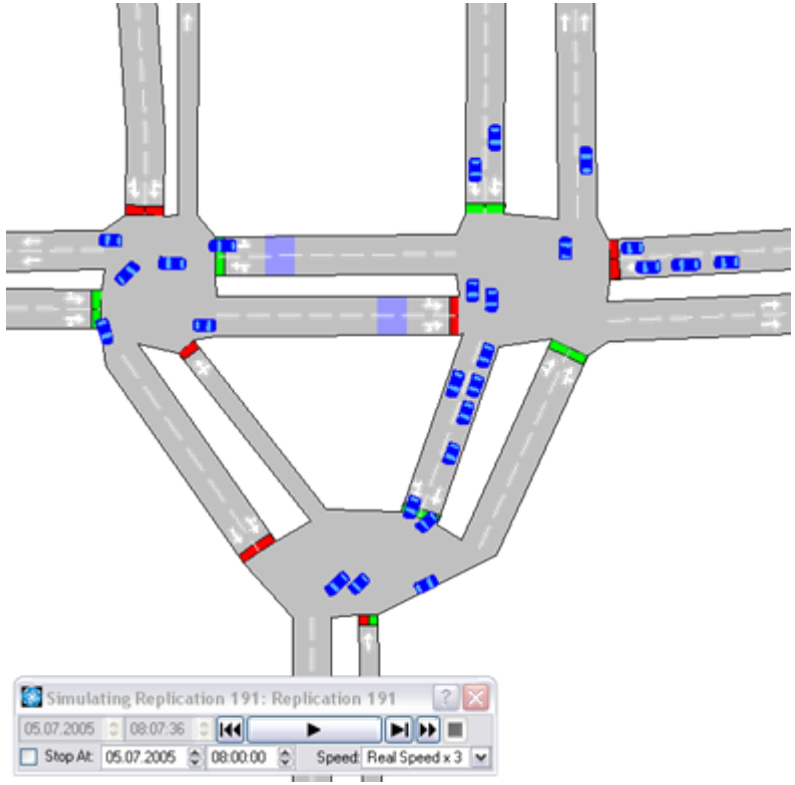
Layered structure: Detailed view



Status

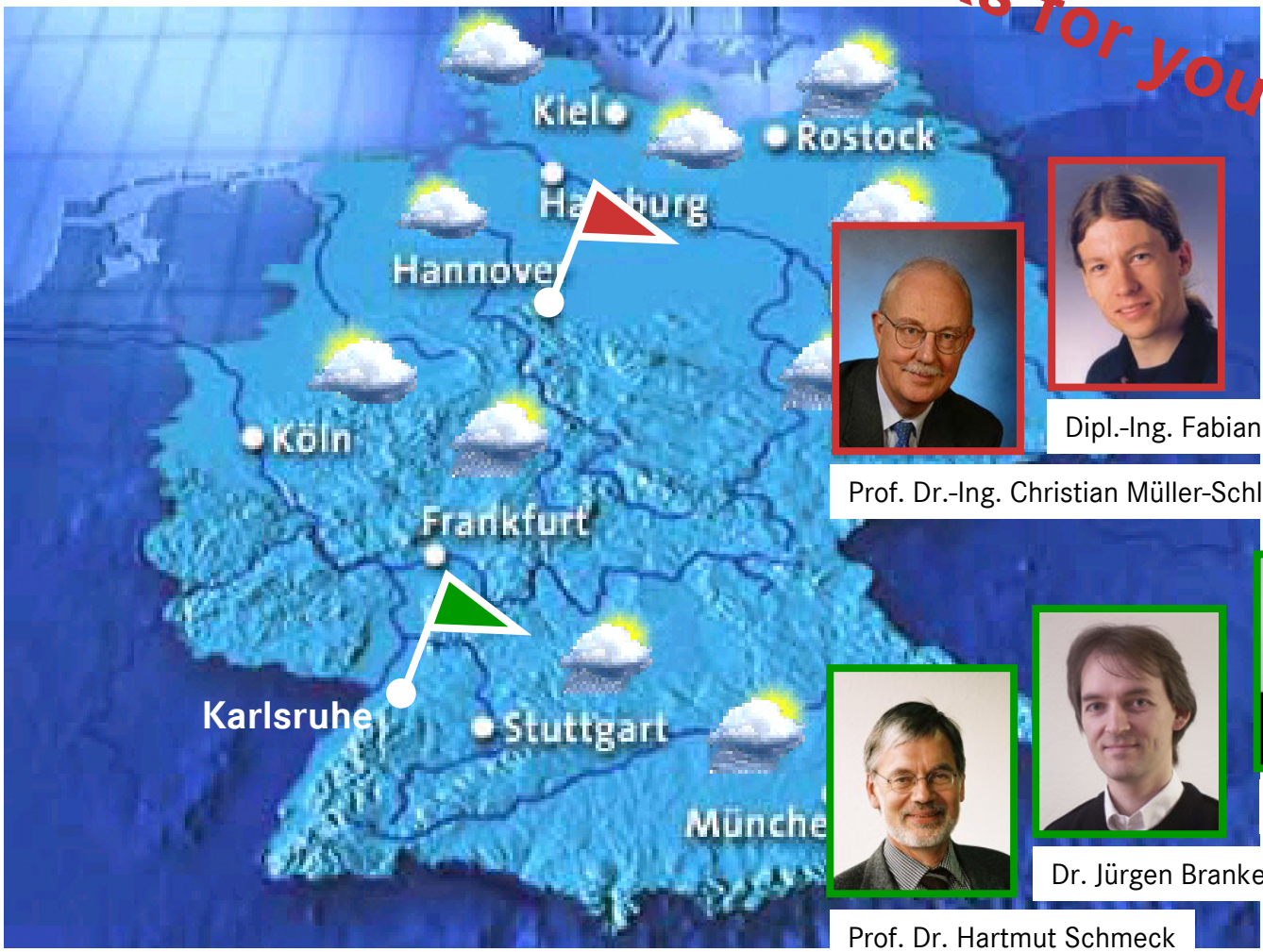
- Microscopic traffic simulator AIMSUN
- Model: n intersections
- Observer: Cooperation with project QE
- Potential cooperation: AutoNomos project

- Phase I (2005-2007): Emphasis on local node behavior
- Phase II: Cooperation in street networks



Team/Members

Thanks for your attention



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