

SAPPORO

A Platform for Intelligent Integrated Traffic Management



SAPPORO

Final Report and Further Research

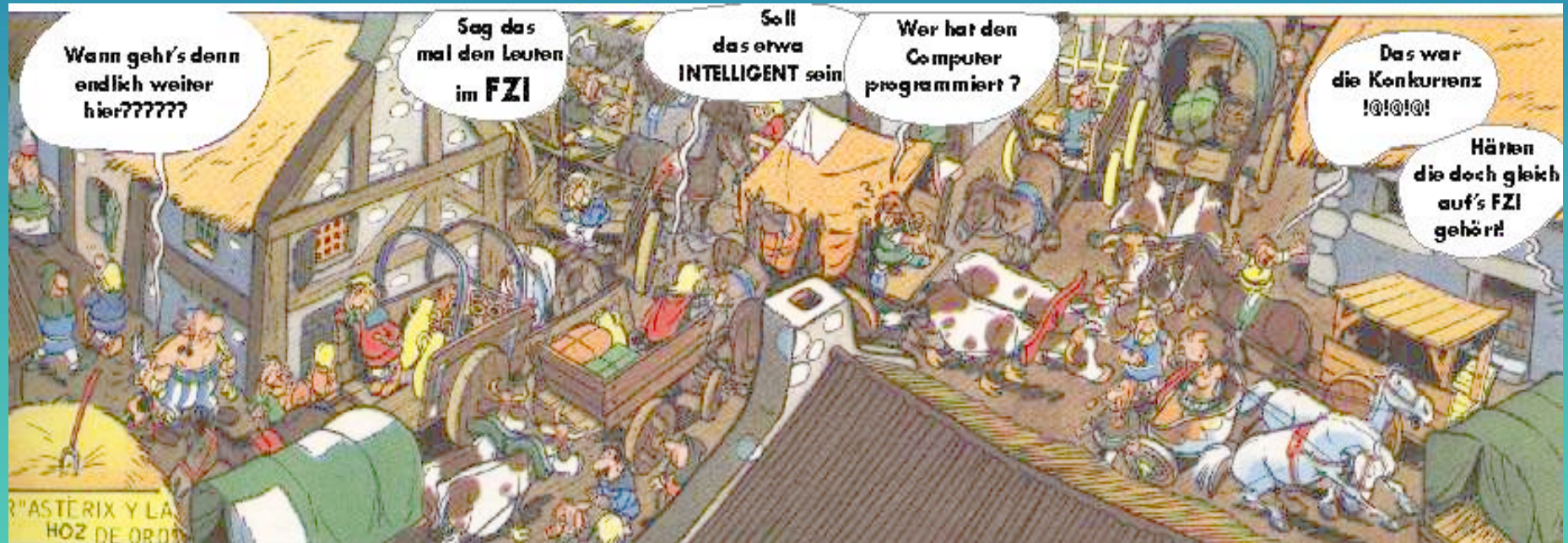


Overview

- architecture of Sapporo
- methods and techniques
- new features
- extensions
- further research



Motivation



Project Goals

- **Artificial Intelligence-based methods for traffic modeling, simulation and control**
- **prototype system**
- **advanced solutions to traffic control problems**



Architecture of Sapporo

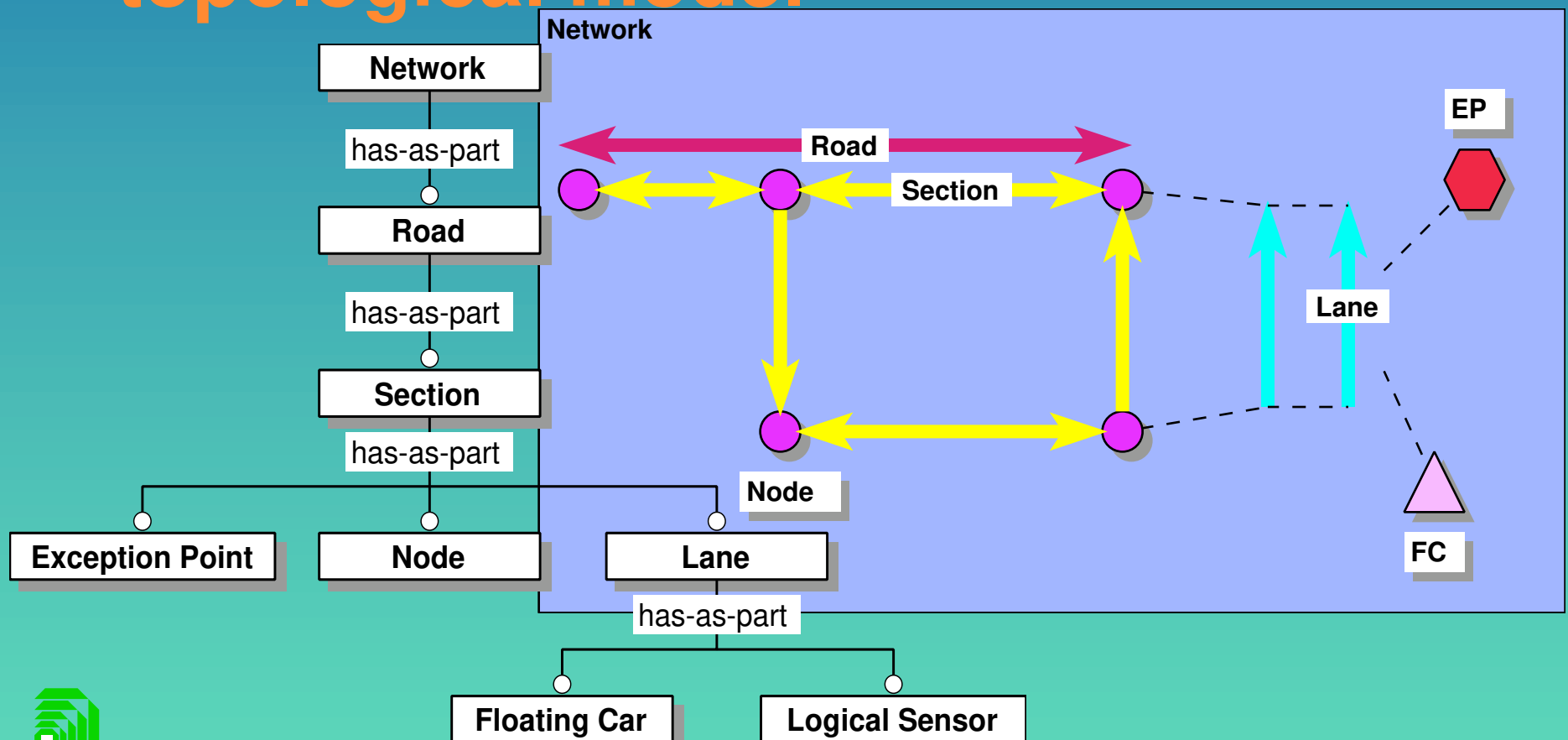
- basic models
- tools
- interfaces



Basic Models

Architecture

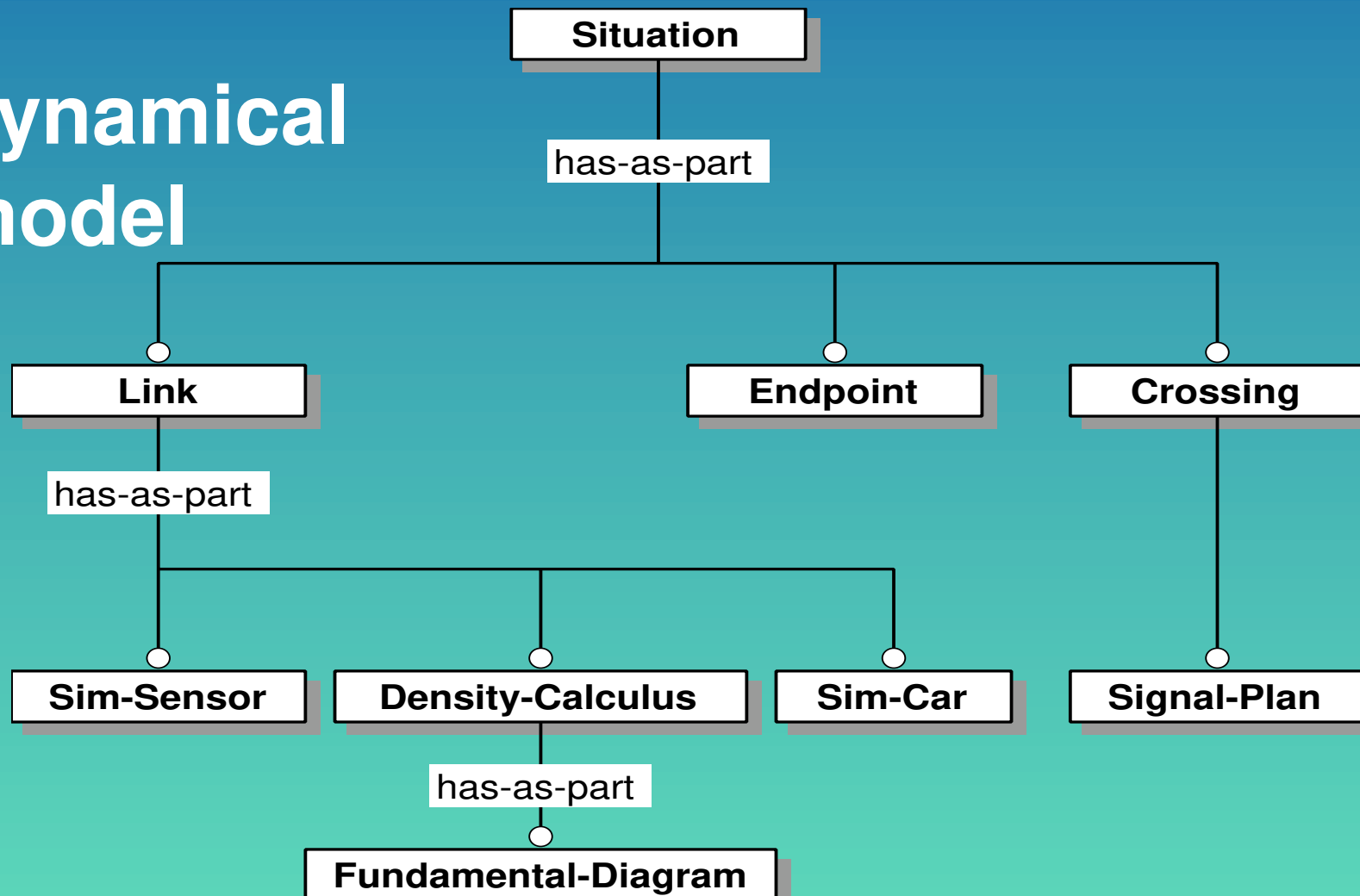
- topological model



Basic Models

Architecture

- dynamical model



Basic Models

Architecture

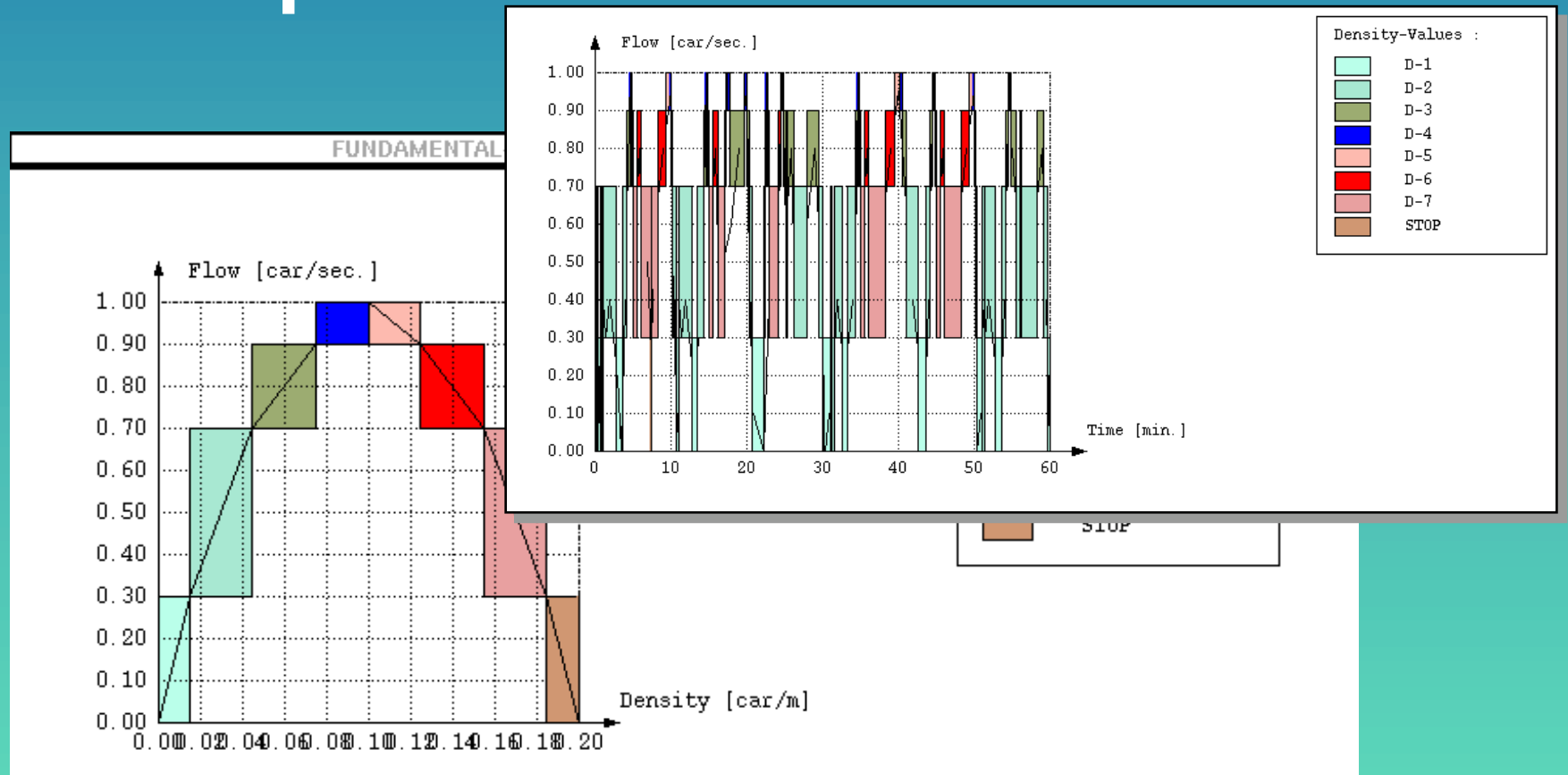
- geometrical model



Basic Models

Architecture

- traffic parameter model



Basic Models

Architecture

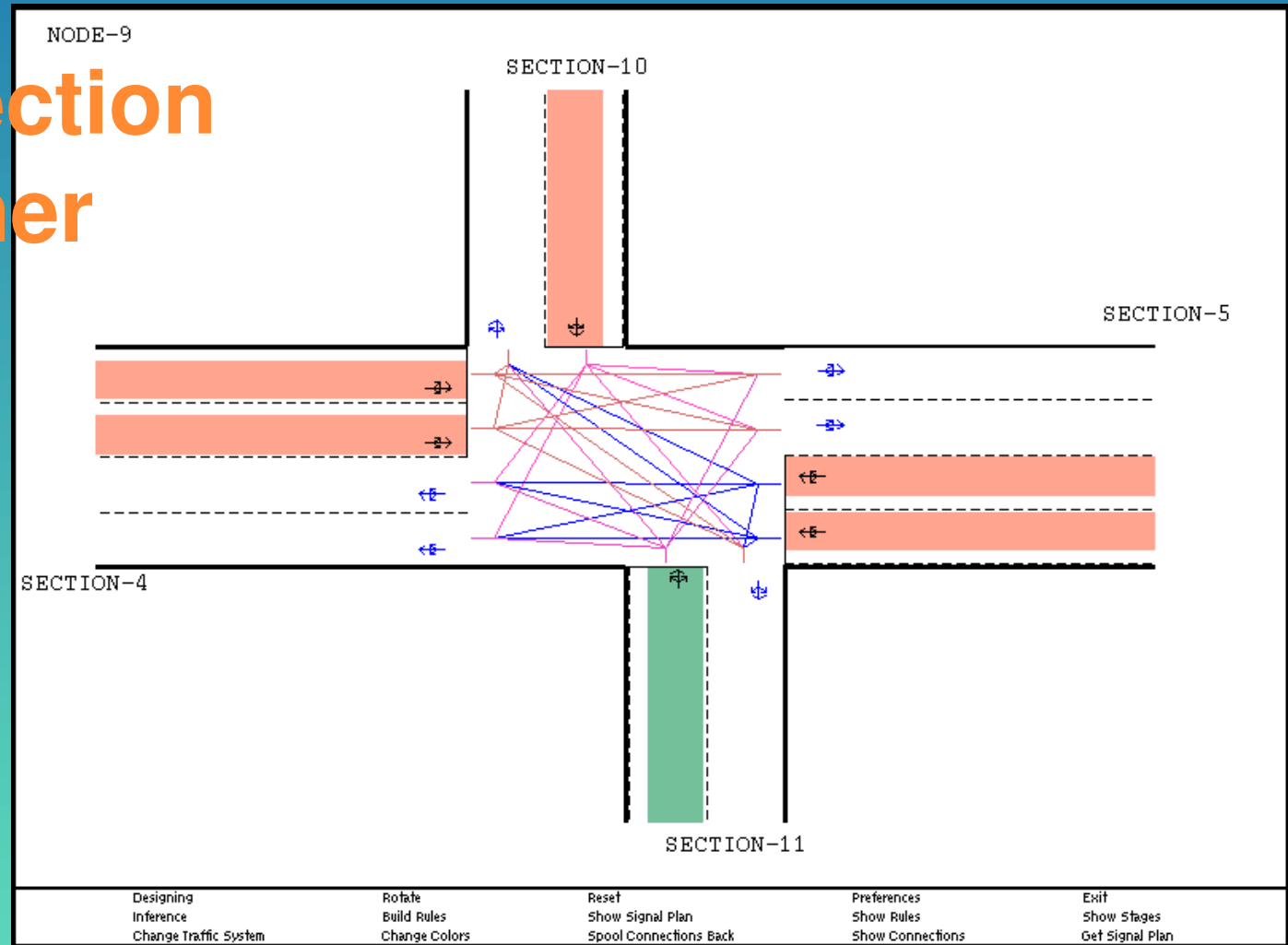
- **logical model**
 - insertion rules for density zones
 - meta-rules for generation of individual signal plan generation rules
 - constraint system for propagation of changes in the associative object network



Tools

Architecture

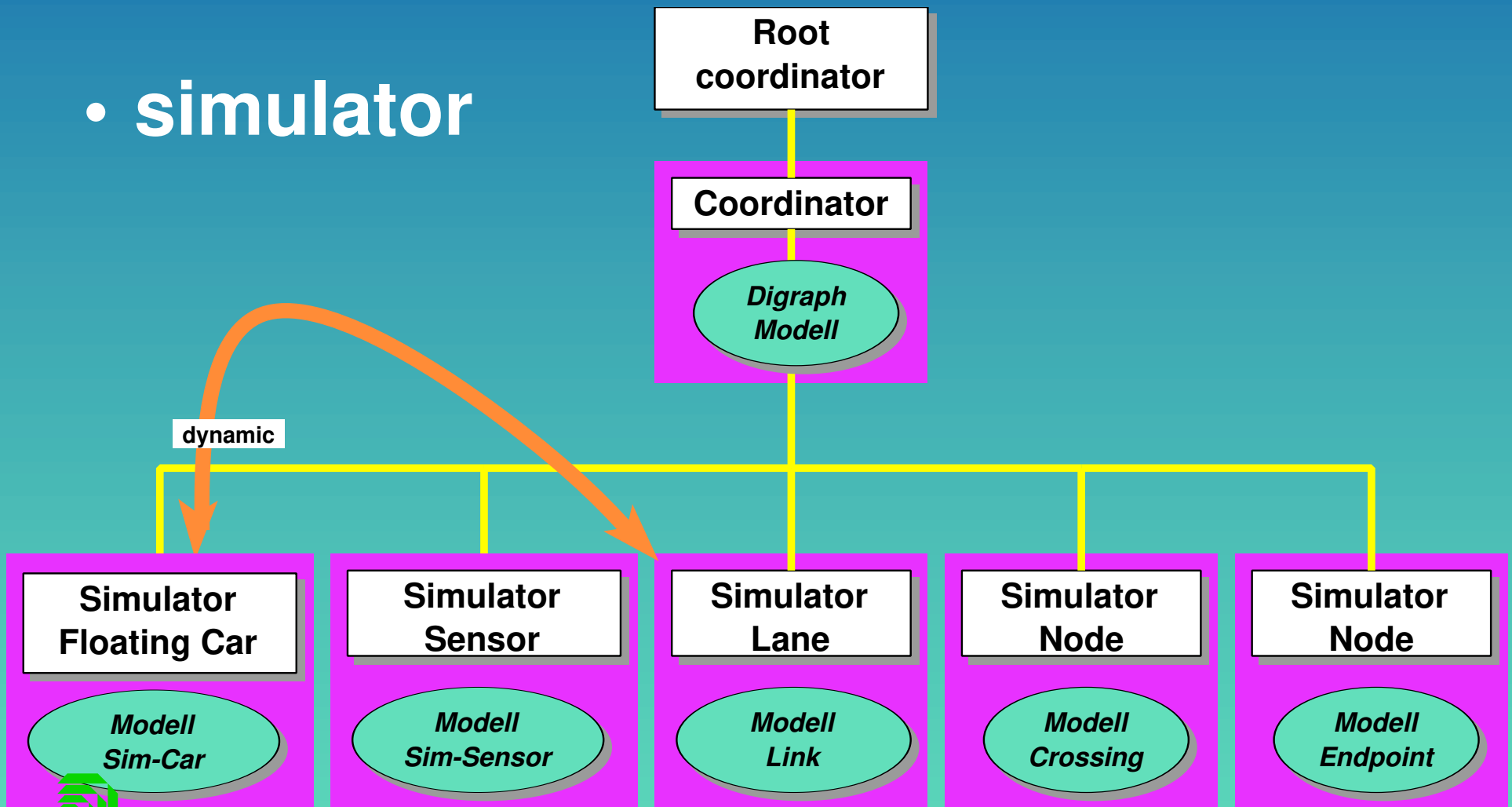
- Intersection Designer



Tools

Architecture

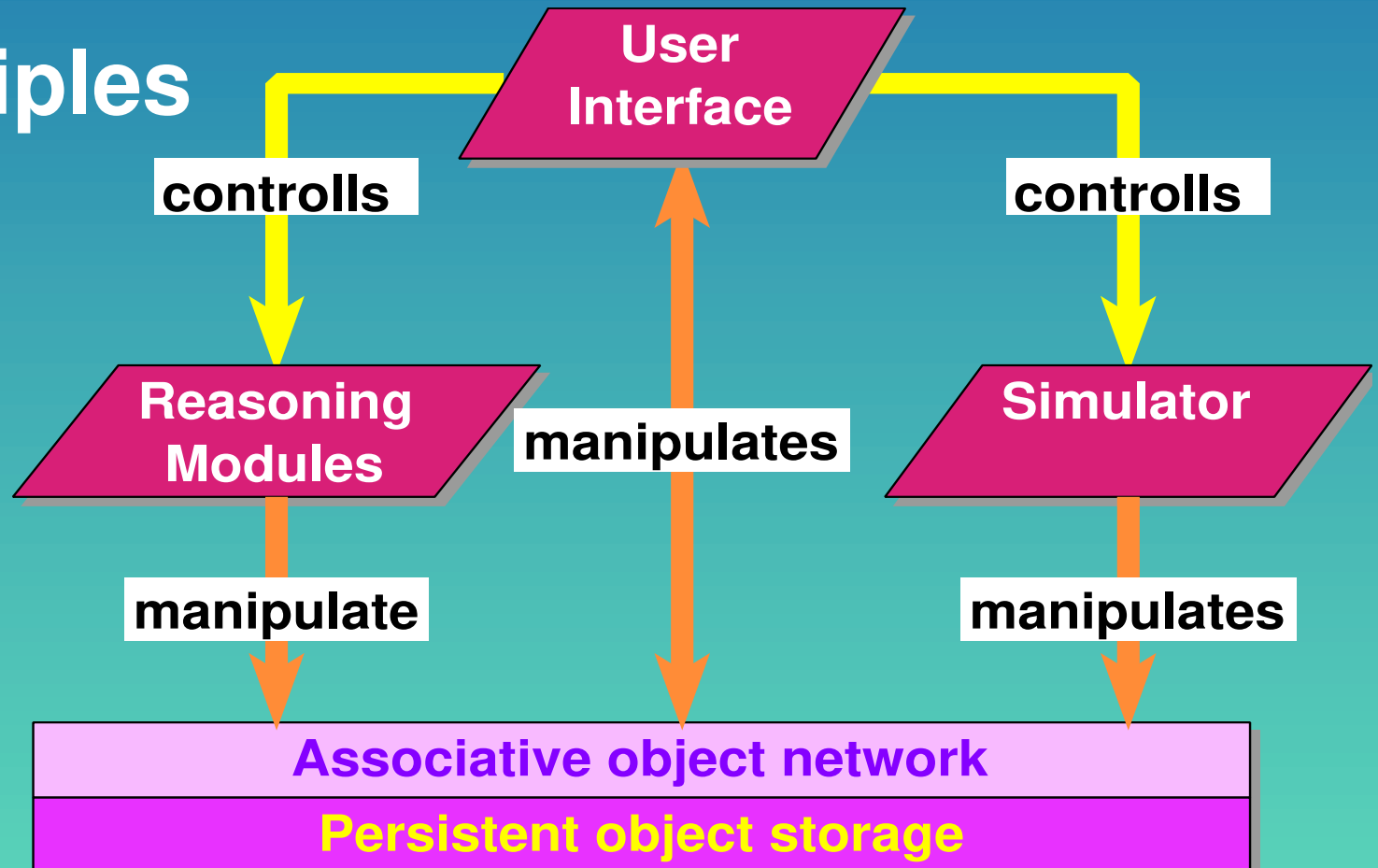
- simulator



Interfaces

Architecture

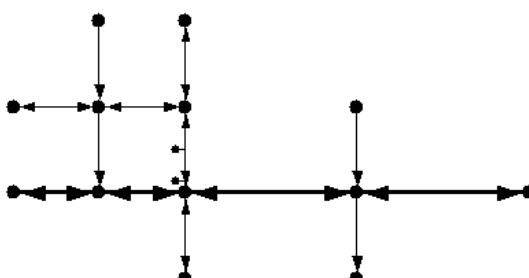
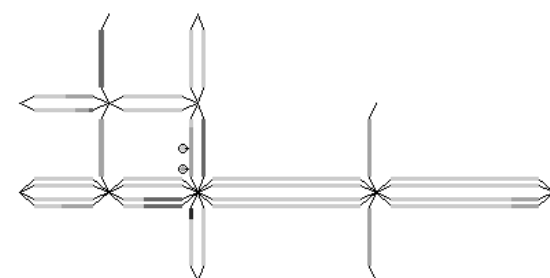
- principles



Interfaces

Architecture

• current look

<p>SAPORO</p> <table border="1"> <tr> <th>Categories</th> <th>Sim-Objects</th> <th><SIM-SENSOR-CLASS-2-3></th> <th>EVENT-LIST</th> </tr> <tr> <td> <ul style="list-style-type: none"> Networks Roads Stations Nodes Lanes Sources Sinks Cycles Sim-Objects Fundamental-Diagrams Density-Calculus Density-Values Traffic-States Sensors GContexts GObjects Signalplans </td> <td> <ul style="list-style-type: none"> <SIM-ENDPOINT-CLASS-1-t o-Node-7> <SIM-LINK-CLASS-1-to-La ne-17> <SIM-CROSSING-CLASS-1-t o-Node-5> <SIM-SENSOR-CLASS-2-3> <SIM-ENDPOINT-CLASS-2-t o-Node-6> <SIM-CROSSING-CLASS-2-t o-Node-9> <SIM-LINK-CLASS-2-to-La ne-7> <SIM-SENSOR-CLASS-3-4> <SIM-LINK-CLASS-3-to-La ne-26> <SIM-ENDPOINT-CLASS-3-t o-Node-11> <SIM-CROSSING-CLASS-3-t </td> <td> <ul style="list-style-type: none"> INSTANCE-ID INSTANCE-CHANGED INSTANCE-REFERENCED GOBJ BELONGS-TO IS-MEMBER-OF NAME TIME-OF-NEXT-EVENT NEXT-EVENT EVENT-LIST HAS-AS-LINK </td> <td> <ul style="list-style-type: none"> ((259.25 <DENSITY-VALUE-CLASS- 7-D-2> (event: <SIM-LINK-CLASS-11-t o-Lane-3>) (237.8875 <DENSITY-VALUE-CLASS- 6-D-1> (event: <SIM-LINK-CLASS-11-t o-Lane-3>) (232.5 <DENSITY-VALUE-CLASS- 10-D-5> (event: <SIM-LINK-CLASS-11-t </td> </tr> </table>		Categories	Sim-Objects	<SIM-SENSOR-CLASS-2-3>	EVENT-LIST	<ul style="list-style-type: none"> Networks Roads Stations Nodes Lanes Sources Sinks Cycles Sim-Objects Fundamental-Diagrams Density-Calculus Density-Values Traffic-States Sensors GContexts GObjects Signalplans 	<ul style="list-style-type: none"> <SIM-ENDPOINT-CLASS-1-t o-Node-7> <SIM-LINK-CLASS-1-to-La ne-17> <SIM-CROSSING-CLASS-1-t o-Node-5> <SIM-SENSOR-CLASS-2-3> <SIM-ENDPOINT-CLASS-2-t o-Node-6> <SIM-CROSSING-CLASS-2-t o-Node-9> <SIM-LINK-CLASS-2-to-La ne-7> <SIM-SENSOR-CLASS-3-4> <SIM-LINK-CLASS-3-to-La ne-26> <SIM-ENDPOINT-CLASS-3-t o-Node-11> <SIM-CROSSING-CLASS-3-t 	<ul style="list-style-type: none"> INSTANCE-ID INSTANCE-CHANGED INSTANCE-REFERENCED GOBJ BELONGS-TO IS-MEMBER-OF NAME TIME-OF-NEXT-EVENT NEXT-EVENT EVENT-LIST HAS-AS-LINK 	<ul style="list-style-type: none"> ((259.25 <DENSITY-VALUE-CLASS- 7-D-2> (event: <SIM-LINK-CLASS-11-t o-Lane-3>) (237.8875 <DENSITY-VALUE-CLASS- 6-D-1> (event: <SIM-LINK-CLASS-11-t o-Lane-3>) (232.5 <DENSITY-VALUE-CLASS- 10-D-5> (event: <SIM-LINK-CLASS-11-t 	<ul style="list-style-type: none"> Attach DCs Exit Browser Big Map Clear Map Draw Map Reset All Zoom In Zoom Out Monitor Insert Sensor Insert Exception Edit Signalplans Open DB Close DB Abort DB Store DB Store Topologie Load DC Create DC Update DC Show FD Show BS-T Show NDZ-T Sim Install Sim Start Create Sit Load Sit Clear Sit Sim Replay
Categories	Sim-Objects	<SIM-SENSOR-CLASS-2-3>	EVENT-LIST							
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		<p>Replay Monitoring at t = 300 sec</p> 								
<p>Command: Browser Command: Sim Install Command: Sim Start Command: Simulation Replay Command: ^</p>		<p>CURRENT SETTINGS Current Database : EDT-with-SP-Test/ Current Network : Entenhausen Downtown Current Density C. : Valencia 45 Simulation Objects installed</p>								



Methods and Techniques

- qualitative reasoning for traffic modeling
- object-oriented programming for overall implementation
- rule- and constraint-based reasoning for signal plan generation



DAI methods for intersection control

OOP

Methods

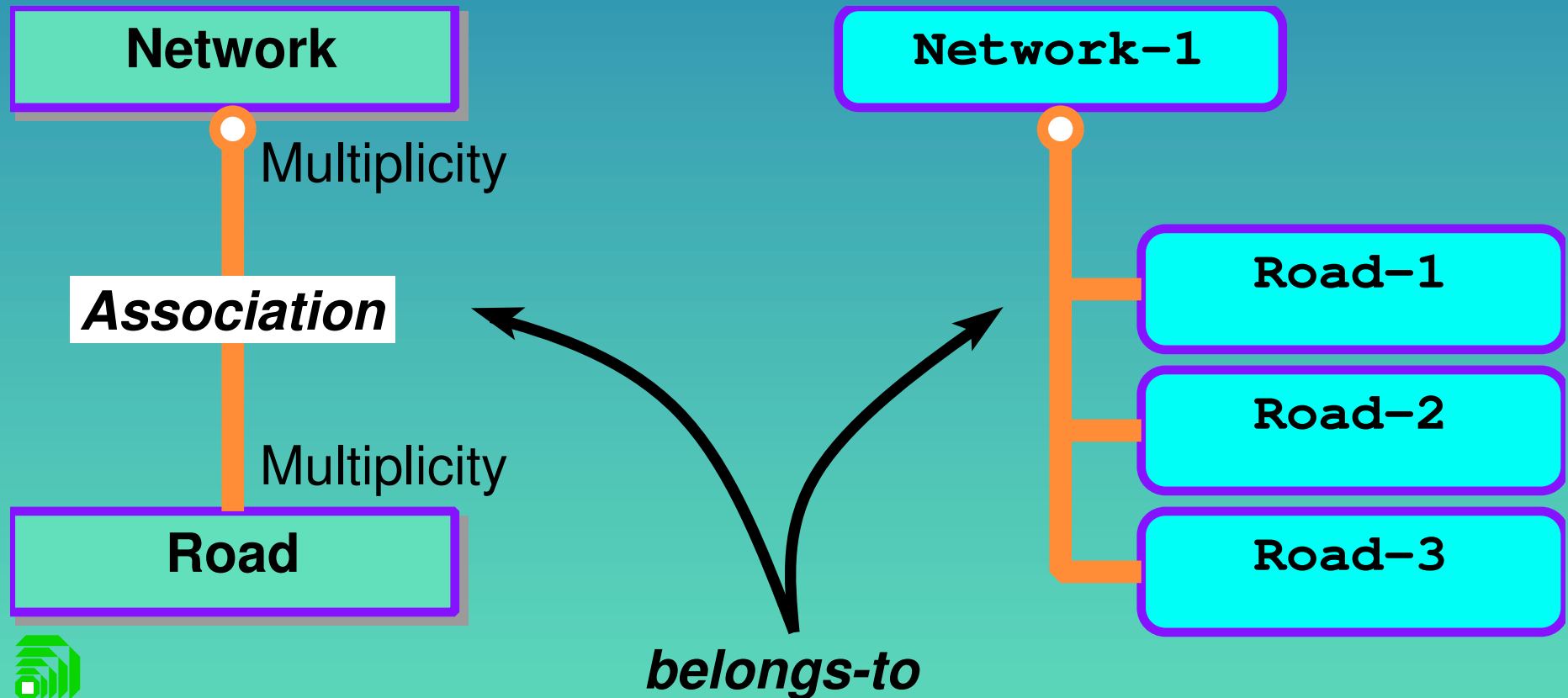
- **associative object networks**
 - semantic networks
 - reasoning capability
 - flexible knowledge representation
 - support by tools necessary



OOP

Methods

- principle of associative object nets



OOP

Methods

- **example: topological model**



New Features

- **persistent objects**
- **logical sensors**
- **exception points**
- **floating cars**
- **traffic control**



Persistent Objects

*New
Features*

- **high connectivity among objects**
 - long instantiation time
 - static character of relations
 - system snapshots: situations + configurations
- **CLOS-DB**
 - public domain by FZI
 - textual storage
 - instance manager
 - support of association nets



Logical Sensors

*New
Features*

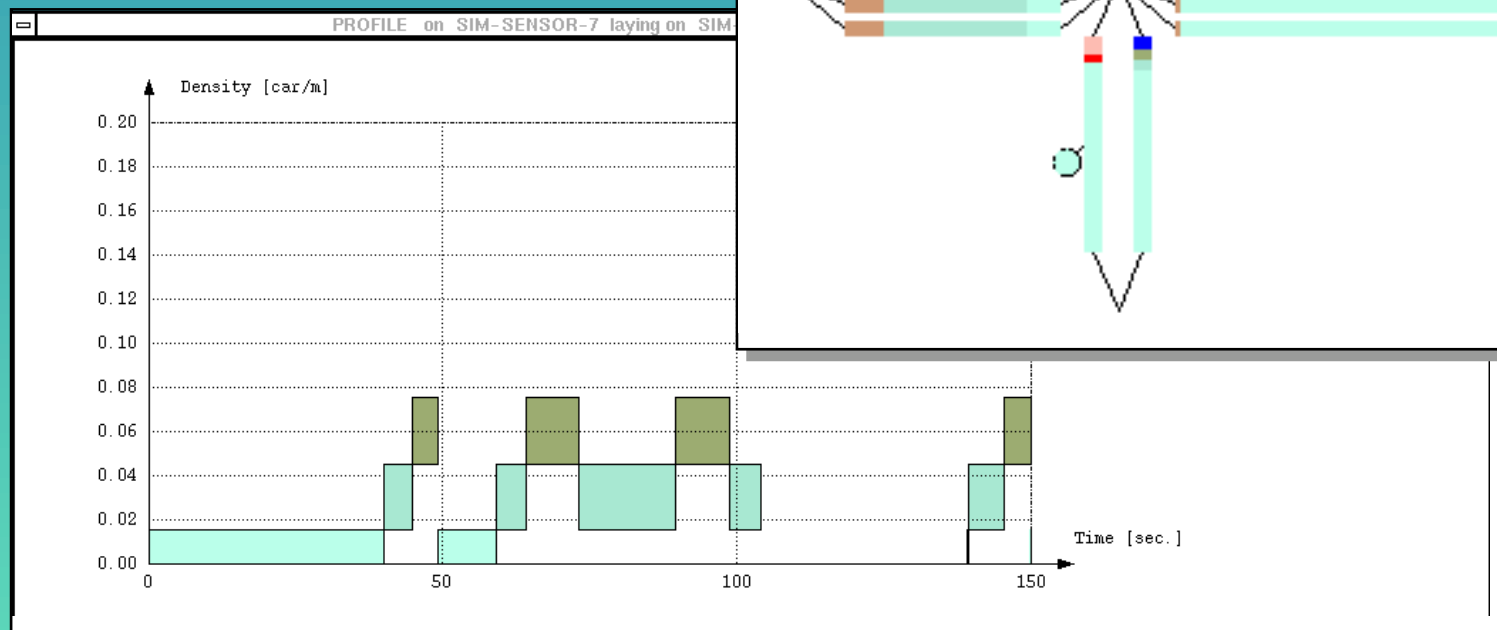
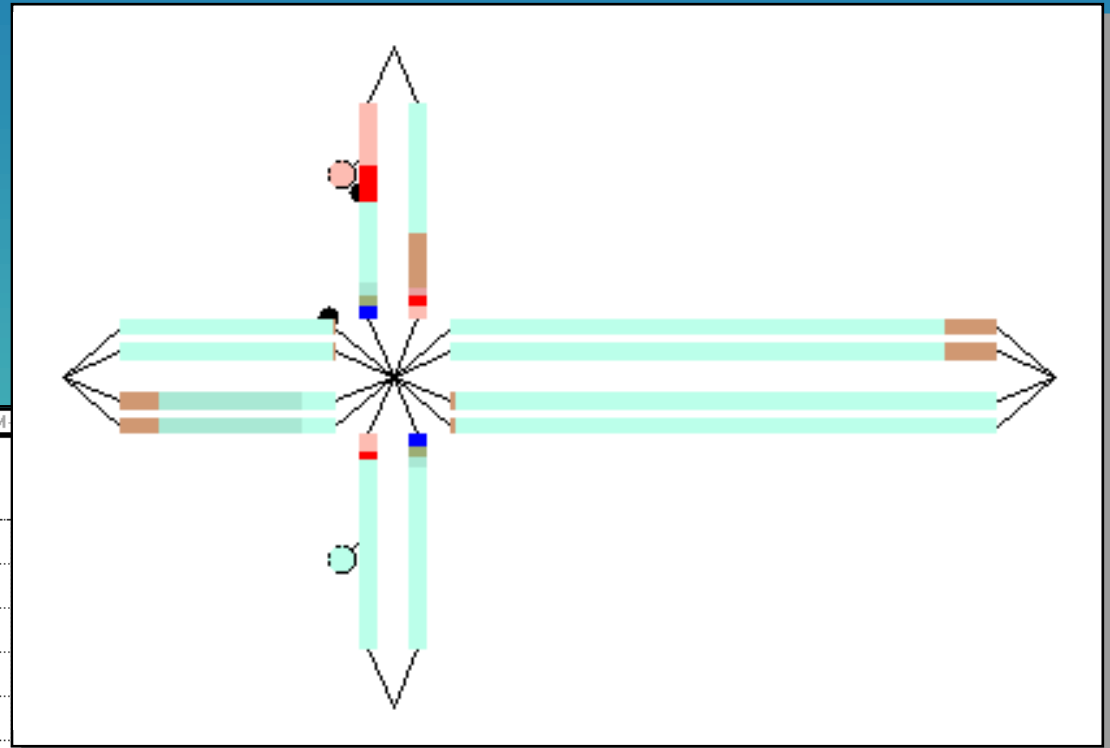
- **abstract sensor**
 - independent of physical device
 - measurement of occupancy, density
 - calculation of mean occupancy, mean density, mean speed
- **local traffic information for control and management**
- **interactive manipulation in Sapporo**



Logical Sensors

New
Features

- interfaces



Exception Points

*New
Features*

- **incident locations**
 - accidents, road works, blockings
- **abstract node**
 - turning ratios
 - lane connectivity
 - signal plan



Floating Cars

*New
Features*

- **general aspects**
 - quality measurement of control regime
 - best cost/benefit ratio
 - realization by sensors and transponders in taxis and public vehicles
- **modeling aspects**
 - microscopic
 - integration via DEVS simulation architecture
 - actor paradigm for microscopic components



Floating Cars

New
Features

- interface

Sim Car Parameters car starting at "SIM"

Name of the car : Porsche911
 Infnit Route : **Yes** No
 Driver Behaviour : Slow
 Normal

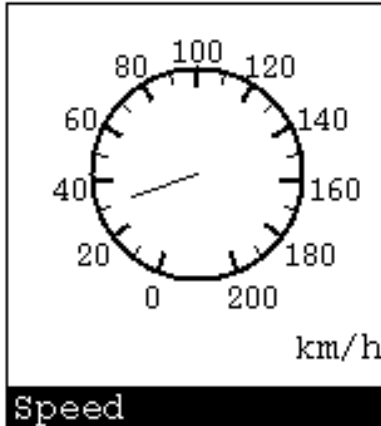
Multiple Choose Menu

Change Panel Attachment Show Panel

SIM-CAR-1 / Porsche911	<input checked="" type="checkbox"/>
SIM-CAR-2 / Cabby	<input checked="" type="checkbox"/>
SIM-CAR-3 / Mad Max	<input checked="" type="checkbox"/>

Do It

Car Panel of Mad Max



Speed

0:02:30 Travel Time

<SIM-LINK-4-to-Lane-4>
<SIM-LINK-26-to-Lane-26>
<SIM-LINK-27-to-Lane-27>
<SIM-LINK-20-to-Lane-20>

67.50 km/h

Highest Sp

5.75 km/h

Mean Speed

0.00 km/h

Lowest Spe

EXIT

Traffic Control

New
Features

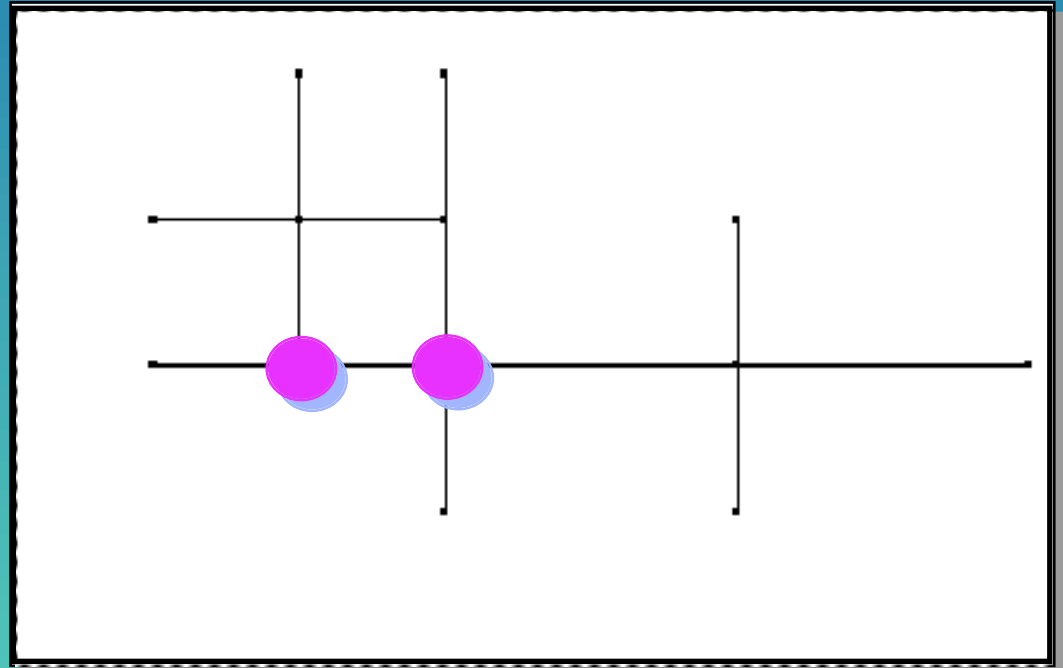
- every node has at least 1 signal plan
- signal plan editor

```
☒ Enter Phase Parameters for Signal-Plan "SIGNAL-PLAN-1":
☐ POSITION:      DURATION:      PHASE:
    1           25           (0 29
                          ((<LANE-19-noname> <LANE-11-noname> 50) (<LANE-19-noname> <LANE-12-noname> 50)
                          (<LANE-20-noname> <LANE-11-noname> 50) (<LANE-20-noname> <LANE-12-noname> 50)
                          (<LANE-13-noname> <LANE-21-noname> 50) (<LANE-13-noname> <LANE-22-noname> 50)
                          (<LANE-14-noname> <LANE-21-noname> 50) (<LANE-14-noname> <LANE-22-noname> 50)))
    a number    a number    (30 49 ((<LANE-10-noname> <LANE-4-noname> 100) (<LANE-3-noname> <LANE-9-noname> 100)))
    a number    25           (50 74
                          ((<LANE-19-noname> <LANE-9-noname> 100) (<LANE-20-noname> <LANE-9-noname> 100)
                          (<LANE-13-noname> <LANE-4-noname> 100) (<LANE-14-noname> <LANE-4-noname> 100)
                          (<LANE-10-noname> <LANE-21-noname> 50) (<LANE-10-noname> <LANE-22-noname> 50)
                          (<LANE-3-noname> <LANE-11-noname> 50) (<LANE-3-noname> <LANE-12-noname> 50)))
    a number    a number    (75 99
                          ((<LANE-19-noname> <LANE-4-noname> 100) (<LANE-20-noname> <LANE-4-noname> 100)
                          (<LANE-13-noname> <LANE-9-noname> 50) (<LANE-14-noname> <LANE-9-noname> 50)
                          (<LANE-10-noname> <LANE-11-noname> 50) (<LANE-10-noname> <LANE-12-noname> 50)
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```



Traffic Control

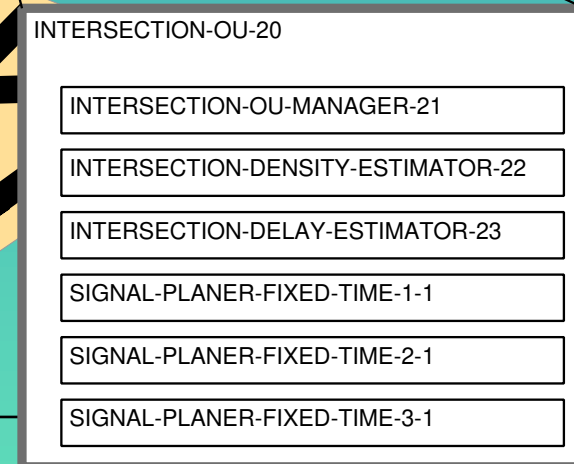
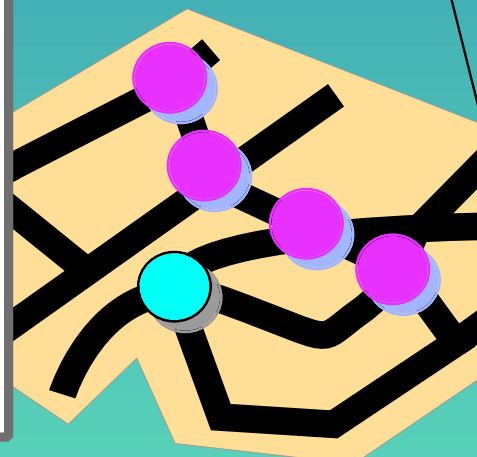
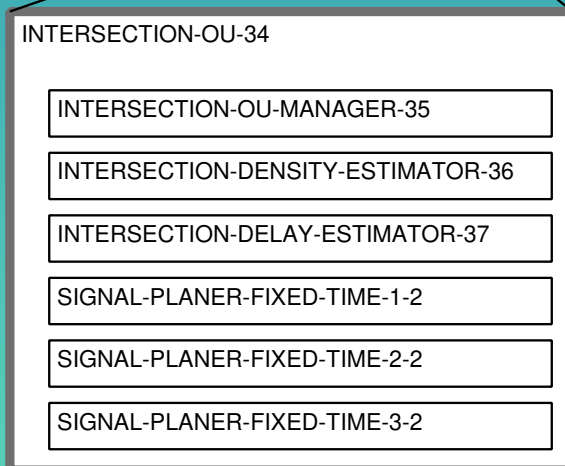
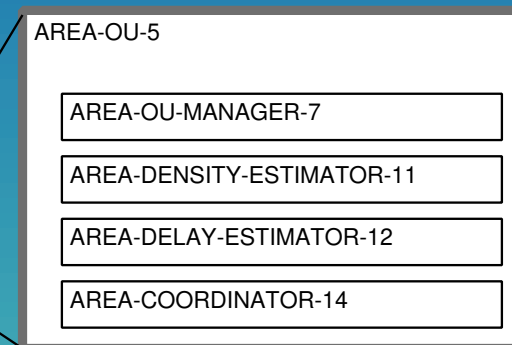
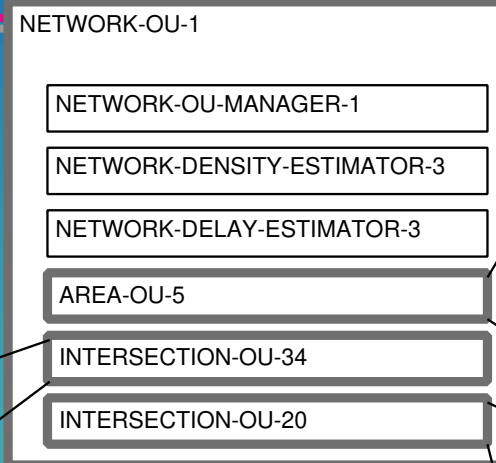
- contract net example
- 2 coordinated intersections
- 3 fixed-time signal plans



Traffic Control

New
Features

- contract net example



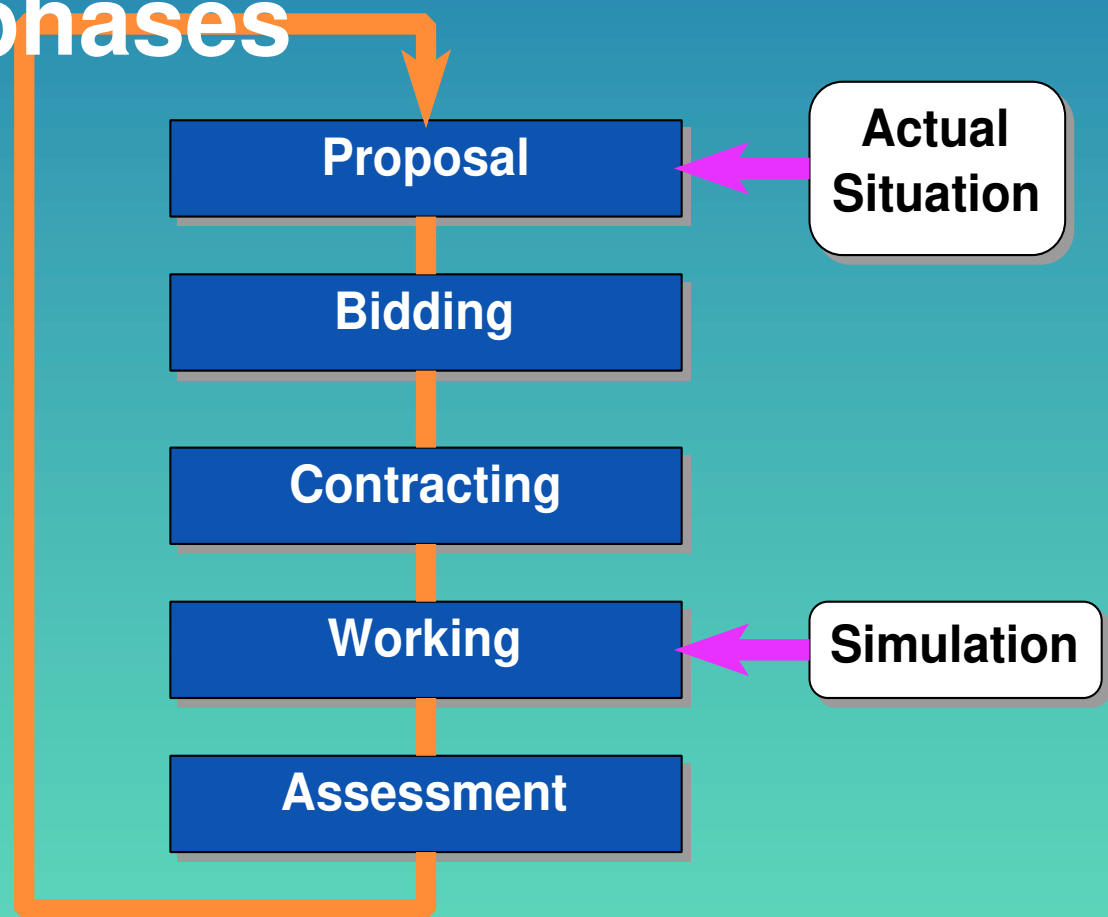
Traffic Control

New
Features

• contract net phases

- change of signal planner
- change of rating level
- change of area-node mapping

Time Horizon ca. 5min



Extensions

- public transport
- pedestrians
- emergency planning
- driver information systems



Public Transport *Extensions*

- **floating cars**
 - buses
 - taxis
- **separate bus lanes**
 - arrival estimation
 - prioritization
- **emergency vehicles**



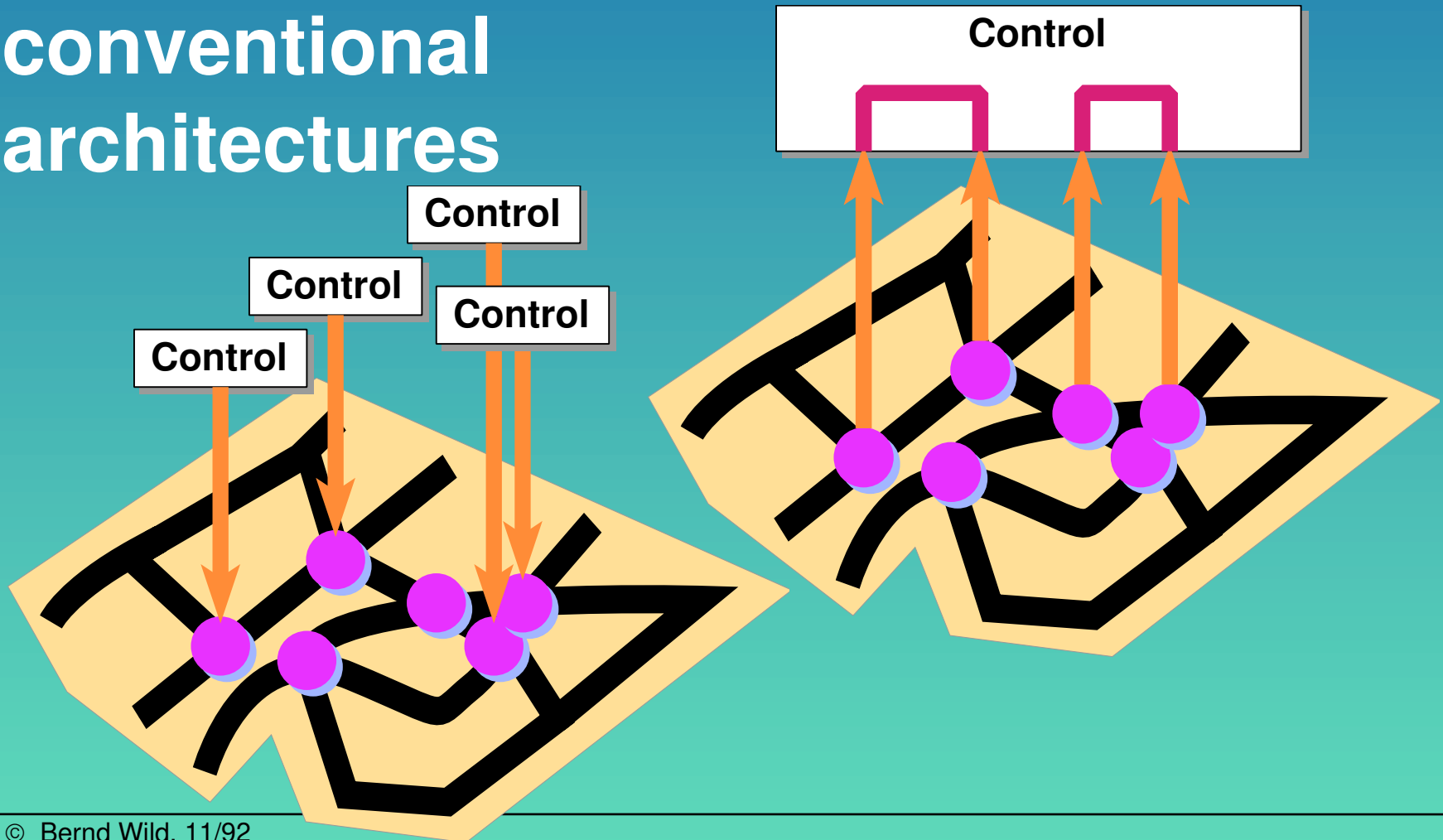
Further Research

- traffic control as distributed problem solving among cooperative nodes
- concurrent architectures for traffic control
- AI-based framework
 - integration of traffic engineering optimization methods



Traffic Control as DPS

- conventional architectures

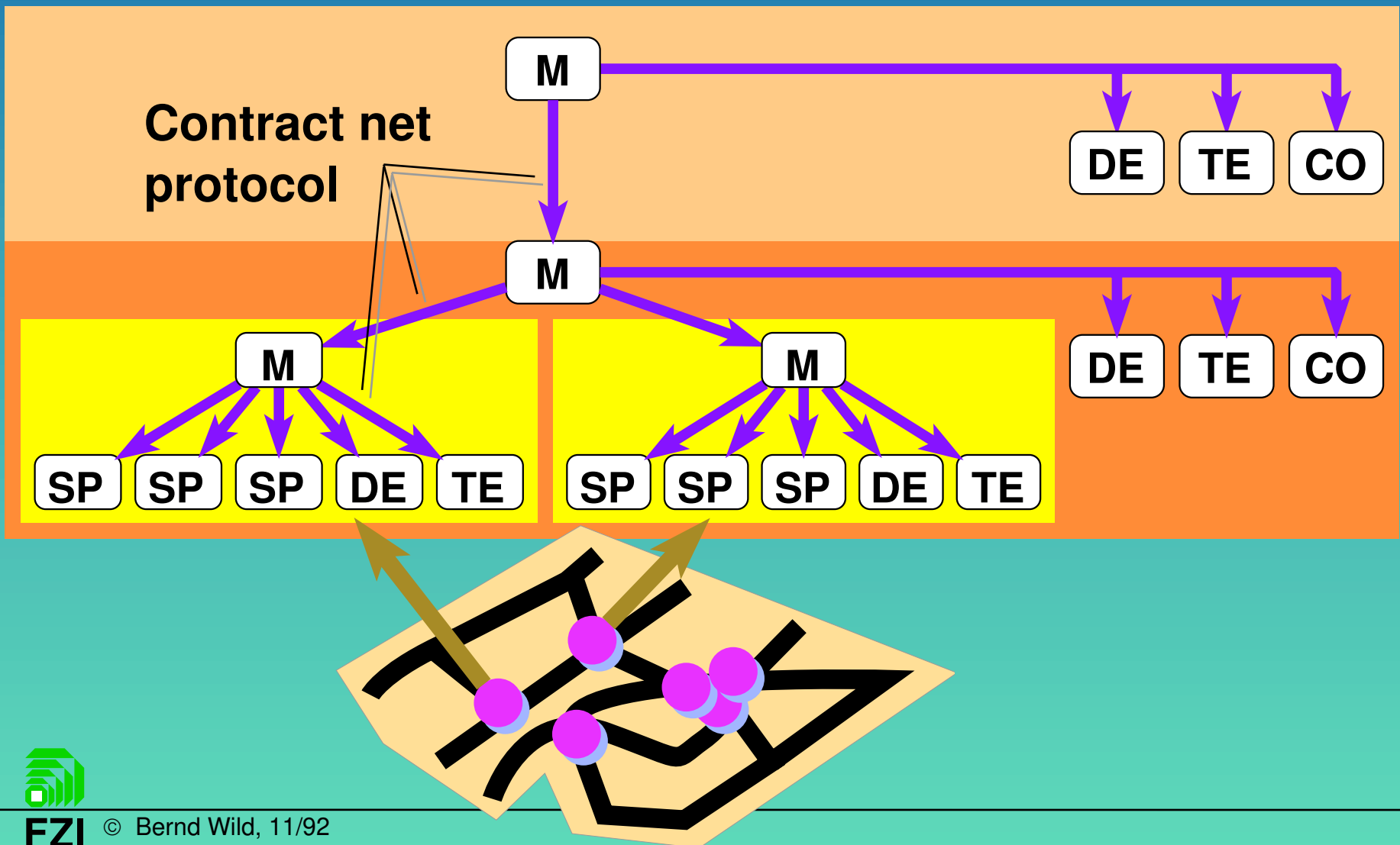


Traffic Control as DPS

- hierarchical organization
- distributed optimization
- cooperative problem solving

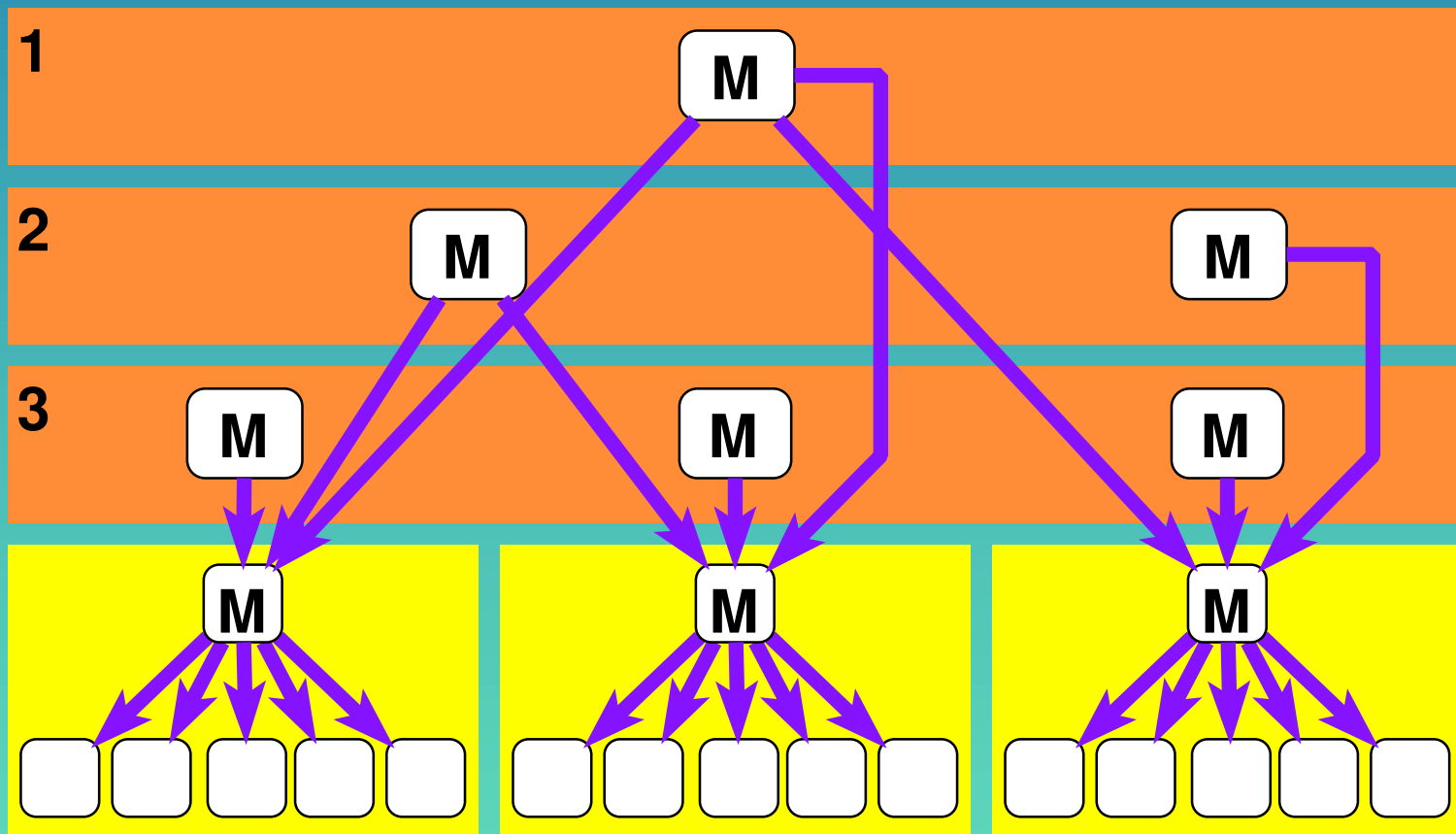


Traffic Control as DPS

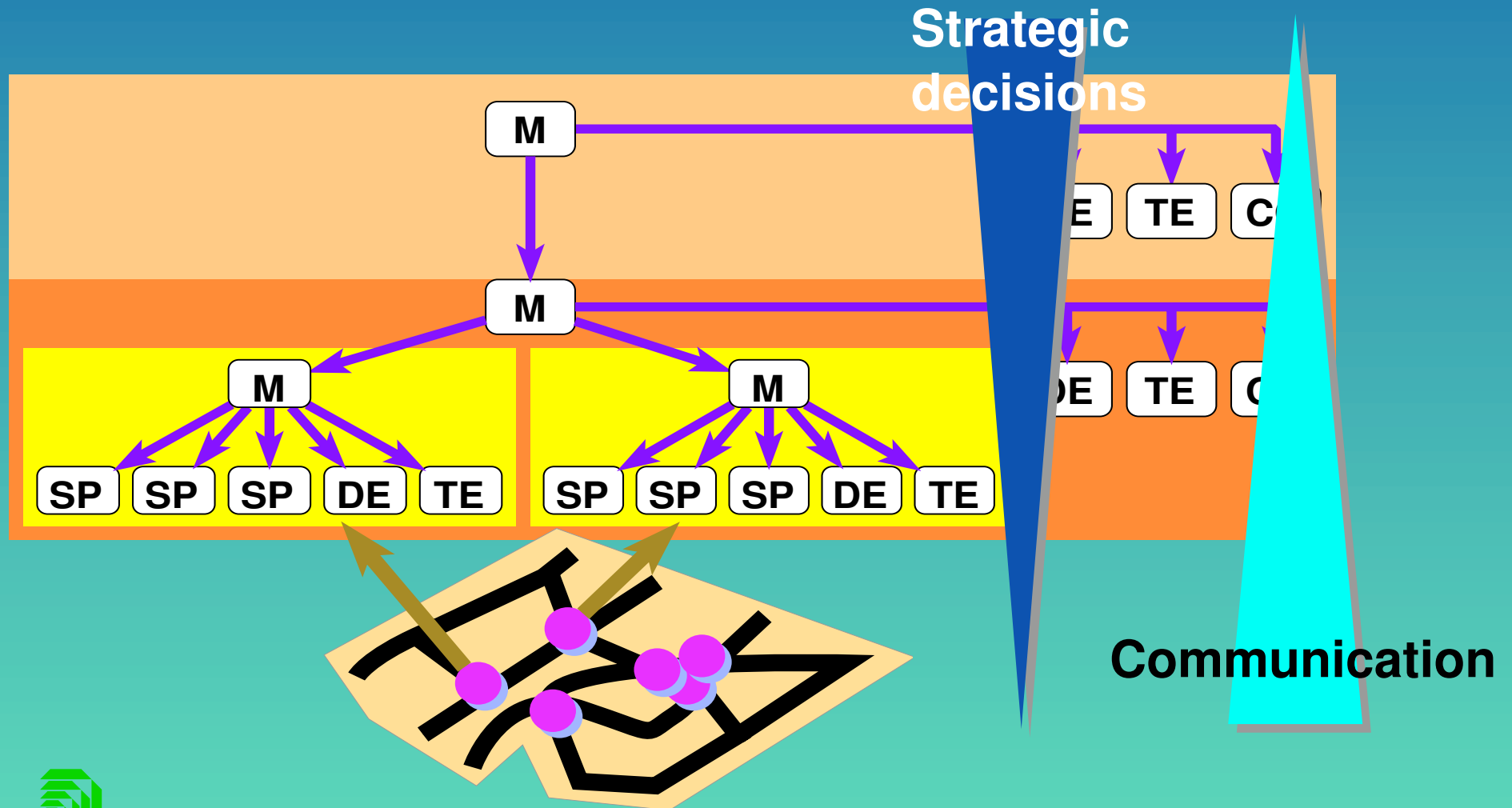


Traffic Control as DPS

- coupling + reorganization



Concurrent Architectures

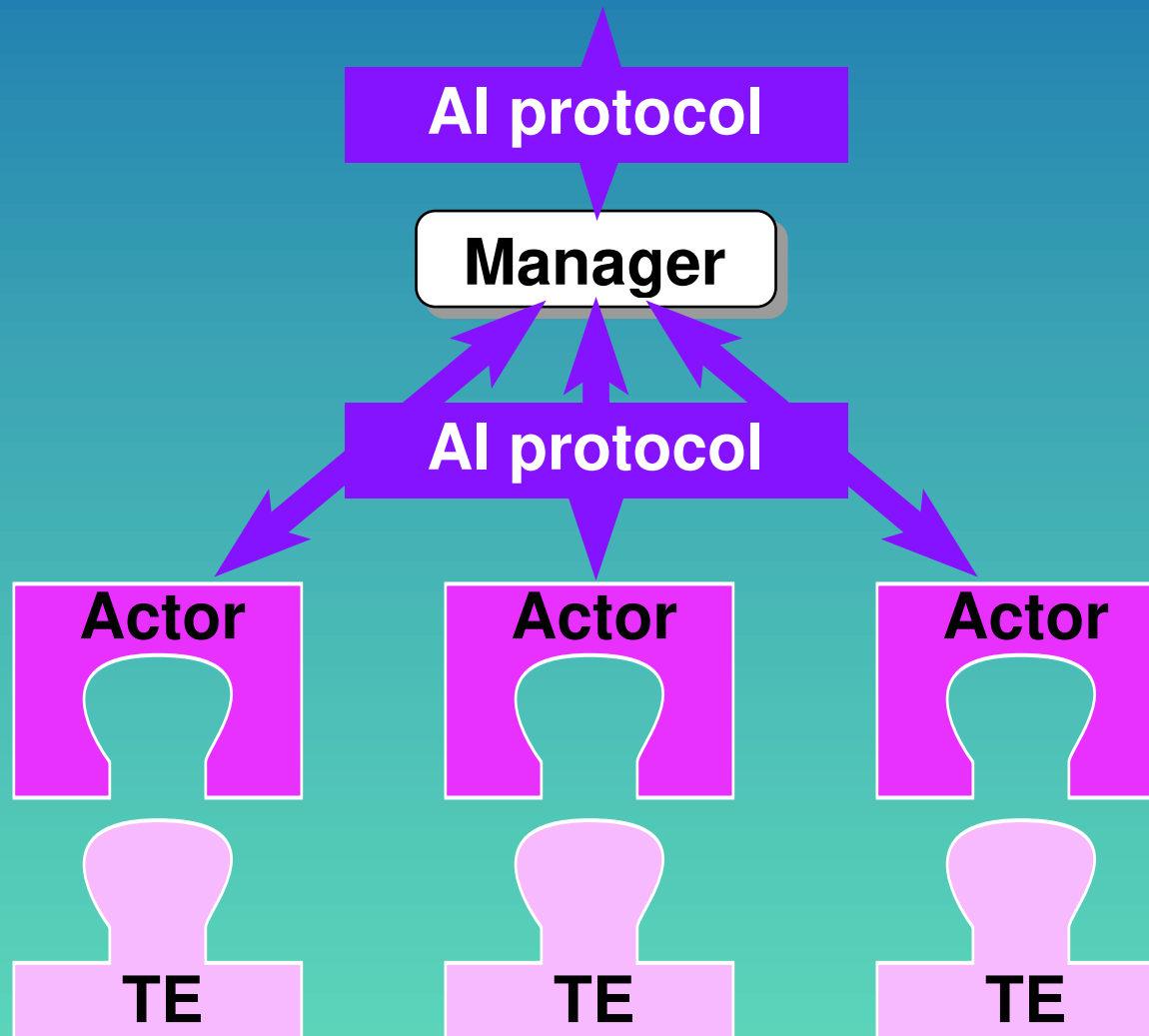


AI-based Framework

- optimization by TE methods
(NO AI!!)
- integration of TE methods
 - abstract interfaces
 - AI protocol
 - AI selection mechanisms
 - Knowledge-bases
 - support of concurrent problem solving



AI-based Framework



Conclusion

- **review of AI methods in traffic engineering**
 - analysis of candidate methods
 - adoption of 4 basic techniques
- **construction of a software prototype**
- **research in distributed traffic control models**



The End

