# Design and Evaluation of Adaptive Traffic Control System for Heterogeneous flow conditions

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# Outline

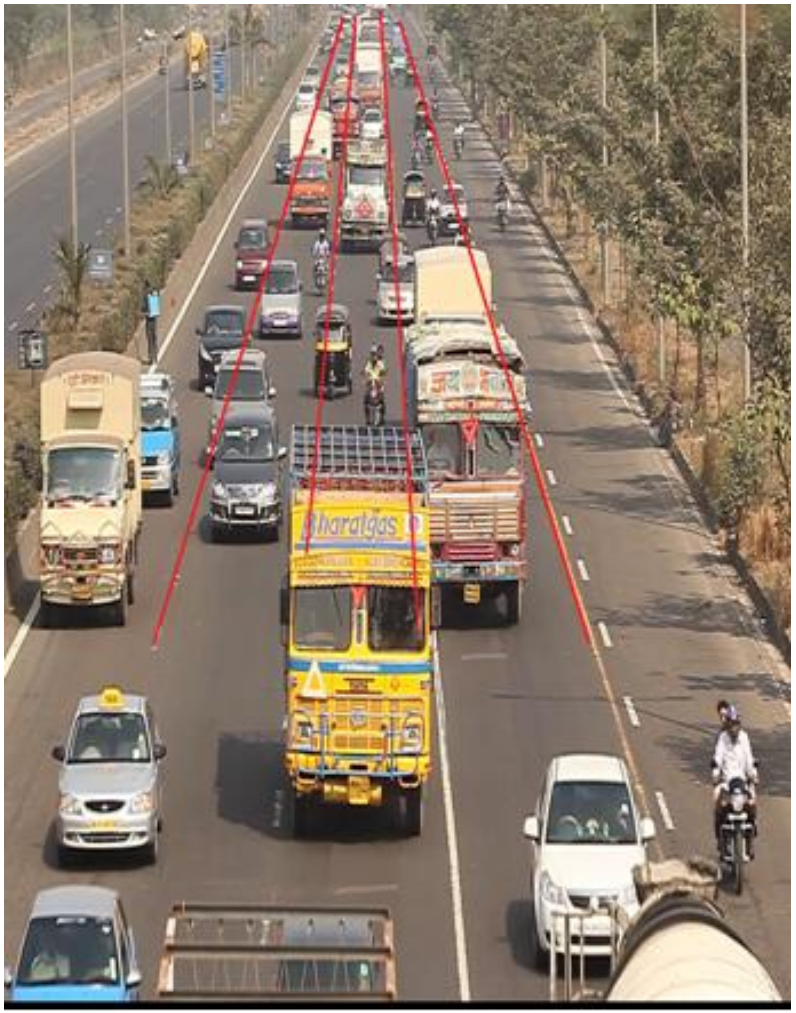
1. Heterogeneous traffic
2. Traffic Simulation
3. Traffic Signal control
4. Adaptive traffic control
5. Conclusion

# Heterogeneous Traffic

- Homogeneous traffic
  - Single vehicle type
- Lane-based Movement
  - Follow a single leader
  - Well defined surrounding vehicle

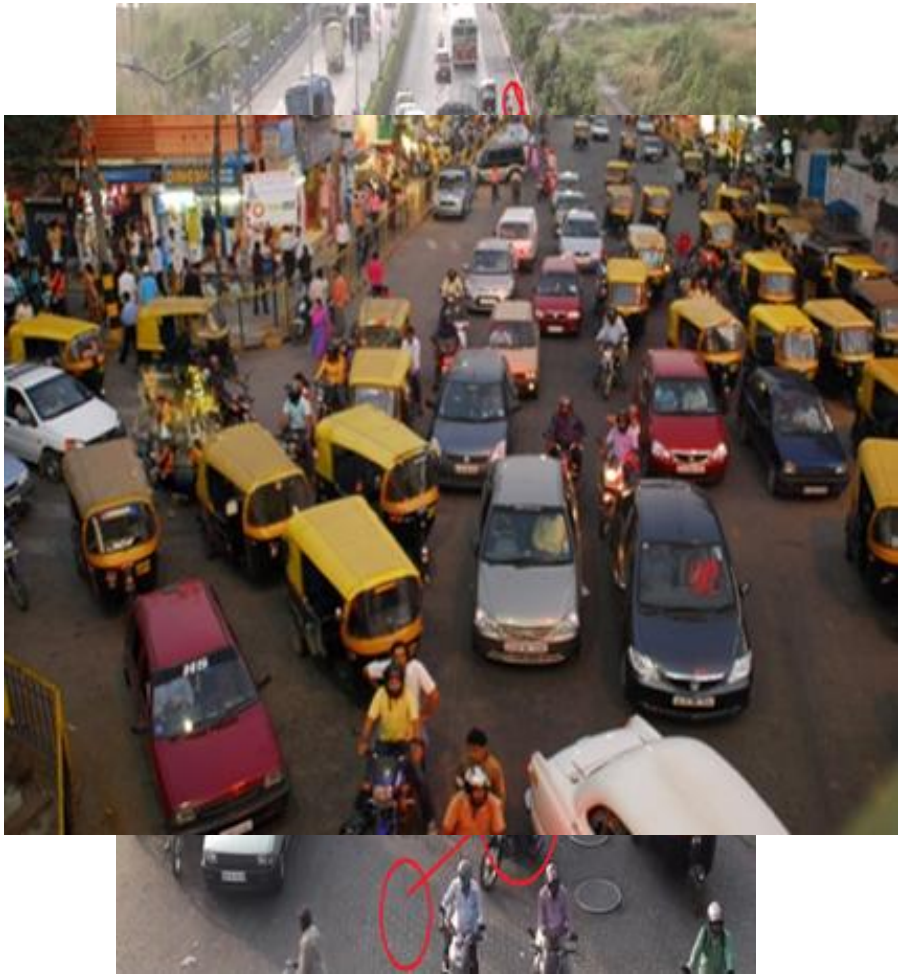
# Heterogeneous Traffic

- Mixed vehicle type
  - Static characteristics
  - Dynamic characteristics
- Non-lane-based
  - Who is my leader?
  - What are my surrounding vehicle?



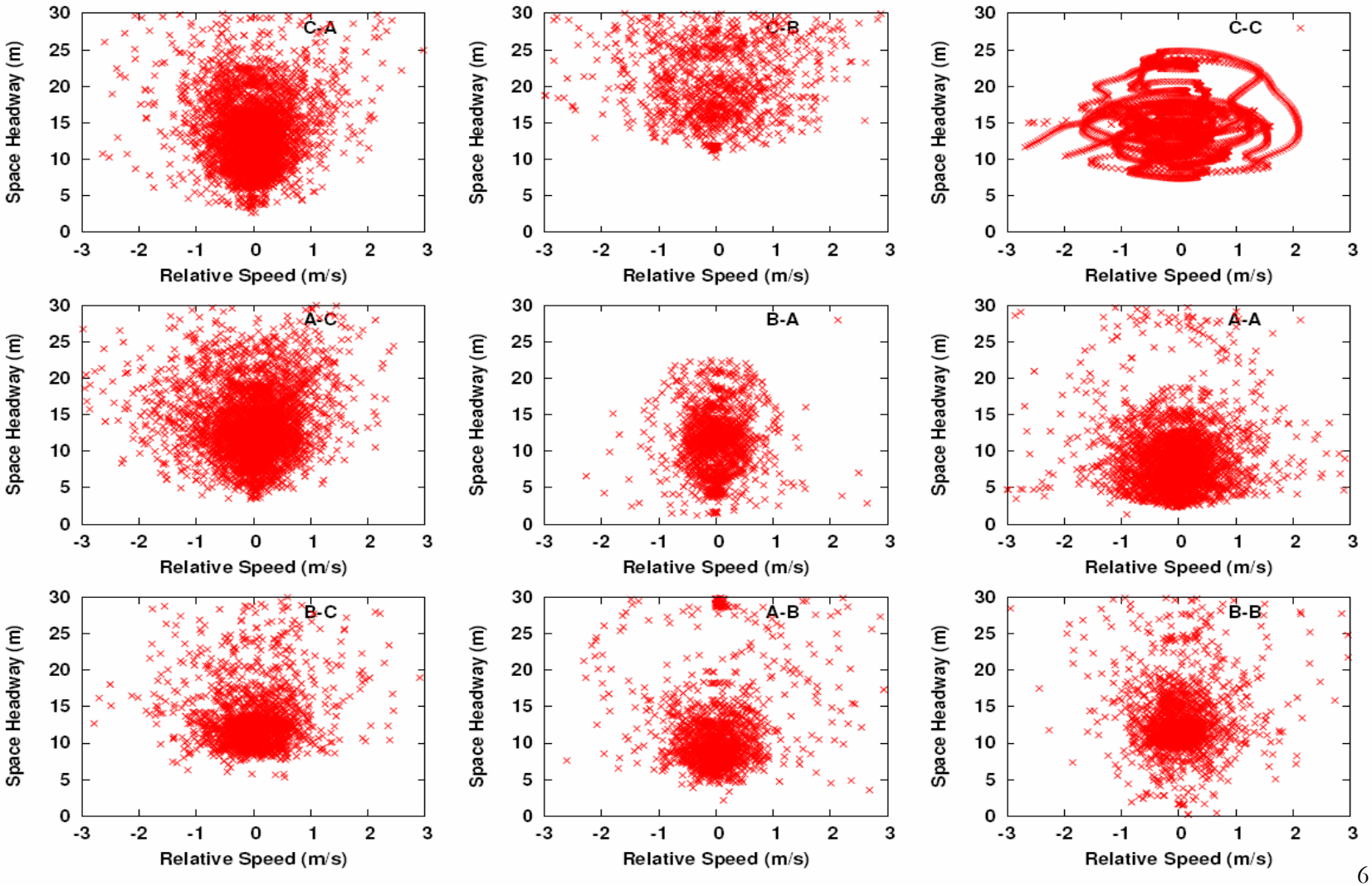
# Heterogeneous Traffic

- Intersection
  - Seepage
  - Maneuverability
  - Stop-line
  - Lane-changing



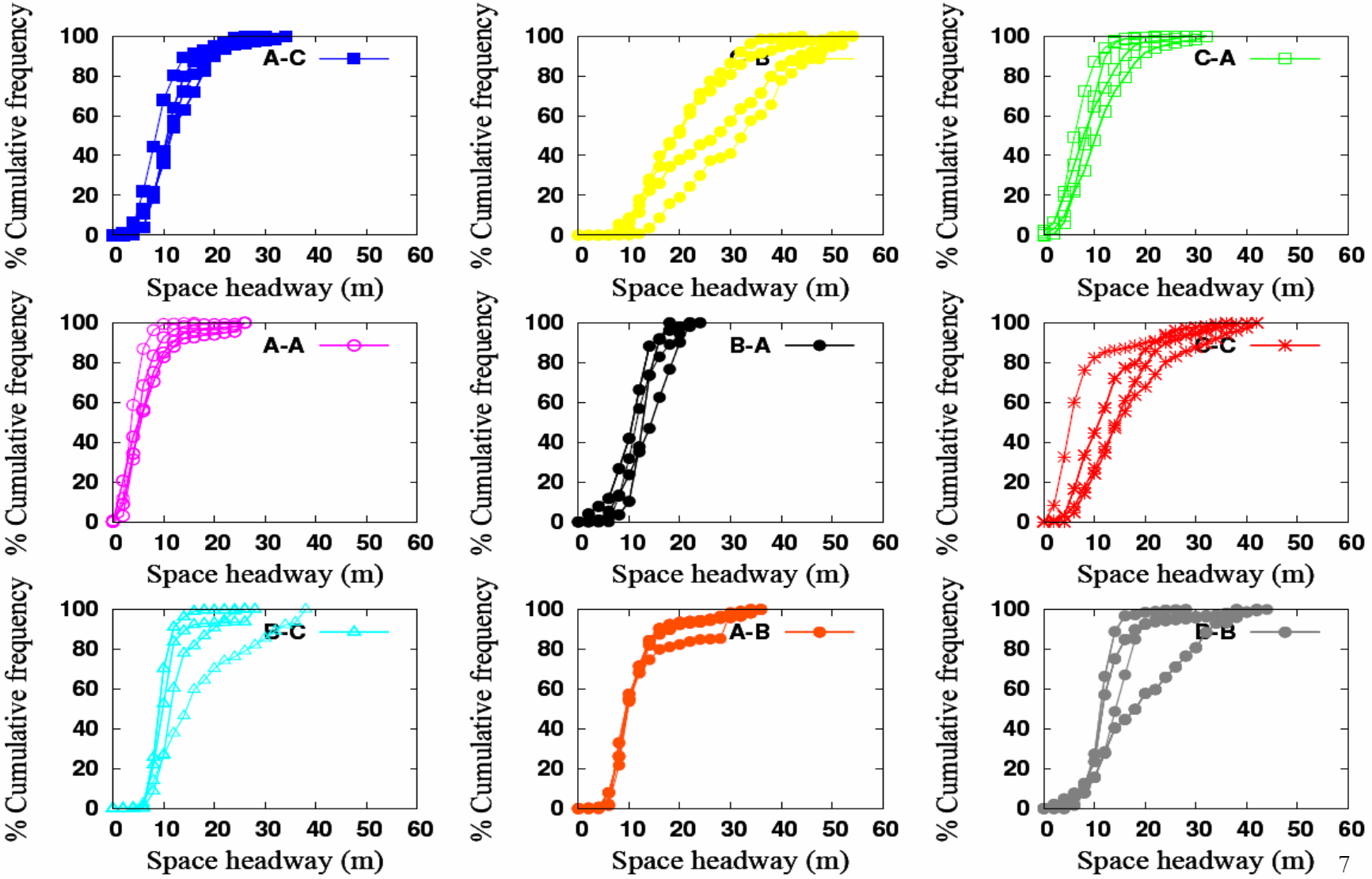
# Heterogeneous Traffic

- Vehicle type dependant car-following



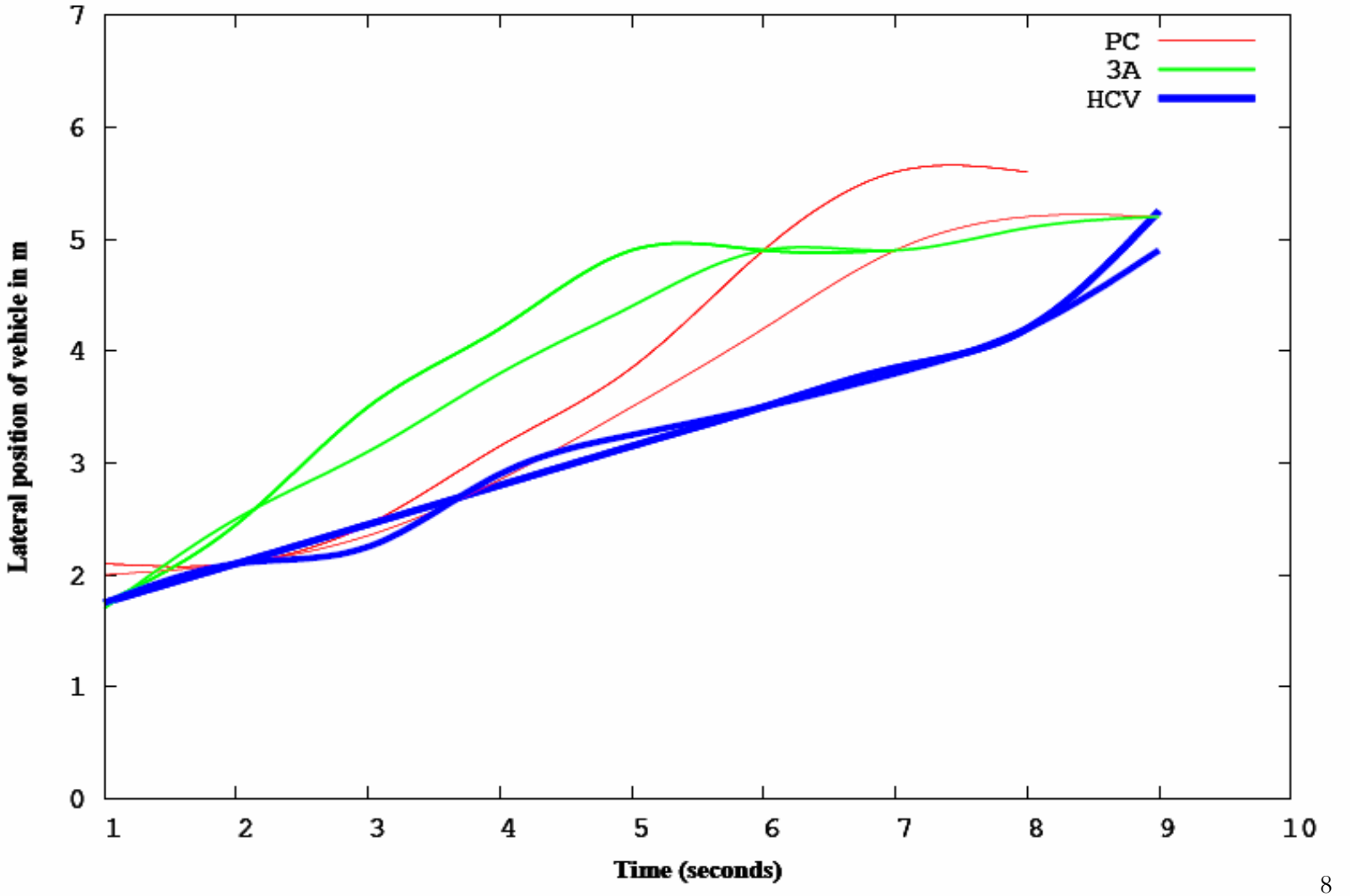
# Heterogeneous Traffic

- Effect of vehicle type on car-following



# Heterogeneous Traffic

- Effect of vehicle type on lane-changing



# Heterogeneous Traffic

- Modeling needs
  - Address mixed vehicle type
  - Model non-lane based movement

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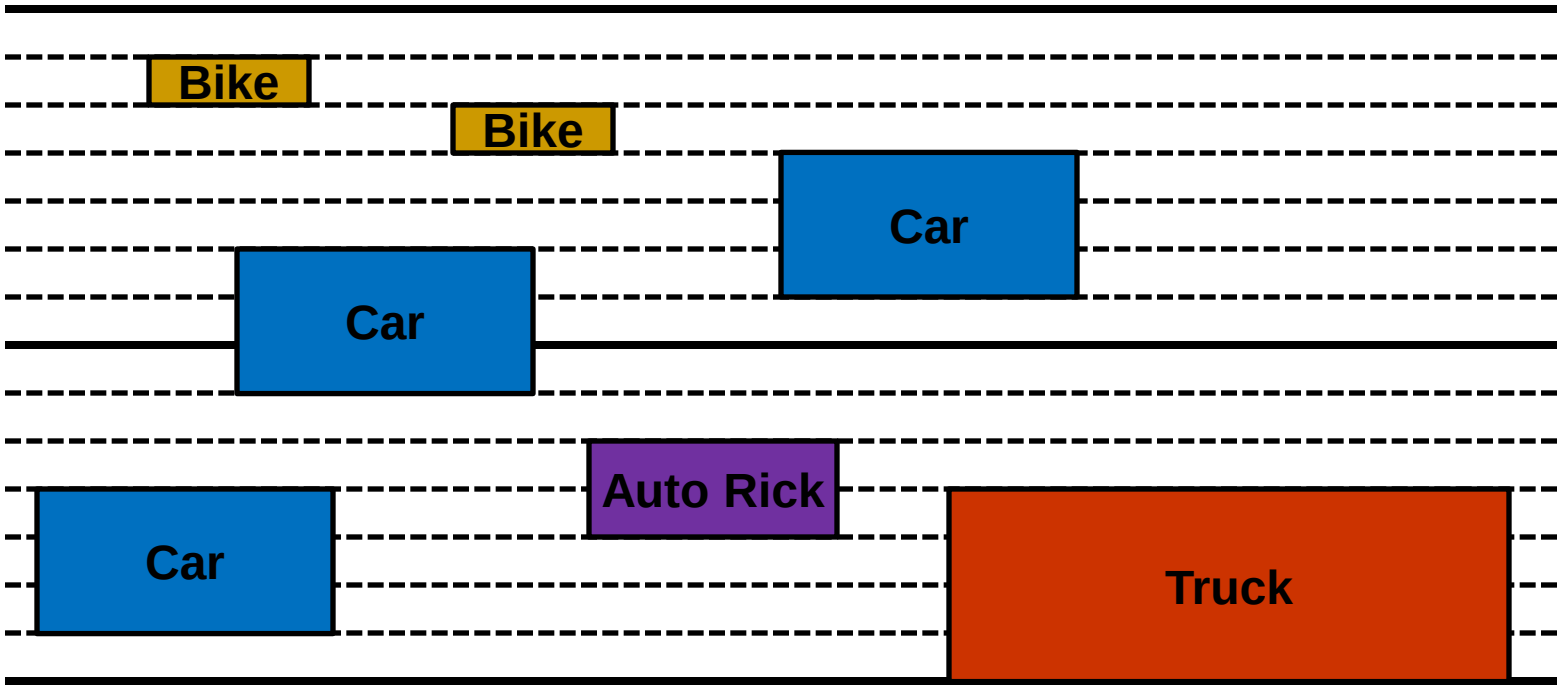
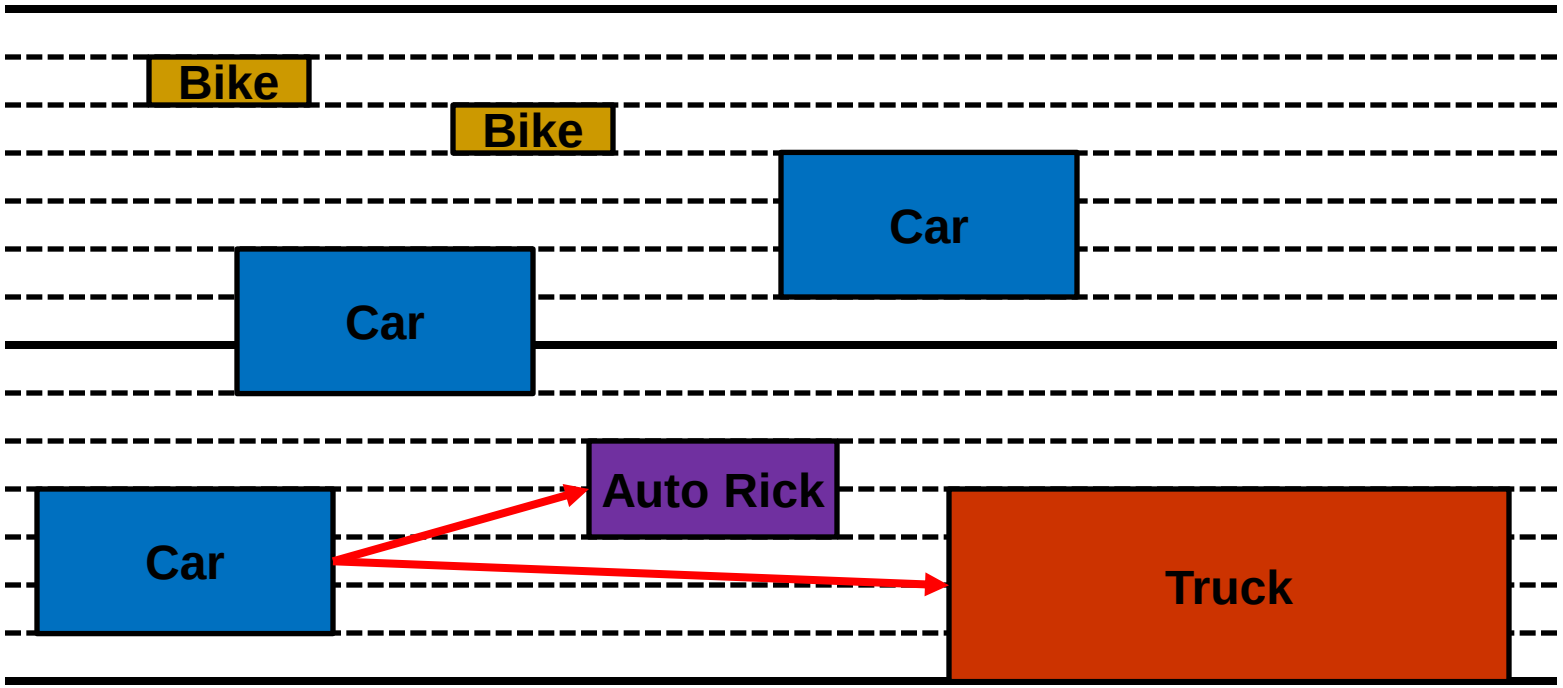
# Strips for non-lane based modelling

- Longitudinal movement
  - Continuous
  - Modified car-following
- Lateral movement
  - Discrete
  - Strip changes



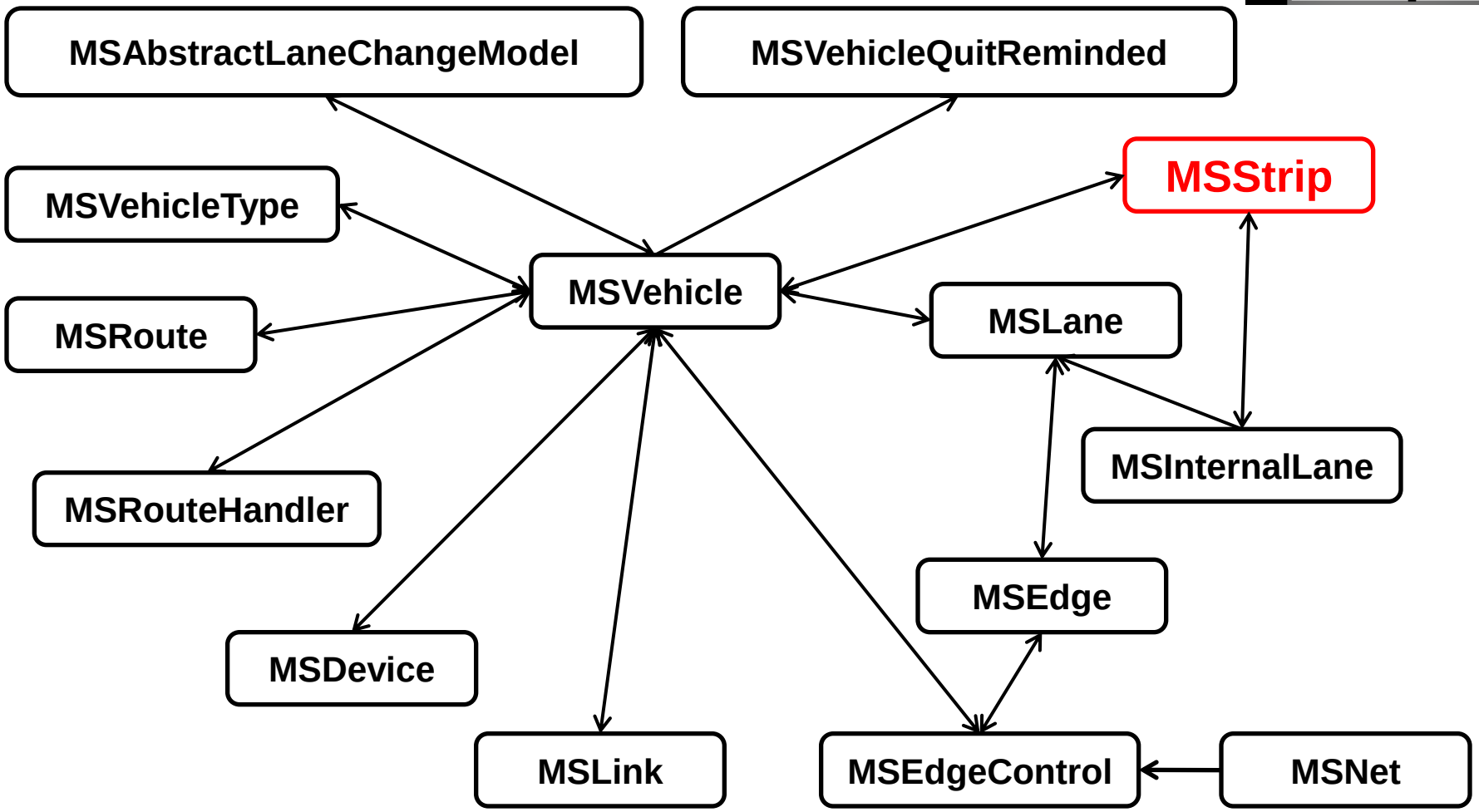
# Strips for non-lane based modelling

- Vehicle-following model
  - Who is my leader?
- Lateral movement model
  - Which strip should I occupy

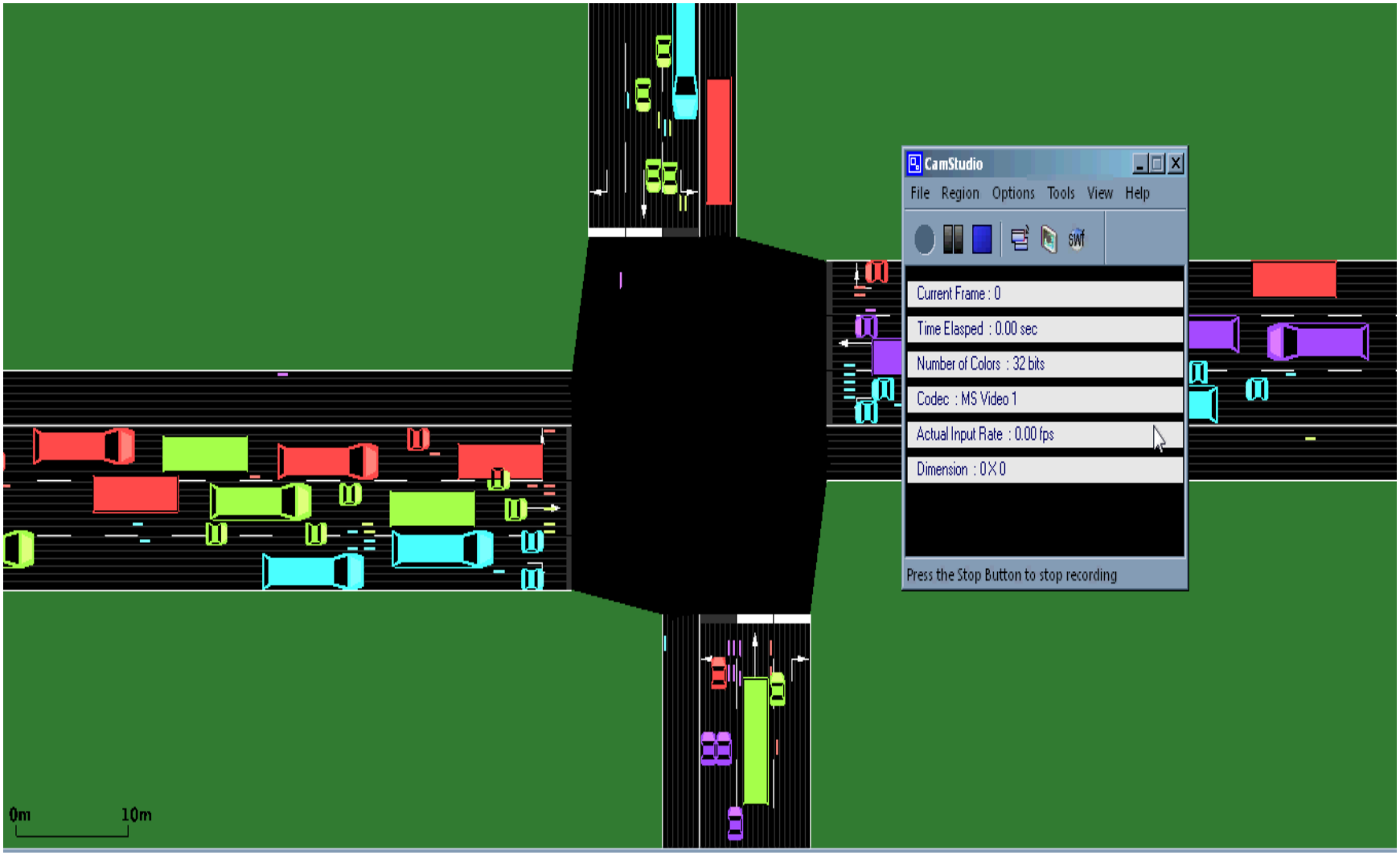


# Implementation of strips

- Simulation of Urban Mobility (SUMO)



# Implementation of strips



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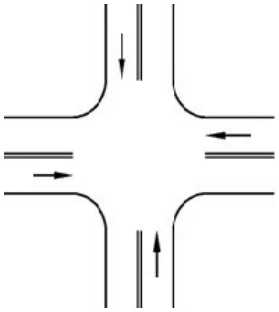
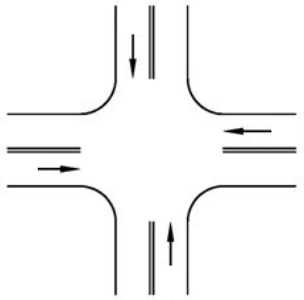
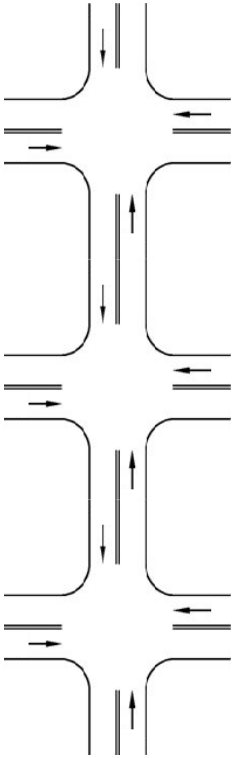
# Traffic Signal Control



Fixed Time Signal

Vehicle Actuated



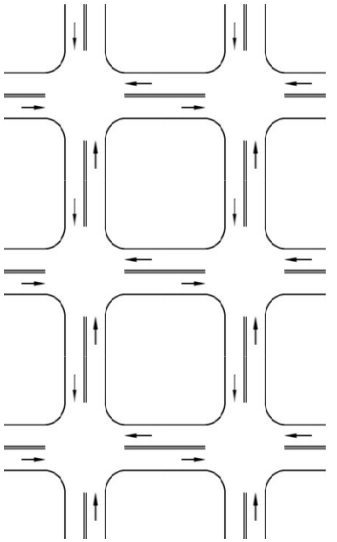


Coordinated Signal

Area Traffic Control

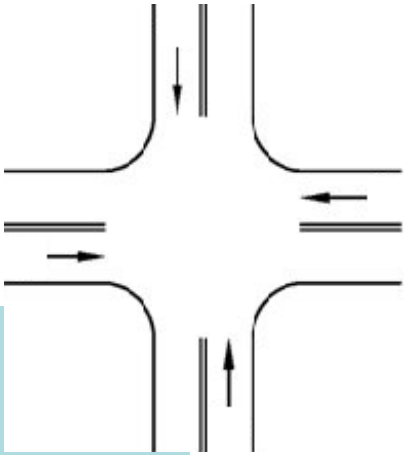
Responsive

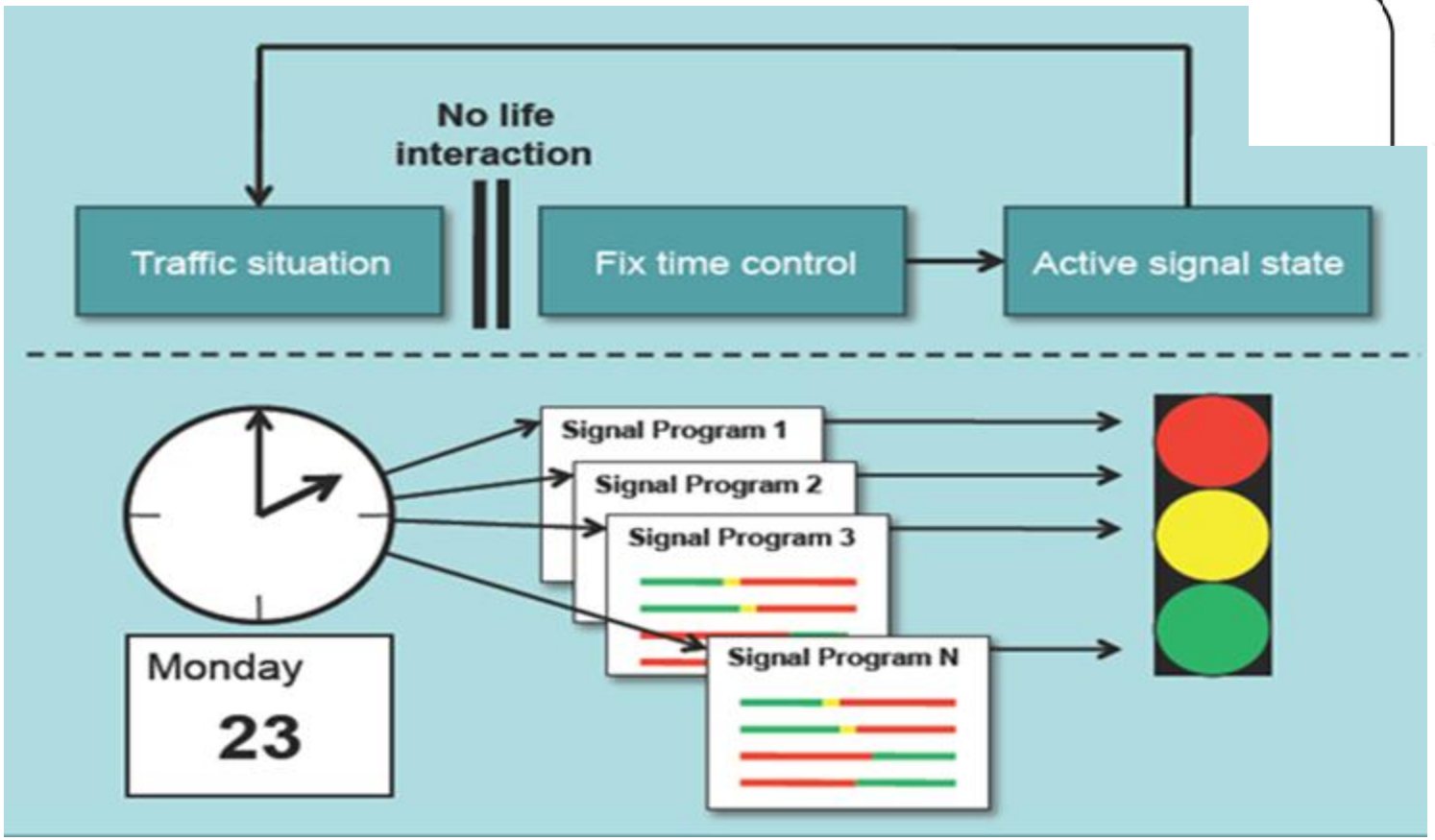
Adaptive



# Traffic Signal Control

- Fixed time control

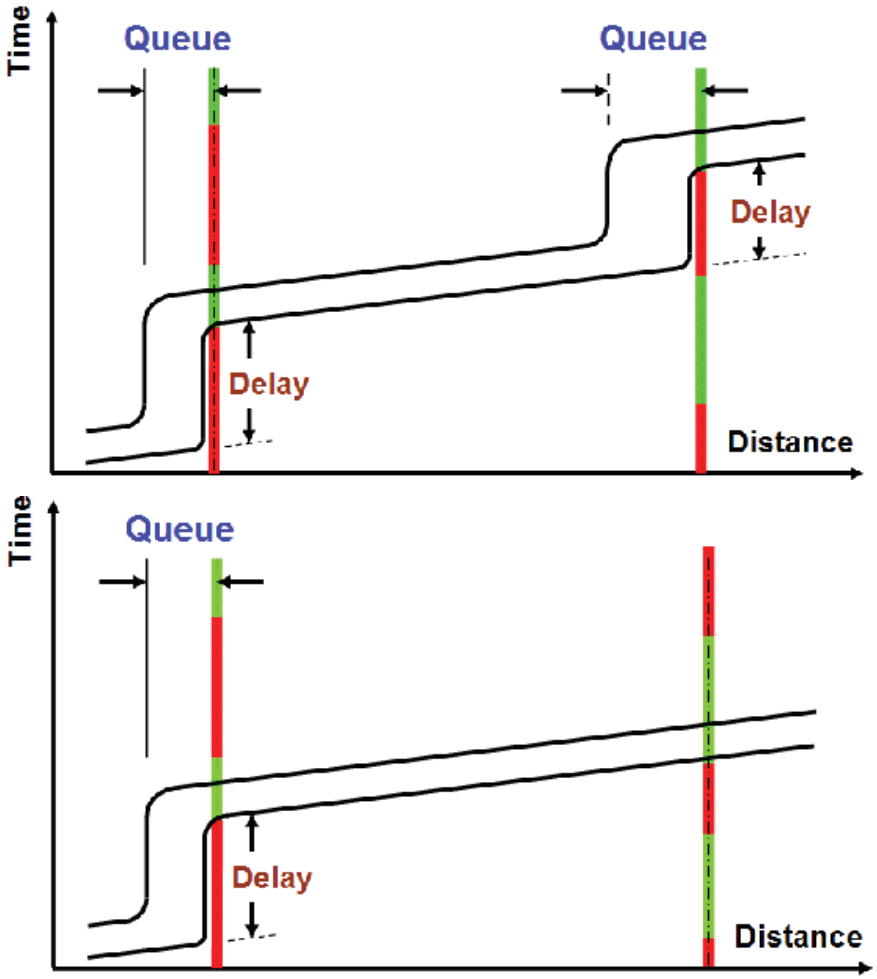




# Traffic Signal Control

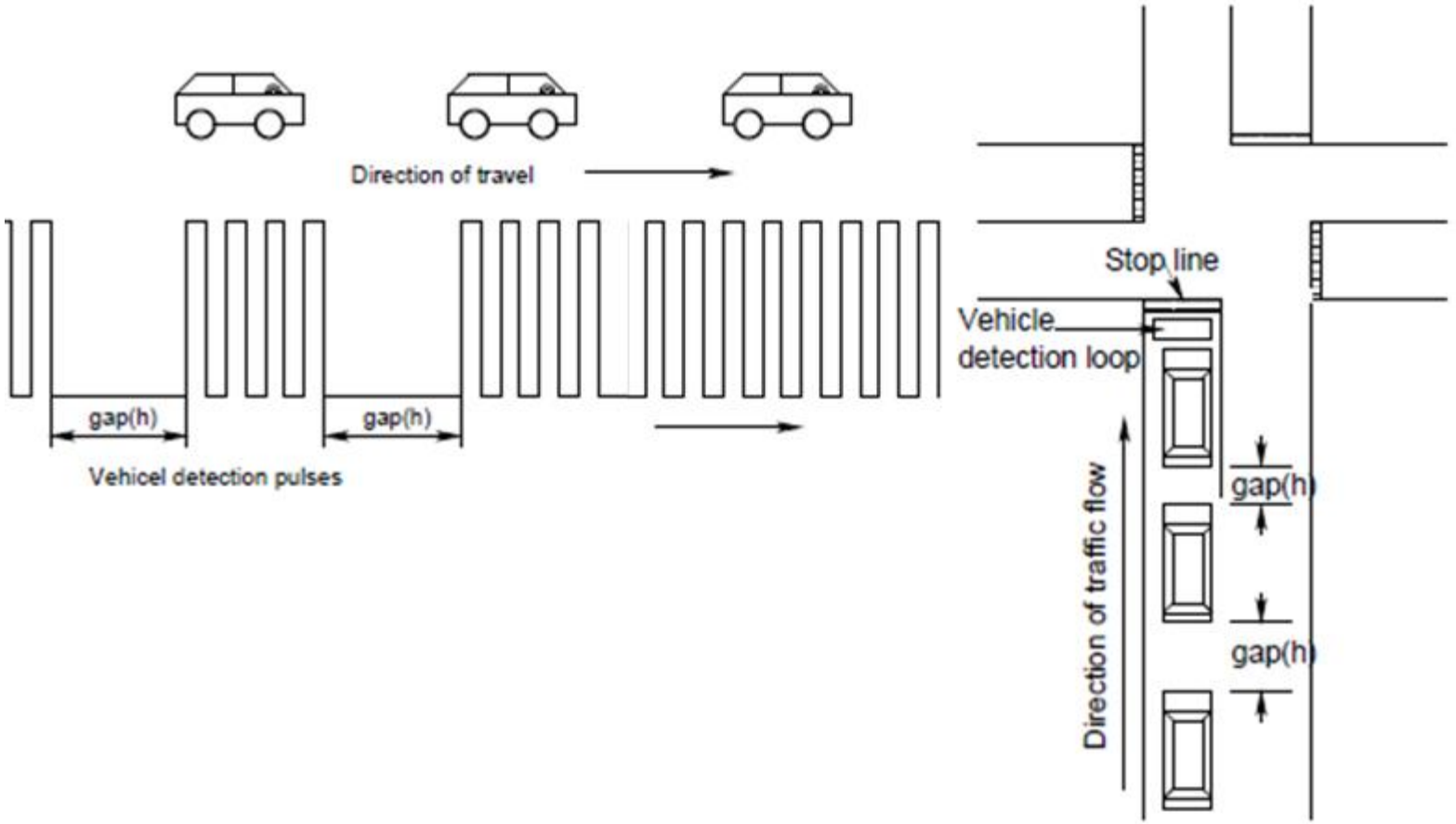
- Coordinated control

  - Offset downstream green start
  - Assumes constant link travel time
  - Implies smooth progression



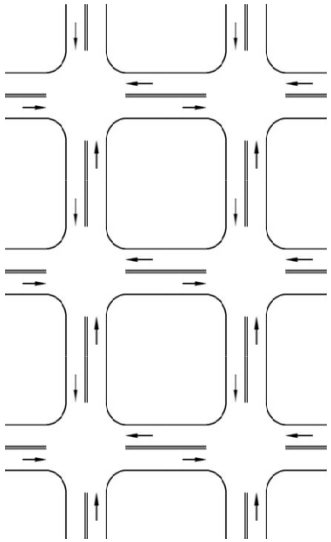
# Traffic Signal Control

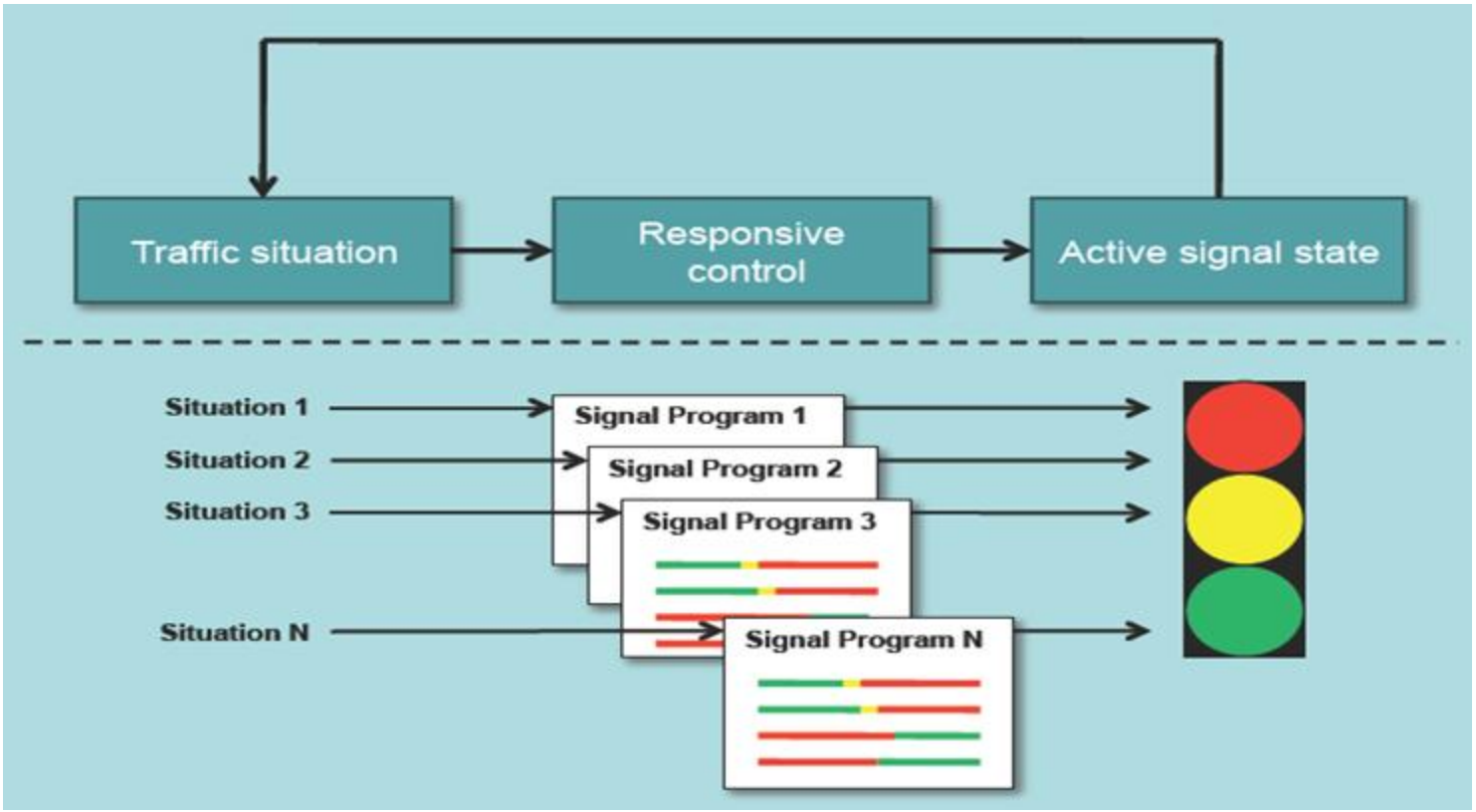
- Vehicle Actuated Control



# Traffic Signal Control

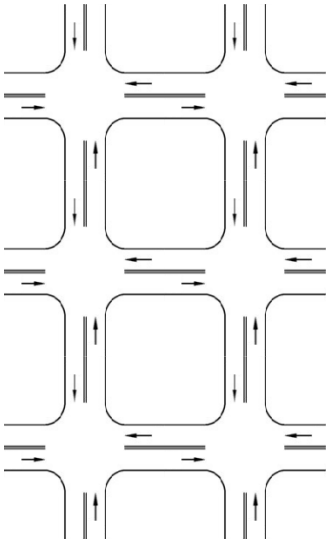
- Area traffic control – Traffic responsive

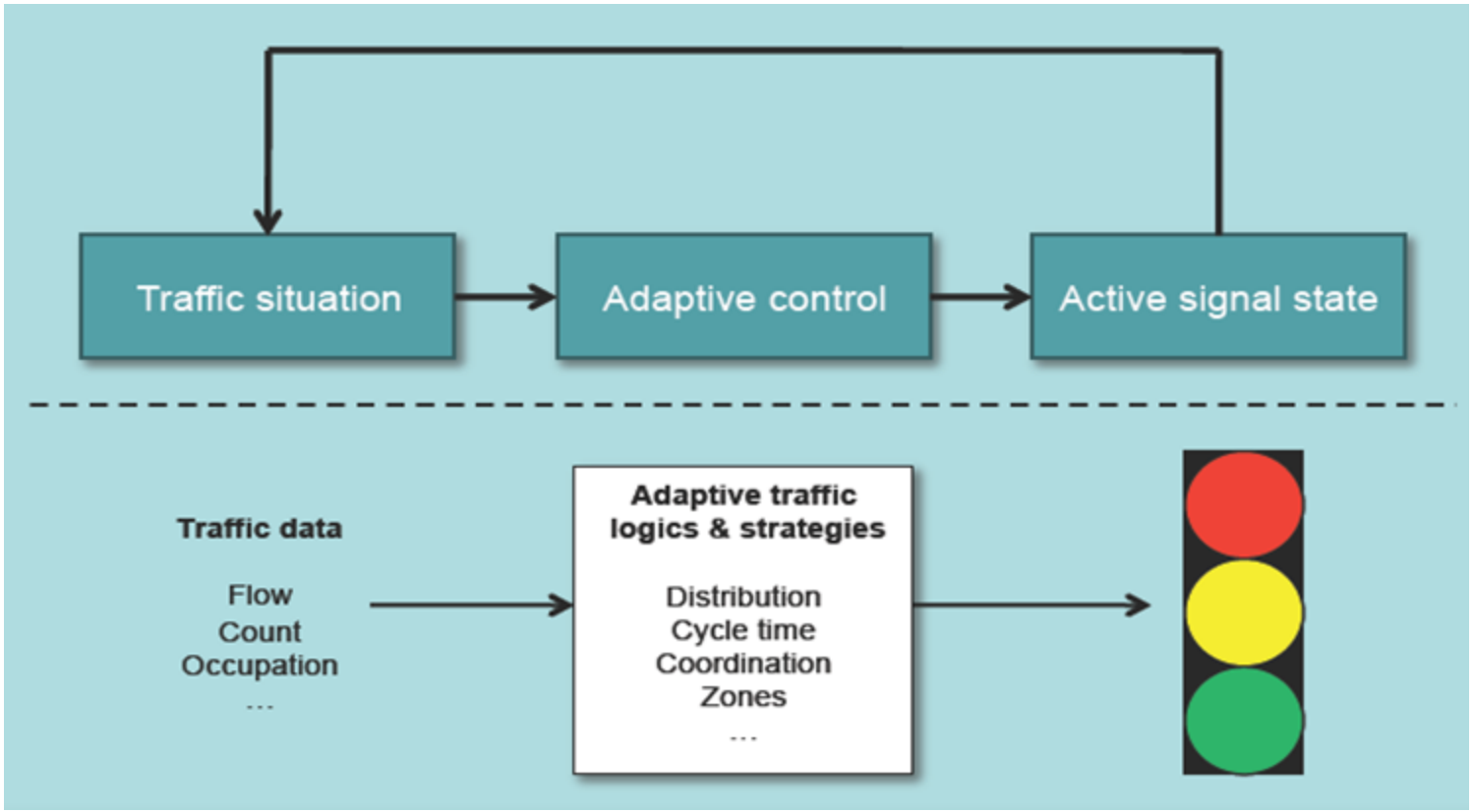




# Traffic Signal Control

- Area traffic control – Adaptive to Traffic



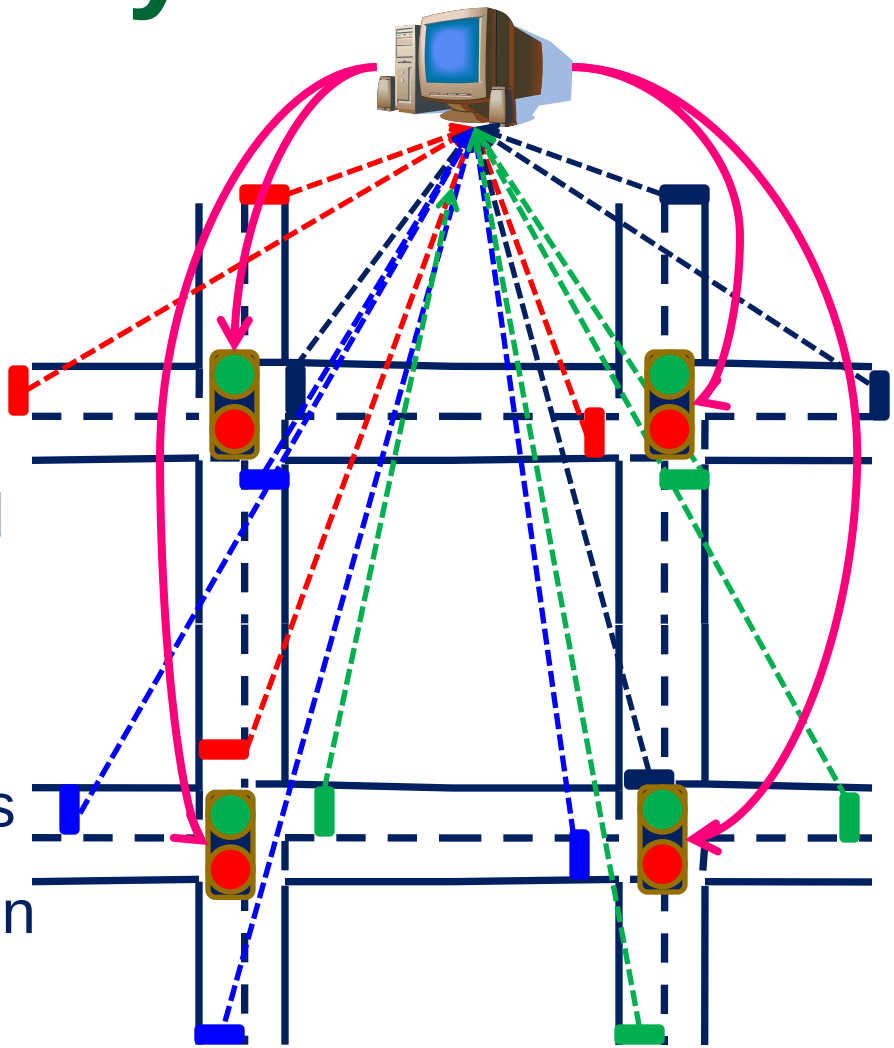


# Traffic Signal Control

- Two Popular Network Systems
  - Centralized system
    - SCOOT
      - Split, Cycle, Offset, Optimization
  - Distributed system
    - SCAT
      - Sydney Coordinated Adaptive Traffic System

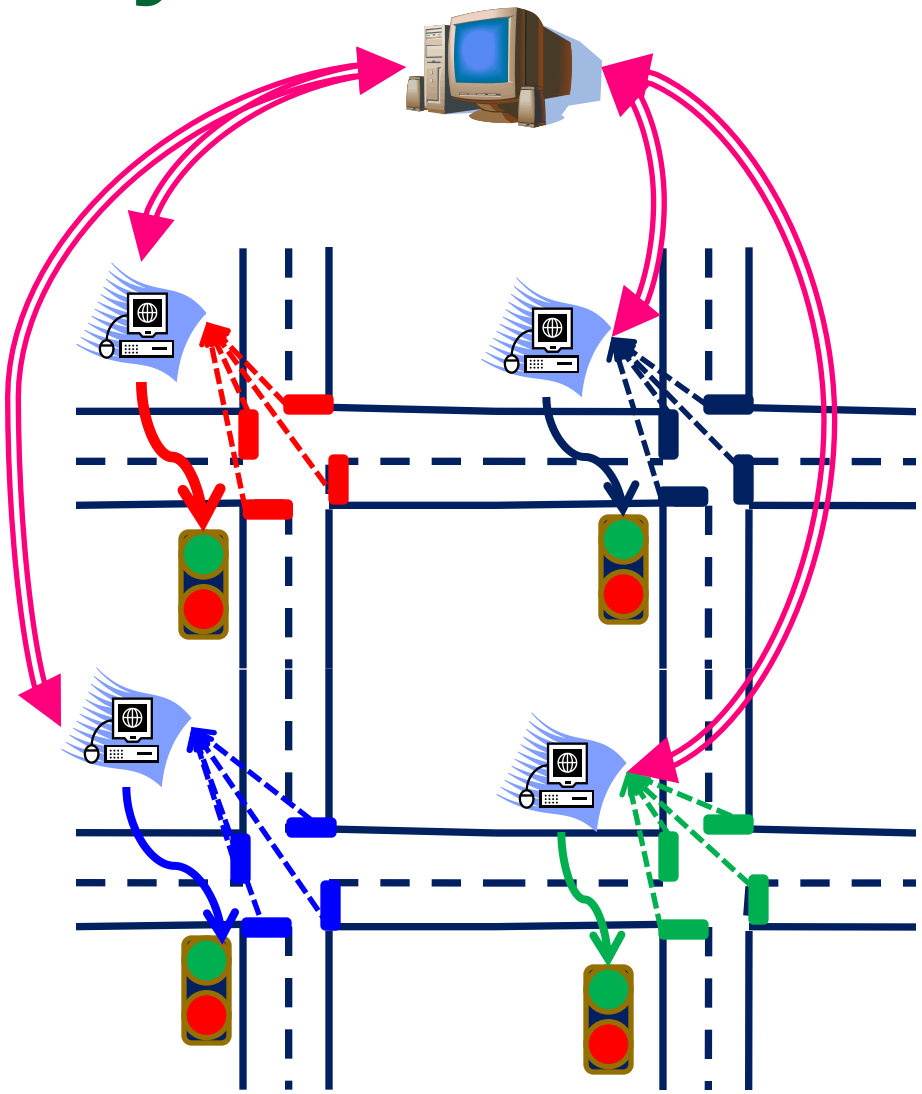
# SCOOT system

- Working philosophy
  - Upstream detection
  - Data communicated to central controller
  - It computes the timing and send to intersections
- Limitations
  - Communication overheads
  - Poor progression prediction
  - Calibration issues



# SCATS system

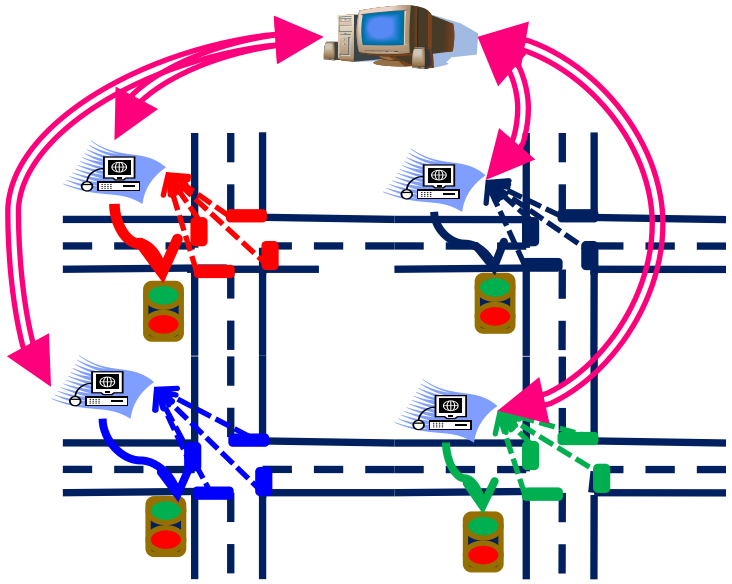
- Working philosophy
  - Downstream detection
  - Local controller acts akin to a VA controller
  - Communicate periodically to the central controller
- Limitations
  - Not an optimal system



# SCOOT vs. SCAT

- SCOOT
  - Centralized System
  - Upstream detection
  - Fixed traffic regions
  - Fallback - fixed
  - Model based
- SCAT
  - Distributed system
  - Stop line detection
  - Adjustable region
  - Fallback - VA
  - Algorithmic

- Requirement
  - Distributed system
  - Stop line detection
  - Adjustable region
  - Fallback – VA
  - Model based



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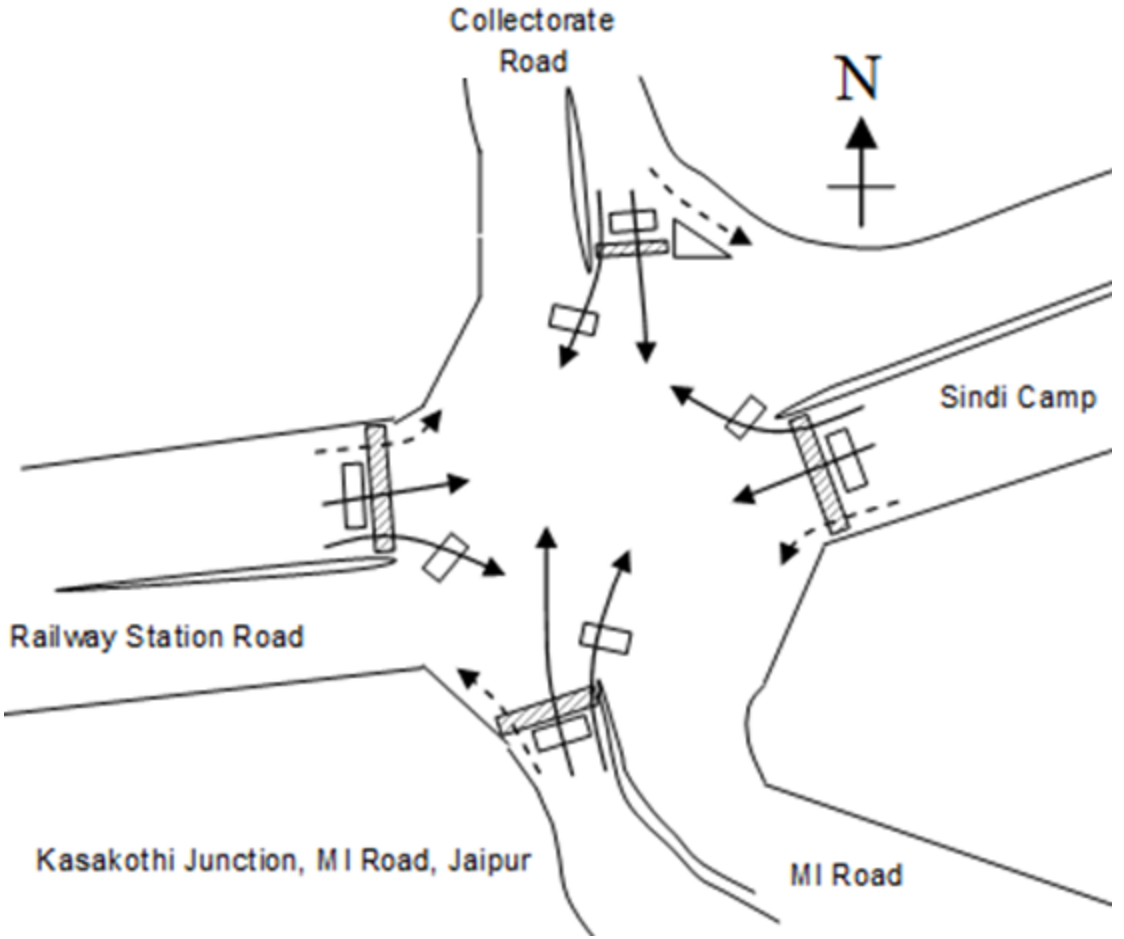
# Adaptive control

- Detector placement
  - Stop-line
  - Loop occupancy
- Performance
  - Based on actual & utilized green time



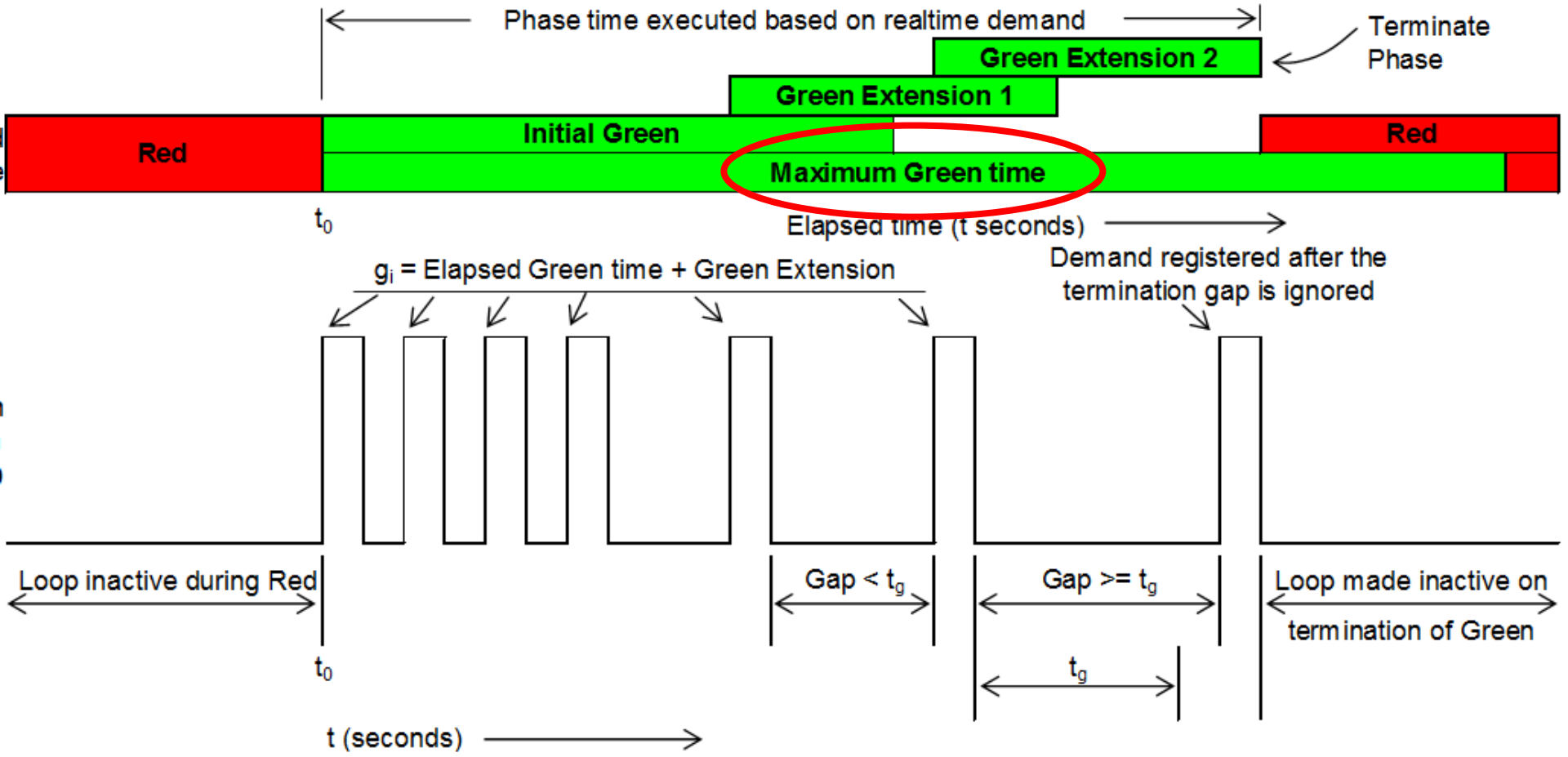
# Adaptive control

## Basic Algorithm

```
for every phase
set green equals queue service time
for every scan time
  get detector state for each lane-group
  compute gap
  if gap greater than threshold
    terminate green
  else increment green time
    limit green to max green time
  if green greater than max green
    terminate green
```

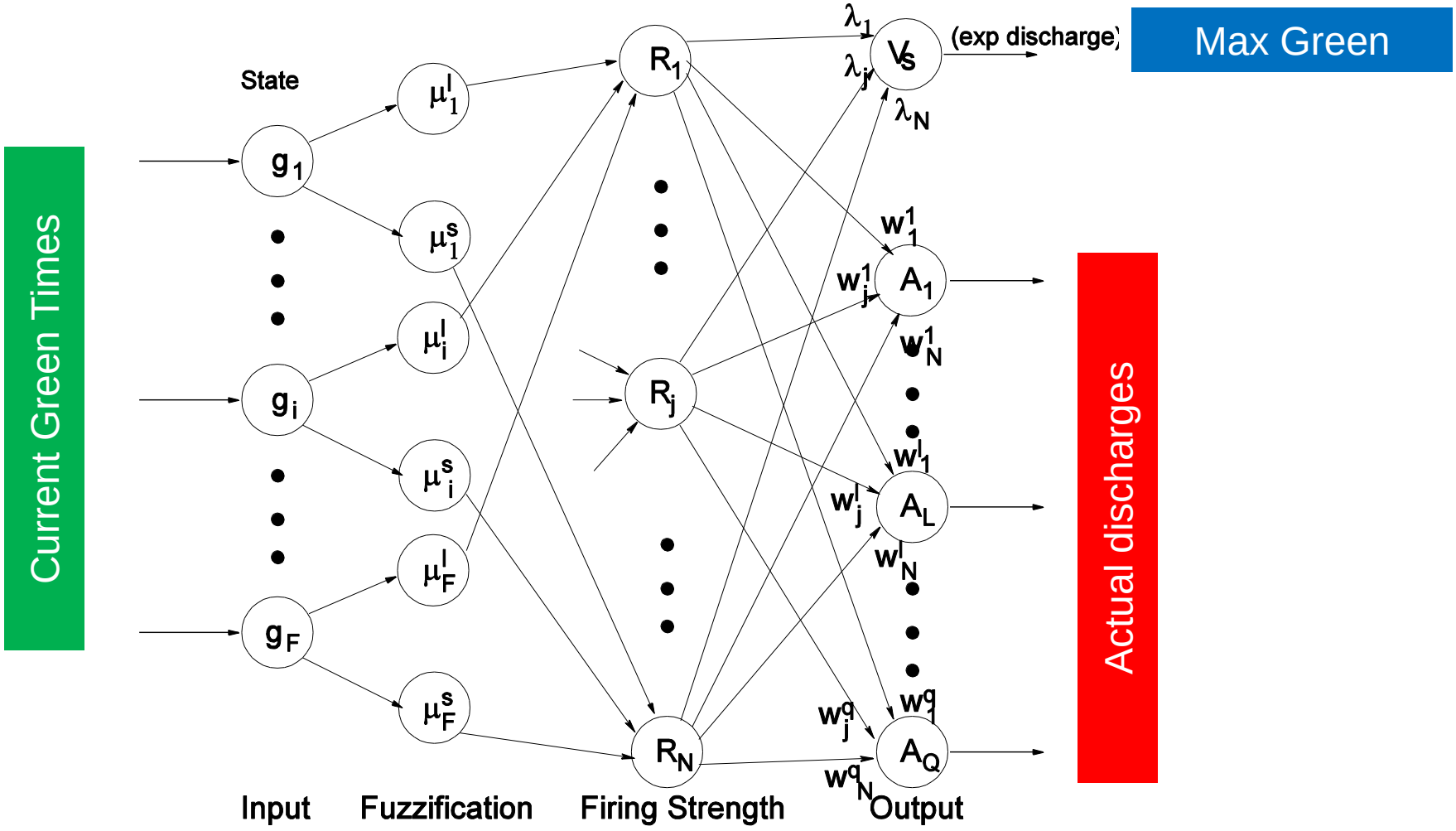
# Adaptive control

- Working principle



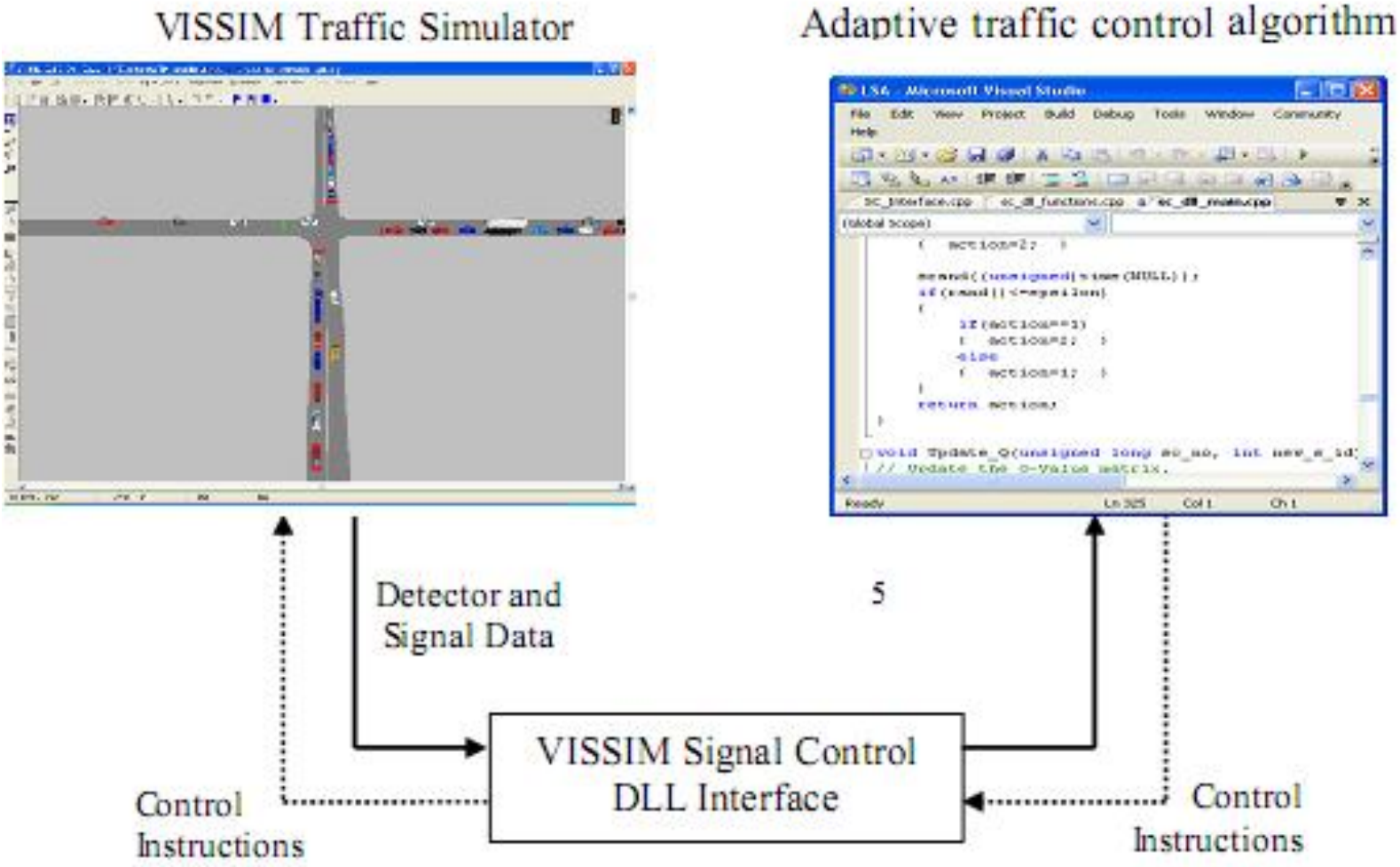
# Adaptive control

## Neuro-Fuzzy model – Estimate Gmax



# Adaptive control

## Evaluation using traffic simulator



# Adaptive control

## Results

| Volume | Control | Delay | Queue |
|---|---|---|---|
| **Low** (V/C 0.3-0.5) | **NF** | 15 | 6 |
| | **VA** | 17 | 6 |
| | **Fixed** | 20 | 8 |
| **Medium** (V/C 0.5-0.8) | **NF** | 20 | 11 |
| | **VA** | 23 | 14 |
| | **Fixed** | 28 | 20 |
| **High** (V/C 0.8-1.2) | **NF** | 44 | 66 |
| | **VA** | 53 | 93 |
| | **Fixed** | 67 | 129 |

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# Conclusion

- Heterogeneous traffic
  - Mixed vehicle type
  - Non-lane based movement
- Strip based simulator
  - Compatible to homogeneous traffic
  - Ability to handle complex driving behavior
- Adaptive control
  - Sensitive to fluctuating traffic demand
  - Evaluation by traffic simulators
  - Optimal use of infrastructure
  - Enhances service quality

# Conclusion - Challenges

- Heterogeneous traffic
  - Complex geometry
- Strip based simulator
  - Better behavioral models
  - Integrated driving models
  - Bike's/Auto movement
- Adaptive control
  - Developing for large systems
  - Optimal control
  - Traffic management capabilities

# Thank You

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