

Vehicle Traffic Microsimulator for Ad-Hoc Networks Research

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June 1, 2004

Motivation

- Mobility has a dominant effect on MANET performance
- Mobility models for vehicular networks have received little attention.
- Traffic microsimulators are not commonly available for ad hoc networks research

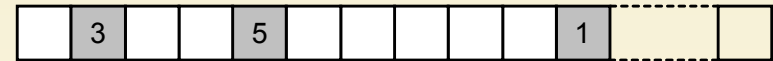
Objective

- Build a simulation platform, RoadSim, that can be used for ad-hoc networks research
- RoadSim avoids the complexities of traffic simulators in order to generate accurate traffic patterns in various simple scenarios such as free flow traffic, traffic jams, and traffic across intersections.

NaSch Model

- The model is based on cellular automata concepts
- Velocity and position are governed by a set of rules

Cellular grid



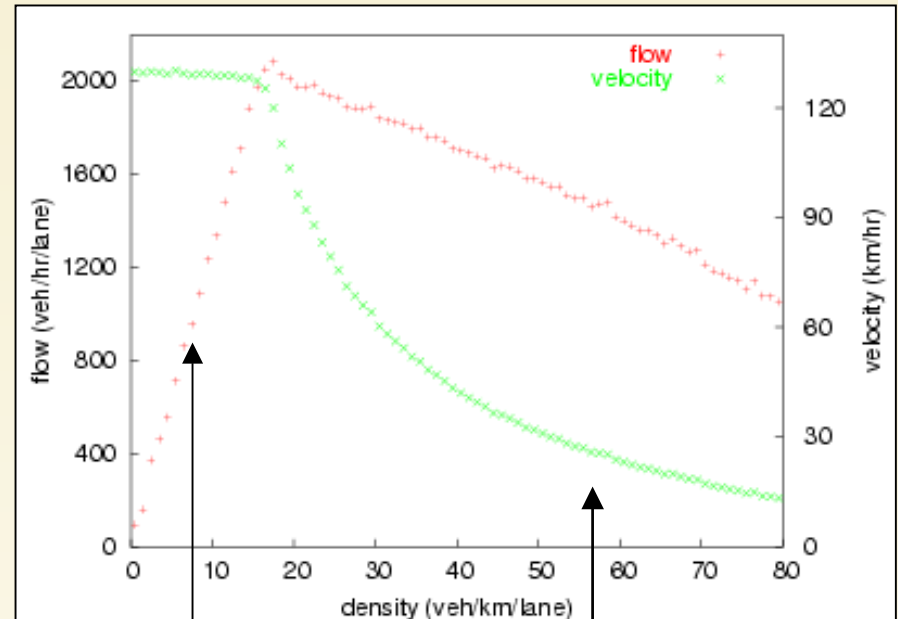
Rules

```
// Update velocity
for(all vehicles i)
  if ( $u_i(t) \geq g_i(t)$ )
     $u_i(t+1) = \max(g_i(t)-1, 0)$       if  $p < p_{\text{noise}}$ 
     $u_i(t+1) = g_i(t)$ 
  else if ( $u_i(t) < u_{\text{max}}$ )
     $u_i(t+1) = u_i(t)$                 if  $p < p_{\text{noise}}$ 
     $u_i(t+1) = u_i(t) + 1$ 
  else
     $u_i(t+1) = u_{\text{max}} - 1$         if  $p < p_{\text{noise}}$ 
     $u_i(t+1) = u_{\text{max}}$ 
  end if
end for

// Update position
for (all vehicles i)
   $x_i(t+1) = x_i(t) + u_i(t+1)$ 
end for
```

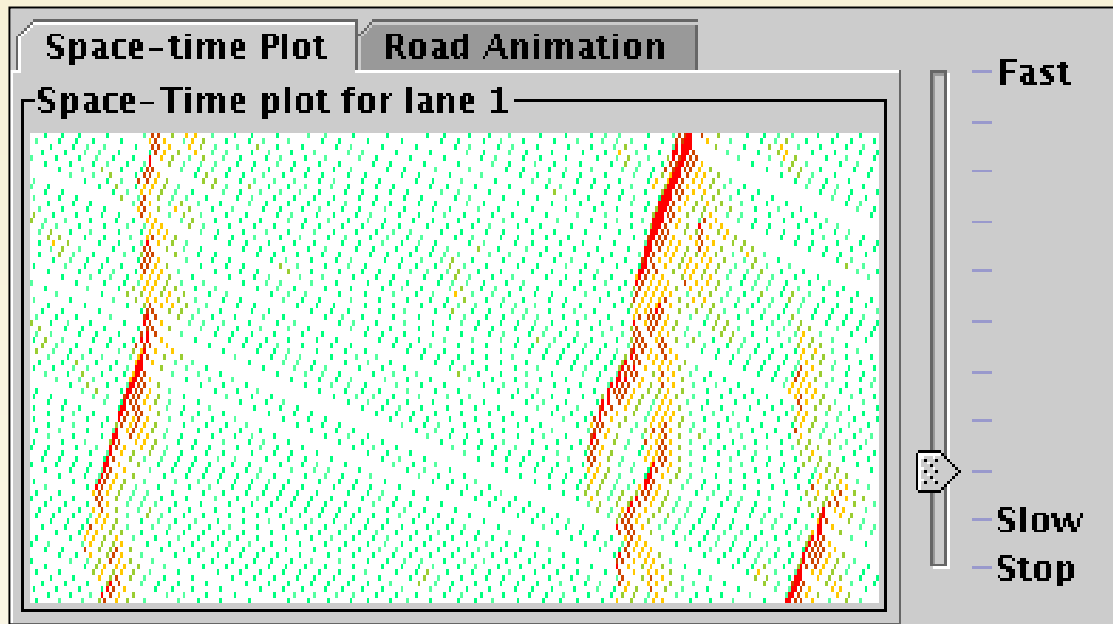
Traffic Flow Characteristics

- The NaSch model shows ability to reproduce basic phenomena encountered in real-life traffic
- There is a critical density that separates free-flow traffic from congestion
- Critical density $\rho_c \approx 17 \text{ km/hr}$
- Max. flow $q(\rho_c) \approx 2100 \text{ veh/km/hr}$



$$q = \rho \cdot u(\rho)$$
$$u = \begin{cases} u_{\max} & \rho < \rho_c \\ \lambda \left(\frac{1}{\rho} - \frac{1}{\rho_{\max}} \right) & \rho \geq \rho_c \end{cases}$$

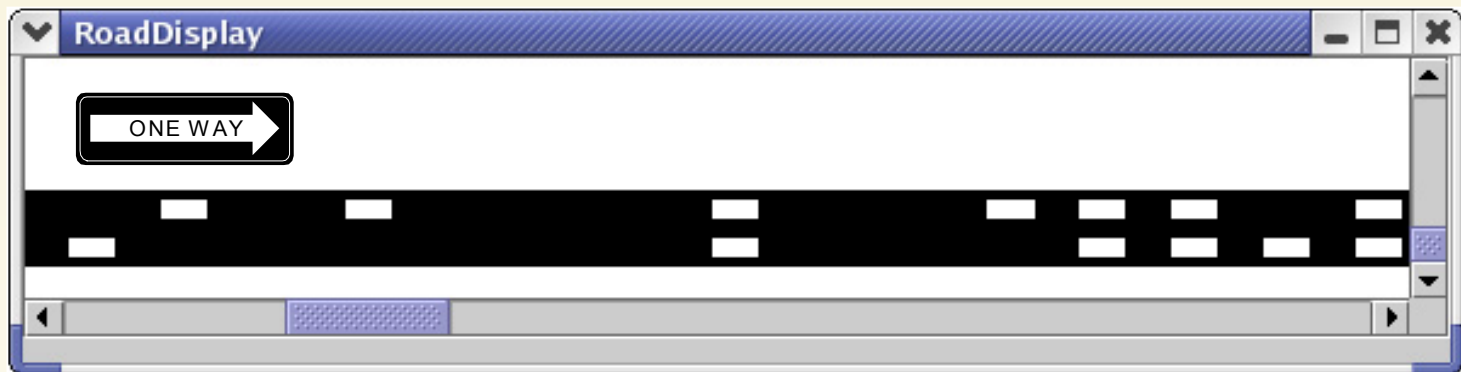
Space-time Plot



$$\rho \approx \rho_c$$

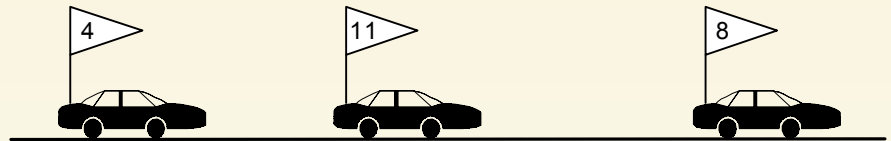
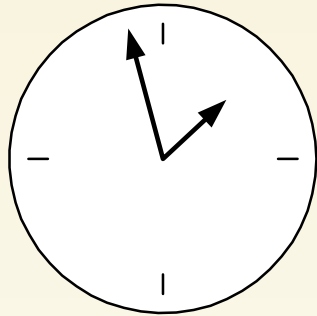
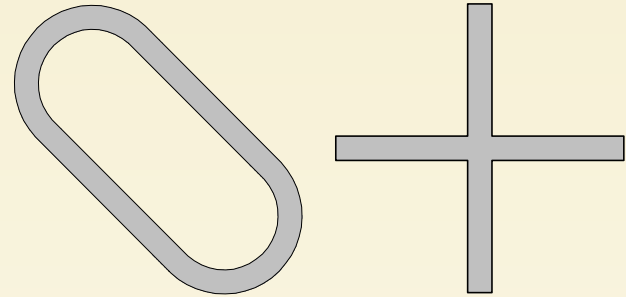
Traffic in Multi-Lane Roads

- RoadSim simulates traffic in multi-lane roads



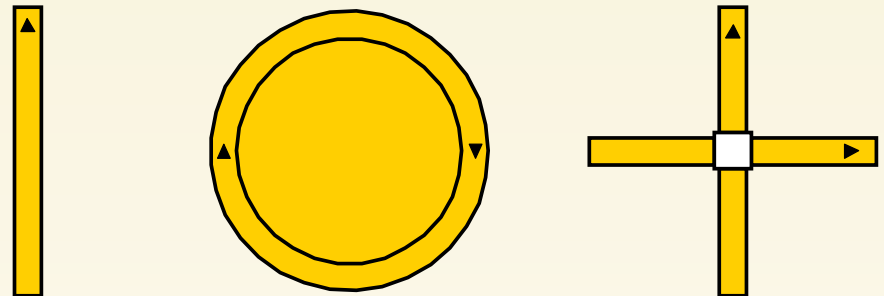
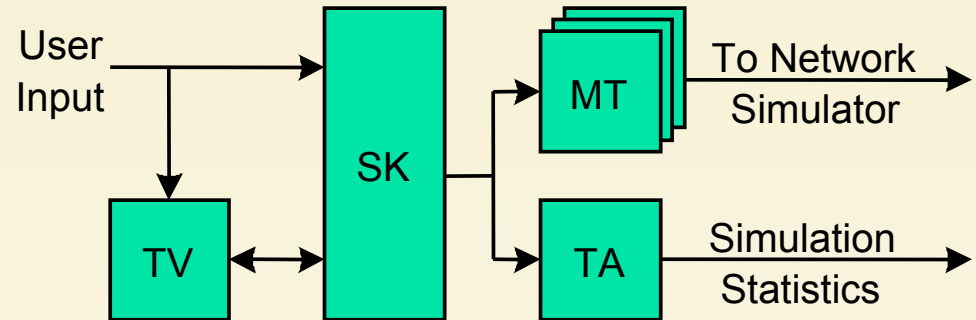
Extensions for Ad Hoc Simulations

- Road geometry
- Node ID
- Time resolution

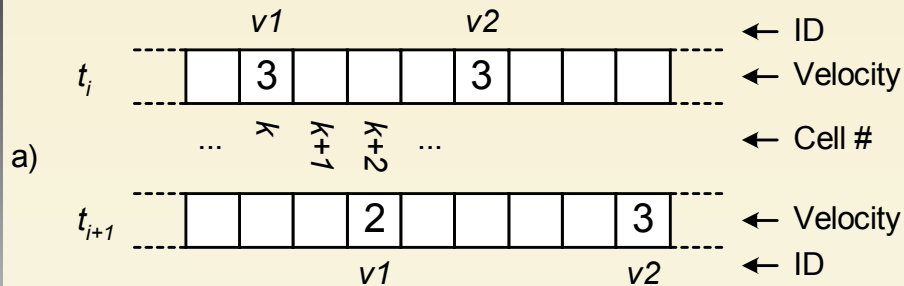


Components

- Simulation Kernel (SK) reads user's input, and advances simulation time by updating the status of all road segments and intersections.
- Movement Translators (MT) convert the CA configuration to movement script file that can be executed by a MANET simulator.
- A Traffic Analyzer (TA) taps on a road segment and collects vehicle density, velocity, and flow statistics.
- A Traffic Viewer (TV) offers a limited graphical interface



Translation to NS-2



b)

```

$V1 set X_ <X(k,n_L)>
$V1 set Y_ <Y(k,n_L)>
$V1 set Z_ 0.0

$ns at <t_i> $V1 setdest <X(k+2,n_L)> <Y(k+2,n_L)> <V(2)>
  
```

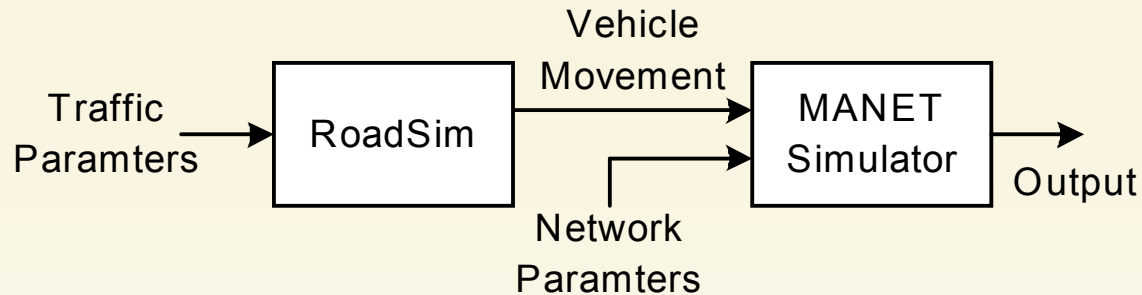


```

$node_(0) set X_ 1747.5
$node_(0) set Y_ 1.6
$node_(0) set Z_ 0.0
$node_(1) set X_ 757.5
$node_(1) set Y_ 4.8
$node_(1) set Z_ 0.0
...
$ns_ at 0 "$node_(0) setdest 1785
1.6 37.5"
$ns_ at 0 "$node_(1) setdest 795
4.8 37.5"
...
$ns_ at 1 "$node_(0) setdest 1822.5
1.6 37.5"
$ns_ at 1 "$node_(1) setdest 832.5
4.8 37.5"
...
  
```

Simulation Environment

- Vehicle traffic microsimulator: generates detailed vehicle movements
- Network Simulator



Applications

- Identifying the effects of various factors (e.g. vehicle density, velocity and distance) on the ability to maintain an active link between a pair of communicating vehicles traveling on a highway
- Studying connectivity in vehicular ad-hoc networks. Simulations are used to determine the minimum transmission range in networks formed in 1- and 2-lane roads, bi-directional roads, and intersections.
- Evaluating some ad hoc routing protocols under vehicle traffic conditions.

Summary & Conclusions

- RoadSim is a simple traffic microsimulator that produces realistic traffic behavior.
- RoadSim extends the basic CA model by
 - Assigning IDs to vehicles
 - Mapping the CA grid to various configurations in a 2-D plane.
 - Translates vehicle movements into command scripts that can be executed by network simulators
- Enhancements:
 - Signalized intersections,
 - variable vehicle velocities,
 - several types of vehicles such as trucks or buses,
 - other types of traffic, such as a public transit system, and
 - more advanced graphical user interface
- CA models can be used to generate movement patterns for other types of ad hoc networks:
 - Pedestrians
 - Robots
 - Sensor networks