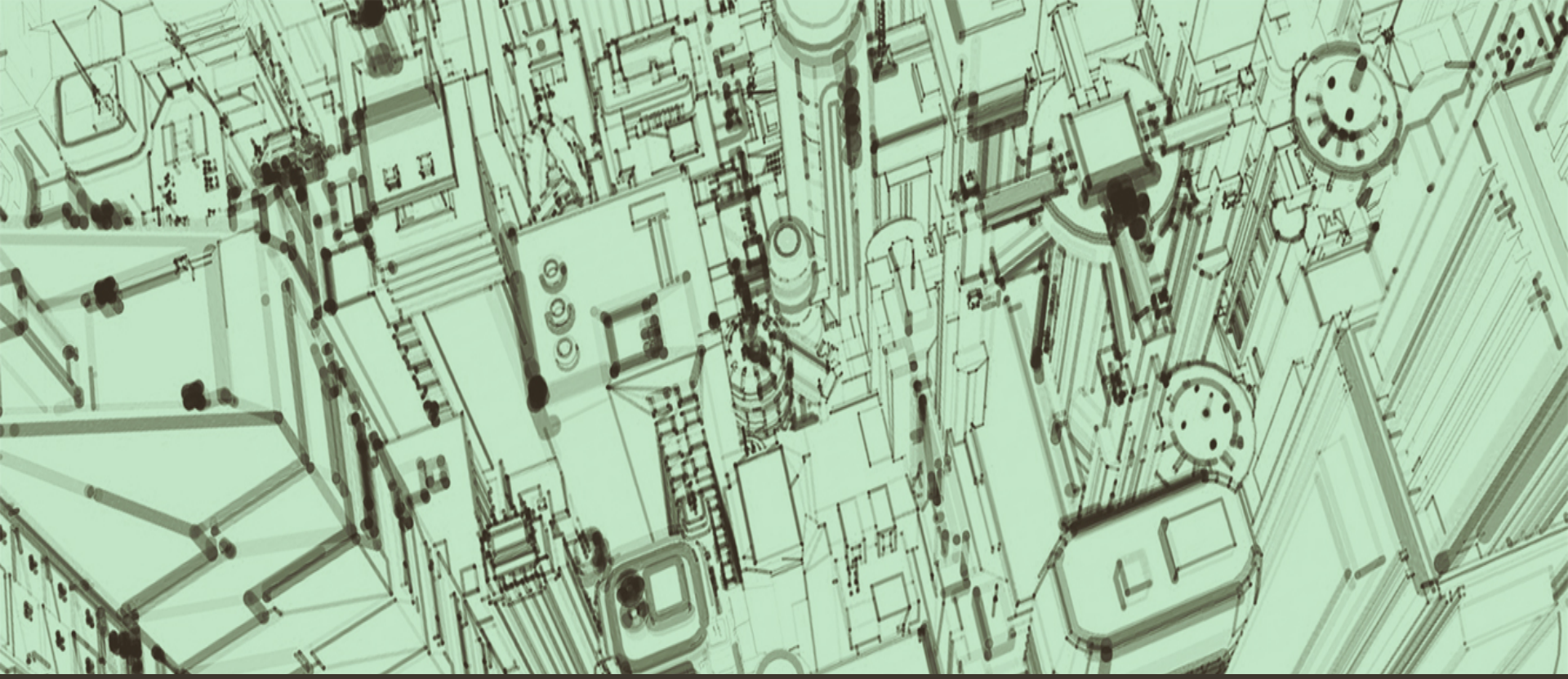


Shuchang Liu
SUID: 968892838

Traffic simulation

Final Project Report – CIS 667 Fall 2016

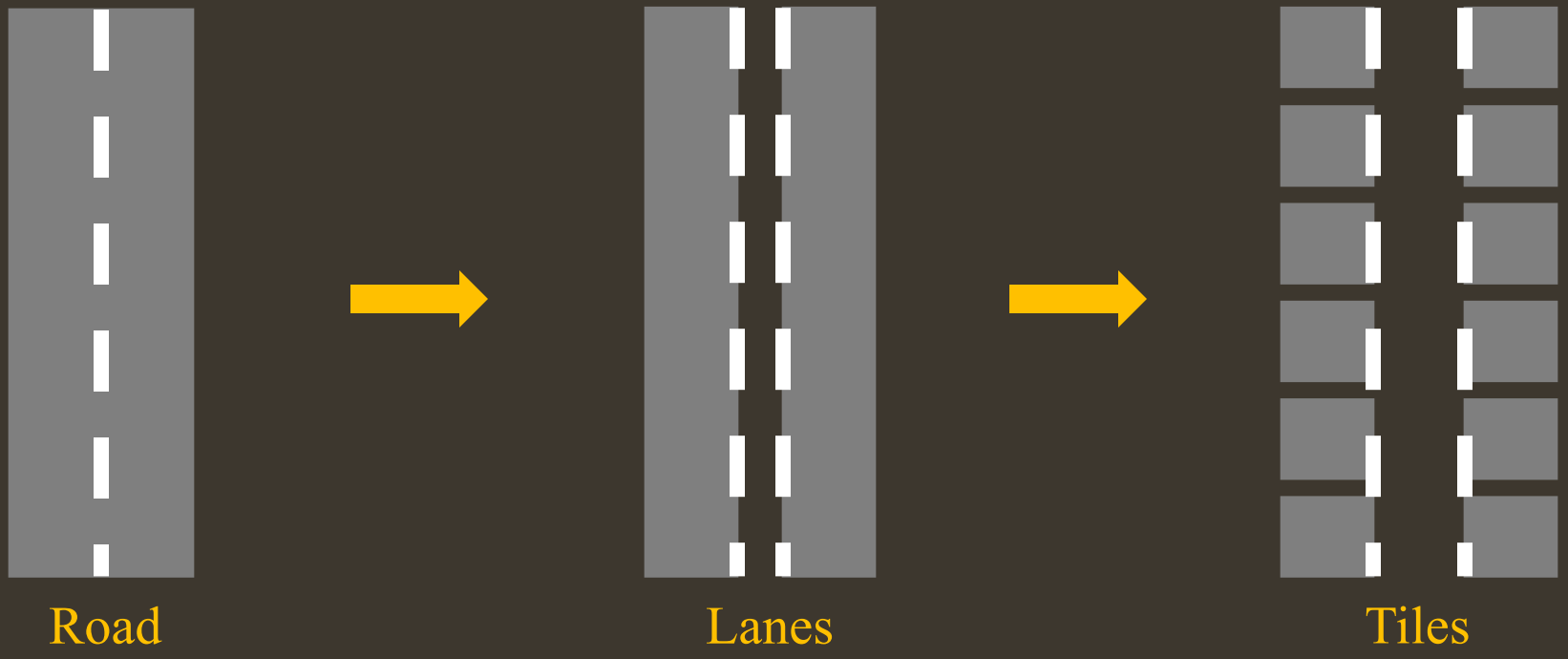
Intuition

- Ultimate goal: simulate the traffic and observe their performance on different road network.

Overview

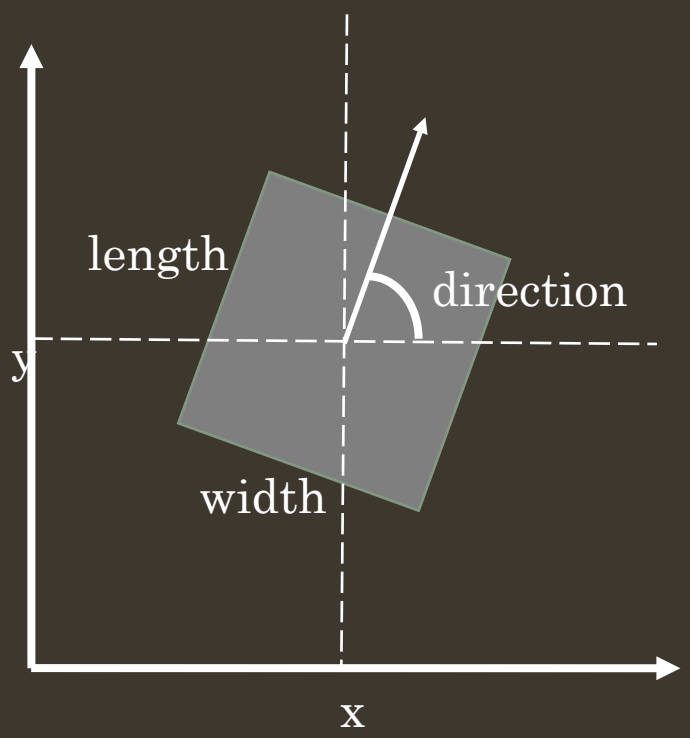
- Road network representation
- Traffic simulation
- Visualization
- Traffic performance on different road network

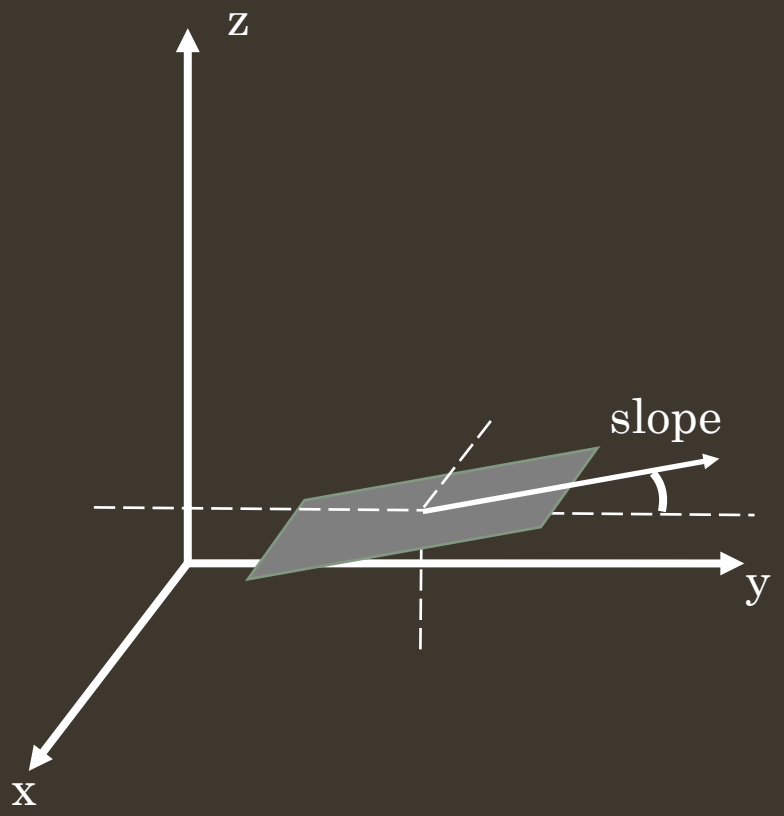
Road Network Representation – Part/Tile based



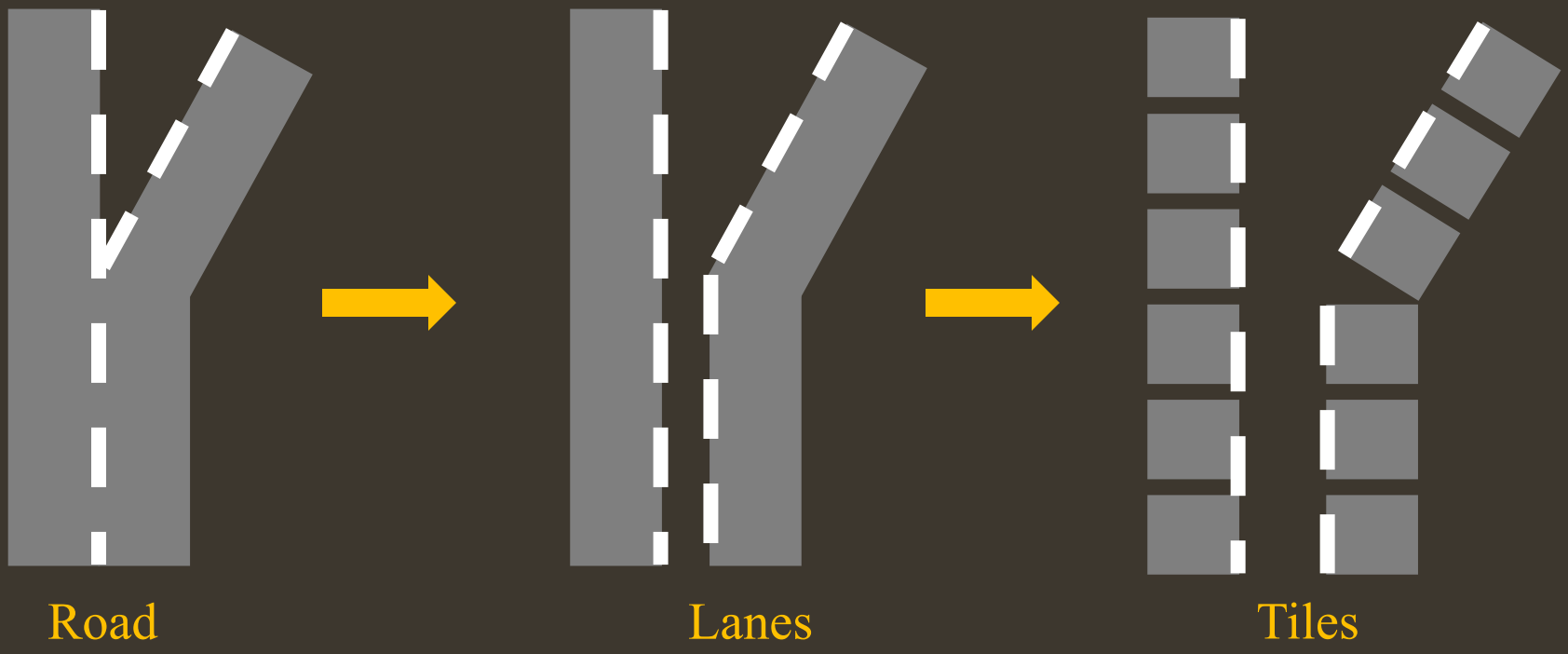
Reference: Daniel Topfer, Jens Spehr, Jan Effertz and Christoph Stiller, Efficient Scene Understanding for Intelligent Vehicles Using a Part-Based Road Representation (ITSC 2013)

Road Network Representation - Basic Element: Road Tile





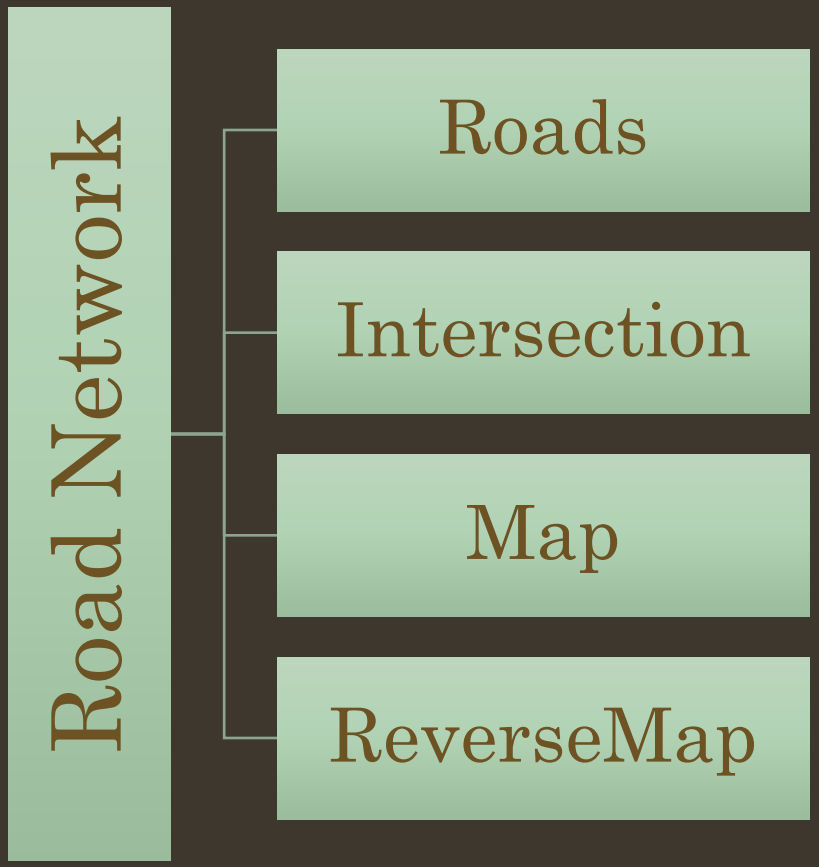
Road Network Representation – Part/Tile based made flexible



Advantage: using simple hierarchical structure to represent sophisticated road network.

Almost any shape can be represented if the tile length is chosen correctly.

Road Network Representation - Hierarchy Component



The road hierarchy using part based representation

The special gate that connect roads

Record which intersection is connected by the end of a road, and which roads can go from an intersection

Record which intersection connect the beginning of a road, and which roads can enter an intersection

Roads and Intersections are only geo-structures.
Map and ReverseMap provide connections and they are used for route search.

Road Network Representation - Features

- All road network elements (including intersections, roads, lanes, and tiles) share same feature:
  - *Geo-location*
- Super class RNLocation
- Class familiy tree:
  - RNLocation: (x,y,z)
    - -RNGate (entry, exit)
    - -RNElement (width, length)
      - --RNRoadTile (slope, direction)
      - --RNLane: consists Array<RNRoadTile>
      - --RNRoad: consists Array<RNLane>
      - --RNIntersection (entries, exits)

Traffic Simulation – Car Representation

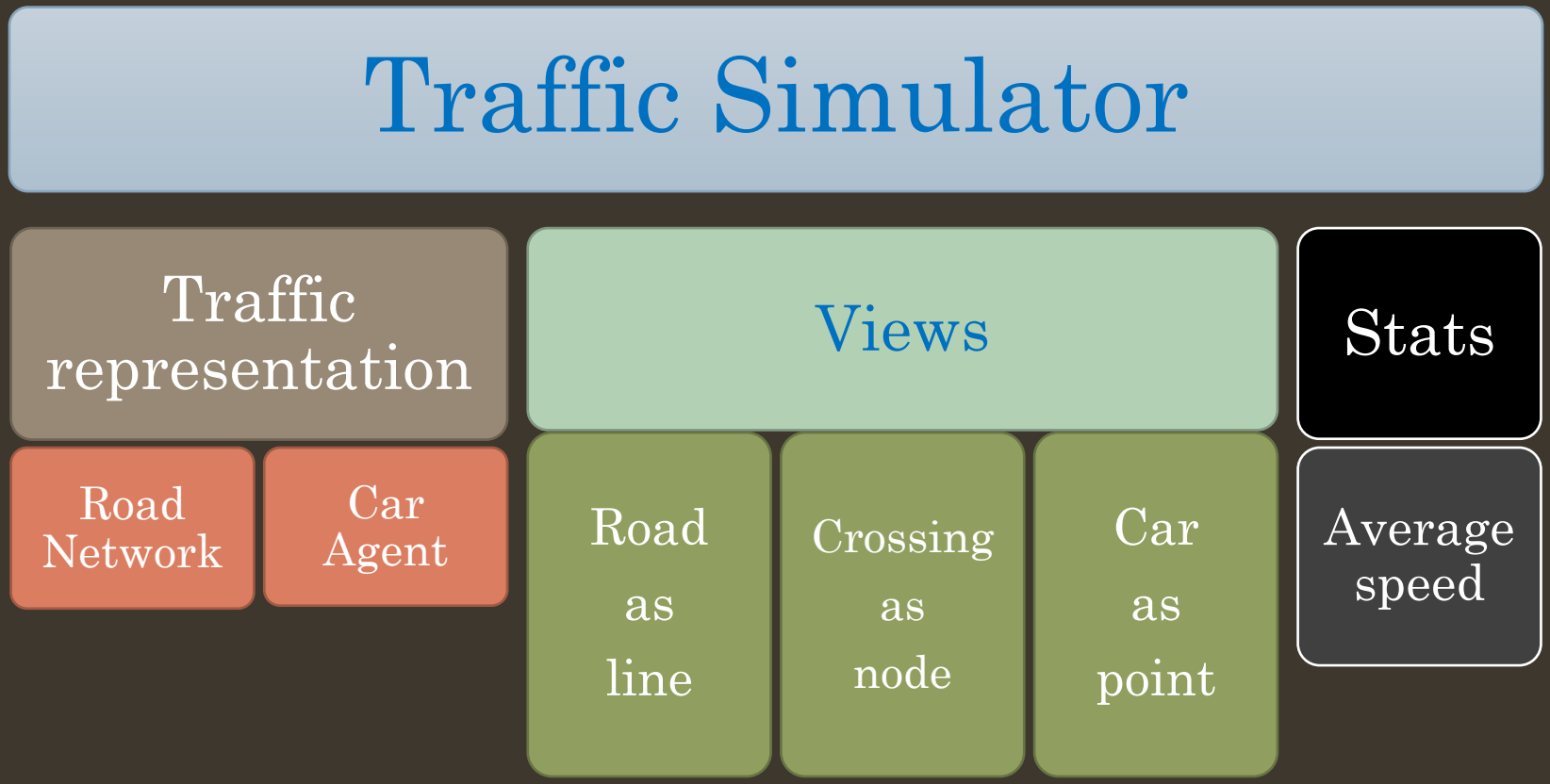
- Car as an agent:
  - Each car take a move based on its road network observed and its current situation recorded.
- Two type of car:
  - A car with a start point and a destination
    - Path search agent
    - Shortest path or least traffic
  - A car takes random walk
    - Local search agent
    - Random walk or least traffic

Traffic Simulation – Intelligent Driver Model(IDM)

- Capture the driver's control of speed by quantify the tendency of accelerate and brake. The driver tends to keep the same speed with the previous car and keep the minimum distance that it can follow.
  - $\Delta v = a\_max * (tendency\ of\ acceleration - tendency\ of\ deceleration)$
  - $tendency\ of\ acceleration = 1 - \left(\frac{v_{previous}}{v_{me}}\right)^{power\ of\ acceleration}$
  - $tendency\ of\ deceleration = 1 - \left(\frac{desired\ \min\ gap}{actual\ distance\ to\ previous\ car}\right)^{power\ of\ deceleration}$
  - $desired\ minimum\ gap(simplified) = \frac{(approaching\ rate * v_{me})}{2 * a\_max}$
- Parameters I chosed:
  - a_max = 1
  - Power of acceleration = 1
  - Power of deceleration = 2

Reference: Martin Treiber, Ansgar Hennecke, and Dirk Helbing, Congested Traffic States in Empirical Observations and Microscopic Simulations (March 18, 2014)

Traffic Simulation – Integration and Views



Traffic Simulation – User Interaction

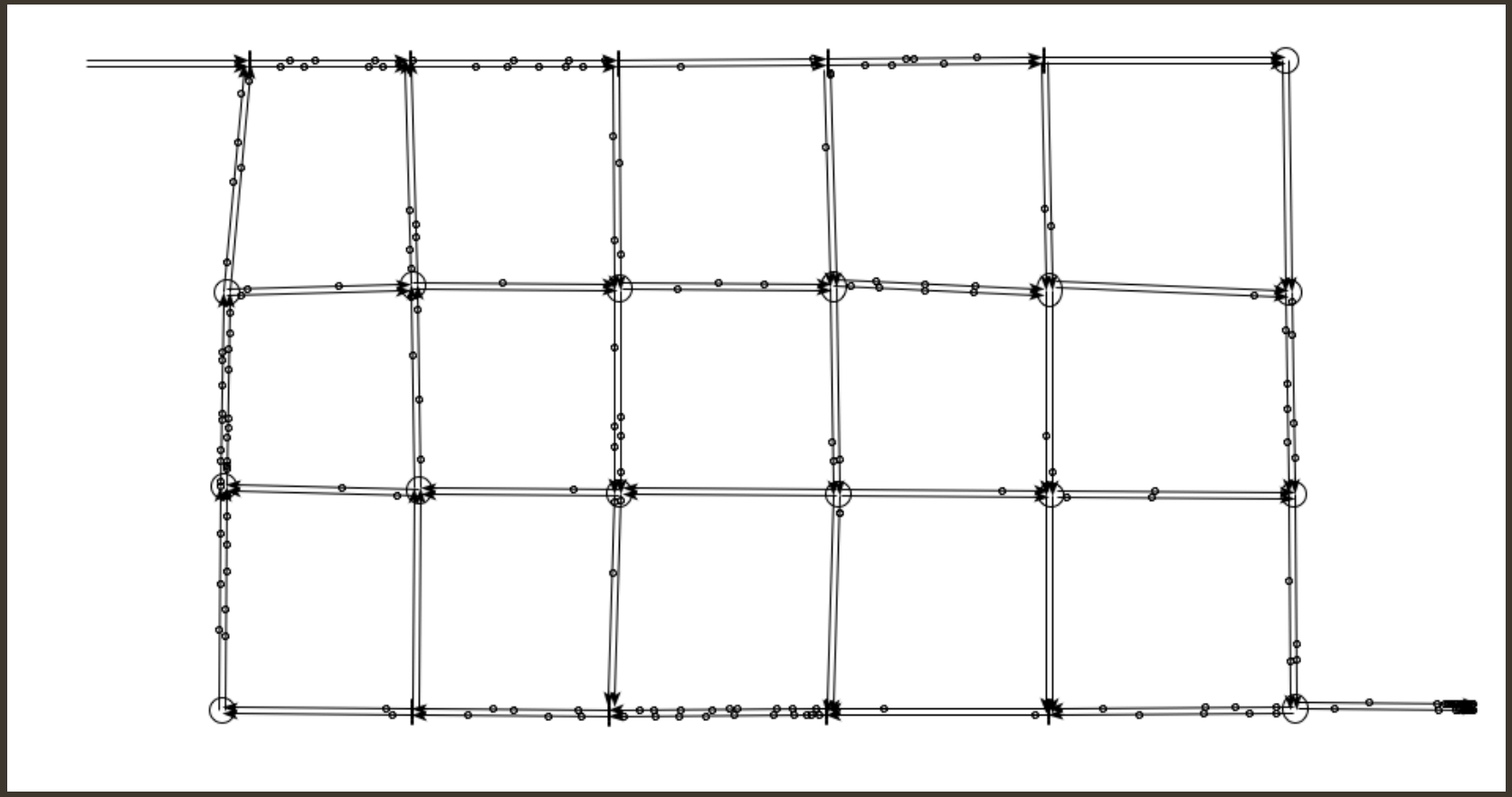
- User operation:
  - Drag a line:
    - Create a road, if the road connect with other roads, create an intersection to connect them
    - Draw thousands of shapes
  - Double click:
    - Start or end traffic simulation
  - Change parameters:
    - Number of lanes per road, max number of cars, reset all
  - Extend the code:
    - Automatically create road network of complicated shapes and traffic of various densities.

Traffic Simulation – Detailed Process Example

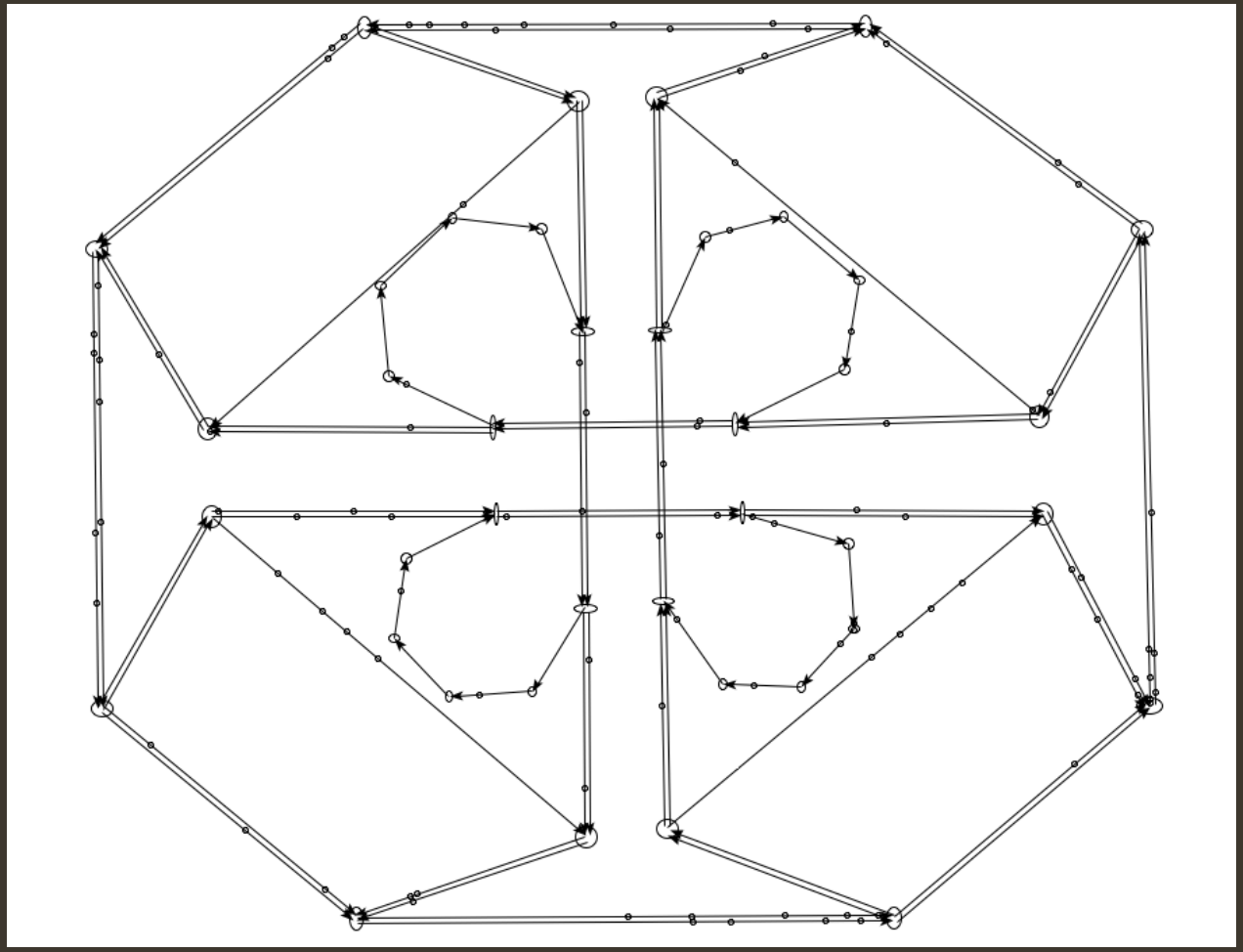
- Car agent program:
  - >Get percept from the road network and traffic situation
    - Current road, next road, destination, previous car
  - >Update its status using the percept
    - Traveling or reached destination or dead end
  - >Generate an action
    - Start moving, keep moving on the current lane; Passing an intersection; Reached destination; IDM to keep distance to other cars.
  - >The traffic simulator decide if the action works
    - Currently all of them works
  - >Do this update process 25 times a second.

Demo

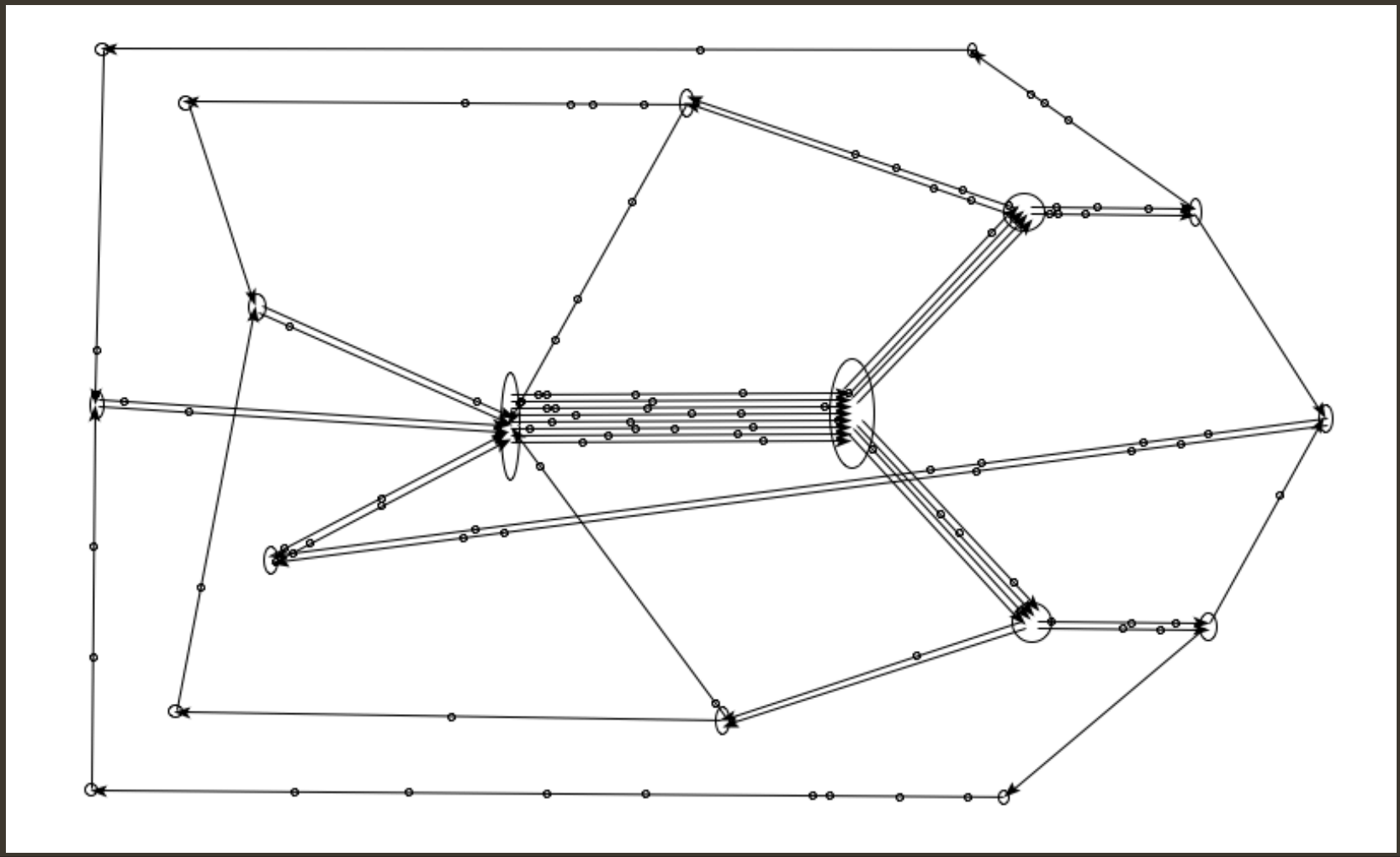
Conclusion
Metro -Flexible Road Network Construction



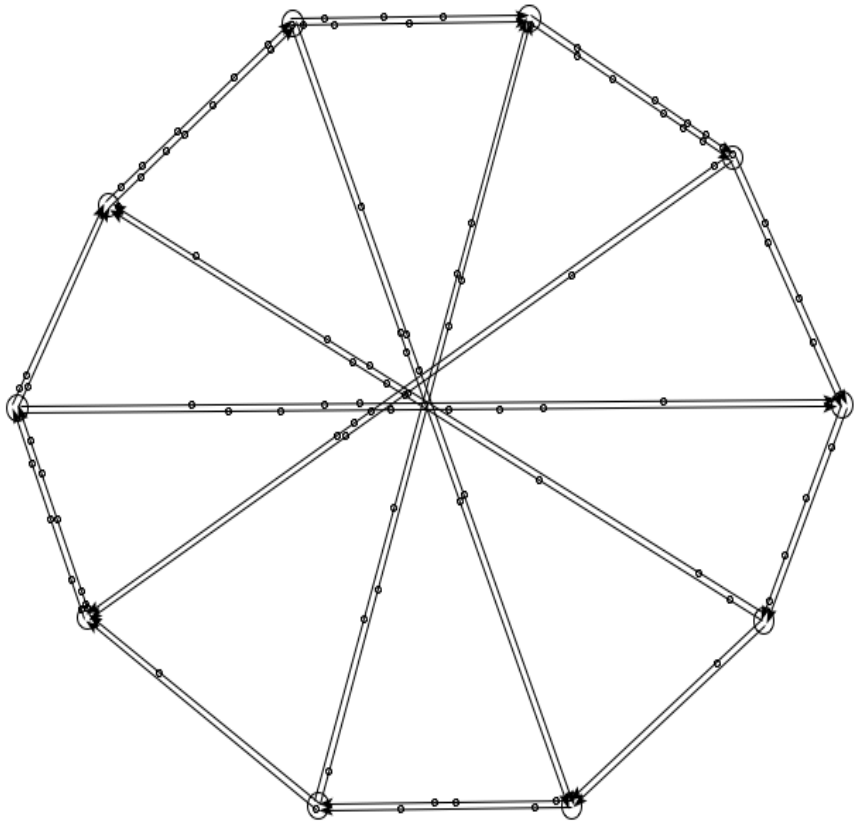
Conclusion
Interchange - Flexible Road Network Construction



Conclusion
Any shape - Flexible Road Network Construction



Conclusion
-Showing statistic results



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Start traffic simulation
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Min / Ave / Max = [0 / 9.00649956429 / 14.4038282071]
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Min / Ave / Max = [0 / 8.28858575944 / 15.6582629294]
Min / Ave / Max = [0 / 7.47670220203 / 15.7208714806]
```

Conclusion
-Observation based on stats

- Traffic average speed:
  - Slower when higher car density
  - For a certain traffic density, it has an optimal average speed. Traffic will slow down if they are faster, and will speed up if they are slower.
  - Even when traffic density is relatively low, some specific part of the traffic is significantly slower than others. This shows “Traffic jam come out of nowhere”.
  - If speed limit is infinite, it will reach this optimal speed eventually , but it fluctuate.
  - If speed limit is lower than the optimal average speed, all cars will reach a stable speed of the speed limit at the end.

Conclusion - Further development

- Change lanes
- Lane rules
  - Left turn only at the next intersection
  - Speed limit
- Fork and Merge
- Traffic light
- Accidents
- Traffic jam