GDC | March 21-25, 2022
San Francisco, CA

KYTHERA AI

Cities at Scale

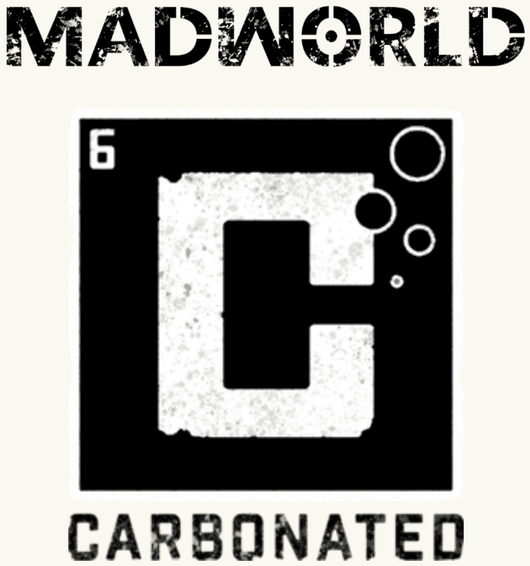
Scheduling Street Life on a Budget

Sandy MacPherson
Kythera AI

#GDC22

Sandy MacPherson

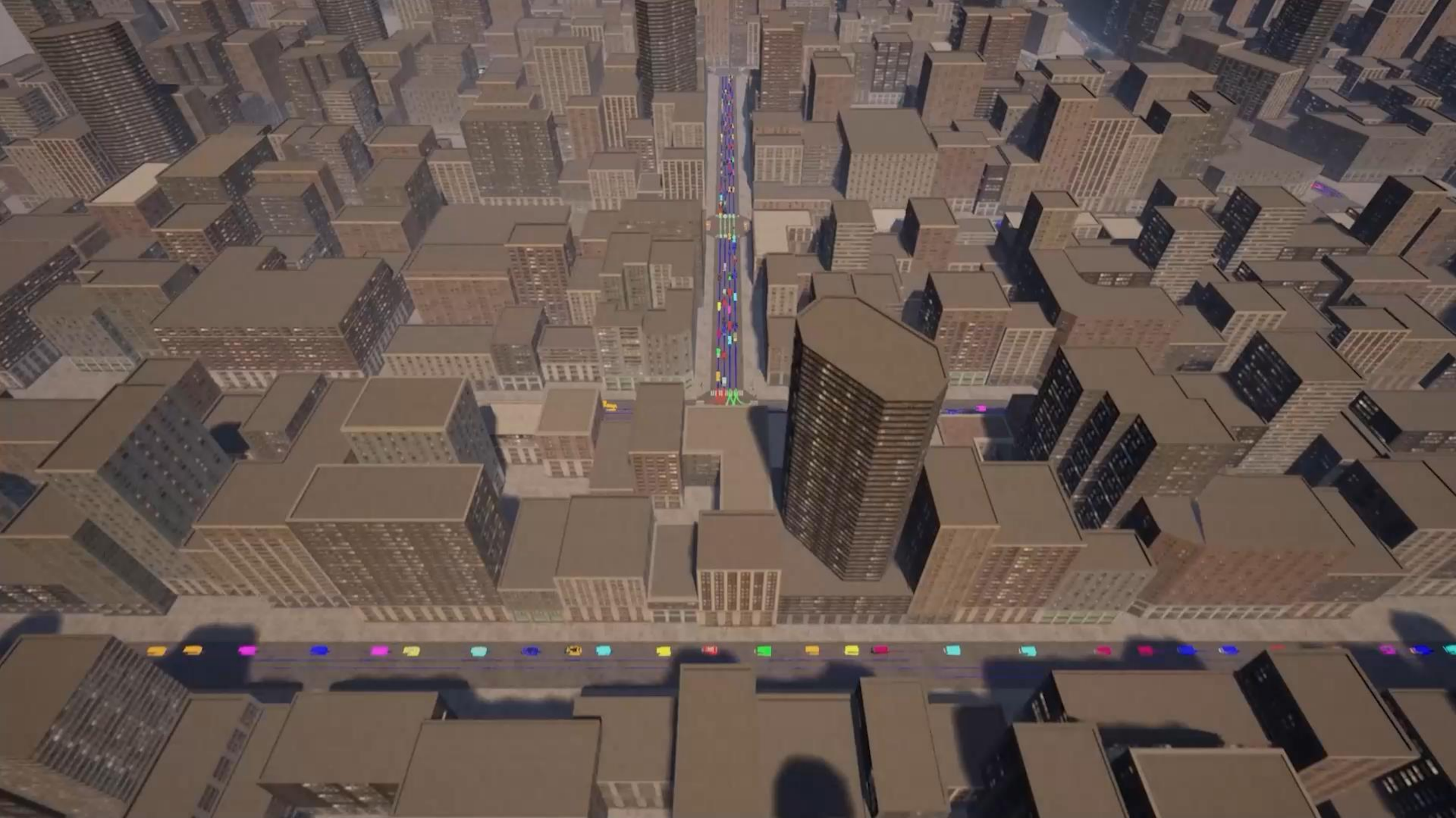
- Senior AI Systems Developer
- Been in games for 10+ years



Dedicated to our friends at FragLab, Kyiv, Ukraine

Introduction

- City-scale simulation of ambient traffic
- Populate city environment with vehicles and pedestrians

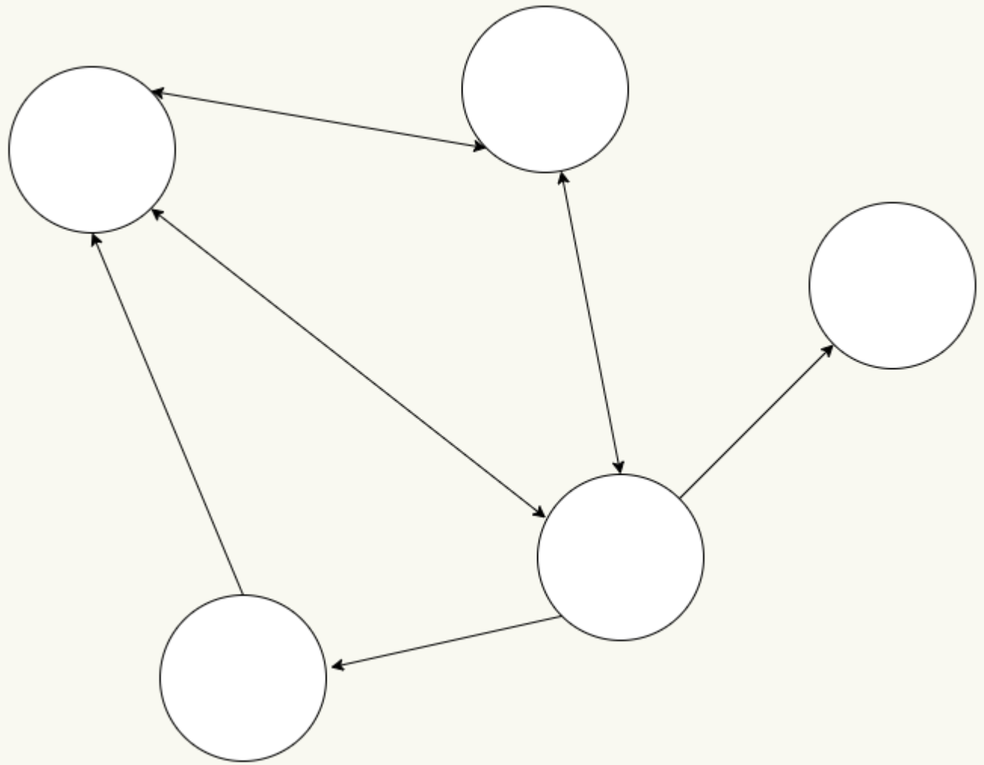


Introduction

- City-scale simulation of ambient traffic
- Populate city environment with vehicles and pedestrians
- Focus on vehicles

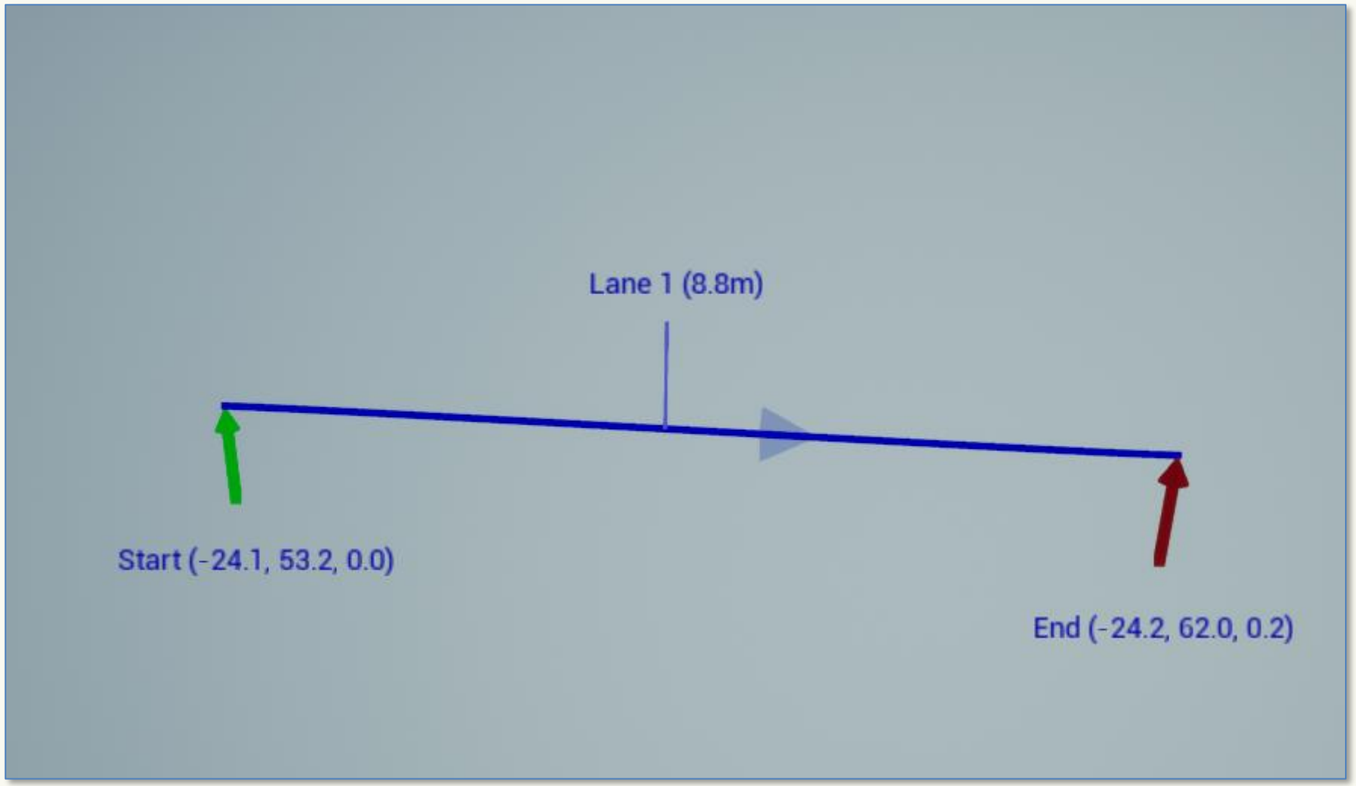
Road Graph

- Structure
  - Essentially a directed graph



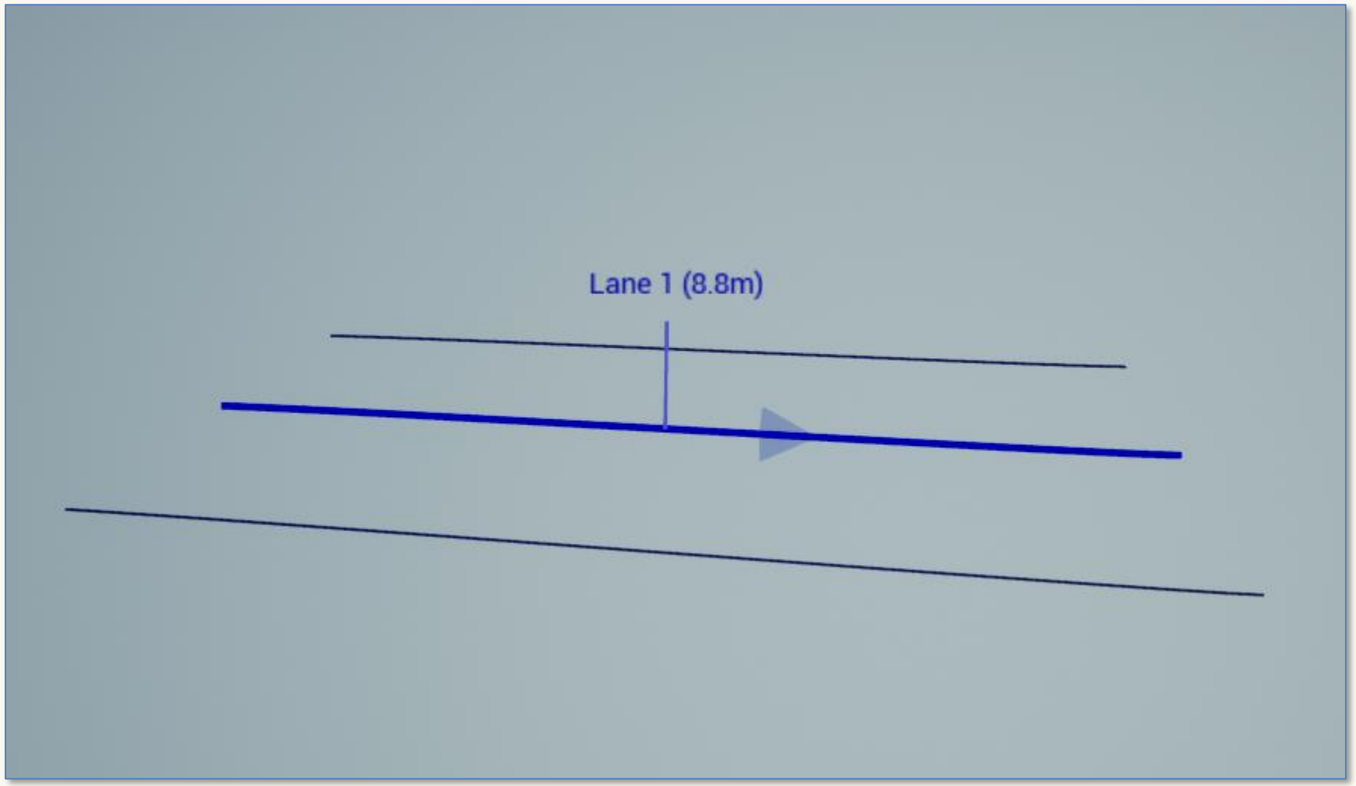
Road Graph

- Structure
  - Essentially a directed graph
  - Lanes are corridors



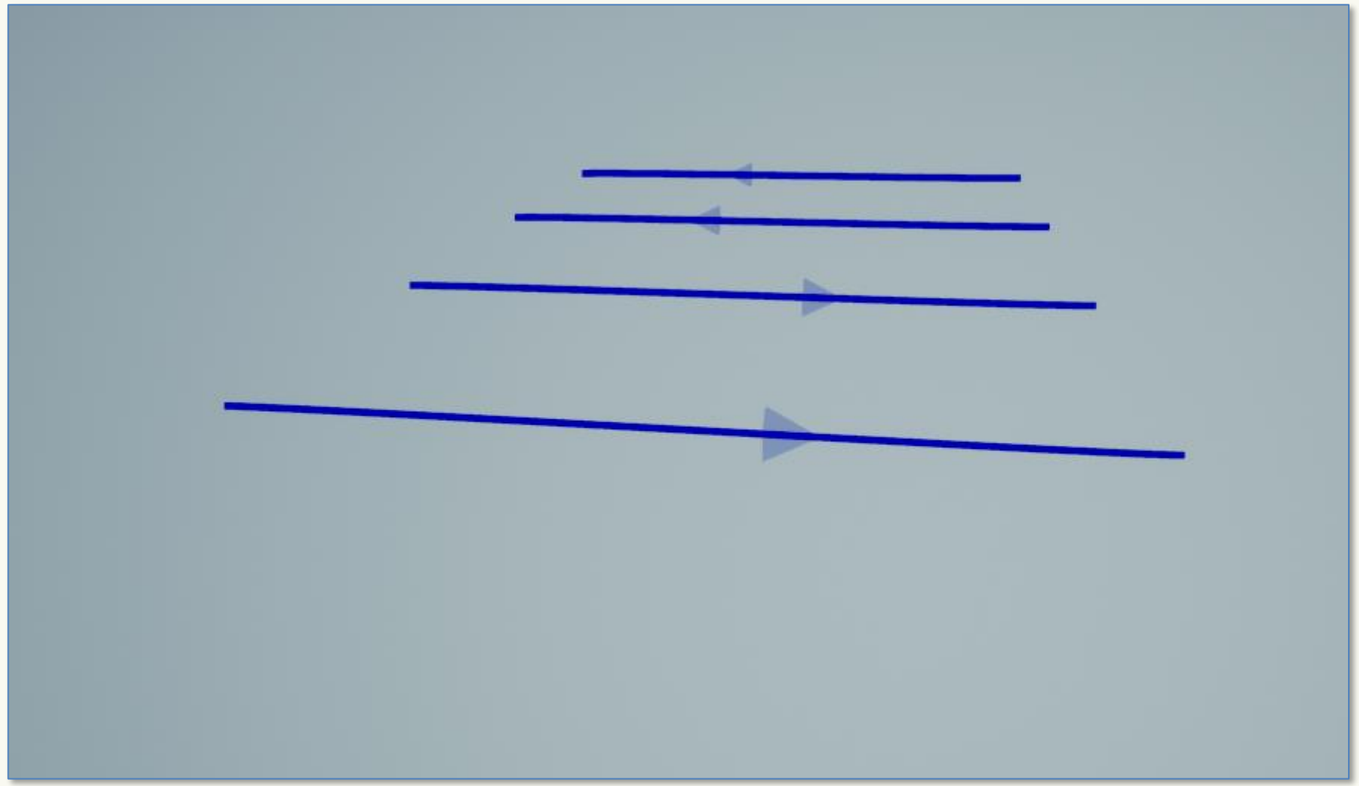
Road Graph

- Structure
  - Essentially a directed graph
  - Lanes are corridors



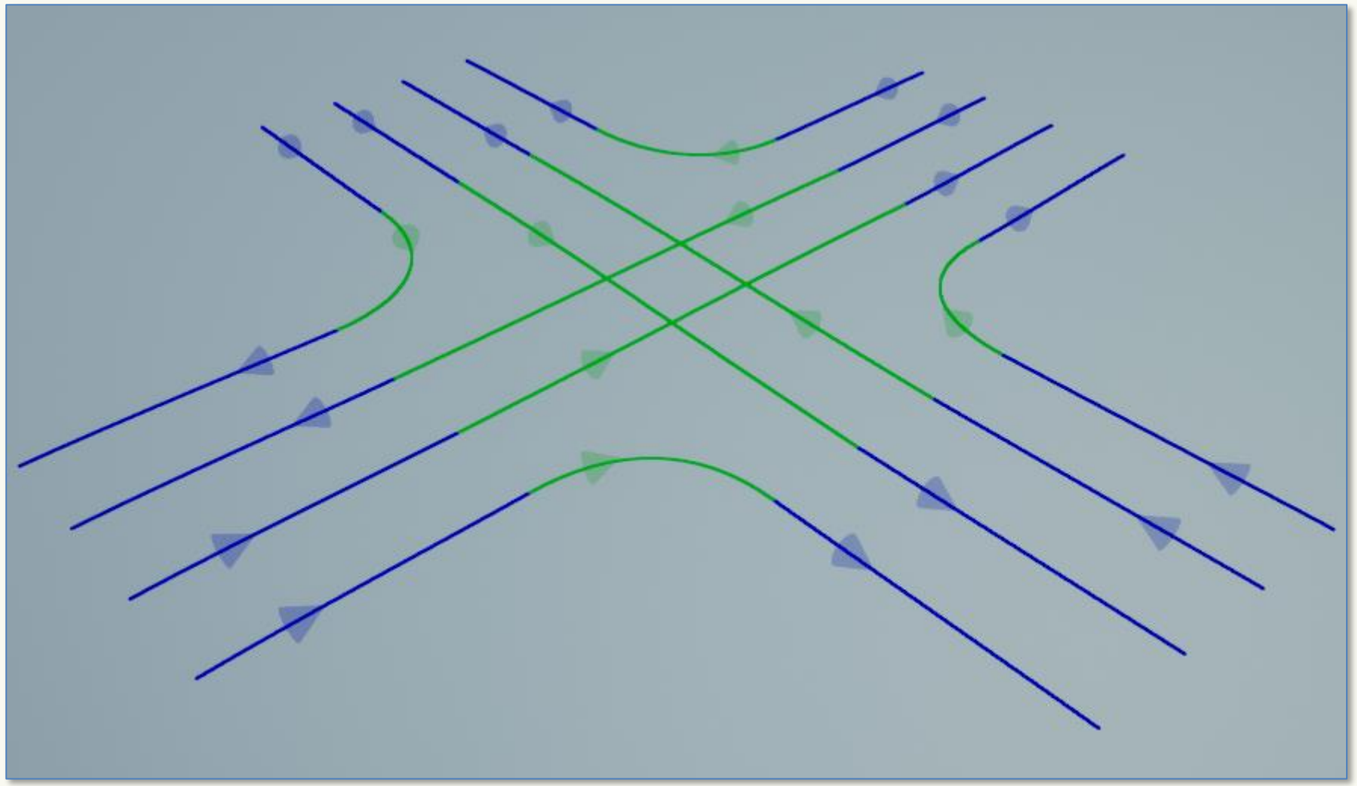
Road Graph

- Structure
  - Essentially a directed graph
  - Lanes are corridors
  - Lanes grouped into roads



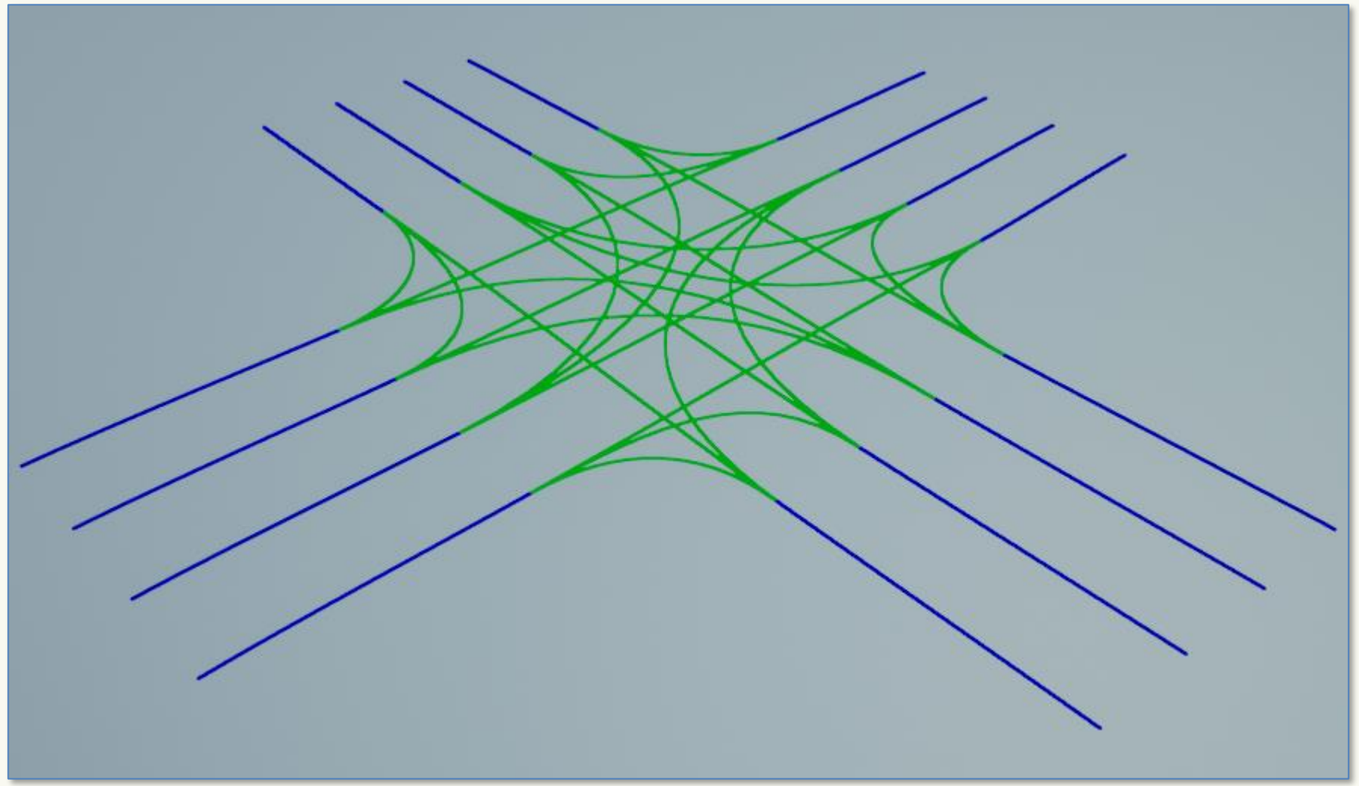
Road Graph

- Structure
  - Essentially a directed graph
  - Lanes are corridors
  - Lanes grouped into roads
  - Roads connected by intersections



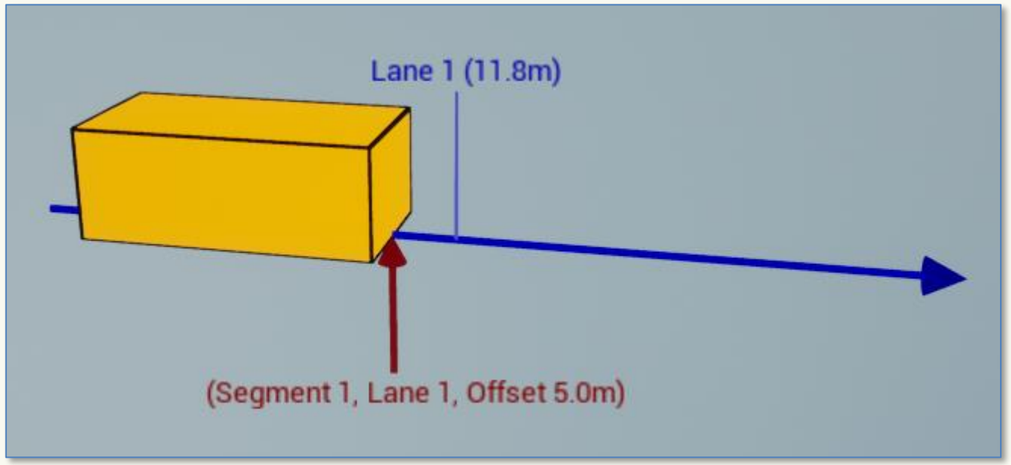
Road Graph

- Structure
  - Essentially a directed graph
  - Lanes are corridors
  - Lanes grouped into roads
  - Roads connected by intersections
  - We call them “segments”
- Many additional features
  - Traffic signals, parking
  - Sidewalks, crosswalks, paths



Positions in Road Space

- Position is lane offset
  - (SegmentID, LaneID, Offset) tuple
  - Simplifies math to one dimension, easy Newton’s Laws of Motion
- World space
  - Internally we rarely use world space
  - Easy conversions from road to world space, and vice versa

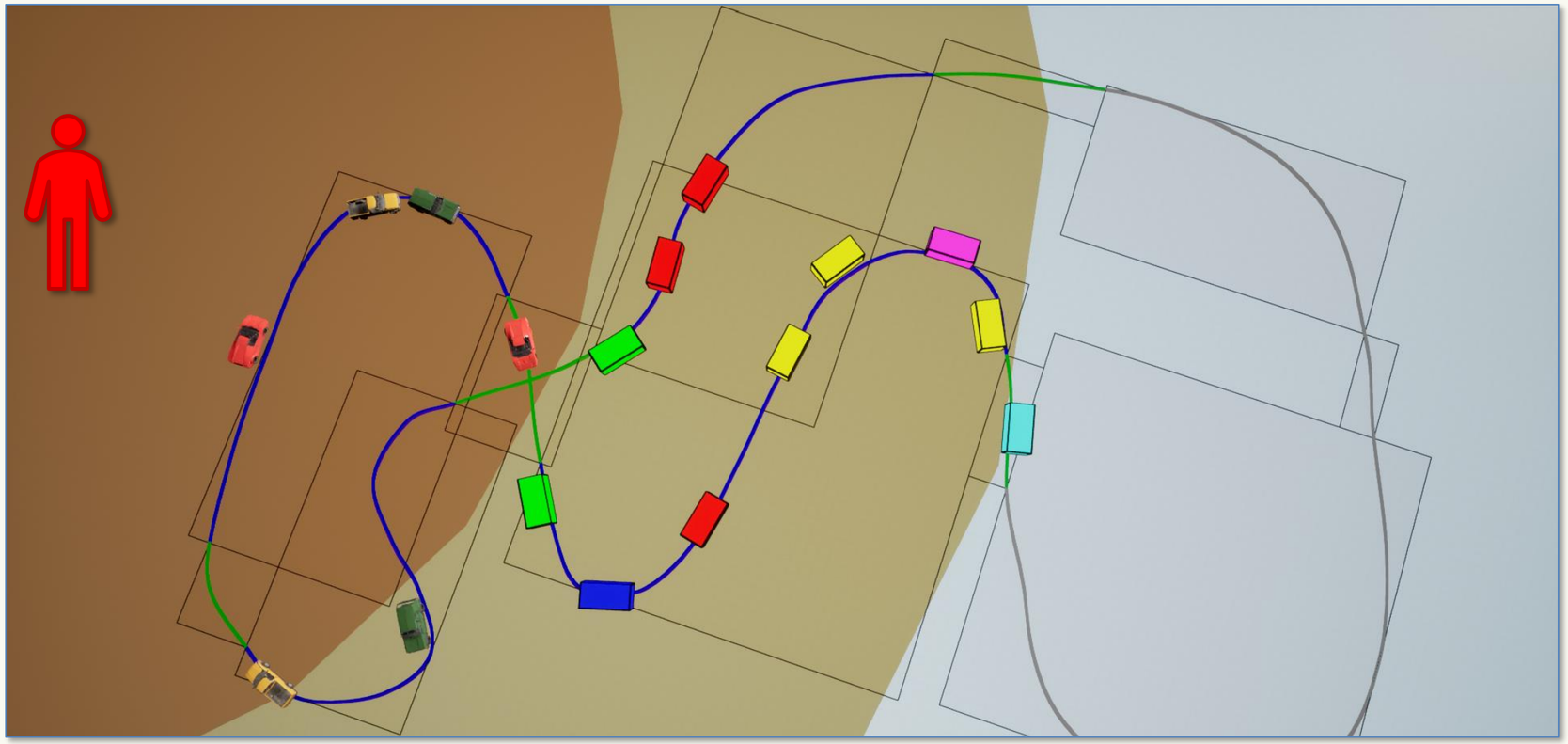


Agent Types and Archetypes

- Vehicles and pedestrians
- IDs map to game entities
- Agents have archetypes
  - Physical size
  - Max speed and acceleration
  - Personality type

Levels of Detail

- Essential for managing large scale agent numbers
- Applied at segment level
- Uses
  - Persistence
  - Spawning
  - Cheating
  - Quality gradient

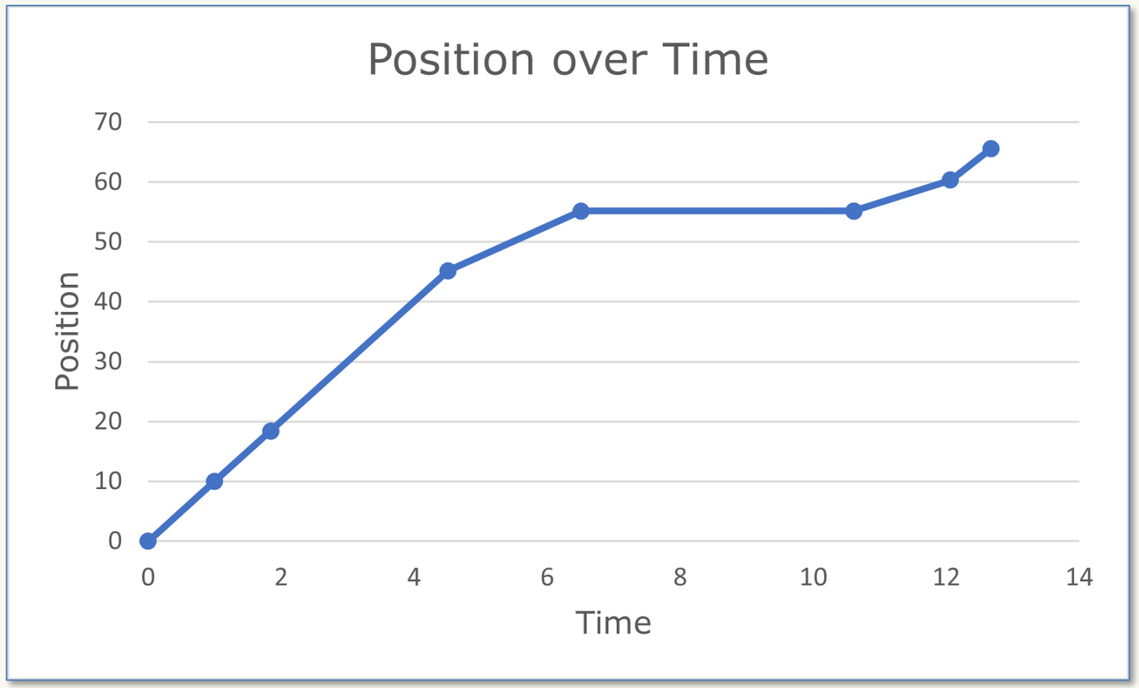


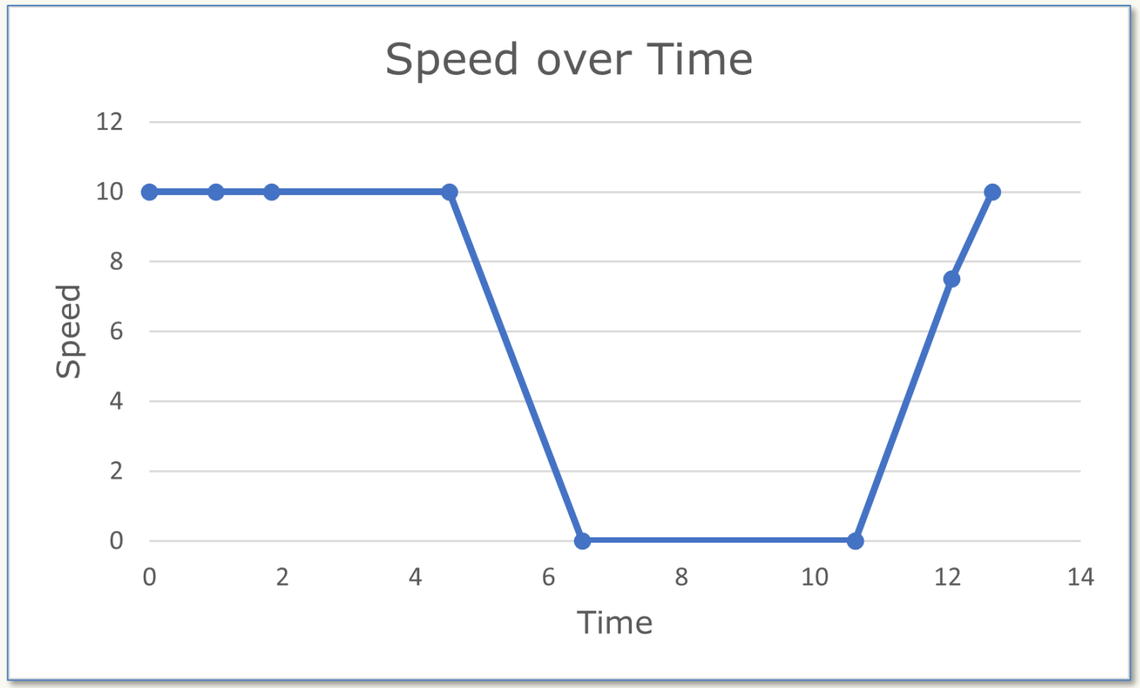
Scheduling

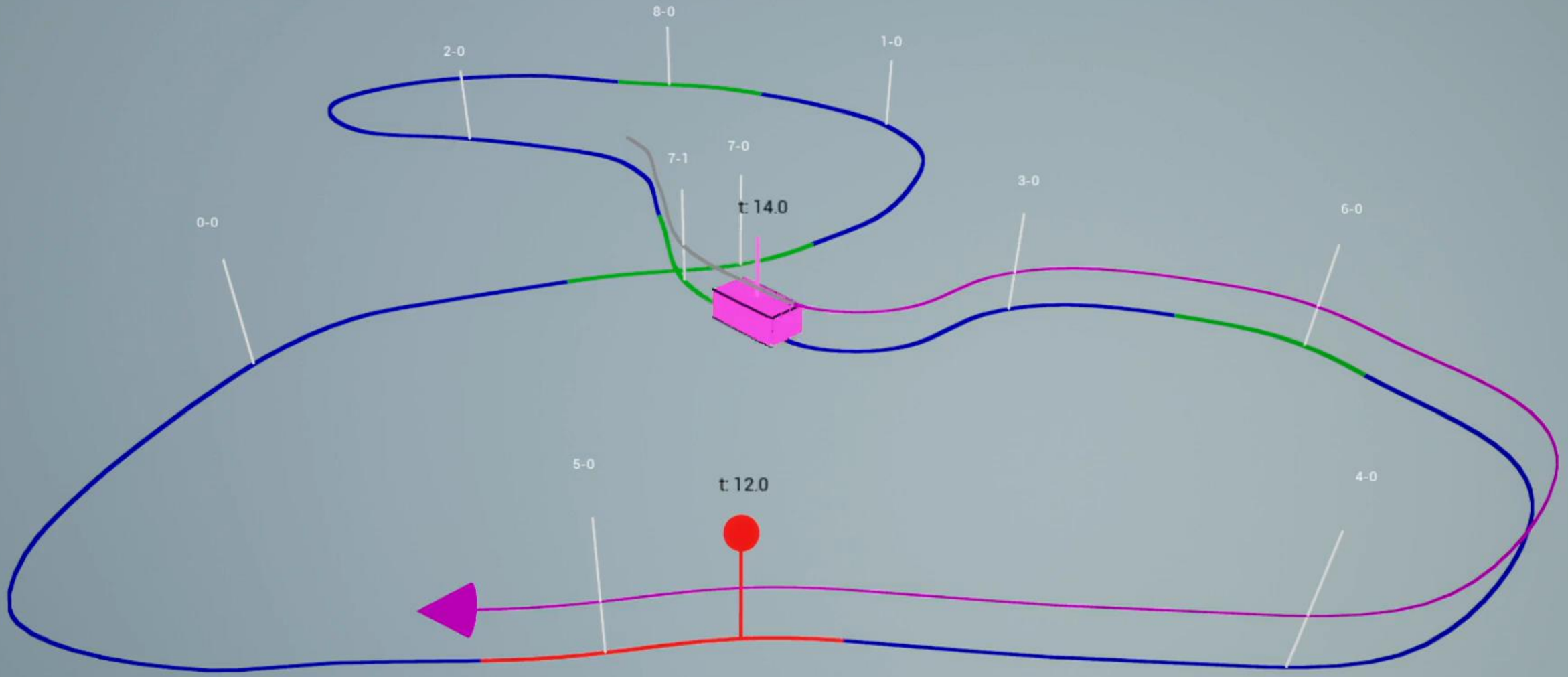
- Rather than process every frame, build a schedule
- Maintain 5-10s of schedule for every agent
- Sequence of keyframes – [time, position, speed]

Scheduling

```
[0] t = 4.39  | Pos: 3/0/0 @ 14.04m | Speed = 10m/s   | Distance = 14.04m
[1] t = 5.39  | Pos: 6/0/0 @ 0m     | Speed = 10m/s   | Distance = 10m
[2] t = 6.23  | Pos: 4/0/0 @ 0m     | Speed = 10m/s   | Distance = 8.44m
[3] t = 8.9   | Pos: 4/0/0 @ 26.72m | Speed = 10m/s   | Distance = 26.72m
[4] t = 10.9  | Pos: 4/0/0 @ 36.72m | Speed = 0m/s    | Distance = 10m
[5] t = 15    | Pos: 4/0/0 @ 36.72m | Speed = 0m/s    | Distance = 0m
[6] t = 15    | Pos: 5/0/0 @ 0m     | Speed = 0m/s    | Distance = 0m
[7] t = 16.45 | Pos: 5/0/0 @ 5.25m  | Speed = 7.25m/s | Distance = 5.25m
[8] t = 17.06 | Pos: 0/0/0 @ 0m     | Speed = 10m/s   | Distance = 5.25m
```






8-0
2-0
1-0
7-0
7-1
3-0
t: 14.0
0-0
6-0
5-0
t: 12.0
4-0

Scheduling

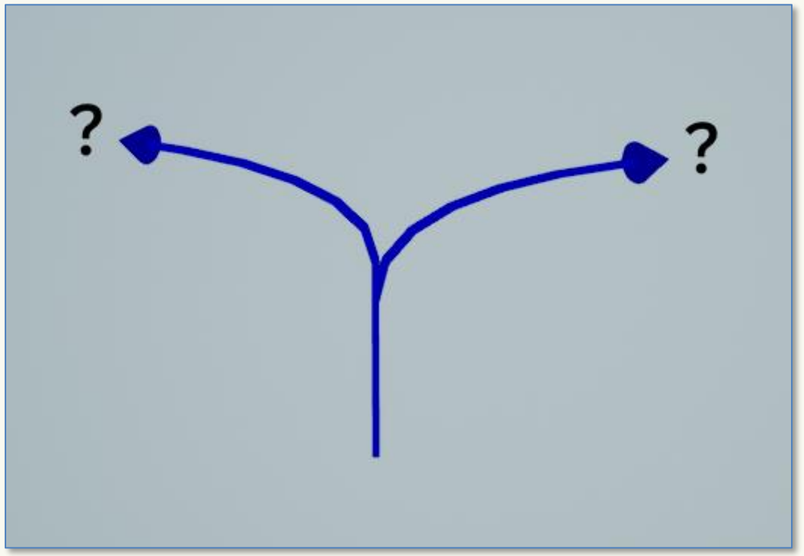
- Order of scheduling is arbitrary on segment level
- Schedule lanes front-to-back
- Schedules generally invariant under level of detail
  - Interpretation can vary with LOD
  - Lane changing is an exception

Why Scheduling?

- Sparse data representation
- Simple 1-D model, easy to apply Newton’s Laws of Motion
- Significantly fewer calculations (done per keyframe, not per update)
- Predict future motion accurately and cheaply
- Scheduling can be time-sliced and load-balanced
- Building schedules is decoupled from using them, so could be done on a separate core or offloaded to the cloud
- Send schedules instead of transforms over the network

Lane Selection

- Passive vehicles drive aimlessly around
- Weighted random choice for next lane
  - Presence of queues of traffic
  - Turning across intersections
  - Lane priorities
  - Game flags like temporarily closing roads
  - Heat maps
- Path following

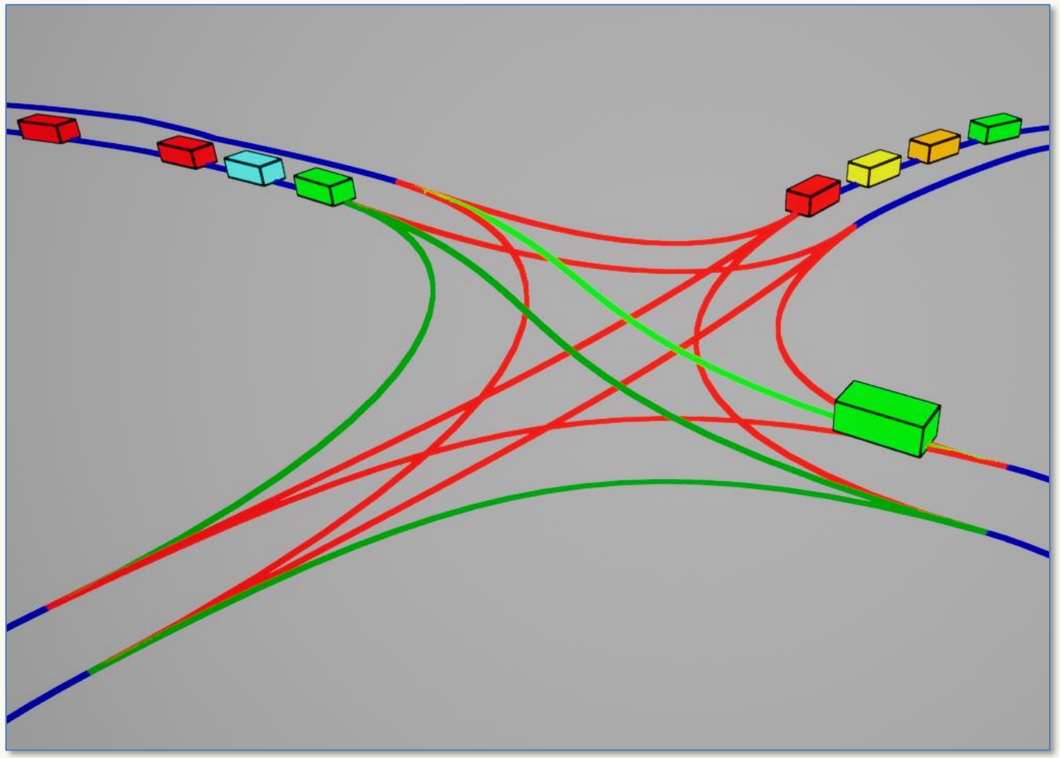


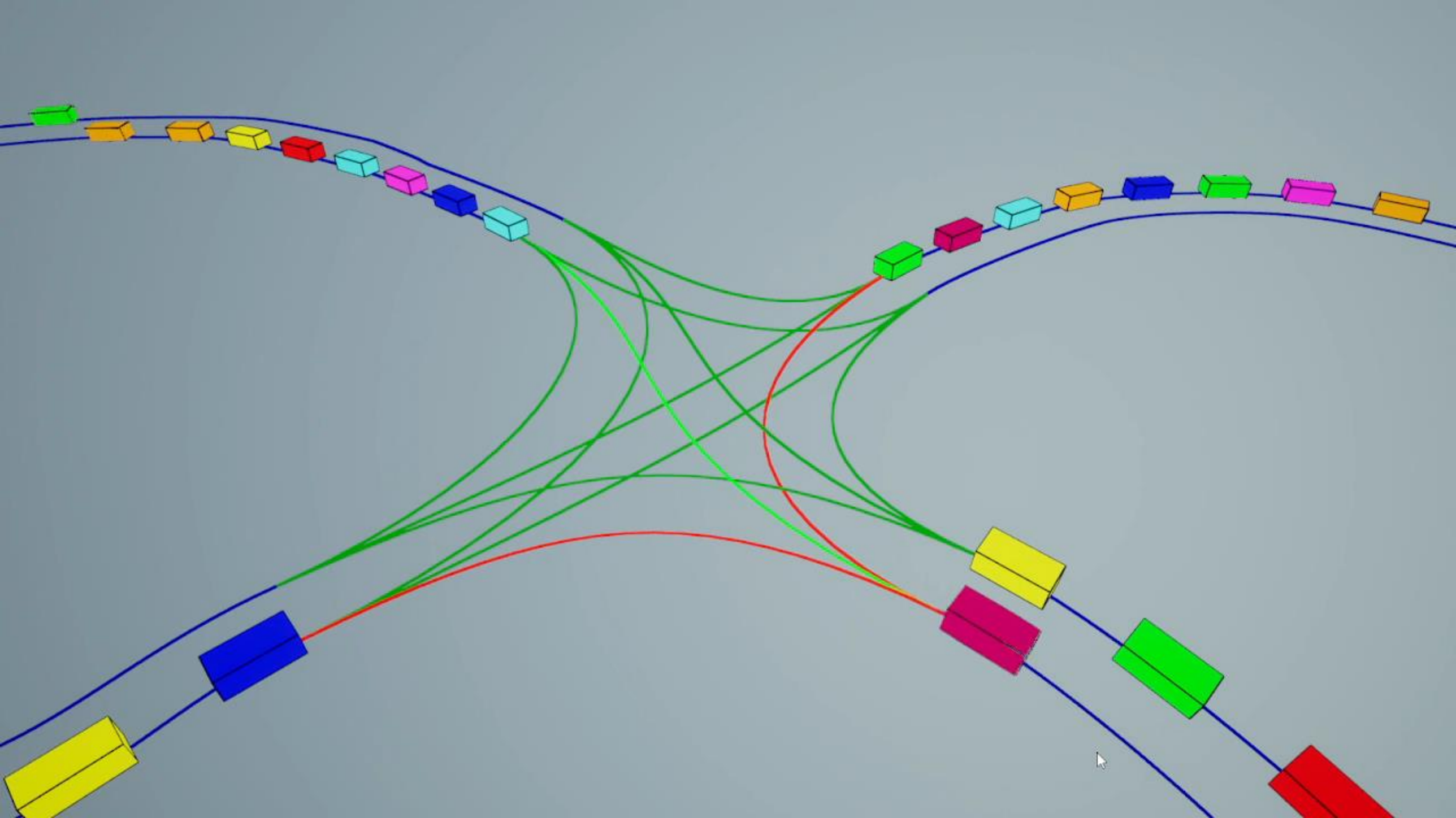
Where (and when) is everybody?

- Schedules describe motion over time
- Lanes hold references to agents, in order
- This information is useful for finding nearby vehicles
  - Find the vehicle in front
  - Look for a gap to change lanes
  - Merge into traffic and enter intersections

Lane Locking

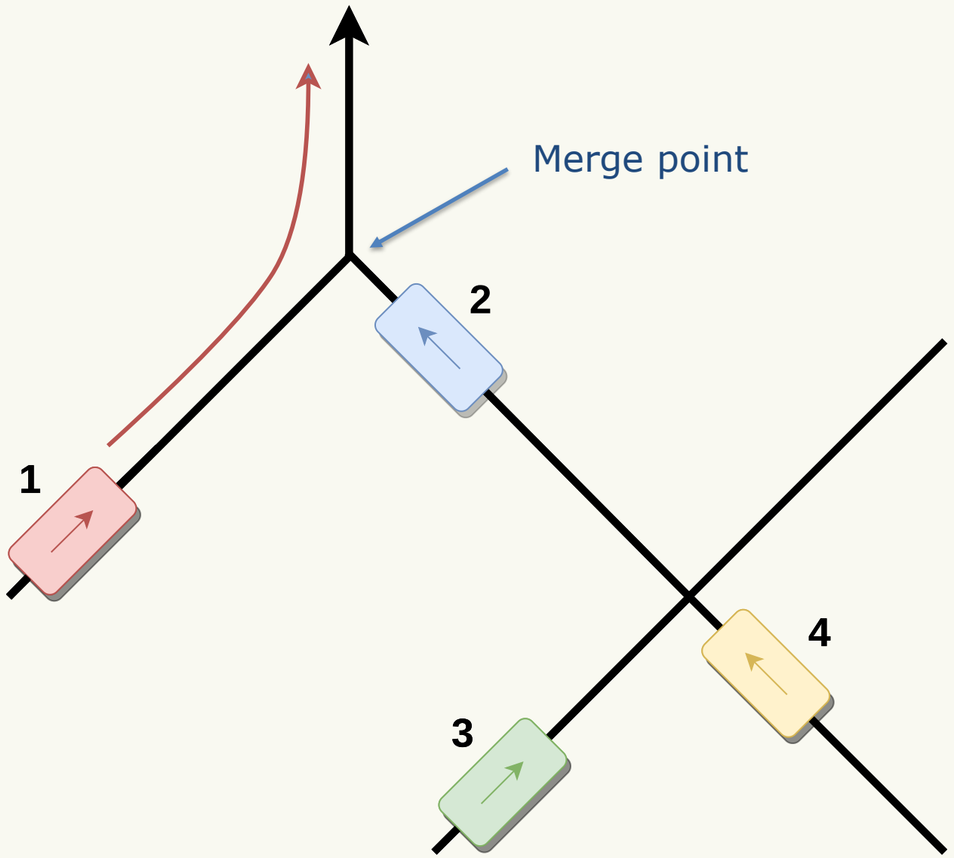
- Intersecting, merging, forking lanes
- Primary vs secondary locks
- Vehicles take and release locks as part of scheduling
- Locking is currently at lane granularity, but could be extended to portions of lanes, allowing for increased traffic flow
- Traffic signals





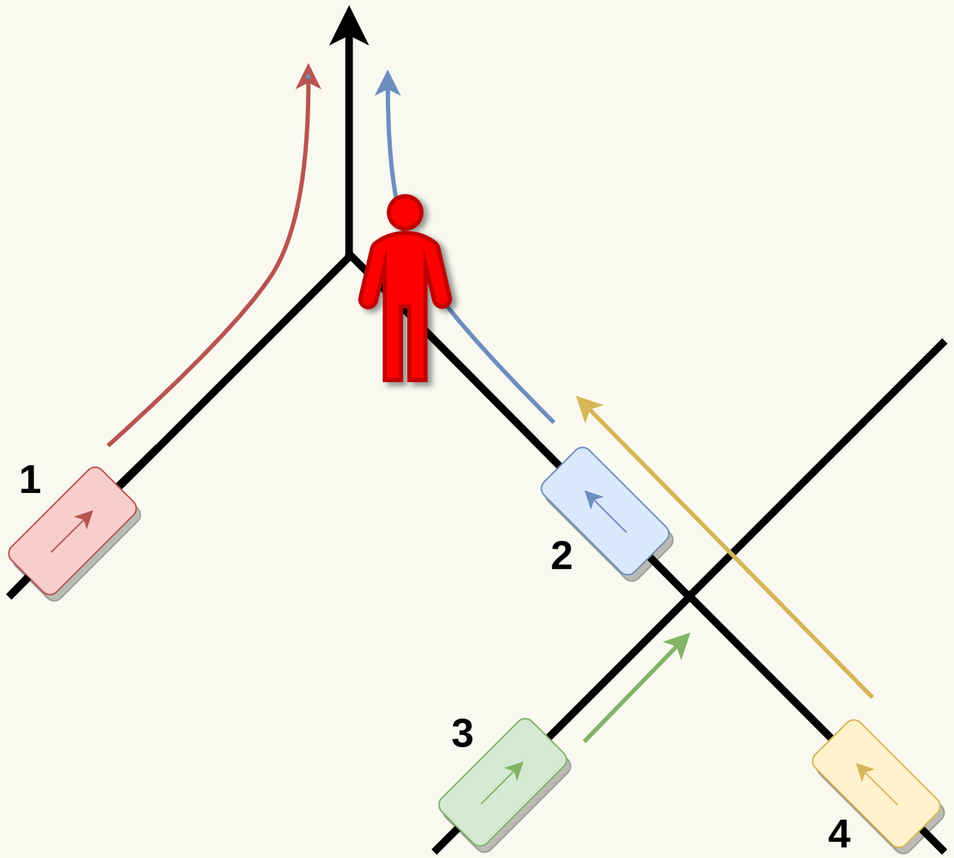
Merging Traffic

- Order of scheduling is important
  - Merging roads
  - Intersections
- Finding competing vehicles is hard
  - Must traverse the road graph backwards, but be careful
- Or schedule anyway and let the next vehicle invalidate it?
- Extra road markup can help



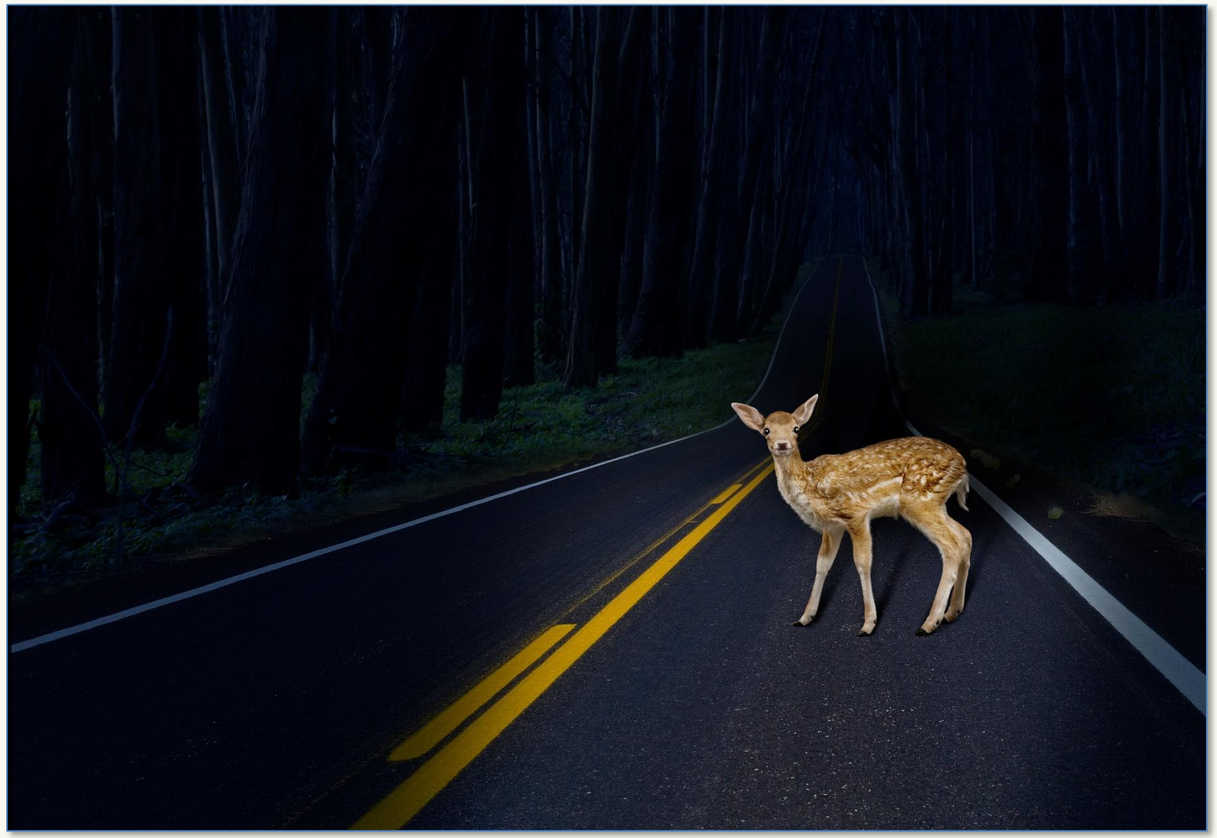
Invalidations

- When a schedule is no longer valid
- Usually triggered by outside interference at a location
  - Player may walk in the road
  - A tree may fall over and block lanes
- Truncate affected schedules
  - Propagates backwards through road graph
  - Can also propagate forwards!
- Expensive, can cause spikes



Outside Interference

- Primary cause of invalidations
- Game entities block the road
  - Wait at temporary blockages
  - Permanent blockages are harder
- Collisions may occur



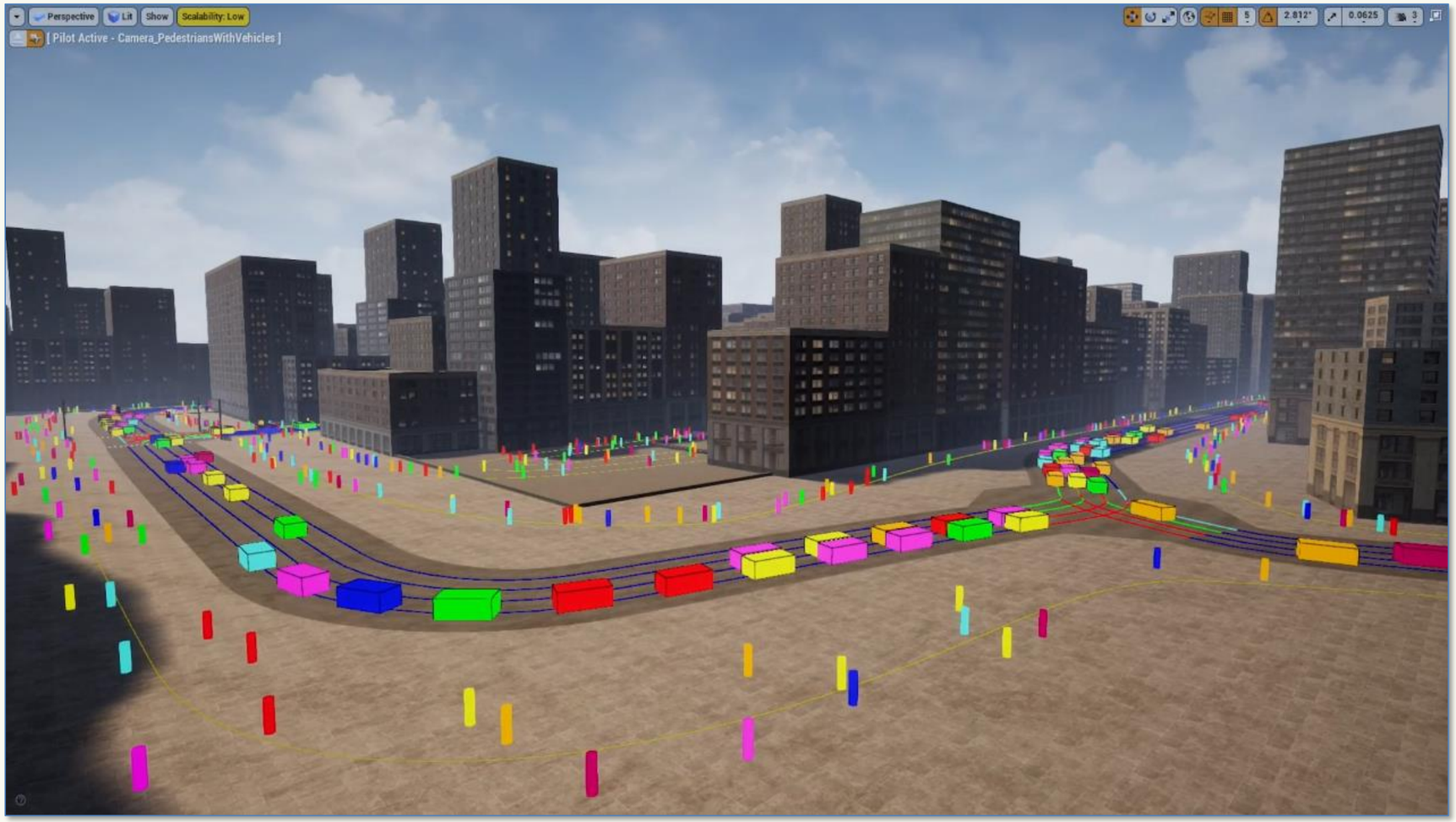
Wrapping Up

- Vehicle scheduling is just a component of the wider system
- Many features didn’t get covered today
  - Road graph construction
  - Pathfinding
  - Pedestrian scheduling
  - …

Contact Us

www.kythera.ai

contact@kythera.ai

@KytheraAI

/company/kythera-ai