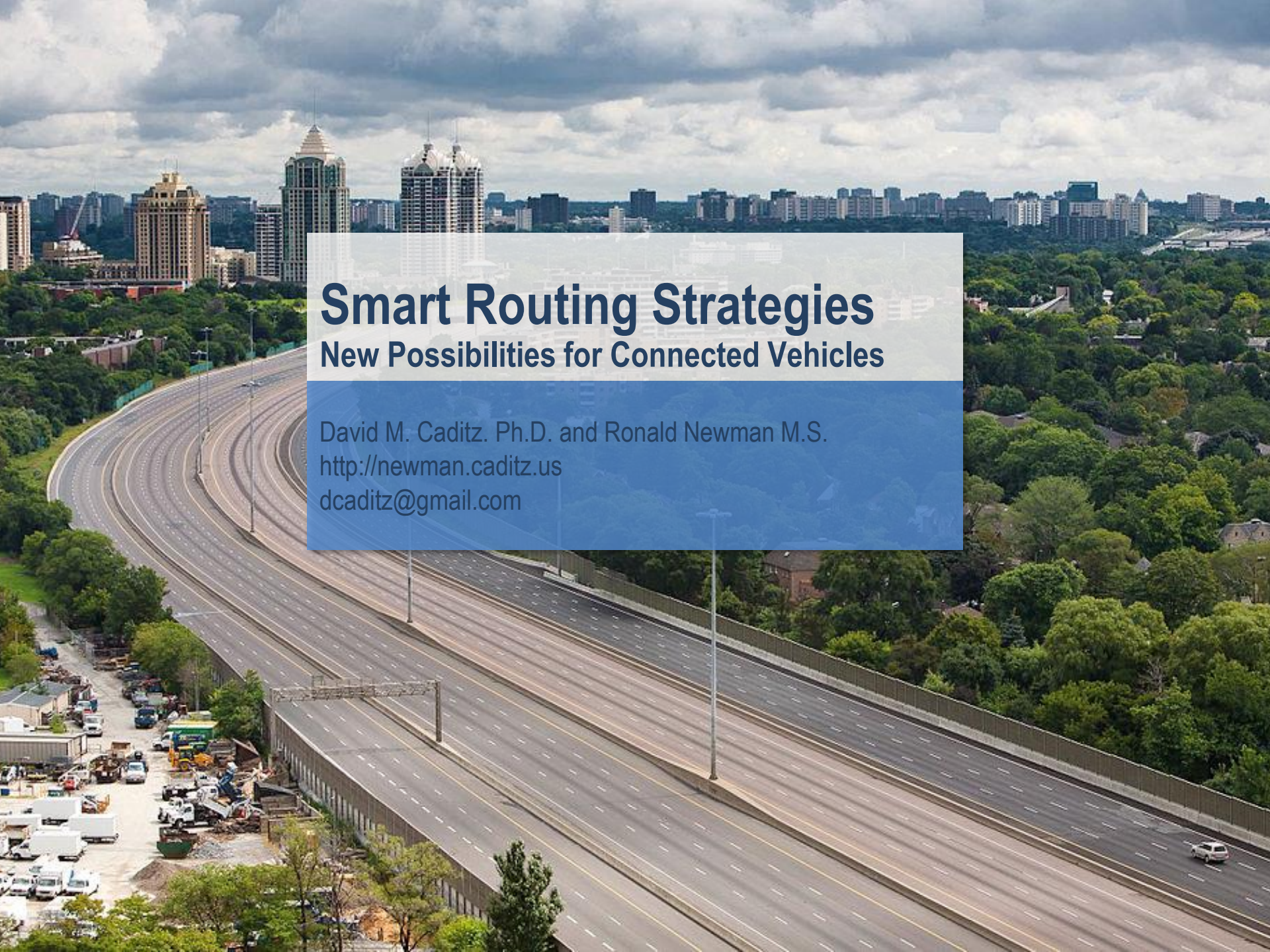


Smart Routing Strategies

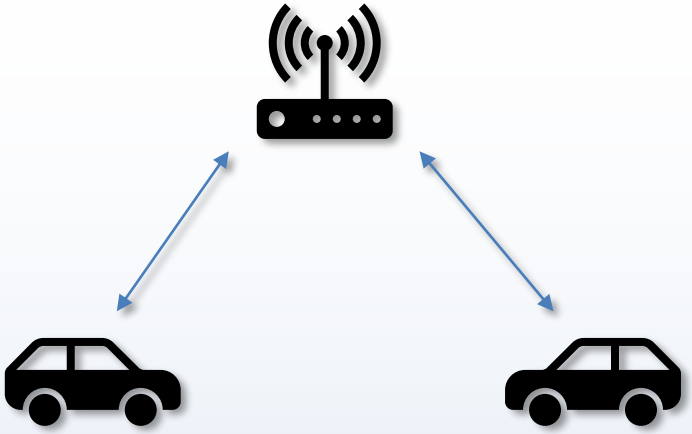
New Possibilities for Connected Vehicles

David M. Caditz. Ph.D. and Ronald Newman M.S.
http://newman.caditz.us
dcaditz@gmail.com

Background

- AV Levels 0-5 (0=100% human, 5 = 100% autonomous)
- V2V, V2I
- Microscopic and Macroscopic flow models
- ODM (origin-destination matrix)
  - PDM (position-destination matrix)
- Assignment
  - User optimized – ‘selfish routing’
  - System optimized

Connected Autonomous Vehicles



Intersection controller

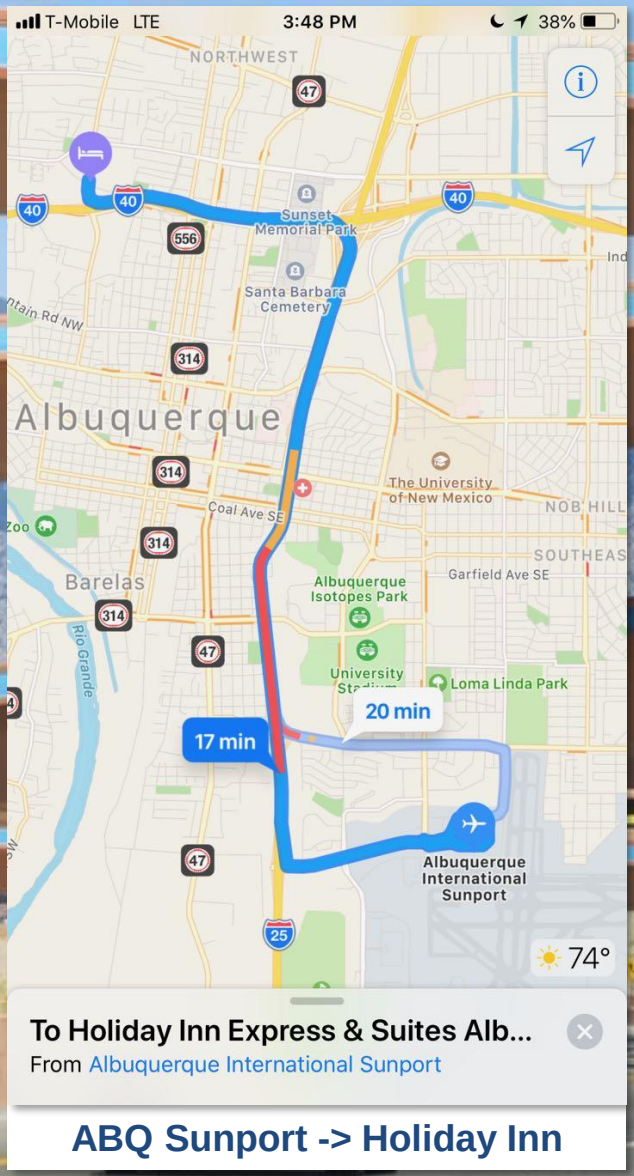
V2I

Cooperative collision avoidance

V2V (peer to peer)

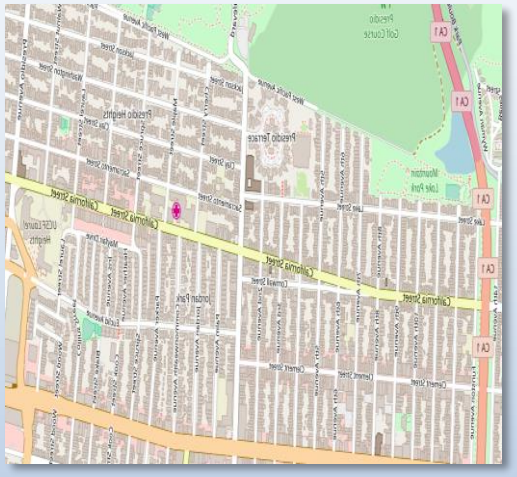
Sensor-based applications
Follow lane, avoid obstacles

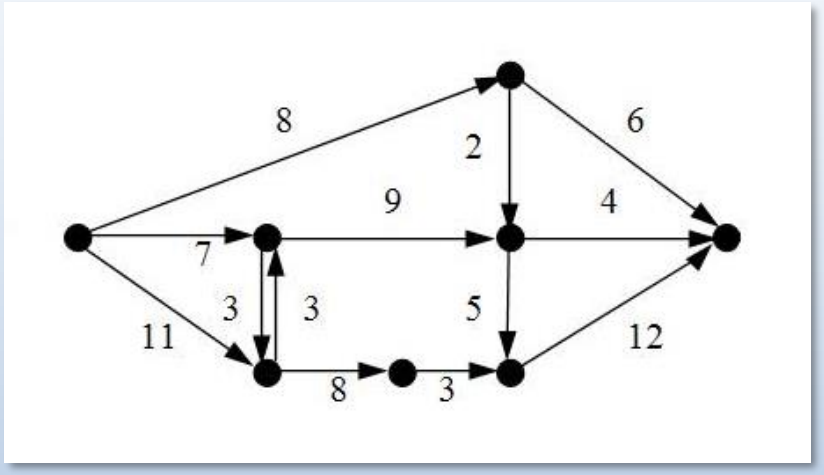
Lidar, machine learning.



ABQ Sunport -> Holiday Inn

Static/Reactive Routing

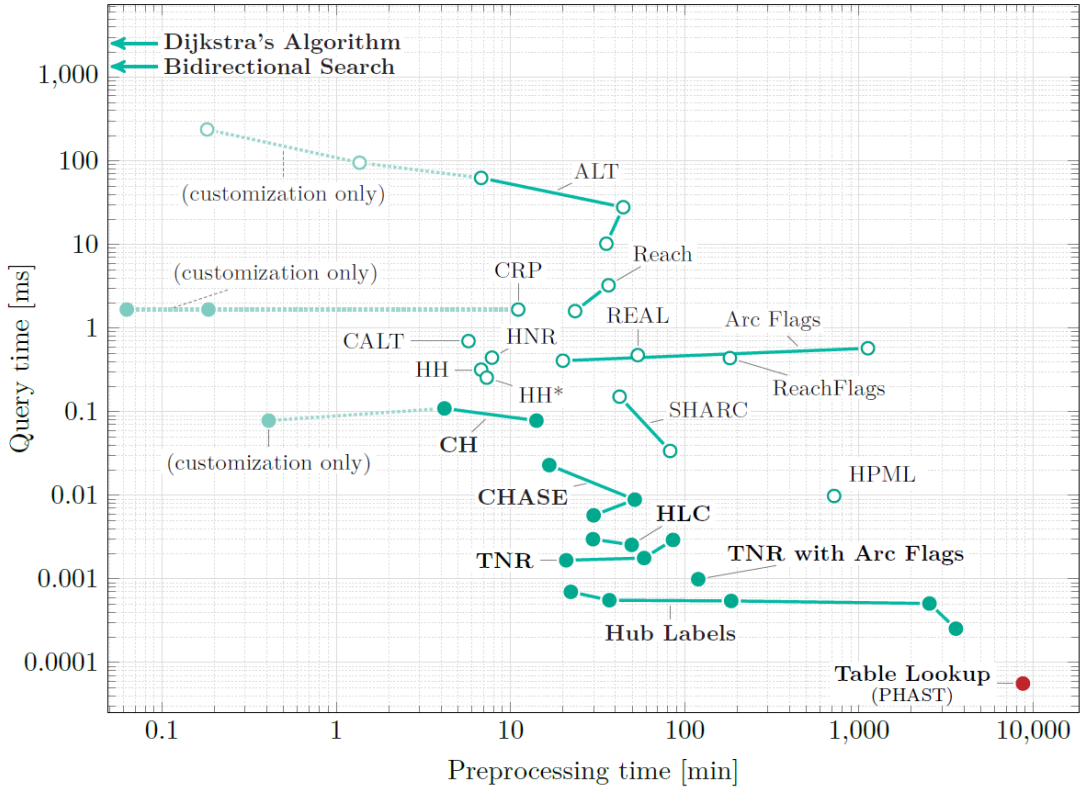




Geo map

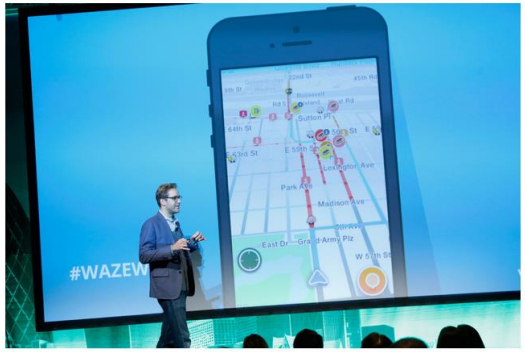
Directed graph

Routing Algorithms



Route Planning in Transportation Networks H. Bast, et al 2015 https://arxiv.org/pdf/1504.05140.pdf

Should Waze be made liable for neighborhood traffic woes?



Product Specialist for Waze Mark Campos speaks on stage at LocationWorld 2016 Day 2 at The Conrad on November 3, 2016 in New York City. BRIAN ACH/GETTY IMAGES FOR LOCATIONWORLD 2

AirTalk® | April 13, 2018

Crowdsourced navigation app Waze blamed for ing traffic jams on side streets

Apr 2018, 11:57 , by Alan Friedman

Tweet Share

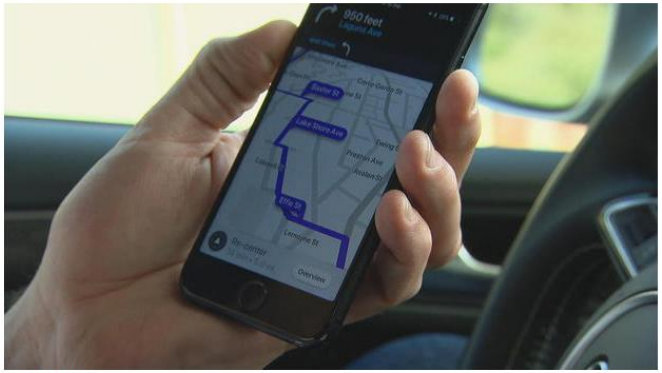
Android + Apps + Google +

L.A. residents complain GPS app Waze is creating "insanity" on their street

Share / Tweet / Reddit / Flipboard / @ Email

It's bumper-to-bumper traffic on Baxter Street as Los Angeles commuters make their way home. Jeff Hartman has lived here for 20 years and said he's never seen it this bad. He said he thinks GPS apps are responsible for the traffic.

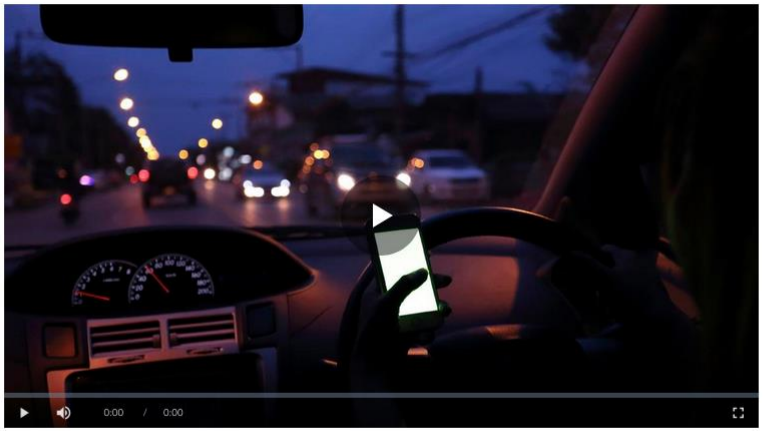
The app most people on the street blame is Waze, reports CBS News correspondent Carter Evans. When you put in an address across town, the normal route is full of traffic, so the routes drivers through Baxter Street.



CBS NEWS

GPS apps causing traffic carnage

07/04/2018 | Newshub staff

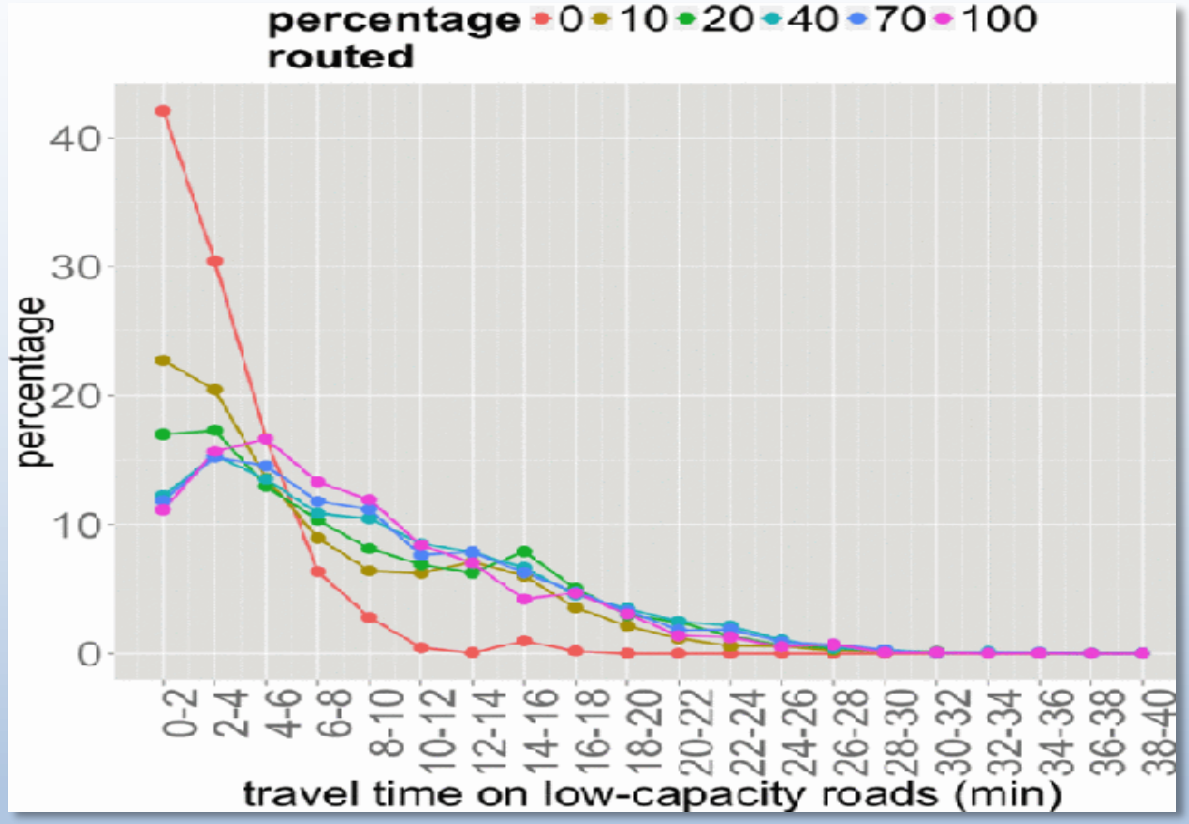


GPS-based apps are creating problems across the US. Credits: Image: iStock; Video: CBS News

Traffic apps have a mind of their own - and don't always take drivers on the best route.

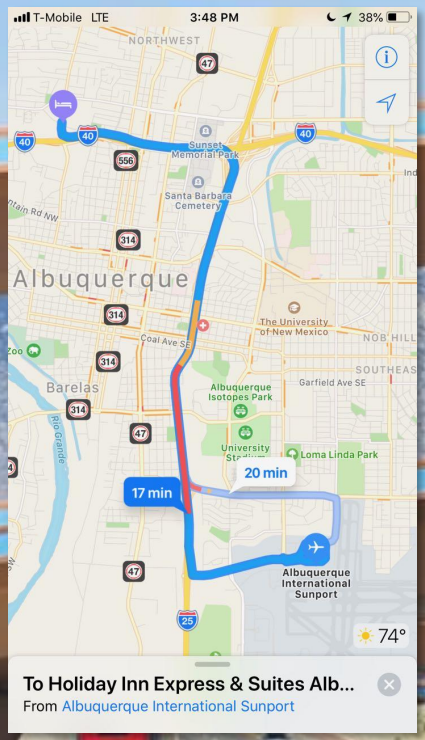
In southern California, GPS is taking drivers on a dangerous detour, causing trouble for them and for homeowners

Routing Compliance



J. Thai, N. Laurent-Brouty and A. M. Bayen, "Negative externalities of GPS-enabled routing applications: A game theoretical approach,“ https://ieeexplore.ieee.org/document/7795614/

Static/Reactive Behaviors



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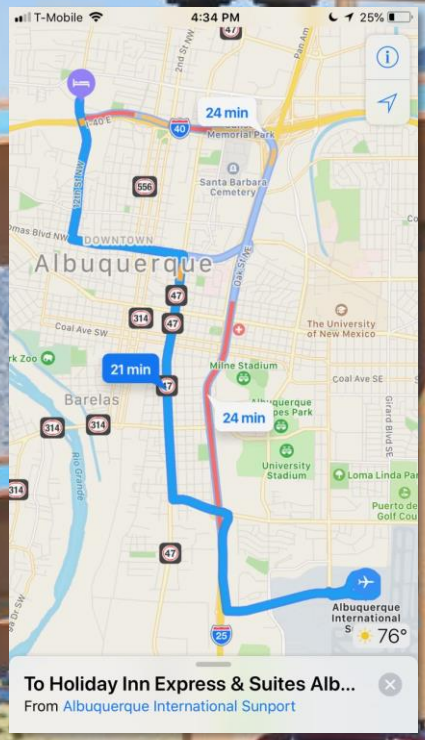

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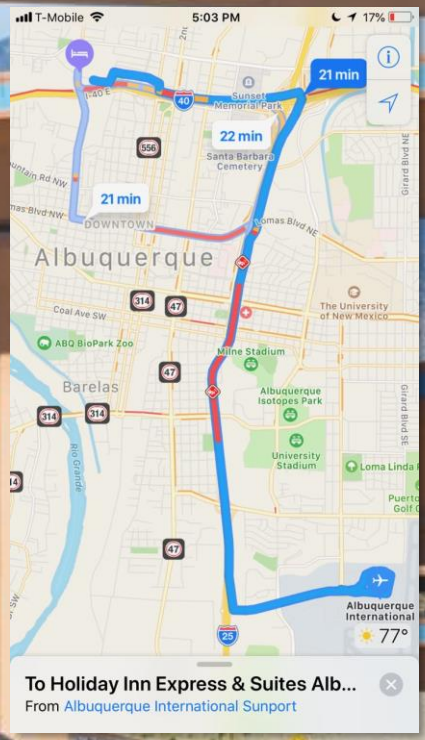

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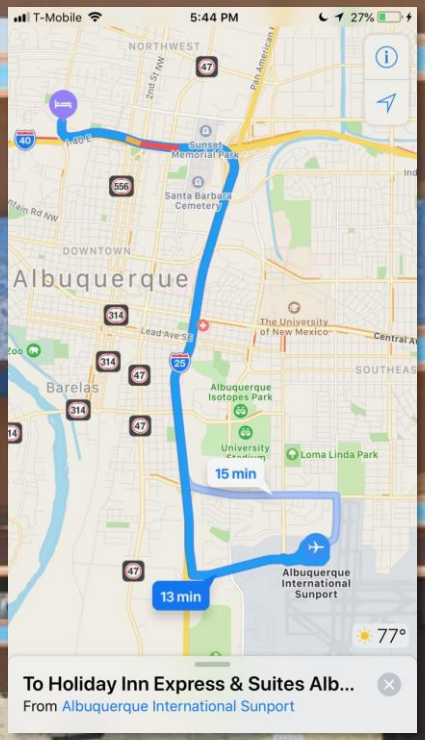

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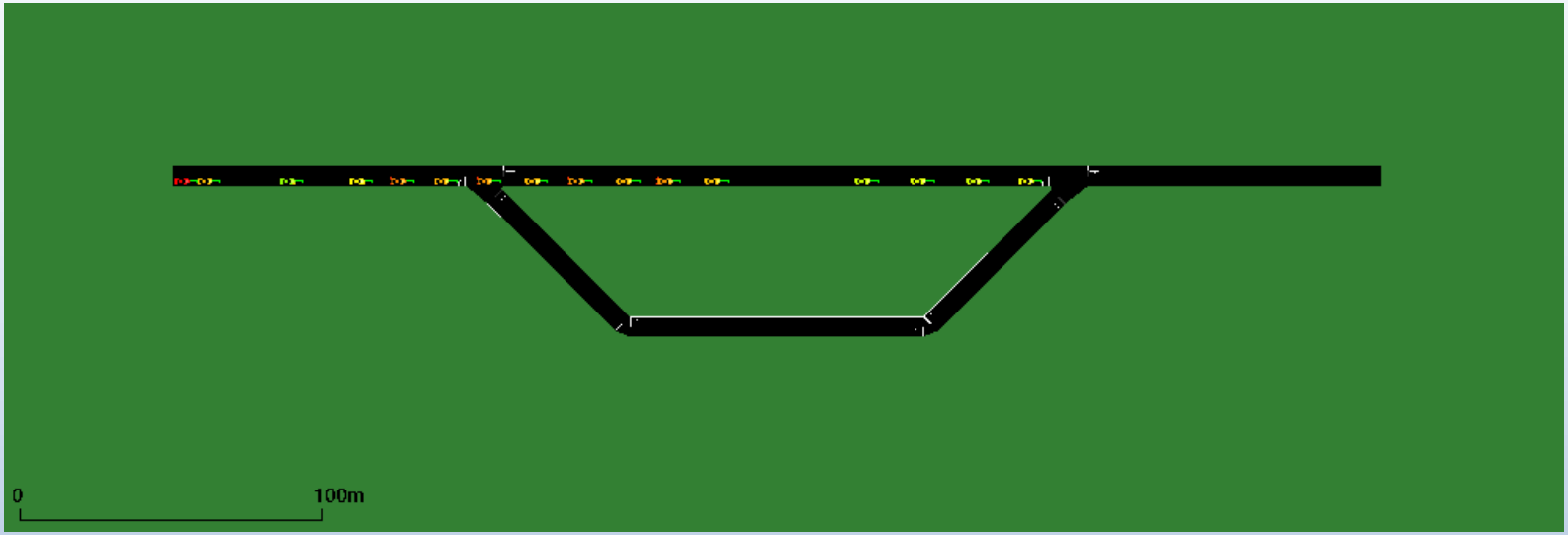
Sunport -> Holiday Inn Hotel

The problem with 100% compliance



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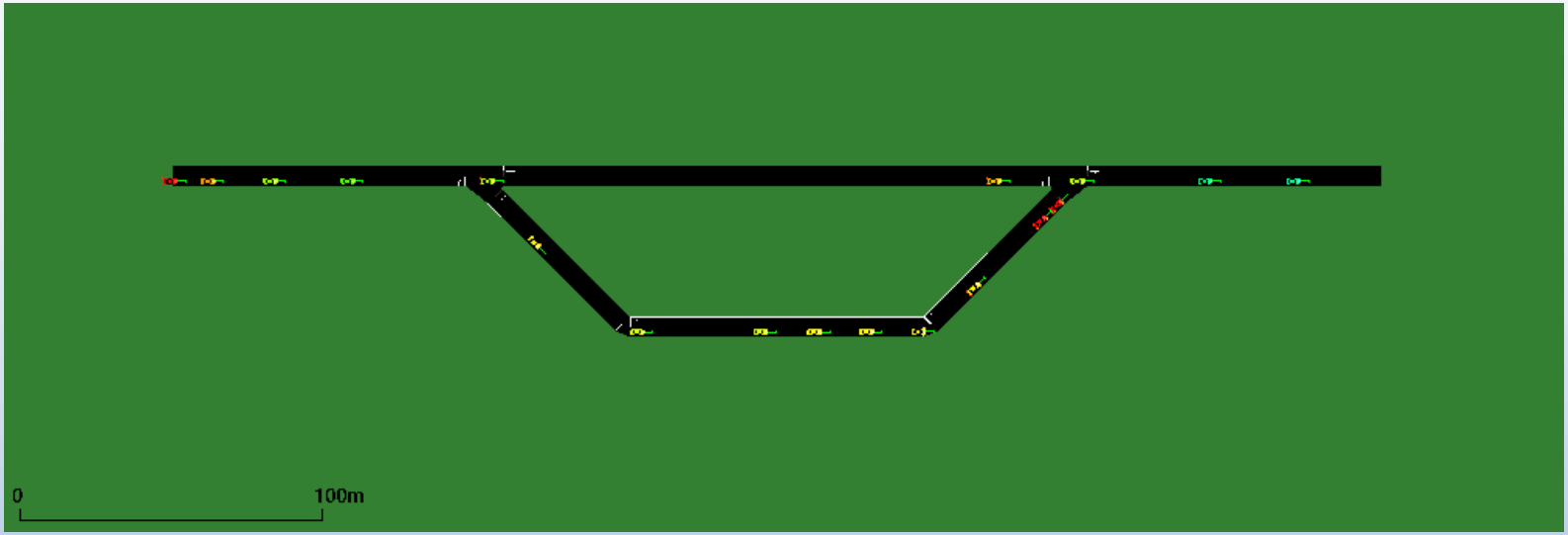
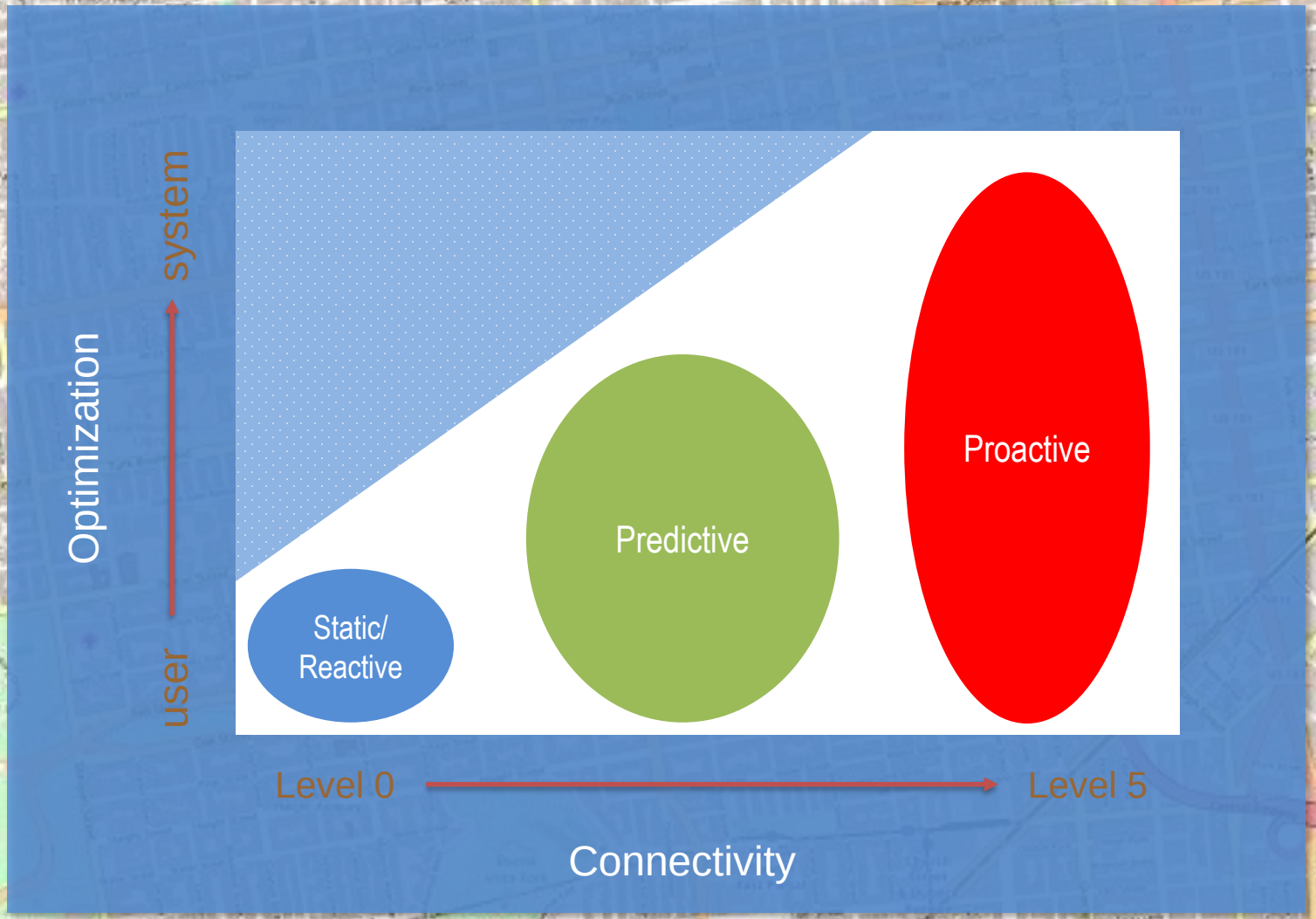


“Information Paradox”

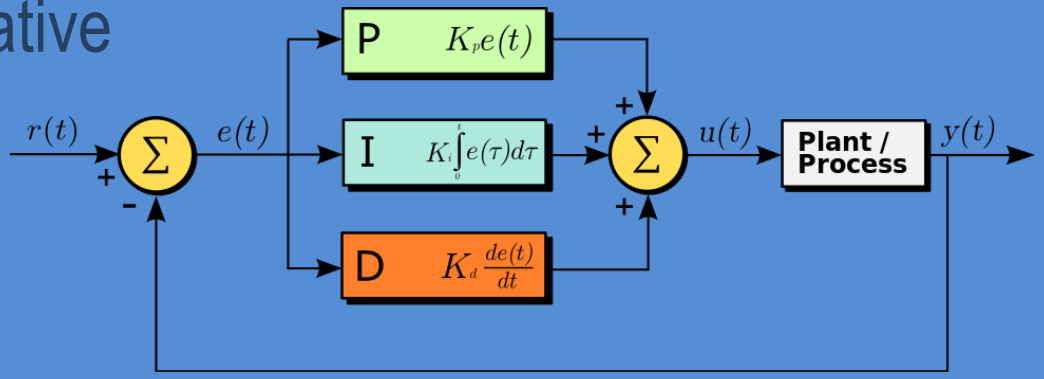
- Knowing current traffic conditions can make things worse
- Similar problem with using traffic history data

- This is an example of Non-Converging Dynamic Traffic Flow


Optimization
system
user
Static/
Reactive
Predictive
Proactive
Level 0
Level 5
Connectivity

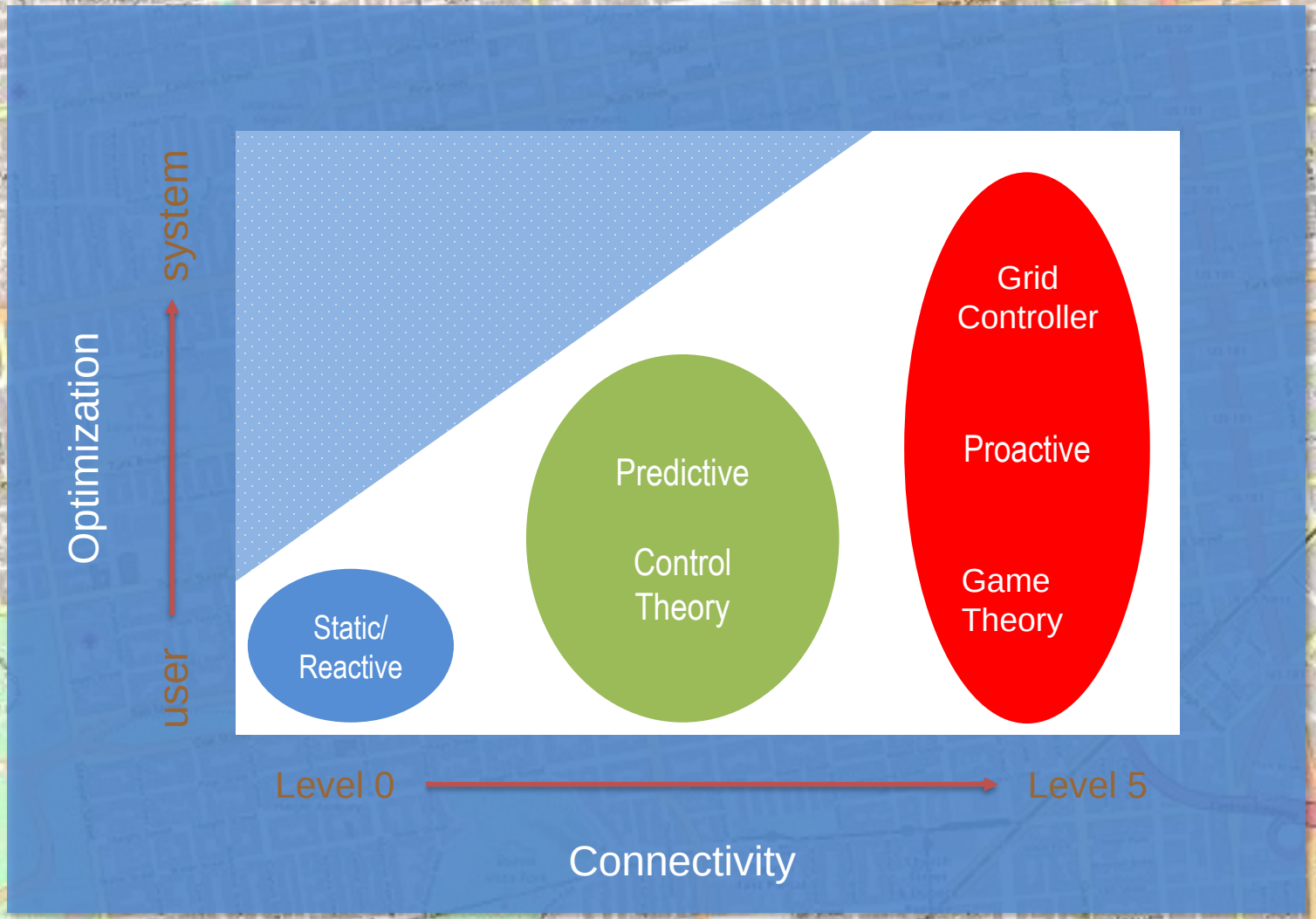
P.I.D. Control Theory

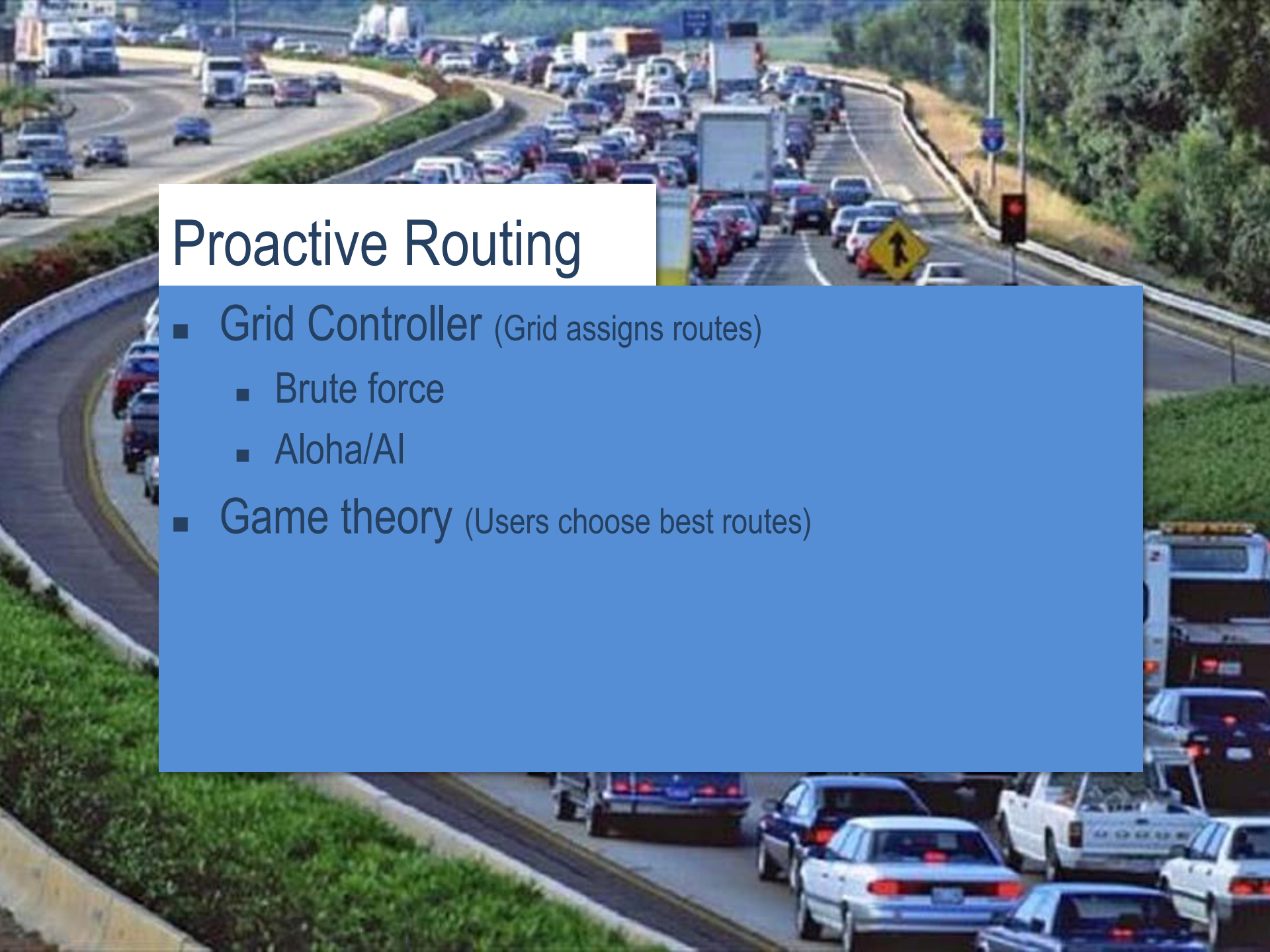
- Proportional
- Integral
- Derivative



Example

- Roadway Load Sharing
- Wave damping: http://traffic-simulation.de/

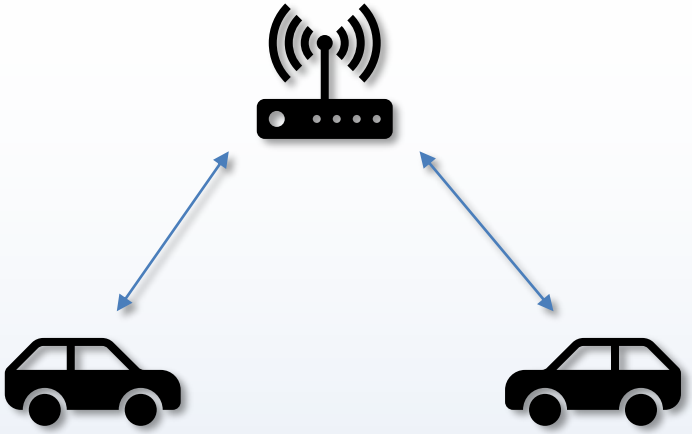

Optimization
system
user
Static/
Reactive
Predictive
Control
Theory
Grid
Controller
Proactive
Game
Theory
Level 0
Level 5
Connectivity



Proactive Routing

- Grid Controller (Grid assigns routes)
  - Brute force
  - Aloha/AI
- Game theory (Users choose best routes)

Connected Autonomous Vehicles



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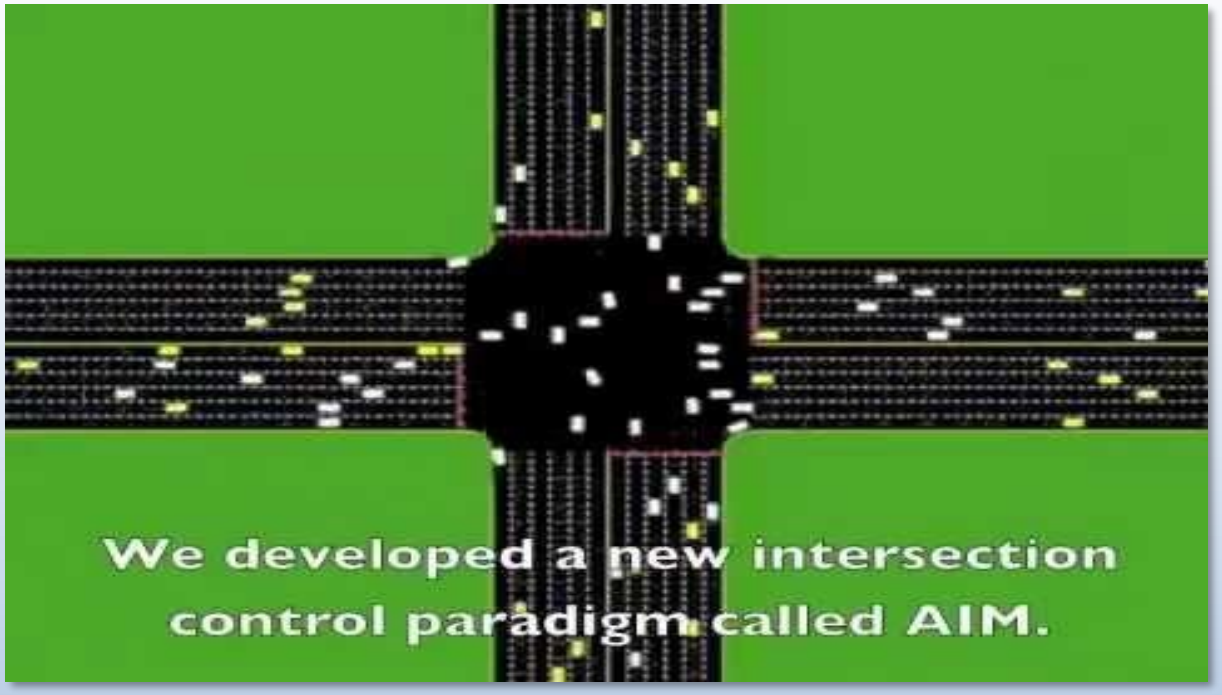
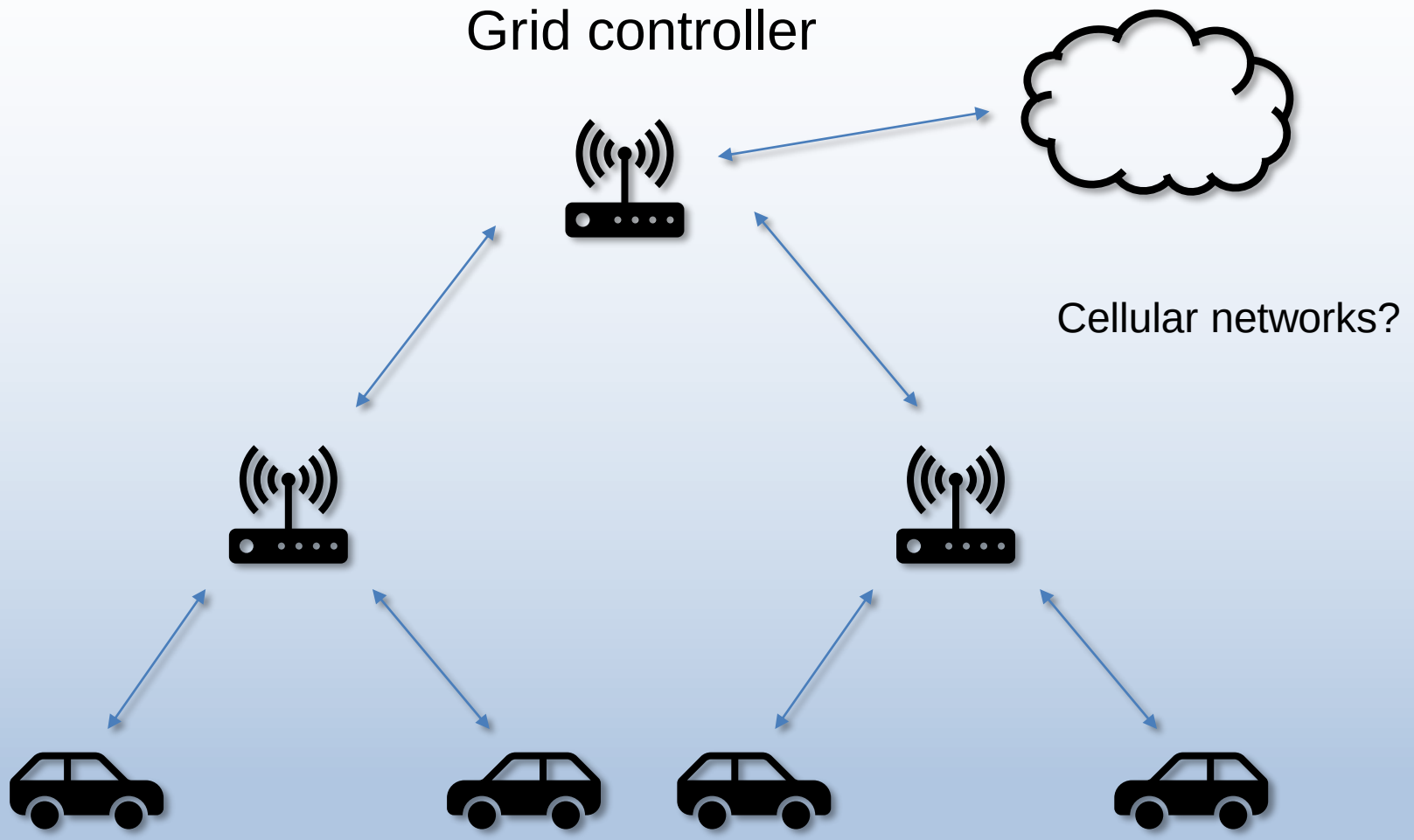
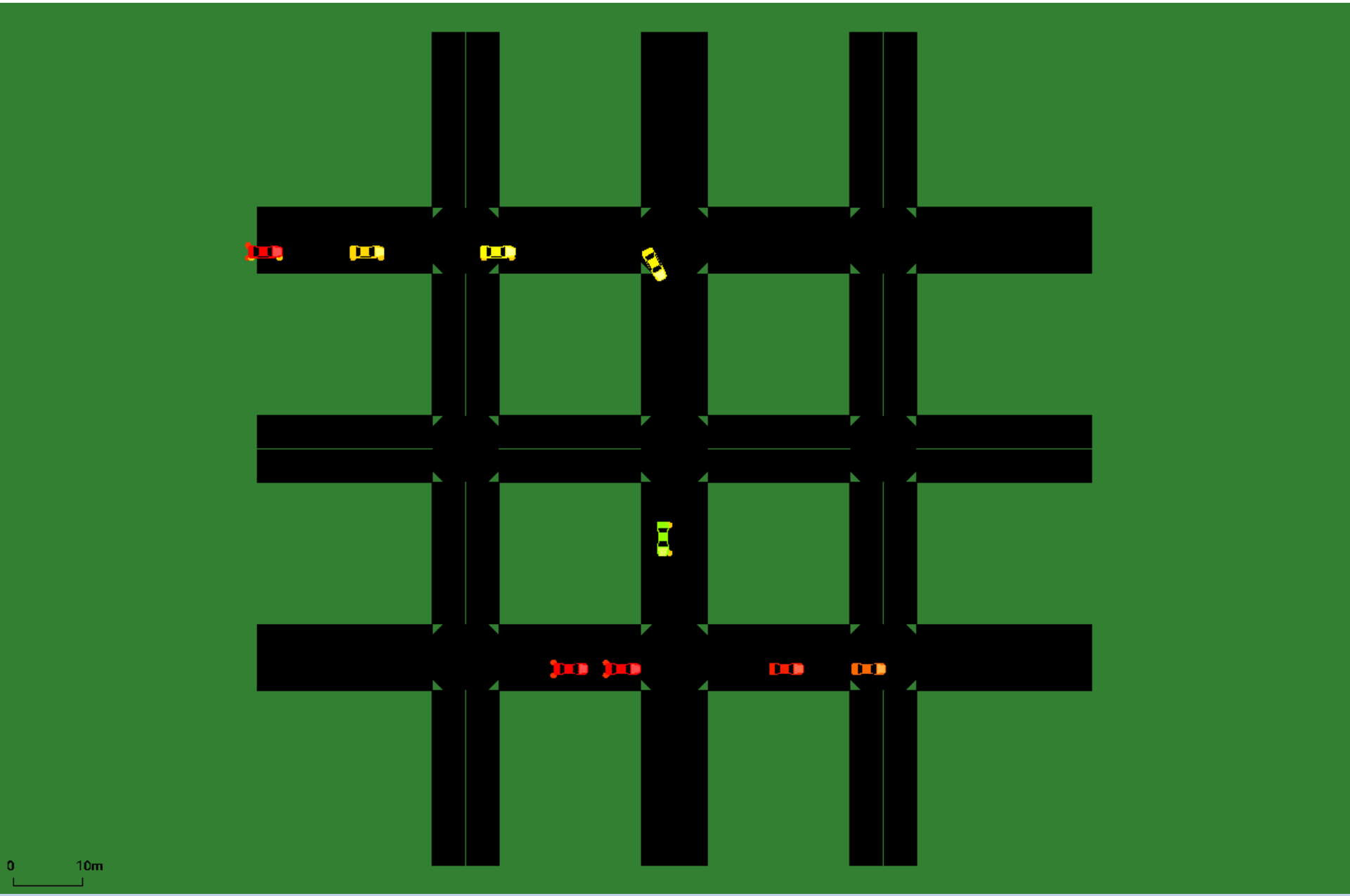


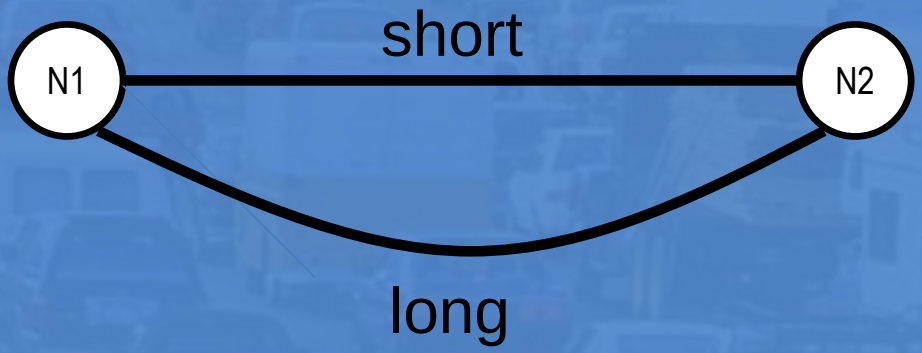
https://www.youtube.com/watch?v=4pbAI40dK0A

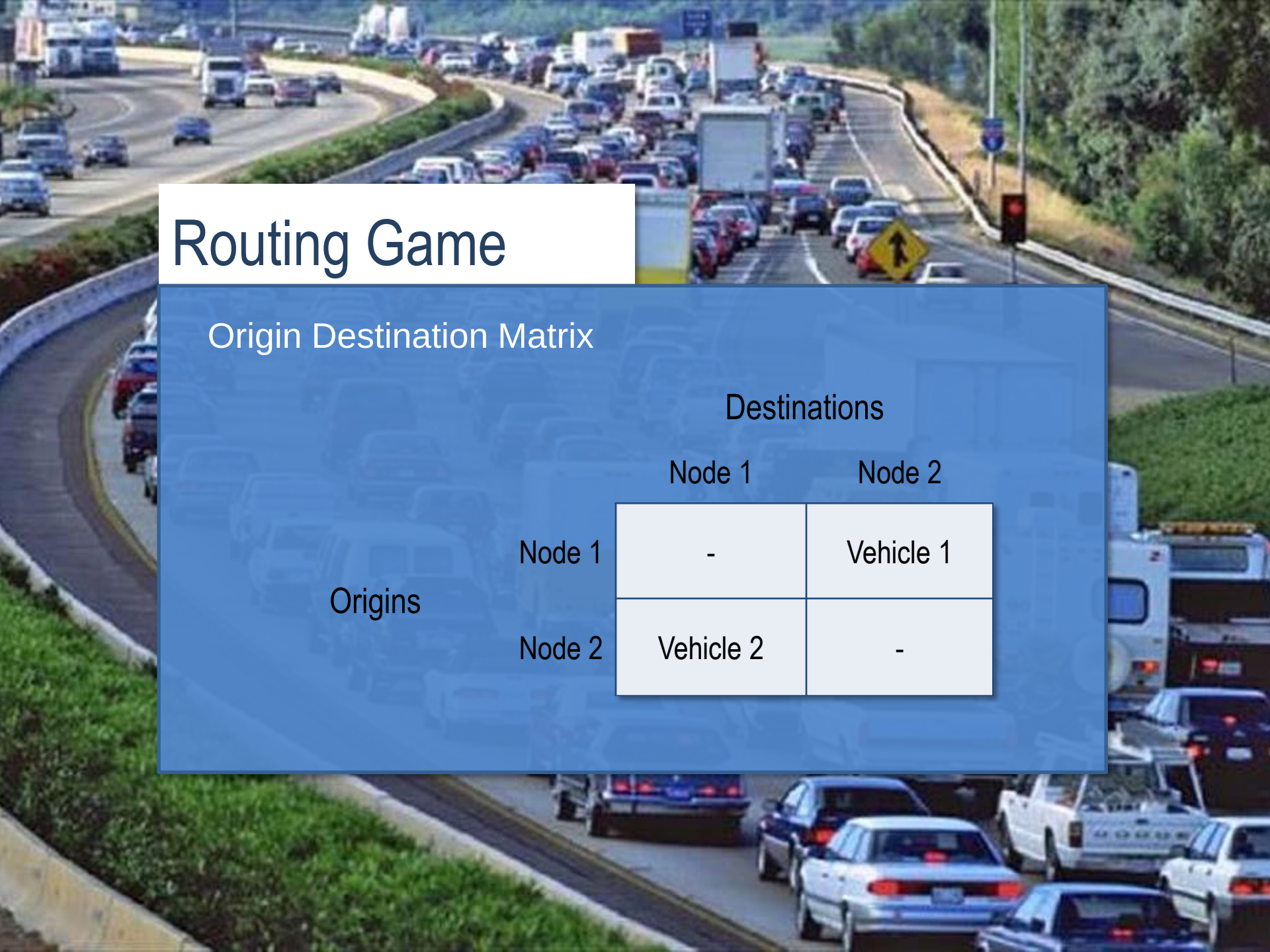

Grid controller
Cellular networks?


0
10m

Routing Game

Network Graph





Routing Game

Origin Destination Matrix

Origins \ Destinations	Node 1	Node 2
Node 1	-	Vehicle 1
Node 2	Vehicle 2	-

Routing Game

Game Matrix 1

Vehicle 1 \ Vehicle 2	Short	Long
Short	(7,5)	(3,6)
Long	(6,3)	(7,6)

Routing Game

Game Matrix 2

Vehicle 1 \ Vehicle 2	Short	Long
Short	(7,7)	(3,6)
Long	(6,3)	(7,6)

Smarter Routing

- Reduce congestion
- Increase energy efficiency
- Reduce travel time
- Reduce vehicle conflicts
- Increase roadway efficiency
- Quiet neighborhoods
- Increase profitability (MAS)

Thank you!

- Questions & Discussion

David M. Caditz. Ph.D. and Ronald Newman M.S.
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