Big Data in Automotive Applications:
Cloud Computing Based Velocity Profile Generation for Minimum Fuel Consumption

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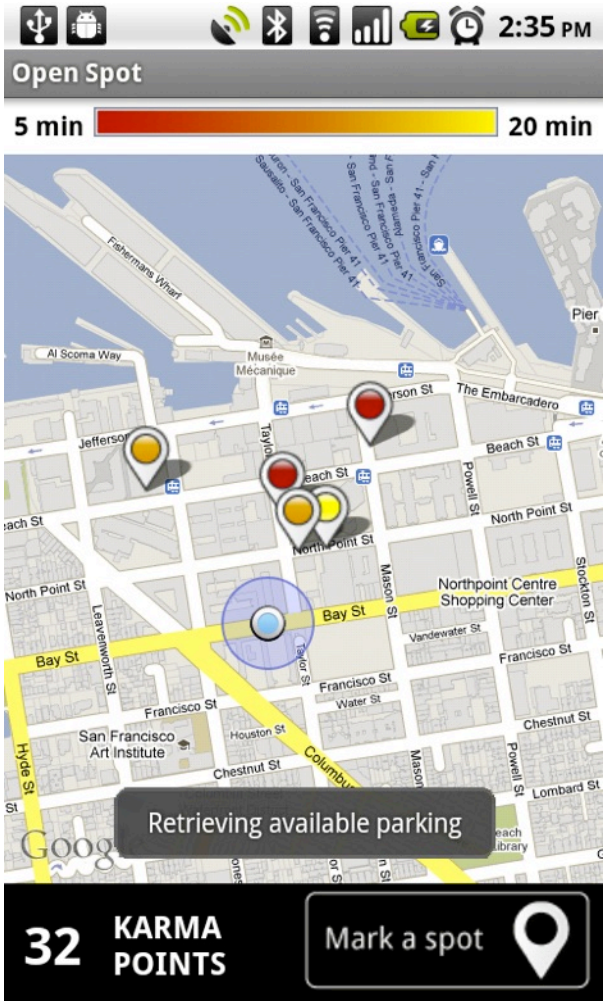
- Introduction

Big Data applications in our vehicles

1. Data Communication for Driver Convenience (Consumer information, Parking Availability, Geographical Data)
2. **Energy management and optimization**
3. High Priority Safety Data (Emergency situations, Hazards)
4. Real-time, time critical (collision avoidance)
5. Traffic Management Data (Traffic Congestion and Road Closures)
6. Auto Industry Customer Service Data (Warranty Data, Diagnosis and Parts Failure)
7. …

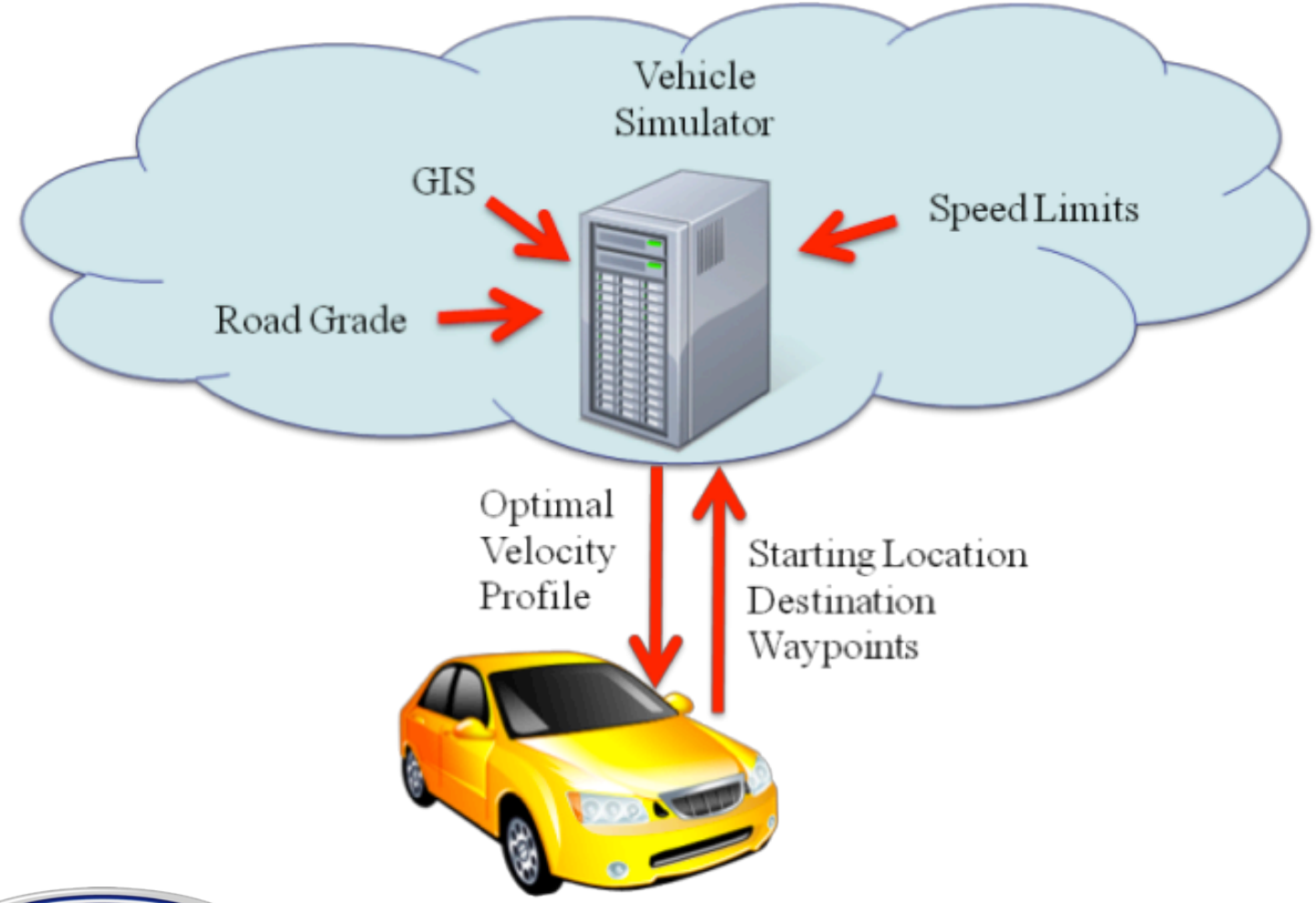
1. Data Communication for Driver Convenience

- Consumer information Data
- Parking Availability Data
- Geographical Data



http://ebiquity.umbc.edu/blogger/2010/07/09/google-open-spot-android-app-finds-parking/

2. Fuel consumption optimization



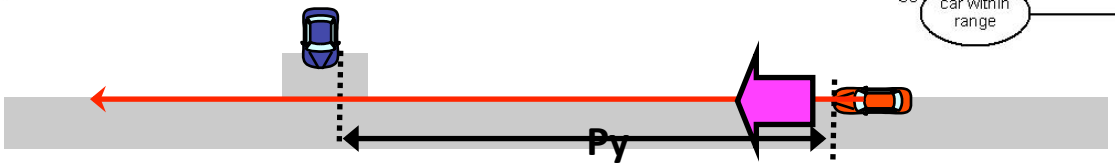
3. Data Communication for Safety and Collaborative Driving

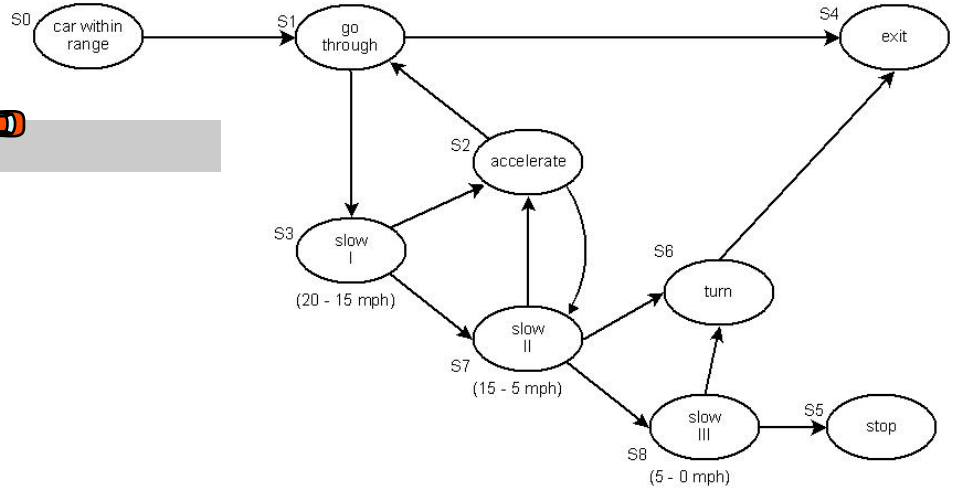
Testing autonomous and semi-autonomous cars sharing information in Columbus.

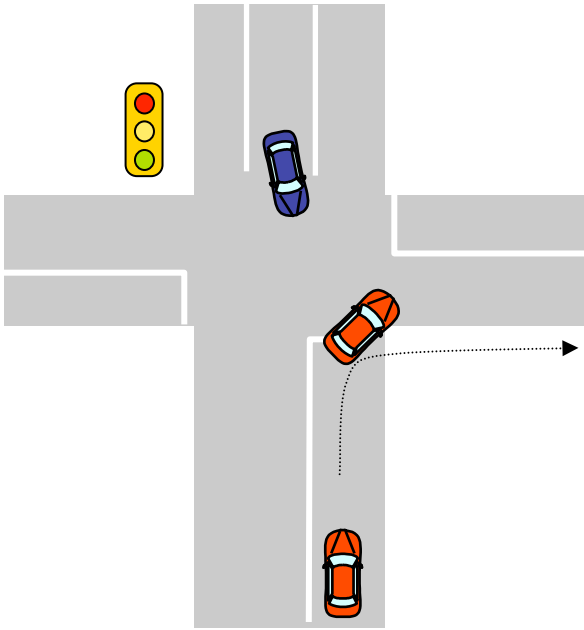
Driving 3 autonomous trucks in Japan.

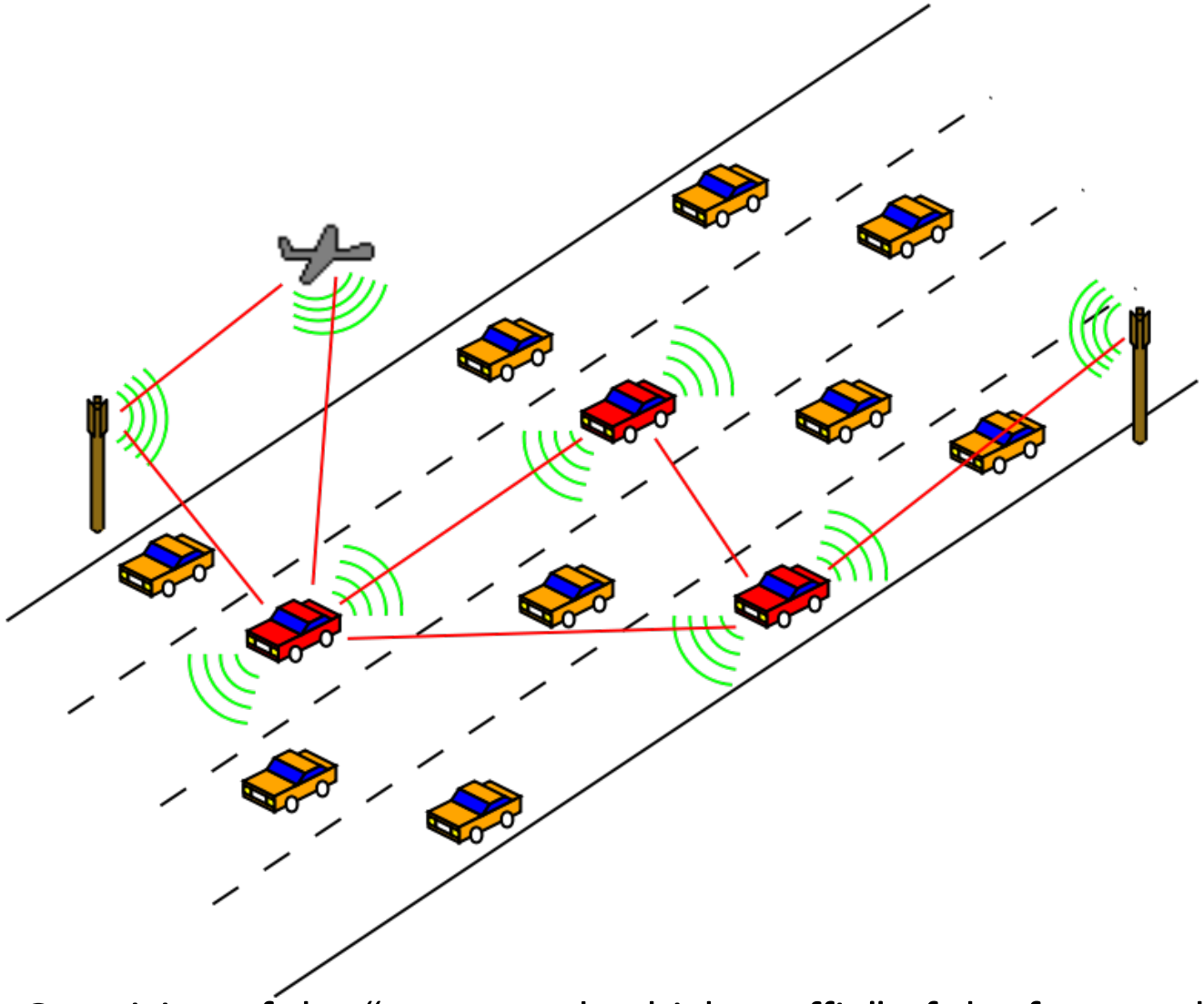
A collaborative driving exercise in Holland.

4. Time critical data – collision avoidance



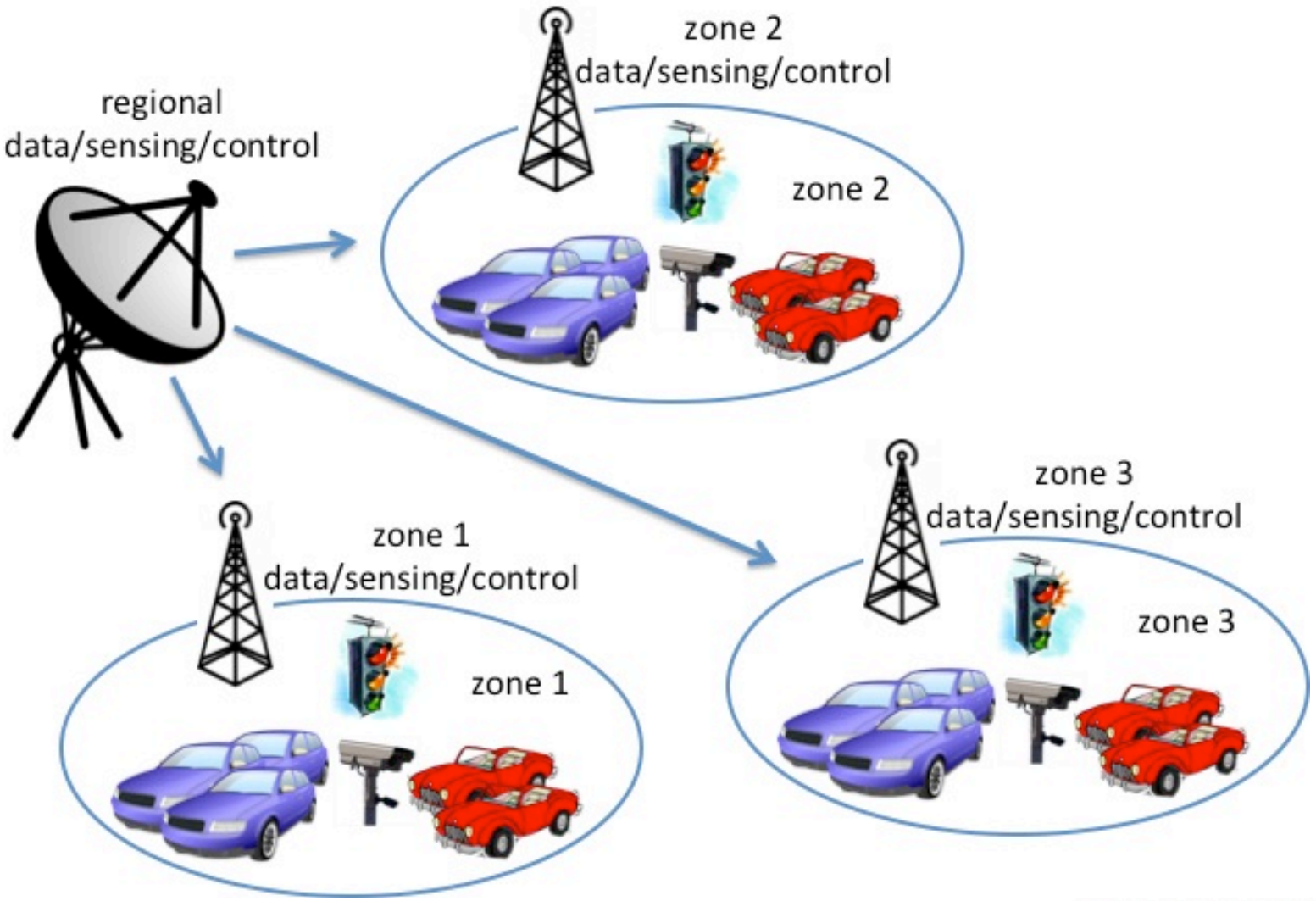






Our vision of the “connected vehicle traffic” of the future where many layers of information is transmitted on demand and extensive measured data about the environment is shared.

Hierarchy of data transmission and sharing



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Research and Advanced Engineering

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Weather

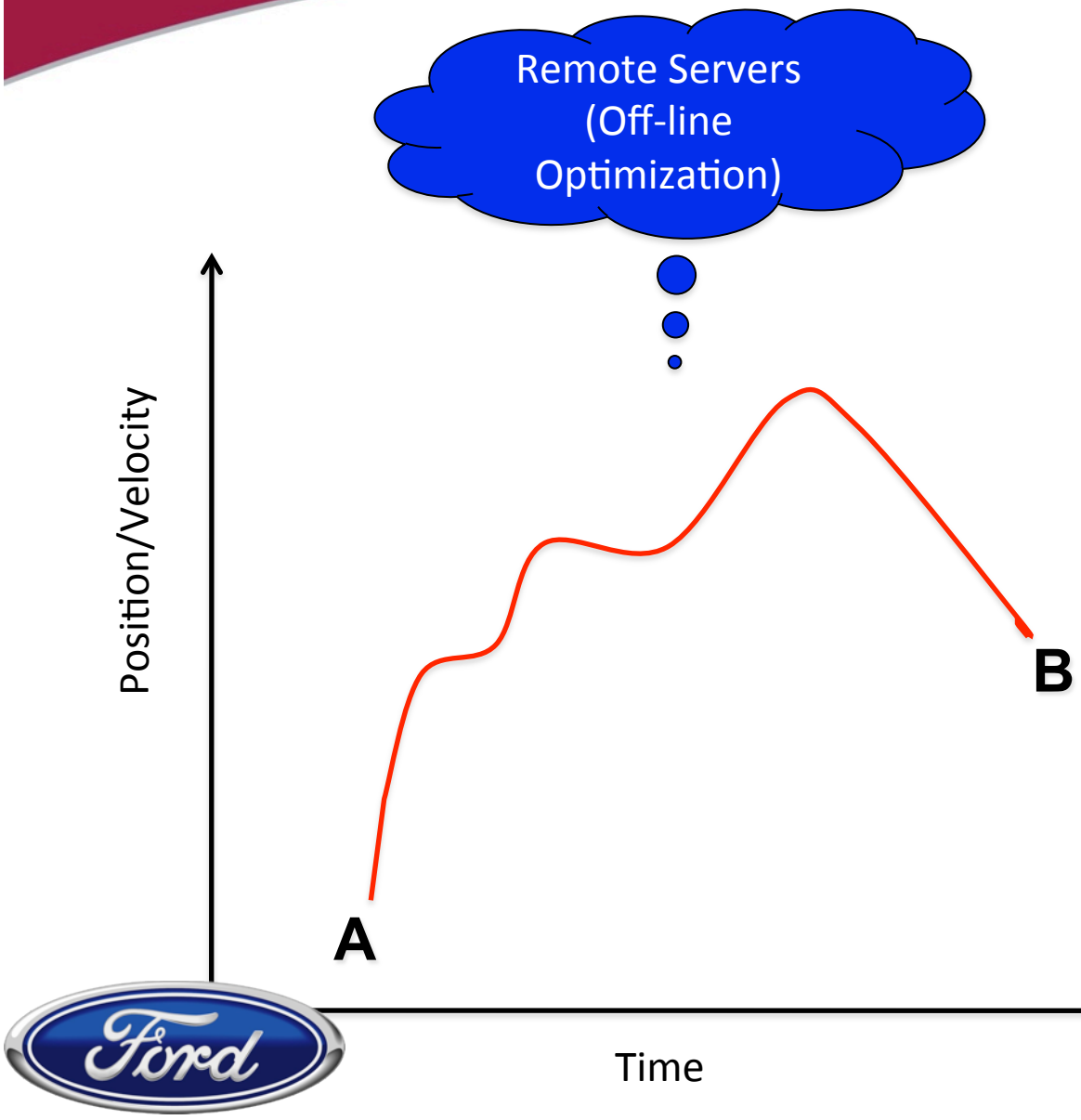
GPS

Charging

Traffic

- Fuel consumption optimization – background and methodology

Cloud Computing Problem Statement:



Objective:

Move the vehicle from position A to B minimizing fuel consumption over the trip.

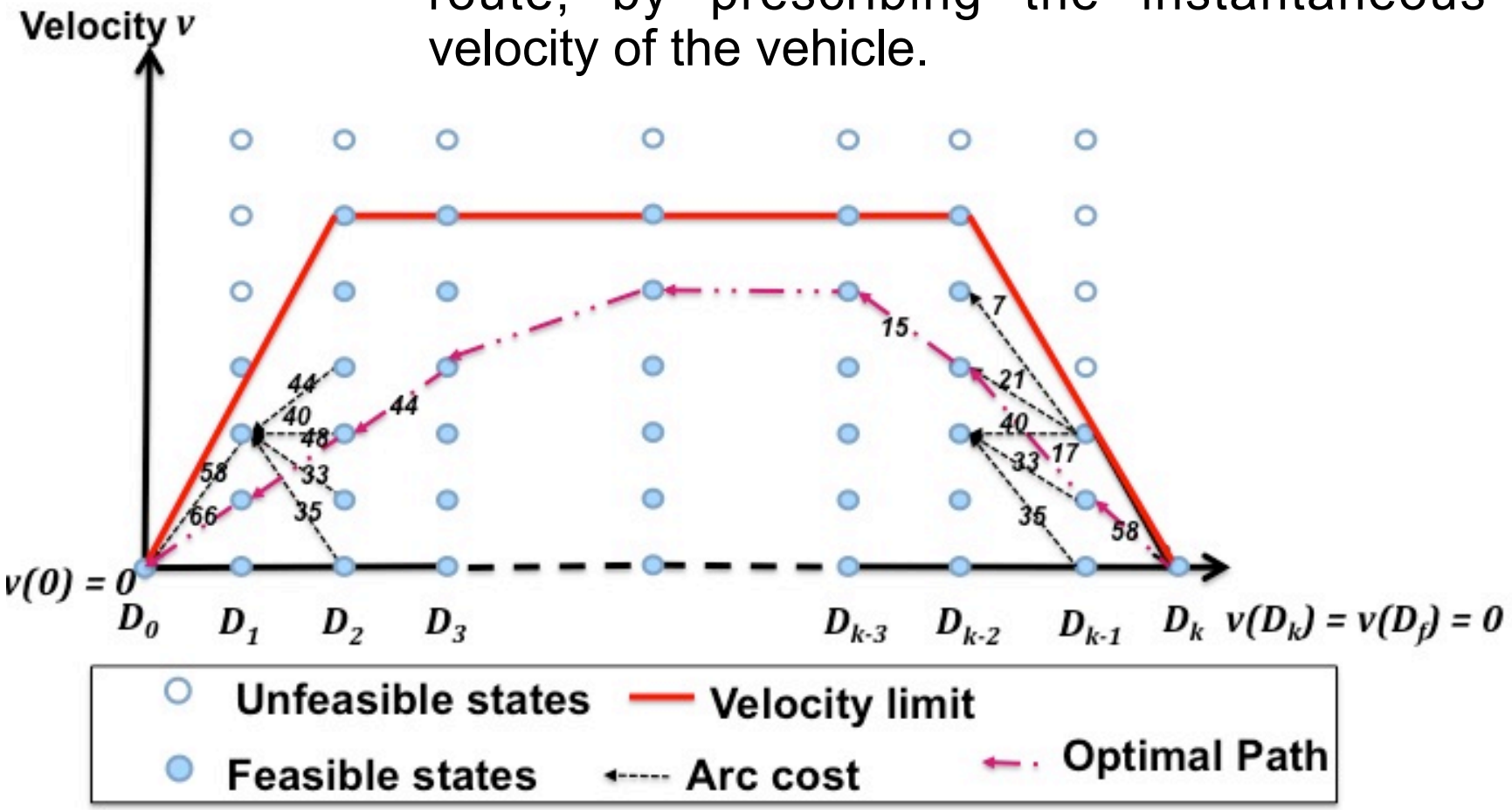
Process:

Build a velocity profile based upon the geometry and speed limits of the road stored in large databases.

To find the optimal solution to move the vehicle from position A to B, a vehicle simulator is used to solve a *dynamic programming* problem

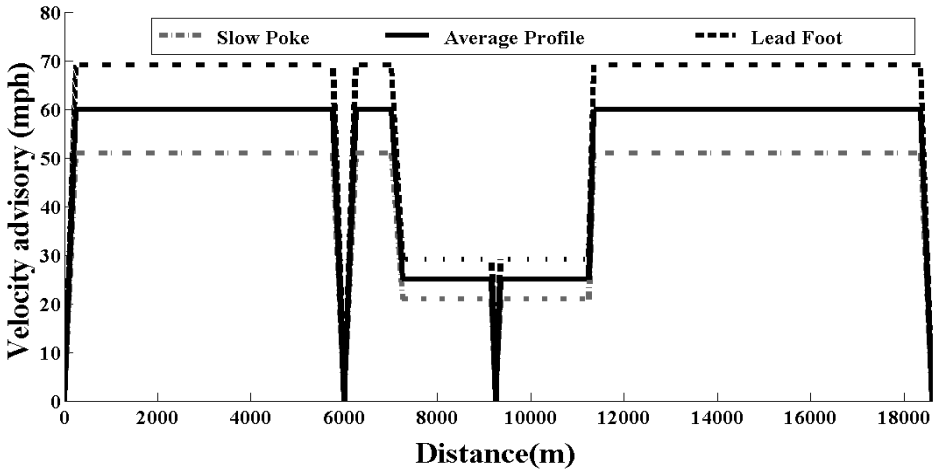
Dynamic Programming Optimization

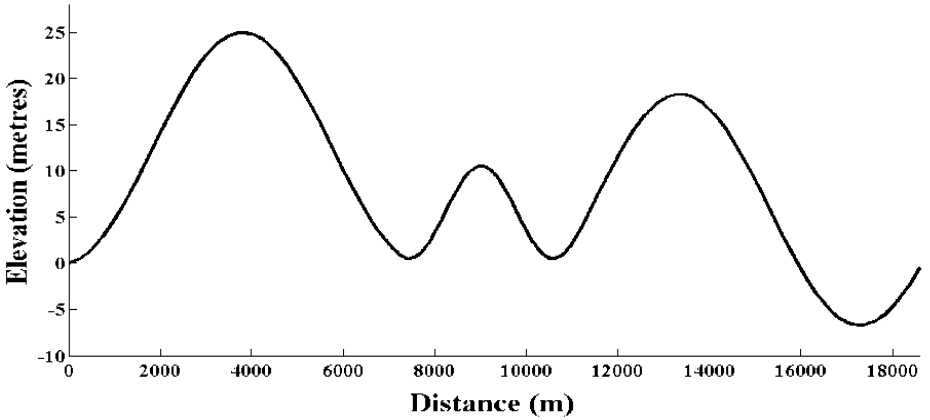
Minimize energy consumption over a known route, by prescribing the instantaneous velocity of the vehicle.



Siulated Driving Scenario A

Highway-Urban Driving profile composed of 2 highway segments followed by urban and highway segments (6km, 1.25km, 4km and 7.35km, respectively) with non-zero road grade.

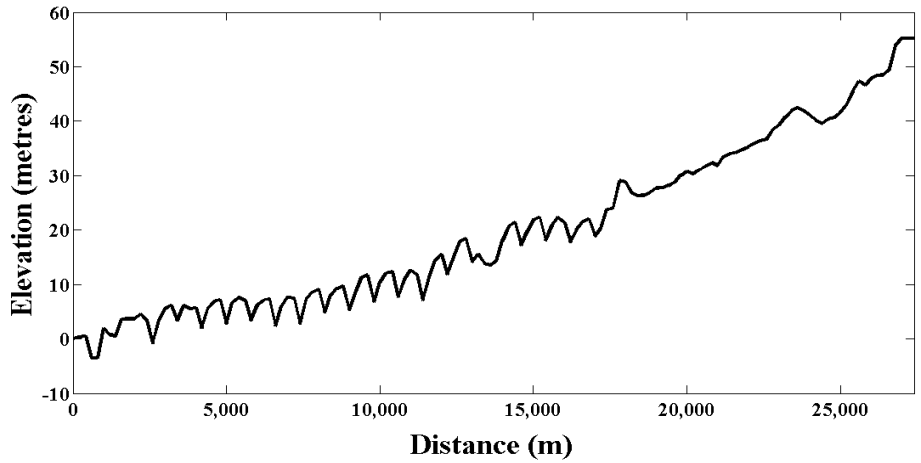




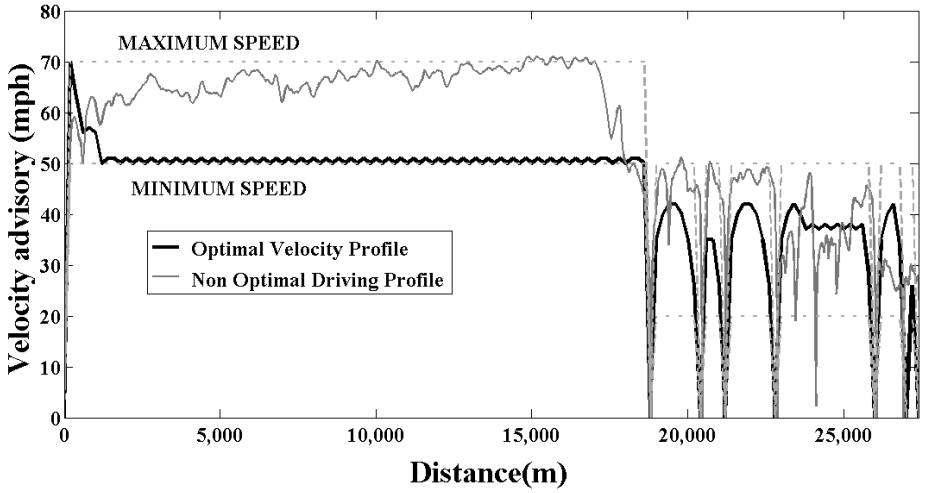
Case Study	Additional Fuel Consumed (relative to optimal)
Slow Poke	+ 17.5 %
Average Profile	+ 23.2 %
Lead Foot	+ 27.1 %

Simulated Driving Scenario B

Actual driving profile with real grade data. It is composed of an 18.8km highway segment followed by 8.6km urban segment with multiple stops events and road elevation.



Case Study	Additional Fuel Consumed	Trip Duration (seconds)
Optimal Profile	-	1578
Slow Poke	+ 8.2 %	2026
Average Profile	+ 10.2 %	1428
Lead Foot	+ 29.2 %	1132
Actual Driving	+ 23.9 %	1462



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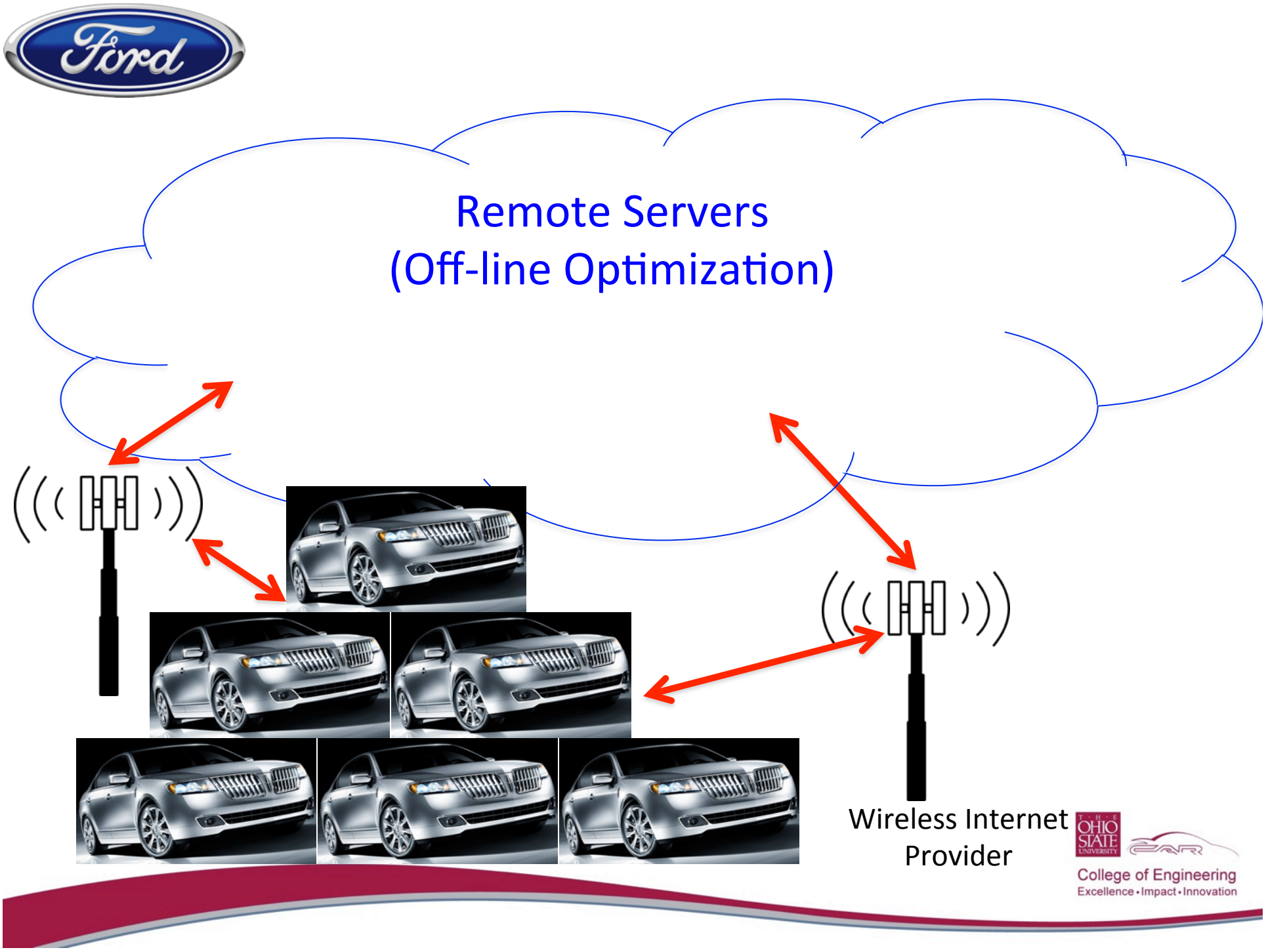
- Vehicle Implementation


Remote Servers
(Off-line Optimization)
Wireless Internet
Provider
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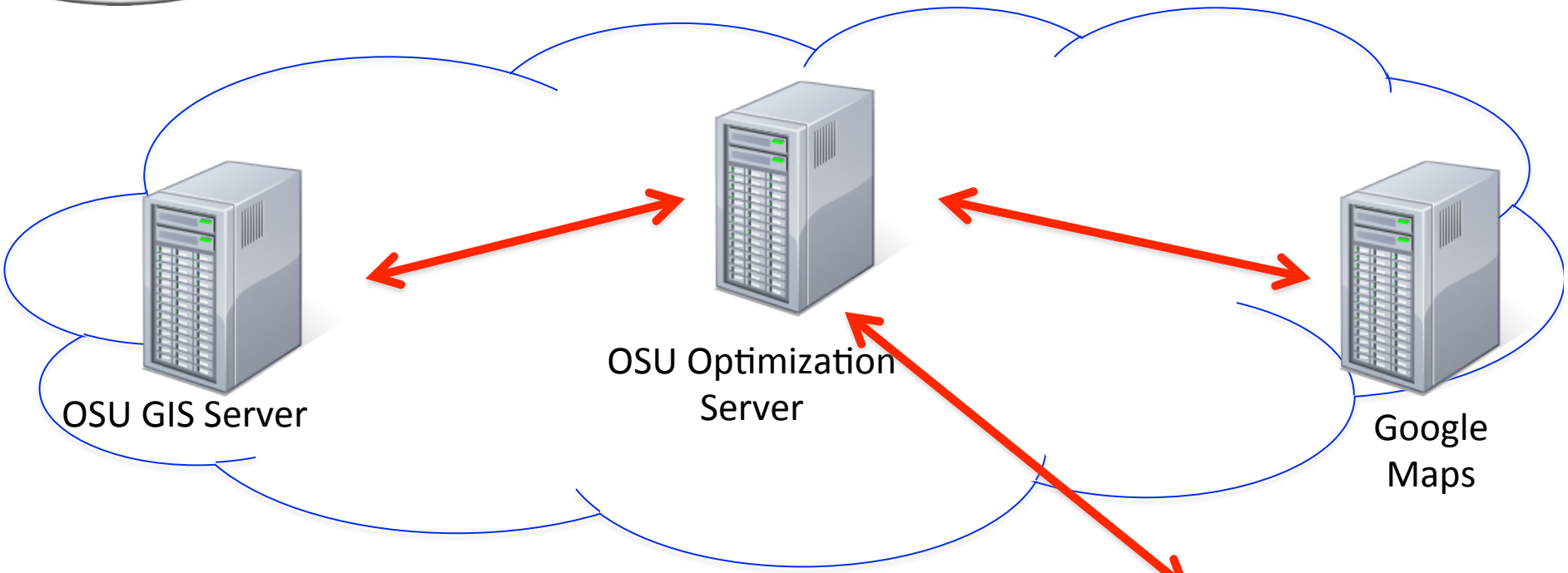
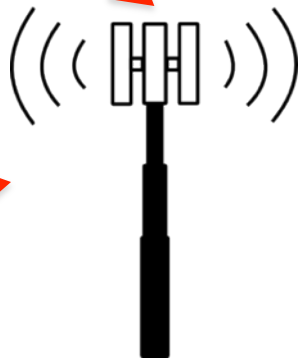


Vehicle equipped with:
Laptop
Small Display
GPS Receiver
CAN-to-USB Dongle



Wireless Internet Provider

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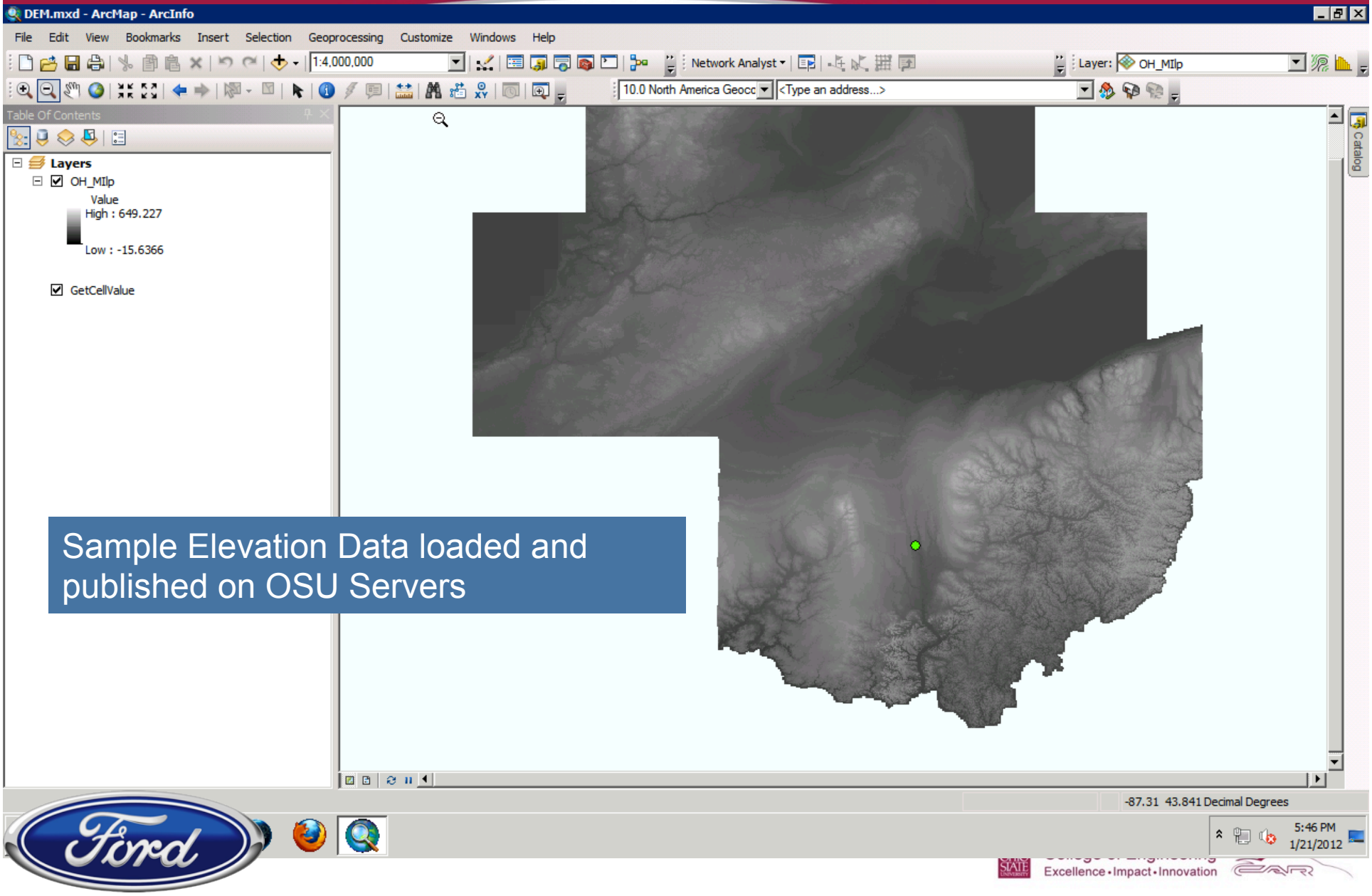
OSU ArcGIS Server

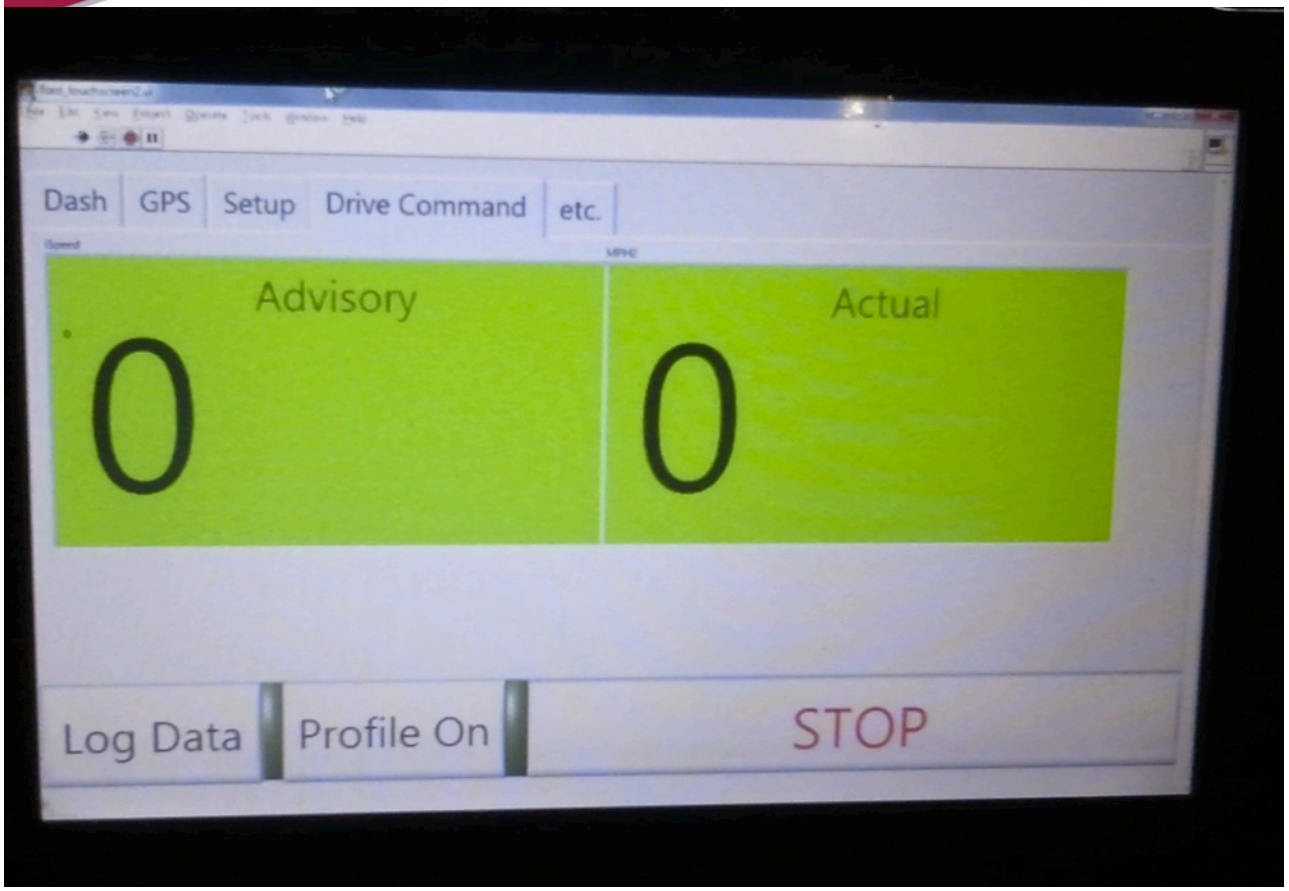
- GIS: Geographic Information Systems
- ArcGIS software is licensed and set up on a server @ CAR
  - Geographic information from:
    - USGS (United States Geological Survey)-Provided DEM data of the entire US
      - 3 meter resolution of Ohio
      - 10 meter resolution of Continental US
  - Total database size of elevation data: 700 GB

ArcGIS Elevation Database



Sample Elevation Data loaded and published on OSU Servers

Driver Interface



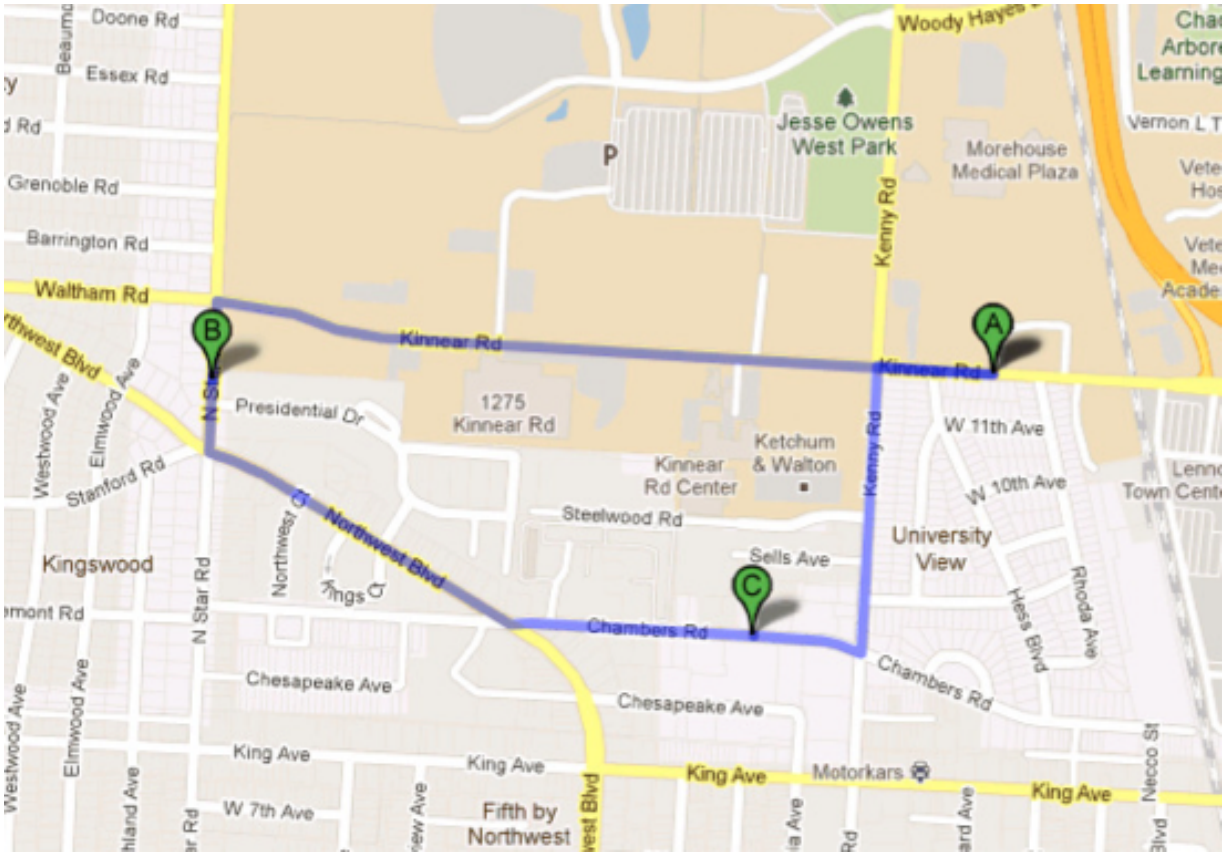
Colors Change Based on Driver behavior:

RED: Going too fast-SLOW down

WHITE: Within Target Range

GREEN: Going too slow-SPEED up

Trial Calibration Loop around CAR



1. System was given the waypoints A, B, and C
2. Google Routing algorithm decides upon a route and transmits coordinates to OSU servers over the internet.
3. Communicate with OSU GIS server and get elevations.
4. Run Optimization

Total Trip Distance ≈ 2.2 Miles

This route will be used for

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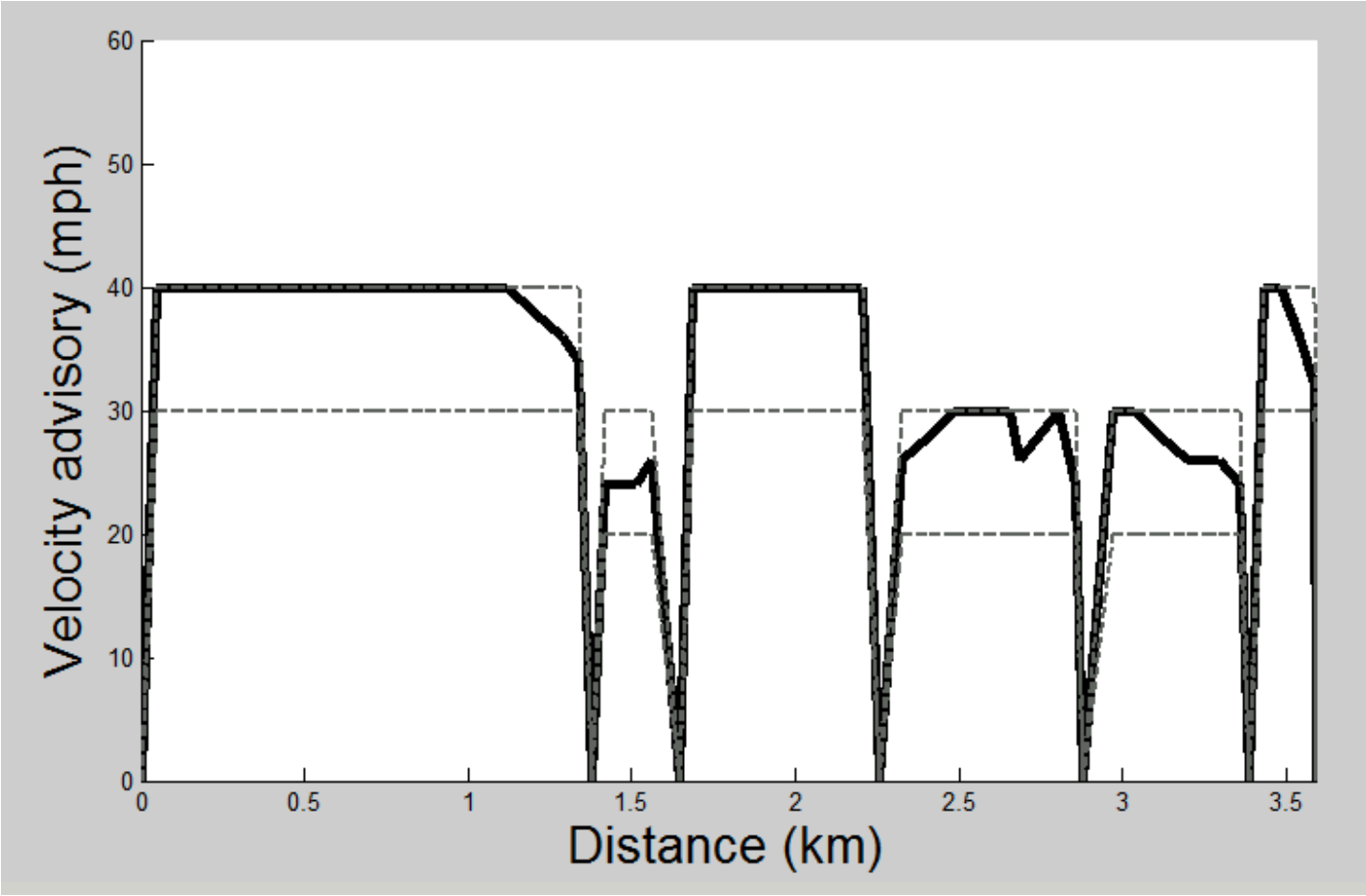
Optimal Profile



Profile was optimized using new Vehicle Model with a velocity Resolution = 2 MPH

Predicted MPG: 24.5

Conclusion

- Velocity planning: Through the solution of an optimization problem, we have generated an optimal velocity profile to minimize vehicle fuel consumption through cloud-based optimization.
- Future work includes implementing real-time road traffic information with the cloud-based optimization to recalculate the optimal velocity profile in real-time in response to external traffic disturbances.
- One of the key questions that will be addressed in future research is the scalability of this concept to large numbers of vehicles, and the implications with regard to wireless communications, computing and real-time requirements.


Thank you for your kind attention!
Questions?
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