URBAN MOBILITY IN CLEAN, GREEN CITIES

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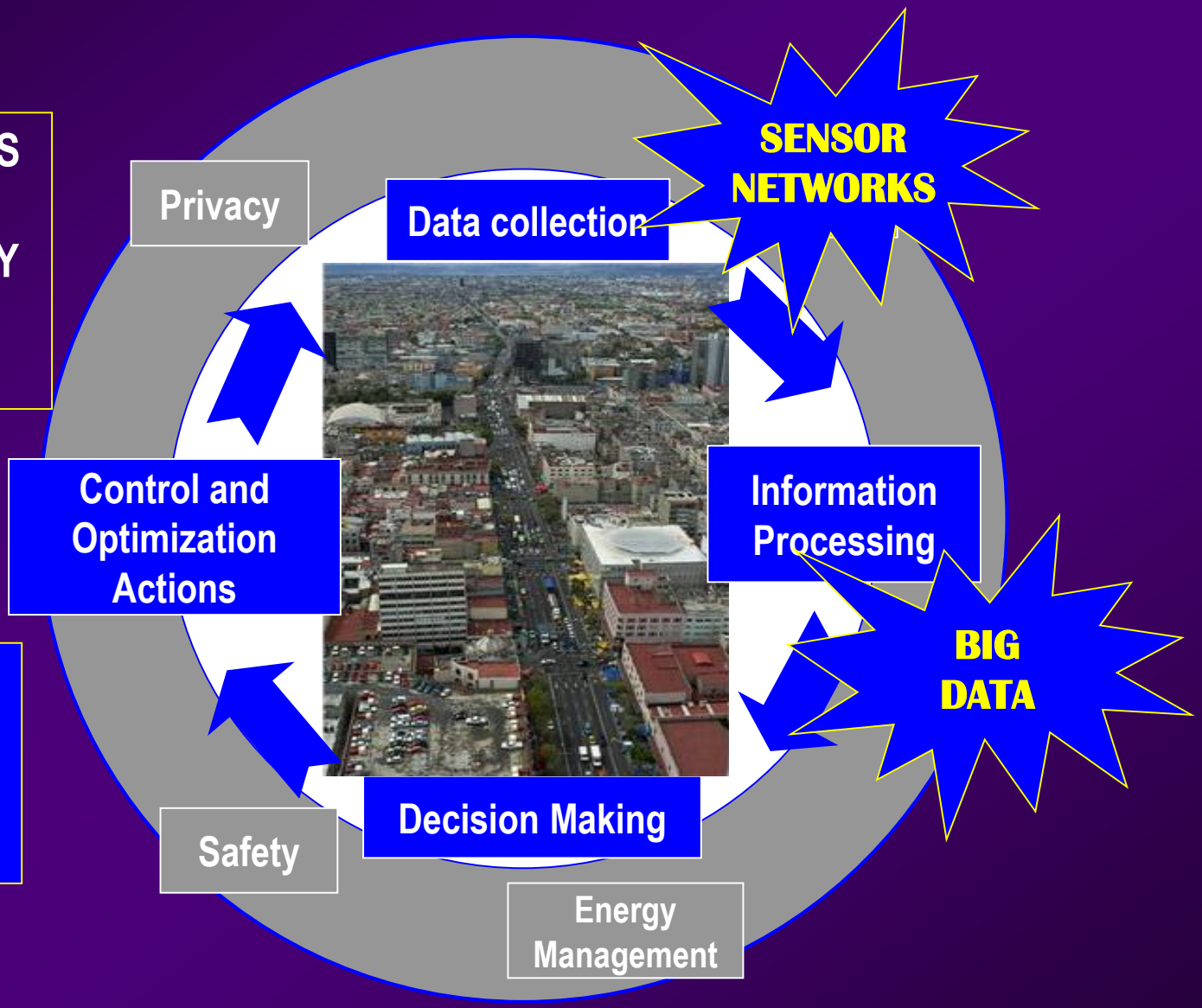
SMART CITY

COLLECTING DATA IS NOT "SMART" - JUST A NECESSARY STEP TO BEING "SMART"

PROCESSING DATA TO MAKE GOOD DECISIONS IS "SMART"



WHAT IS A "SMART CITY" ?

"A city well performing in a forward-looking way in [economy, people, governance, mobility, environment, and living] built on the smart combination of endowments and activities of self-decisive, independent and aware citizens."

Hitachi's vision for the Smart Sustainable City seeks to achieve concern for the global environment and lifestyle safety and convenience through the coordination of infrastructure. Smart Sustainable Cities realized through the coordination of infrastructures consist of two infrastructure layers that support consumers' lifestyles together with the urban management infrastructure that links these together using IT

Smart Sustainable Cities use information and communication technologies (ICT) to be more intelligent and efficient in the use of resources, resulting in cost and energy savings, improved service delivery and quality of life, and reduced environmental footprint--all supporting innovation and the low-carbon economy.

"We believe a city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance."

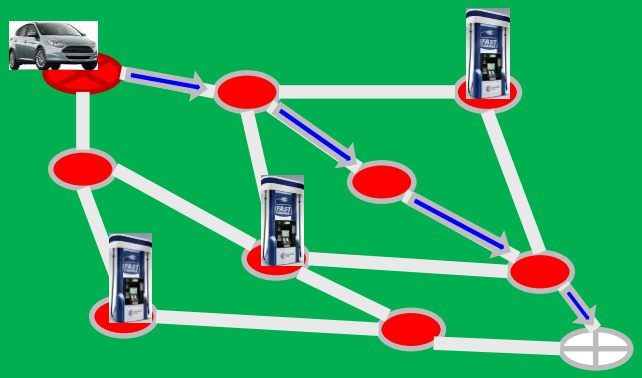
URBAN MOBILITY APPLICATIONS

SMART PARKING

2011 IBM/IEEE Smarter Planet Challenge prize

Finds optimal parking space for driver
+ reserves it

ELECTRIC VEHICLE (EV) ROUTING AND RECHARGING



Optimally routes EVs to minimize travel times
+ finds optimal charging station + reserves it

URBAN MOBILITY APPLICATIONS

TRAFFIC CONTROL

Exploit "connected vehicles" technology:
from (selfish) "driver optimal" to
"system optimal" traffic control

TRAFFIC LIGHTCONTROL

Real-time, data-driven dynamic traffic light control:

- **Alleviate congestion**
- **Reduce pollution and fuel waste**

URBAN MOBILITY APPLICATIONS

STREET BUMP

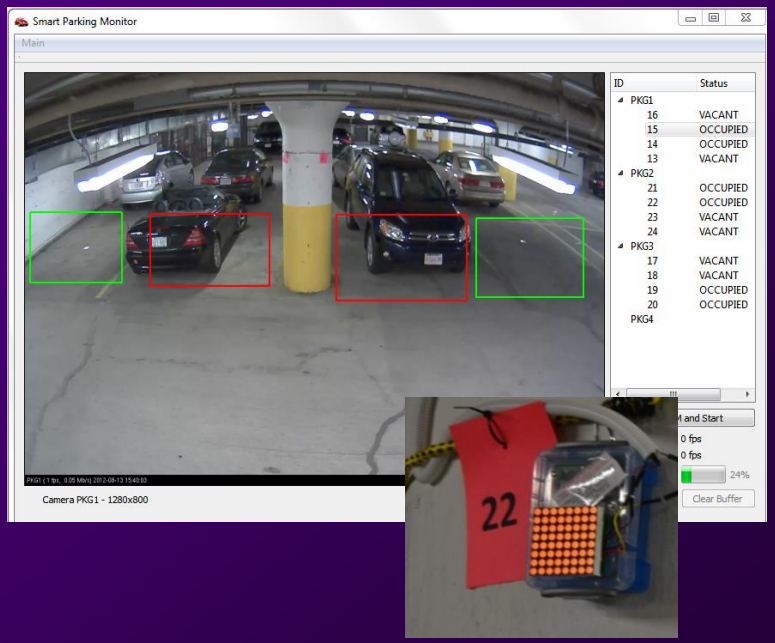
2014 IBM/IEEE Smarter Planet Challenge prize

Detect roadway "bumps" + classify them + prioritize and dispatch crews

Used in Boston

SMART PARKING

iPhone app



SMART PARKING

30% of vehicles on the road in the downtowns of major cities are cruising for a parking spot. It takes the average driver 7.8 minutes to find a parking spot in the downtown core of a major city.

R. Arnott, T.Rave, R.Schob, *Alleviating Urban Traffic Congestion.* 2005

GUIDANCE-BASED PARKING – DRAWBACKS…

Drivers:

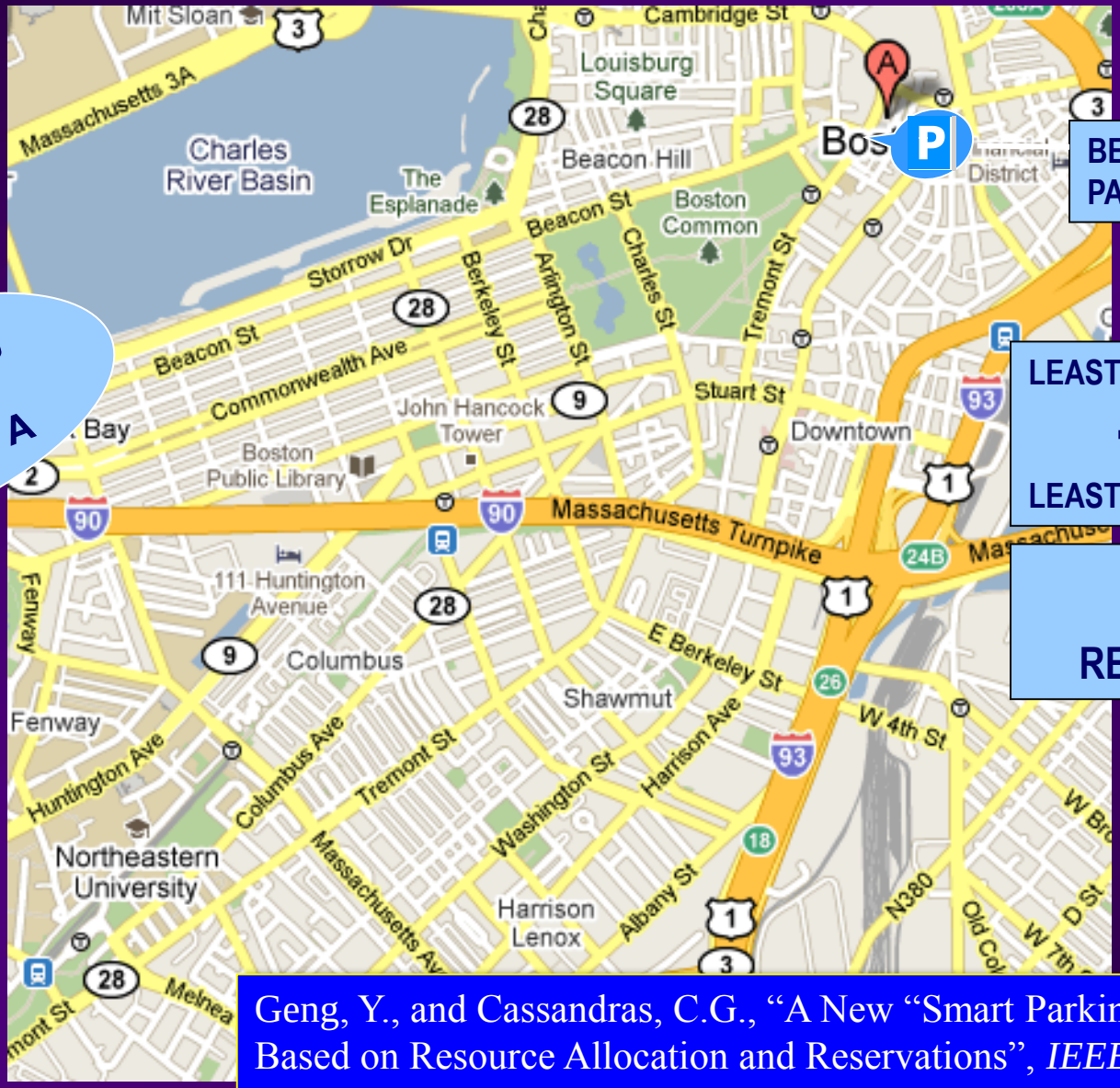
- May not find a vacant space
- May miss better space
- Processing info while driving

City:

- Imbalanced parking utilization
- May create ADDED CONGESTION (as multiple drivers converge to where a space exists)

Searching for parking ⇒ Competing for parking

SMART PARKING



Find best parking spot for DESTINATION **A**

BEST PARKING SPOT

LEAST DISTANCE from A

+

LEAST COST

+

RESERVE IT

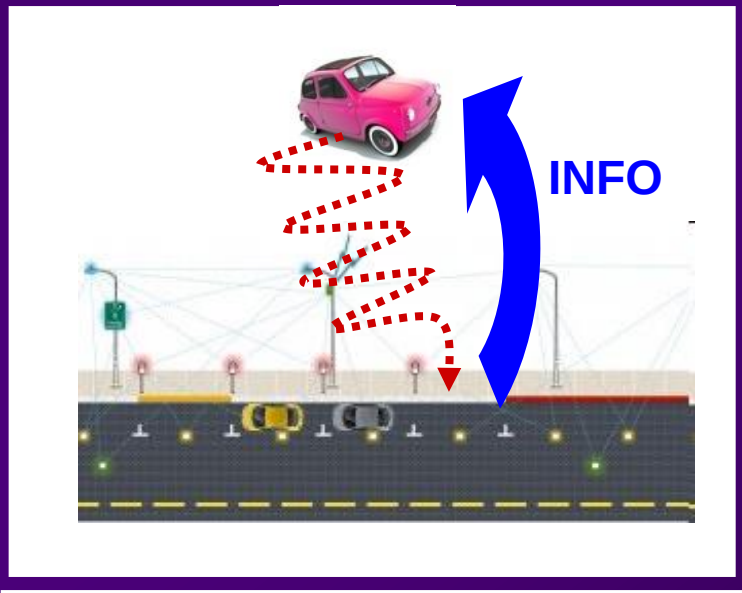
Geng, Y., and Cassandras, C.G., "A New "Smart Parking" System Based on Resource Allocation and Reservations", *IEEE Trans. on Intelligent Transportation Systems*, Vol. 14, 3, pp. 1129-1139, 2013.

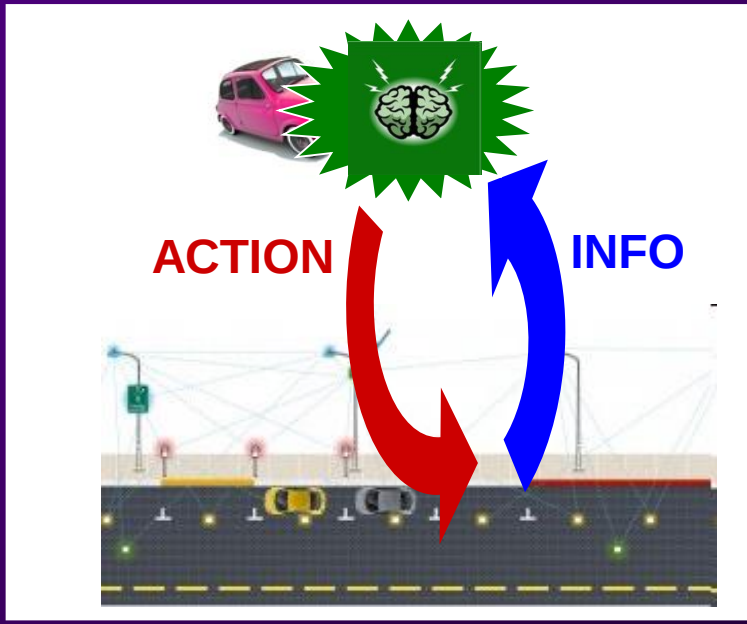
WHAT IS *REALLY* "SMART" ?

COLLECTING DATA IS NOT "SMART"

- JUST A NECESSARY STEP TO BEING "SMART"

PROCESSING DATA TO MAKE GOOD DECISIONS IS "SMART"





SMART PARKING - IMPLEMENTATION

- *2011 IBM/IEEE*

***Smarter Planet Challenge** competition,*

2nd place prize

- *Best Paper/Best Poster Awards*

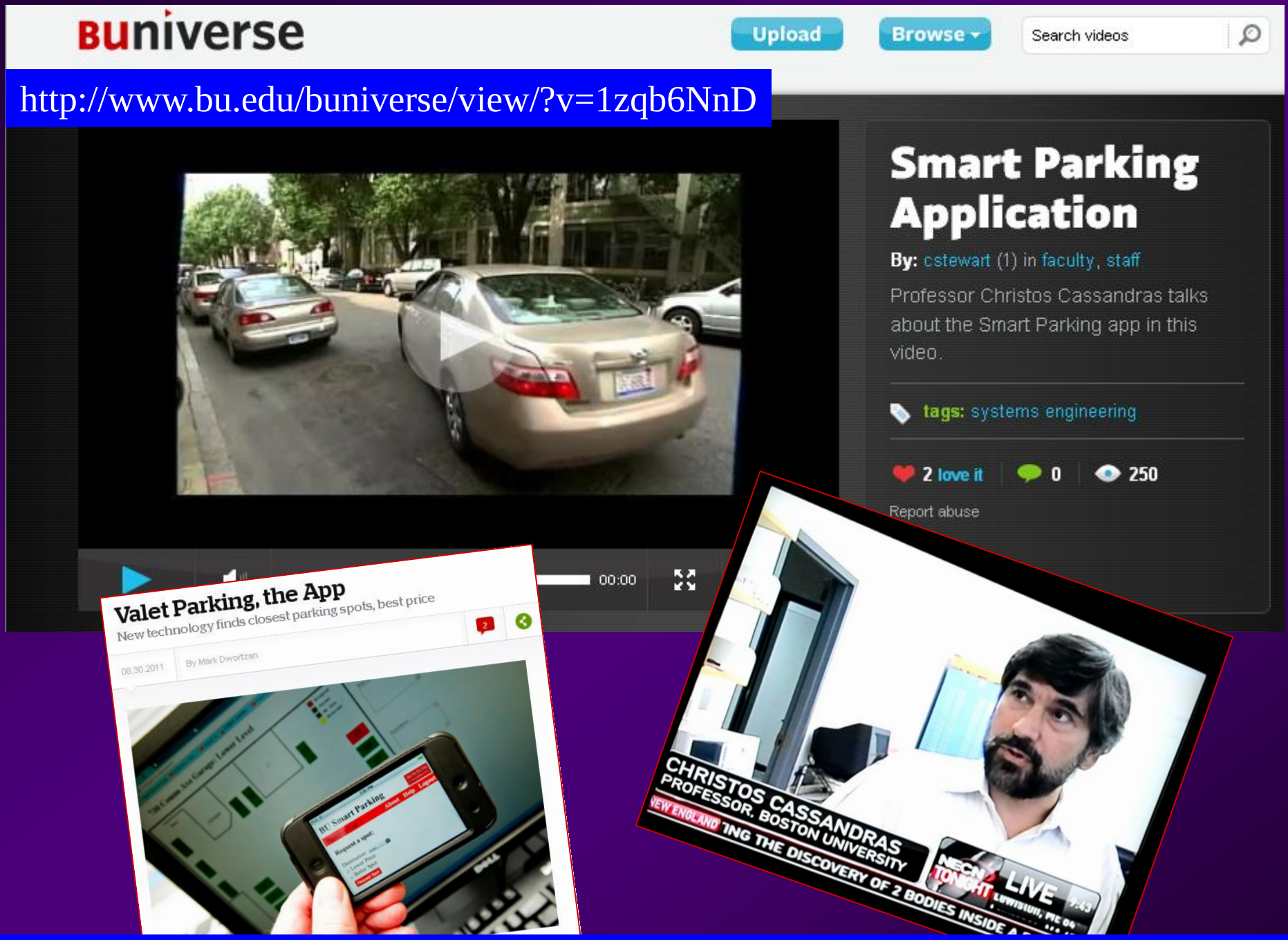
http://smartpark.bu.edu/smartparking_ios6/login.php

Currently in operation at BU garage

(with Smartphone app:

***BU Smart Parking*)**

http://www.bu.edu/buniverse/view/?v=1zqb6NnD



http://www.necn.com/09/23/11/JoeBattParkingapp/landing_scitech.html?blockID=566574&feedID=4213

STREET BUMP: DETECTING "BUMPS" THROUGH SMARTPHONES + "BIG DATA" METHODS

iPhone app

STREET BUMP – PROCESSING "BIG DATA"

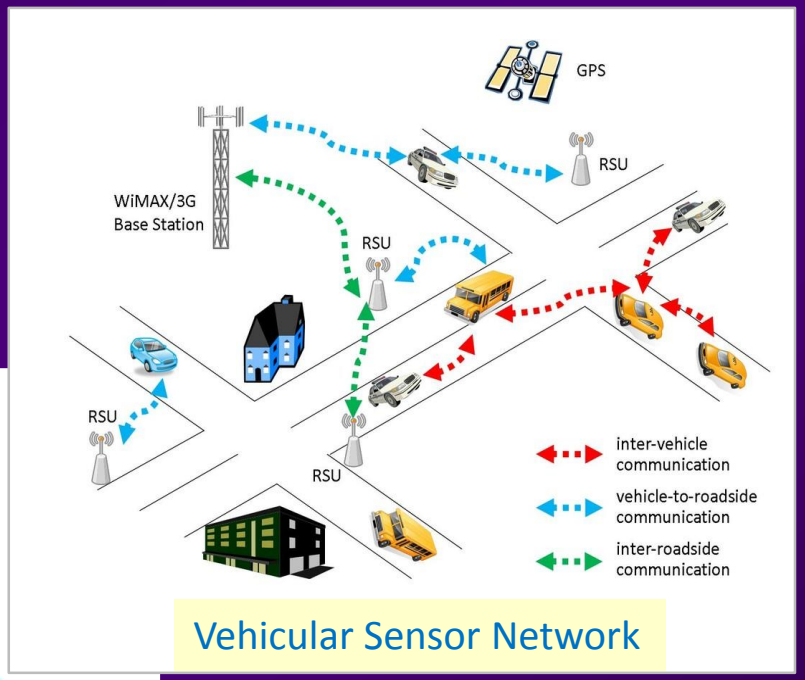
- Detect obstacles using iPhone accelerometer and GPS
- Send to central server through StreetBump app
- Process data to classify obstacles:
  - Anomaly detection and clustering algorithms, similar to cybersecurity problems
- Detect "actionable" obstacles
- Prioritize and dispatch crews to fix problems

LET THE DATA SPEAK: LESS $$ HARDWARE, MORE INTELLIGENCE

TRADITIONAL SENSING:
Expensive (hence, few) very reliable sensors

vs

MODERN TREND:
Many cheap sensors +
Intelligent
Information Processing



Vehicular Sensor Network

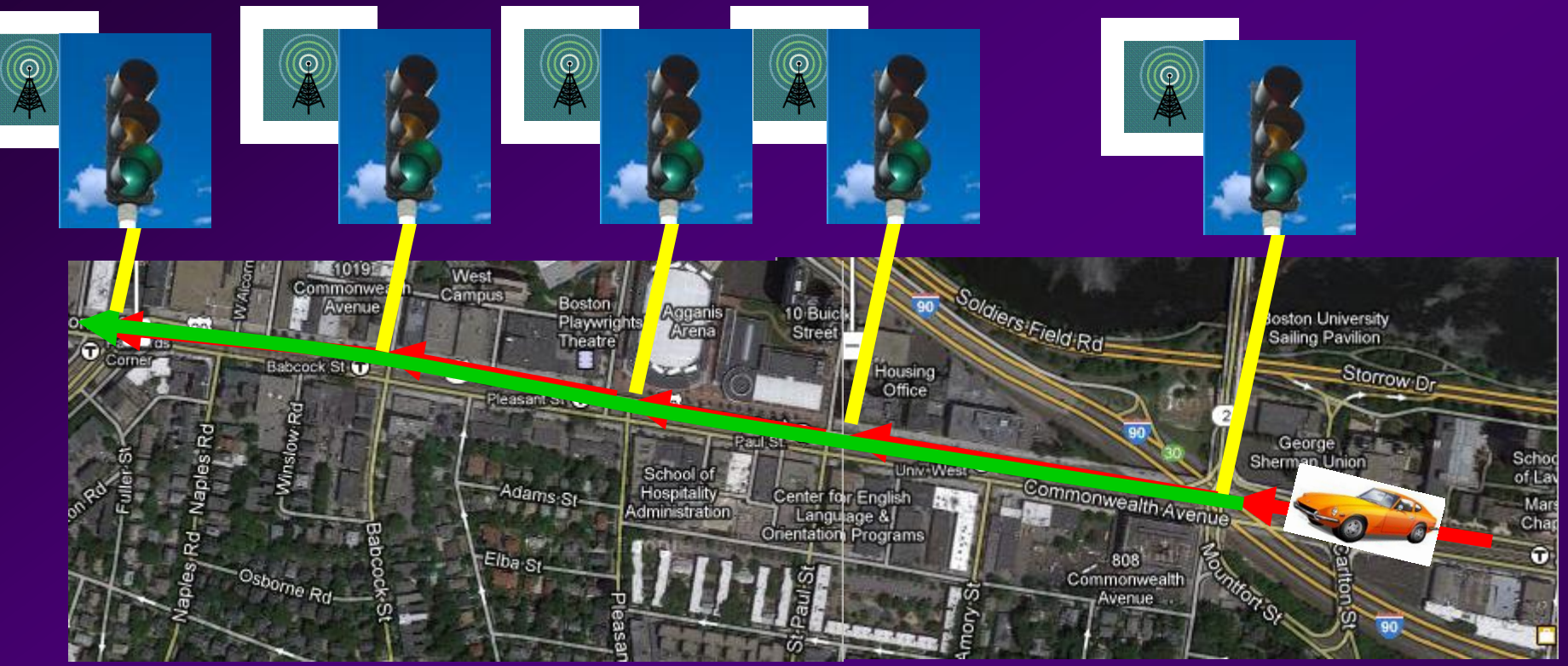
- Minimal (or No) Infrastructure
- Minimal Cost
- Better Coverage: Crowd Sourcing
- Faster Repairs

Citizen Participation !

Incentives for further citizen participation
('thank you' message, free city services, lotteries)

ADAPTIVE TRAFFIC LIGHT CONTROL

REAL-TIME TRAFFIC CONTROL



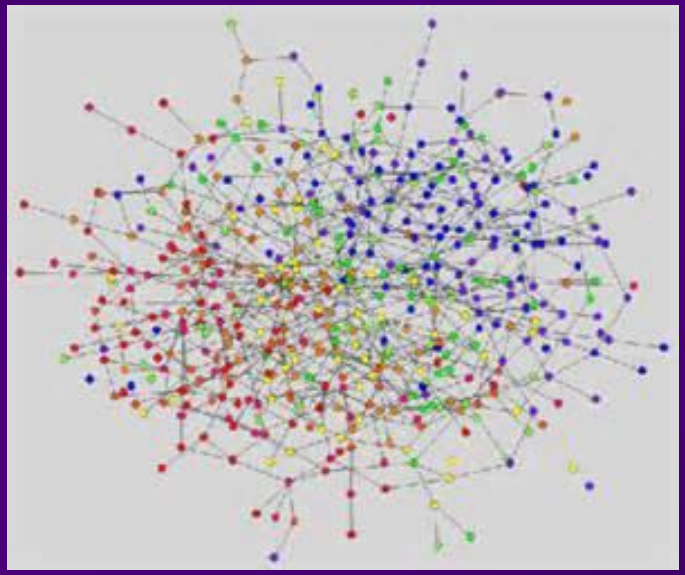
- Automatically adapt red/green light cycles based on observed data
- Predict and alleviate congestion over entire urban network
- Reduce waiting times, congestion
- Reduce pollution and fuel waste

TRAFFIC CONTROL

The BU Bridge mess, Boston, MA (simulation using VISSIM)

WHY CAN'T WE IMPROVE TRAFFIC…

… EVEN IF WE KNOW THE ACHIEVABLE OPTIMUM IN A TRAFFIC NETWORK ???



Because:

- **Not enough controls** (traffic lights, tolls, speed fines)

  → No chance to use feedback

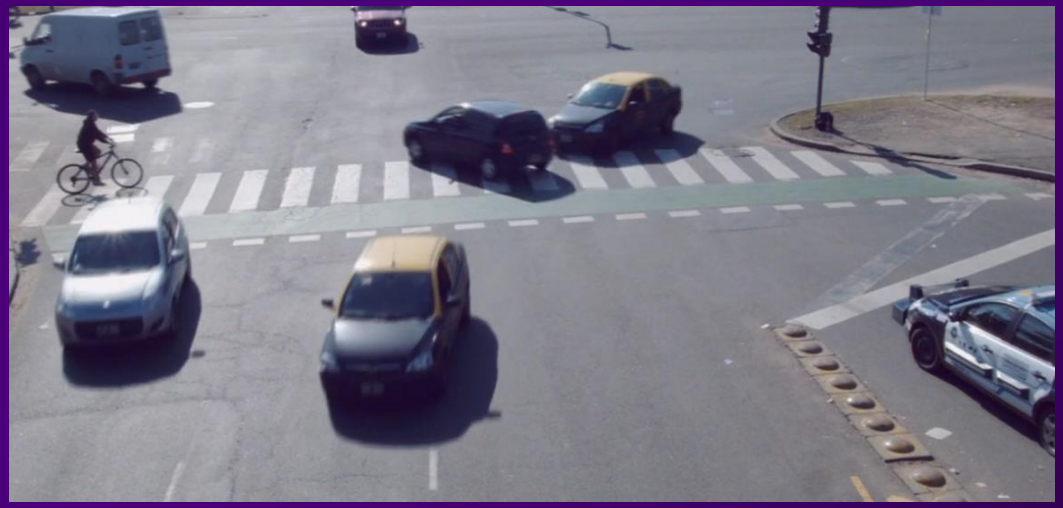
- **Not knowing other drivers' behavior** leads to poor decisions (a simple game-theoretic fact)

  → Drivers seek individual (**selfish**) optimum,
  not system-wide (**social**) optimum

CONNECTED AUTOMATED VEHICLES (CAVs)

NO TRAFFIC LIGHTS, NEVER STOP…

Exploit “connected vehicles” technology

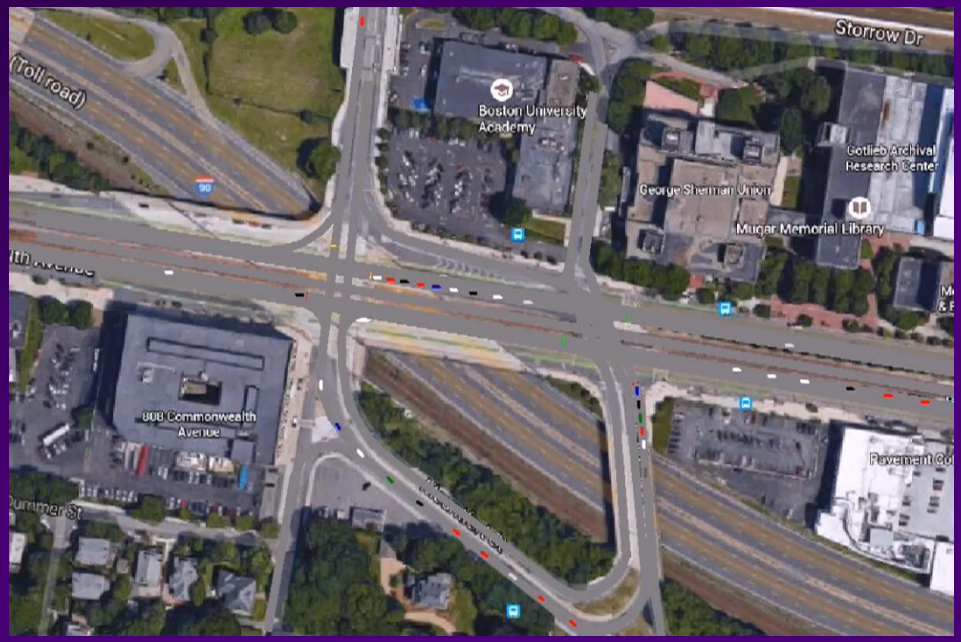


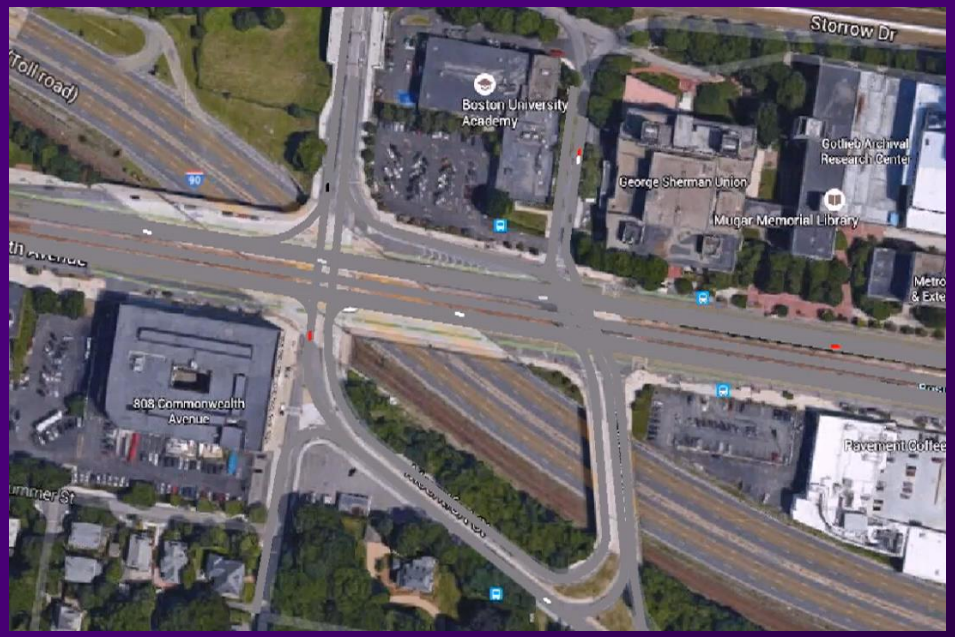
WHO NEEDS TRAFFIC LIGHTS ?

With traffic lights

With decentralized optimal control of CAVs

[Zhang, Malikopoulos, Cassandras, *ACC*, 2016]

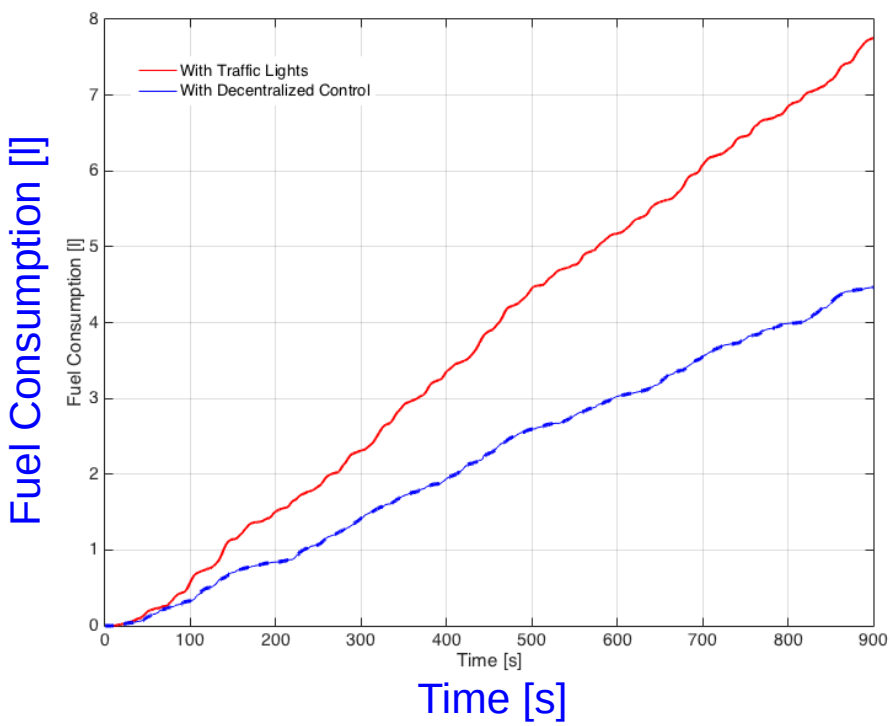


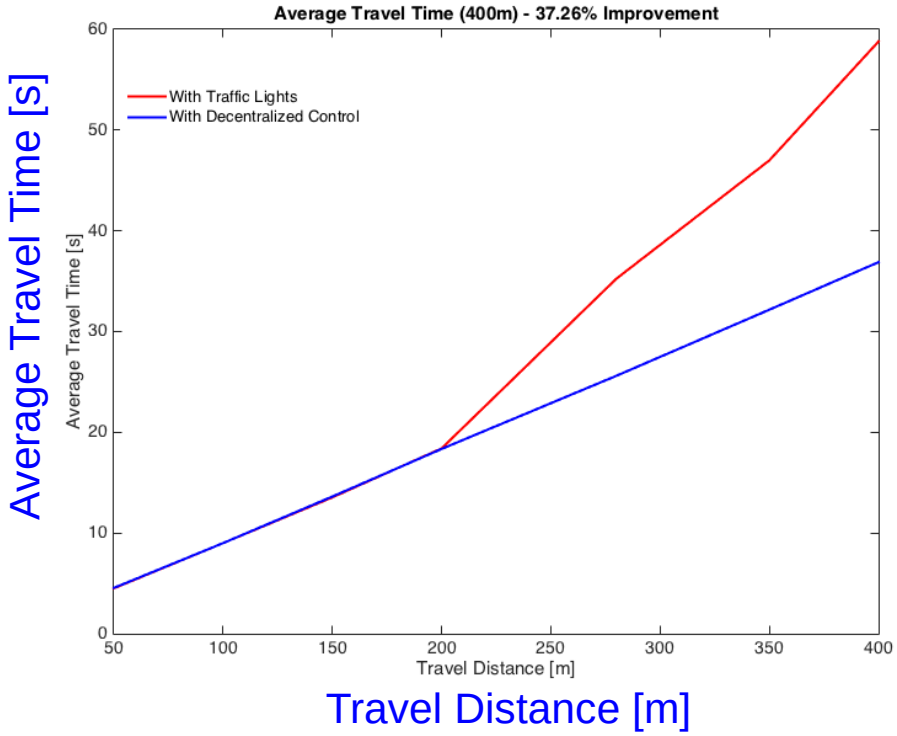


IMPACT ON FUEL CONSUMPTION AND TRAVEL TIMES

- **448 vehicles** crossed the intersection
- **Fuel consumption 42%** improvement
- **Travel time 37%** improvement

WIN-WIN





SCOPE: Smart-city Cloud-based Open Platform and Ecosystem (Mass + NSF + Corp. Partners)