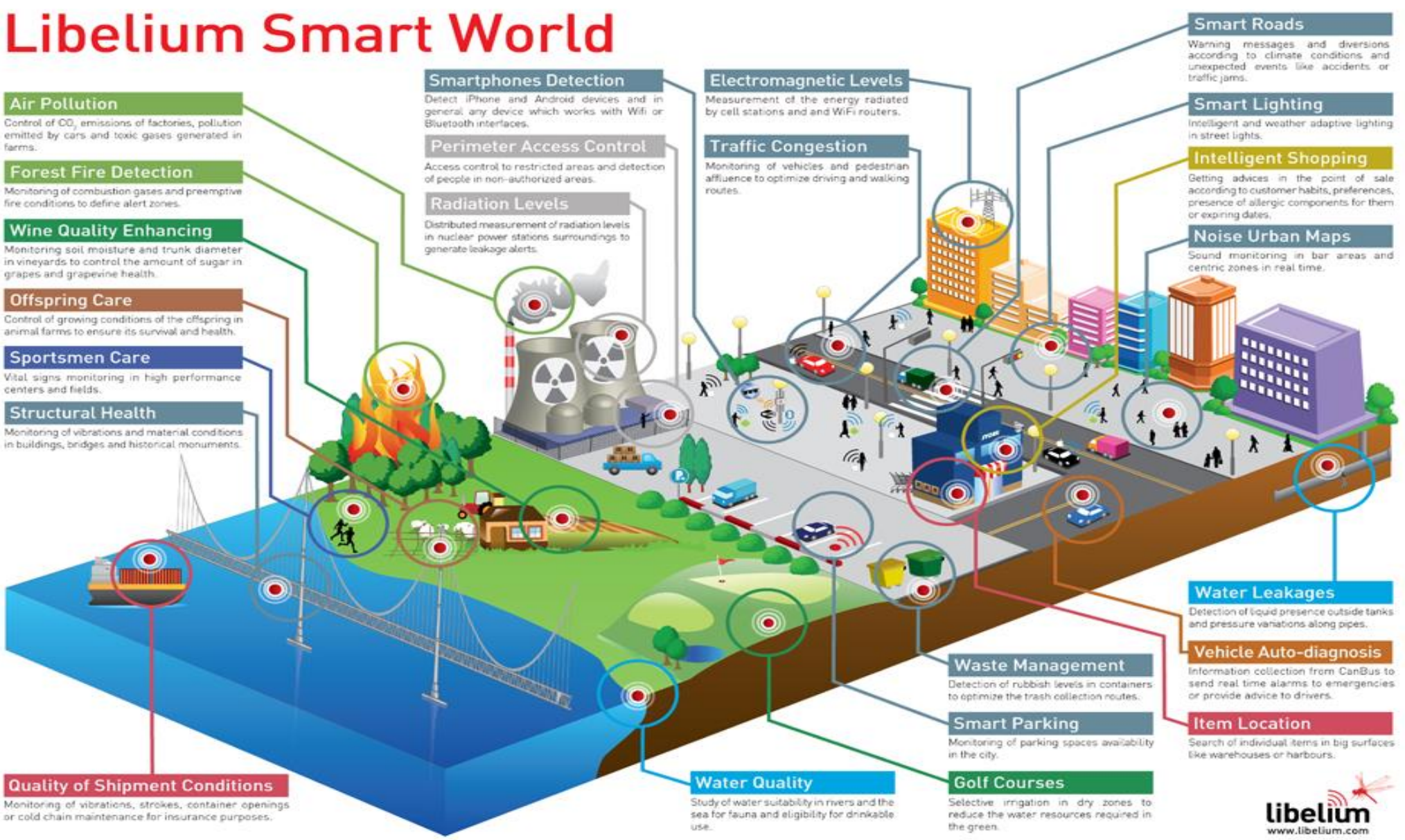
Transportation Analytics

Sanjay Ranka

University of Florida

February 9, 2017

The world around us is getting smarter



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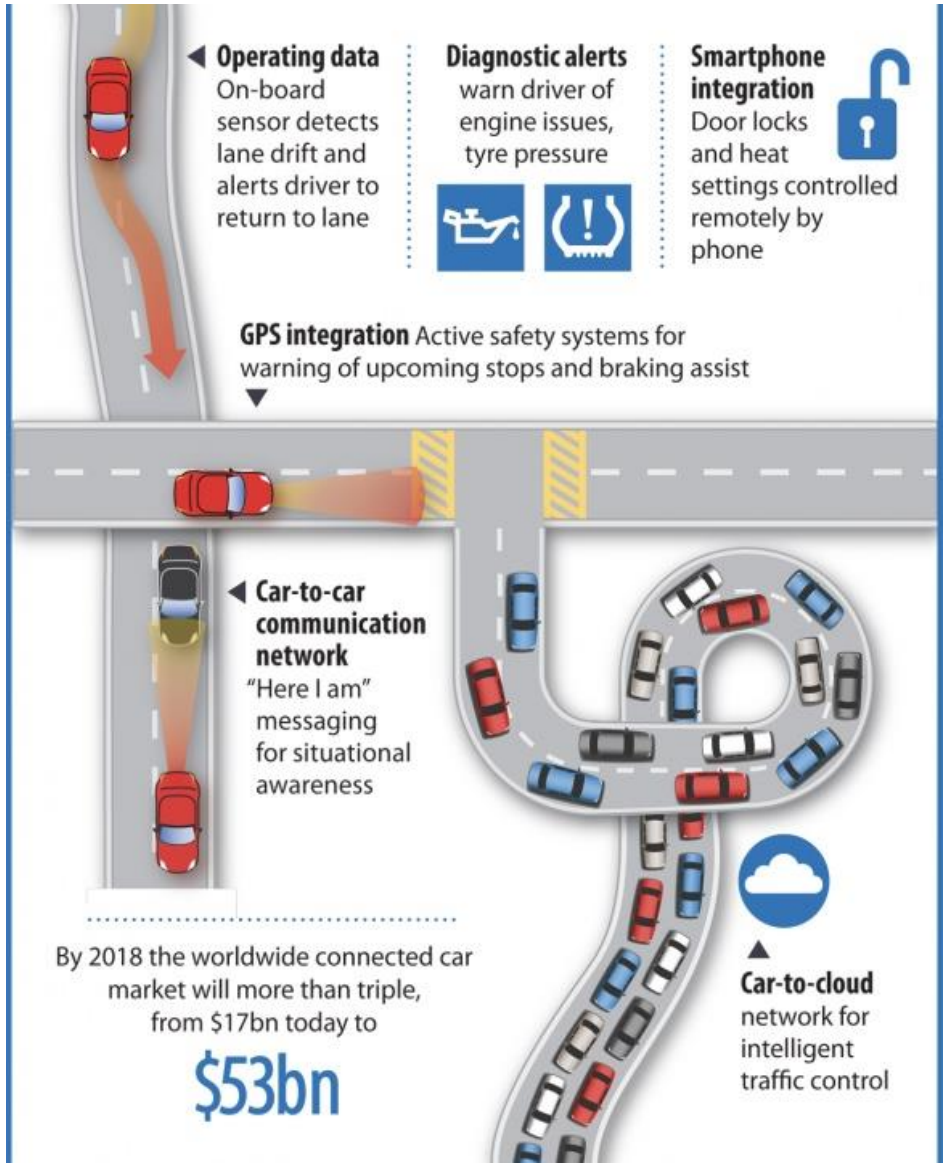
Vehicles are getting more Connected and Automated



Source: http://gelookahead.economist.com/infograph/car-os/

Source: Peter Runcie, CSIRO peter.runcie@data61.csiro.au

Transportation Infrastructure is going through a revolution

Source: USDOT

Source: USDOT

Source: USDOT

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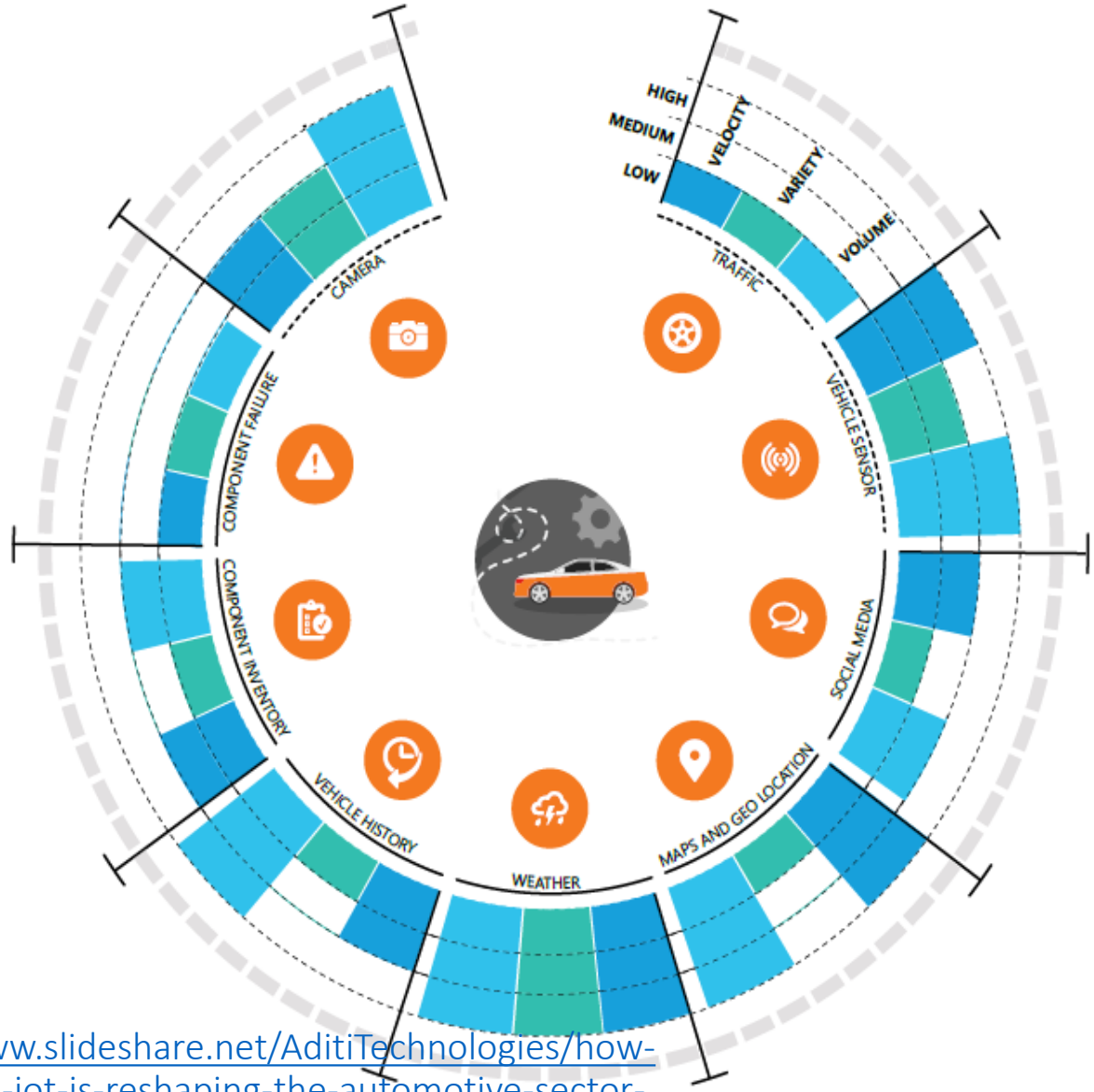
Speed and Volume of Data is increasing

Volume and speeds at which data today is generated, processed and stored will fundamentally alter the transport sector.

- The combination of low-cost sensors, low cost storage devices and new data mining and machine learning algorithms will provide significantly more detailed representations of reality.
- Sensors, data storage and communication capacity in automated and connected vehicles will provide enhanced safety.

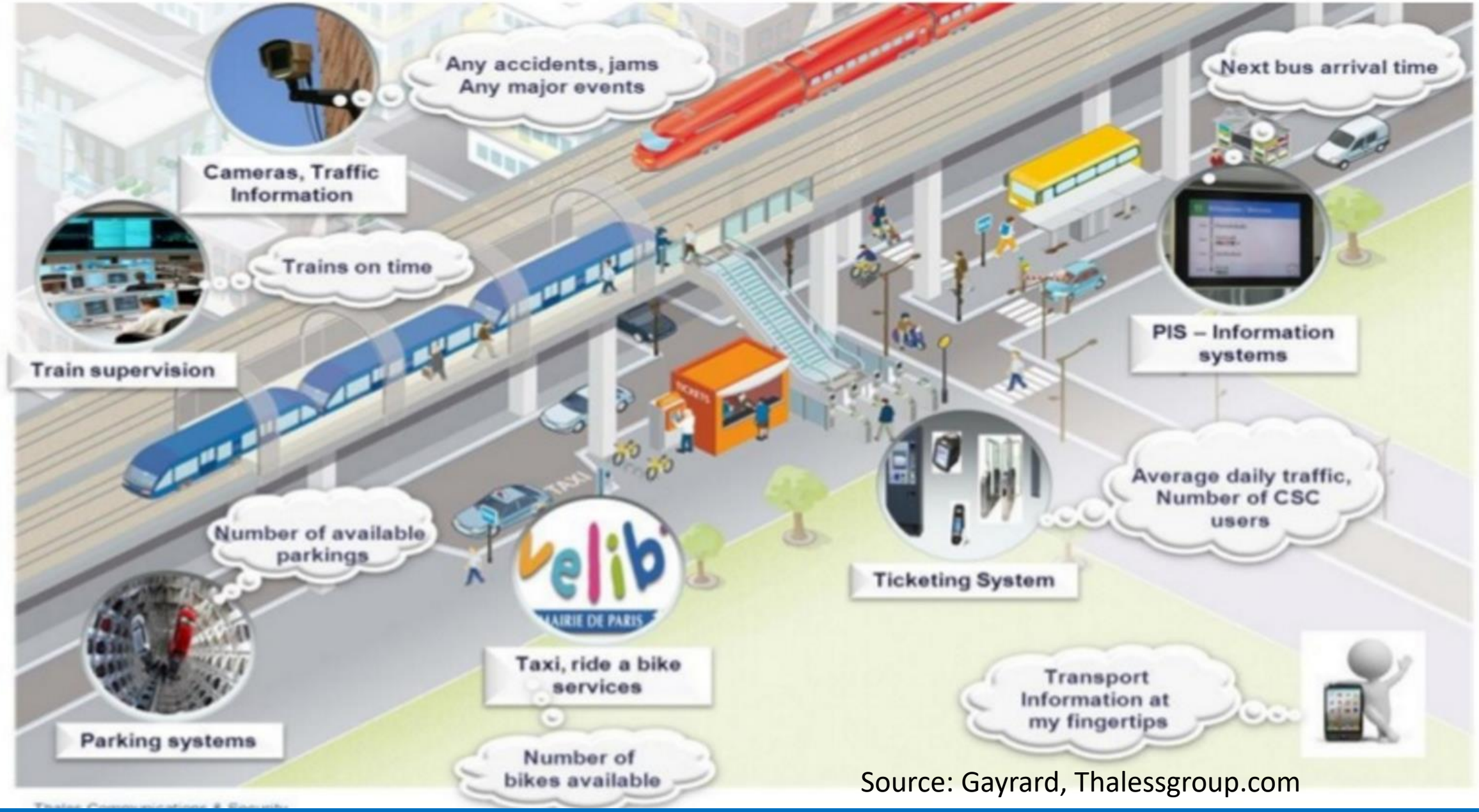
Accuracy of data will be significantly improved by Mobile sensing technologies

- Precisely locate and track people within precision of a few inches in both outdoor and indoor environments.
- Similar technologies can be built into vehicles, enabling precise and persistent tracking.



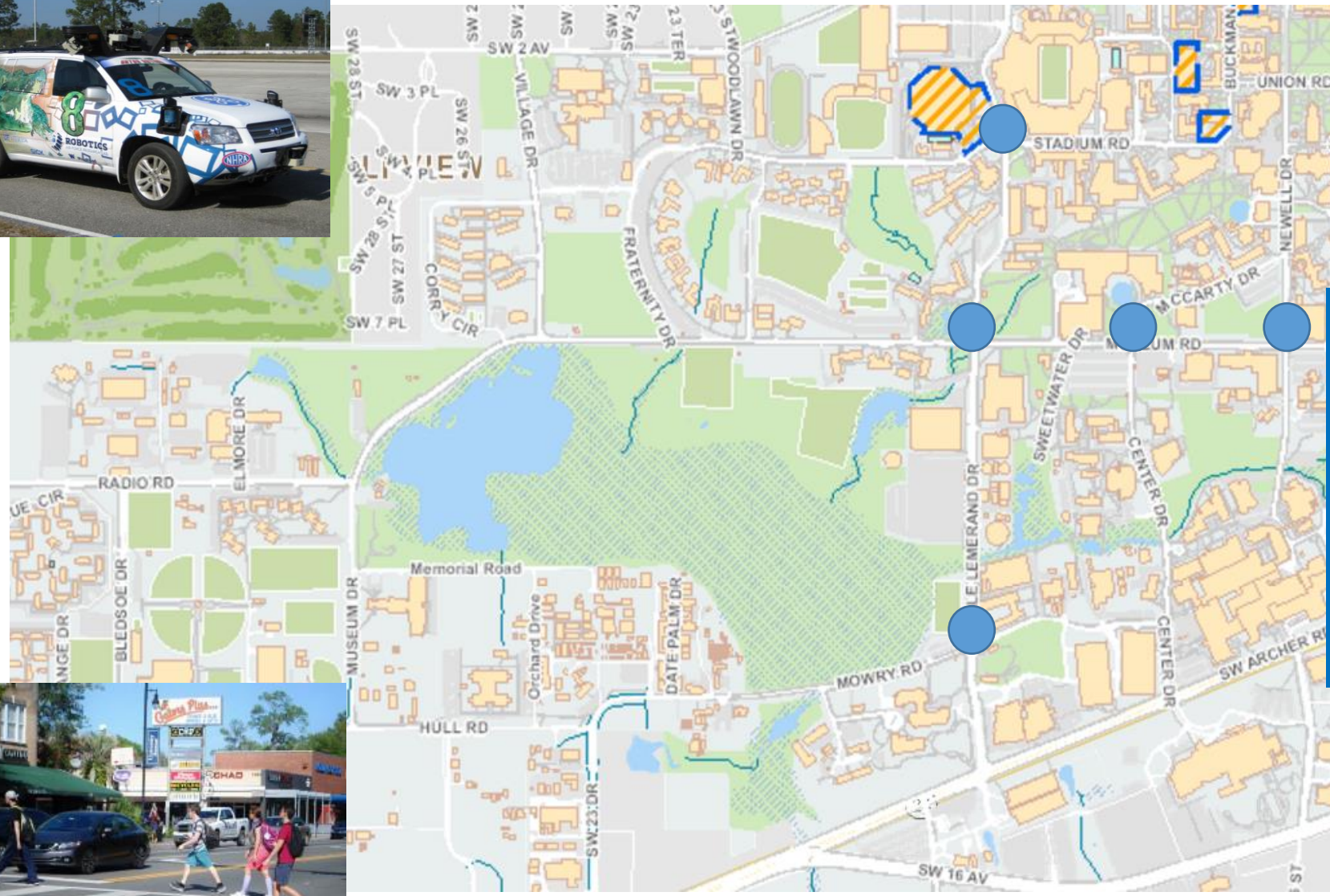
Source: http://www.slideshare.net/AditiTechnologies/how-internet-of-things-iot-is-reshaping-the-automotive-sector-infographic

Intelligent Transportation Services



Source: Gayrard, Thalessgroup.com

I-Street: UF Smart Campus: Five year $10 million project



Focus on

Communication (DSRC)

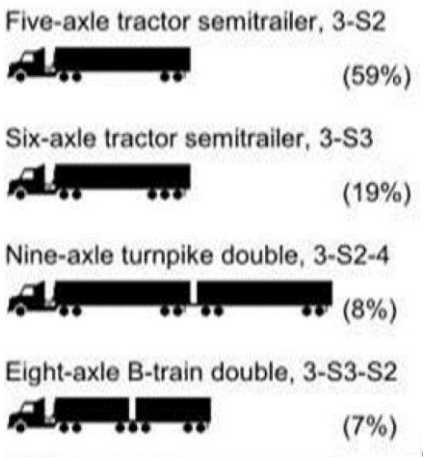
Intelligent Data Analytics

Intelligent Signal Control

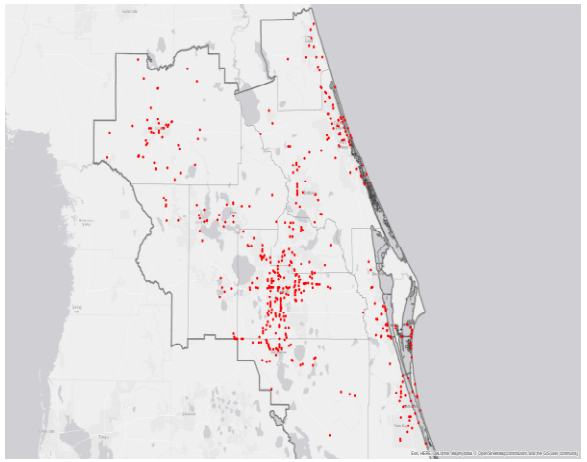
Security and Privacy

Mixed Mode Traffic

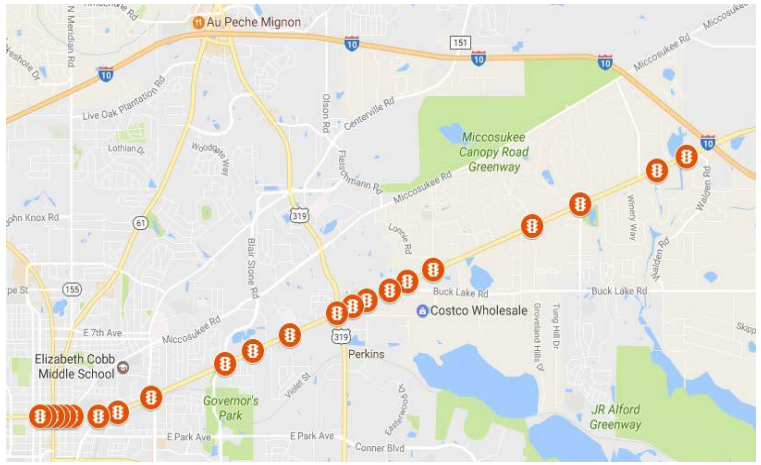
Our Research on Transportation Applications: Sample Projects



Truck Classification

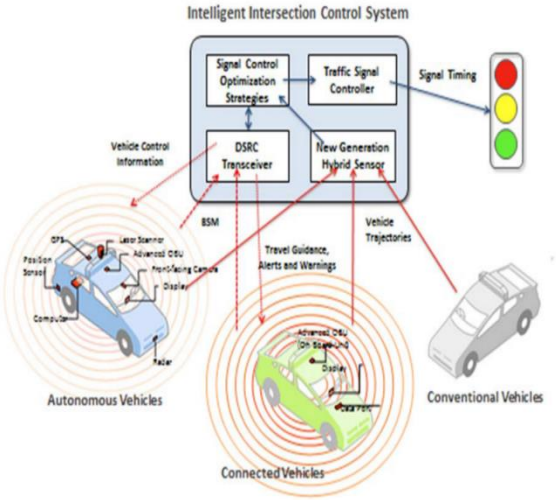


Mining Pedestrian Fatalities

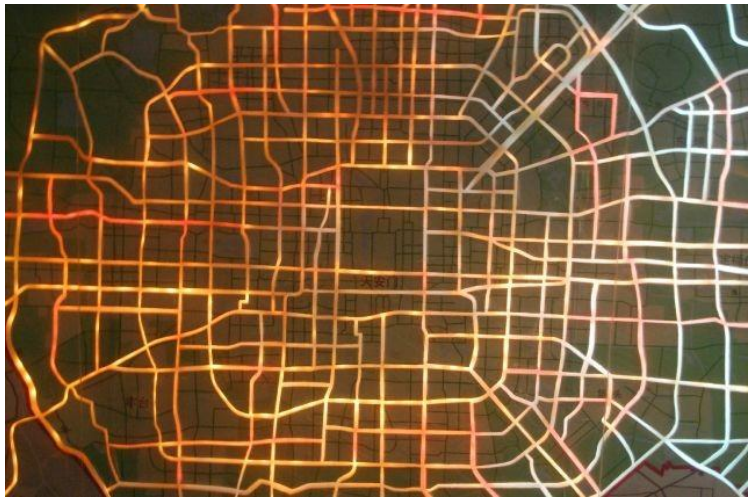


SPaT Data Analytics

Multidisciplinary Collaborations between Computer Science and Transportation Engineers



Optimizing for a Single Intersection



Optimizing for a Transportation Grid

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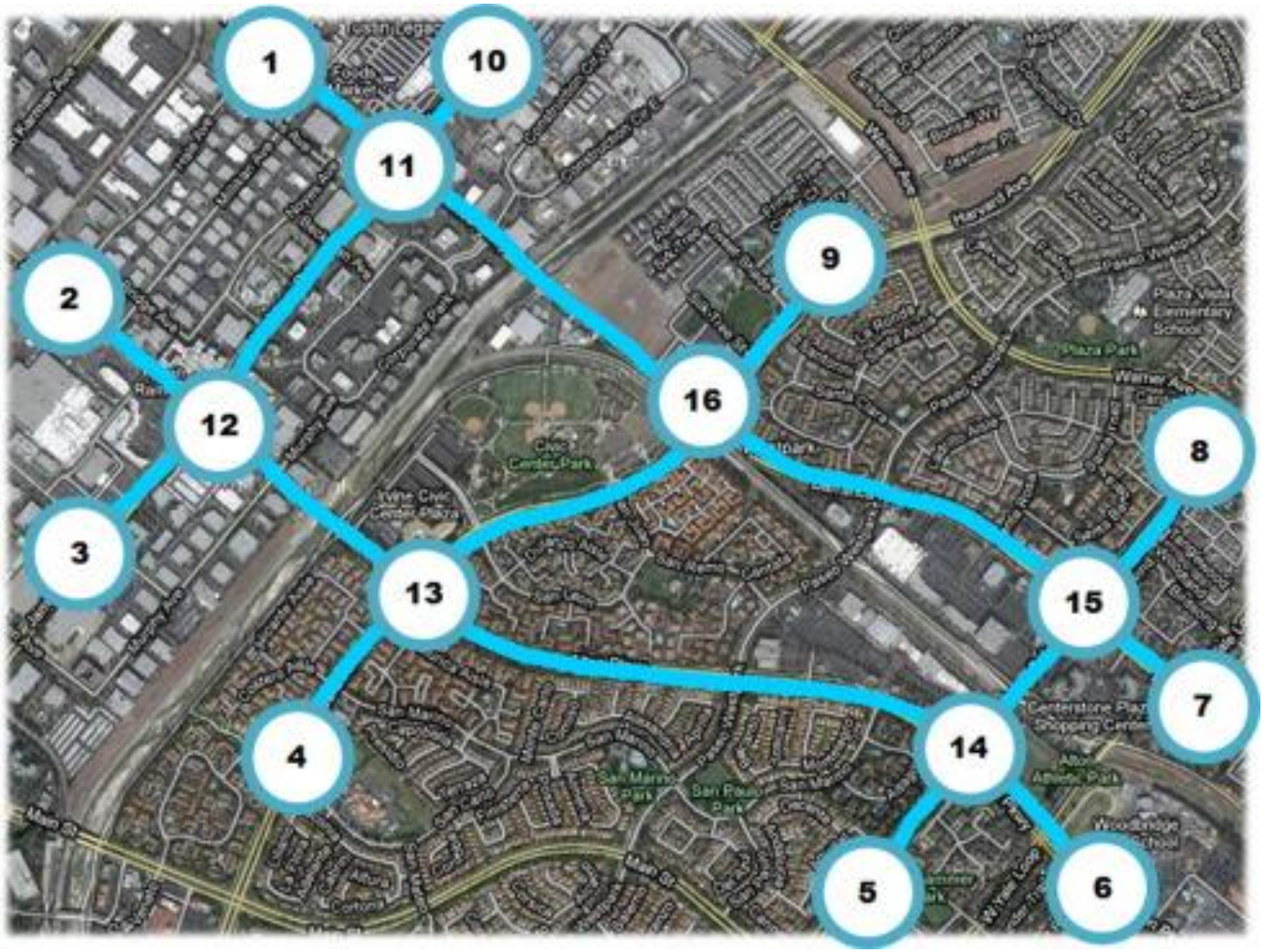
Optimizing Traffic for a Grid



Better overall Performance of Network by

- Minimizing average delay
- Minimizing Queue length
- Maximizing Network Capacity

While

- Ensuring Fairness

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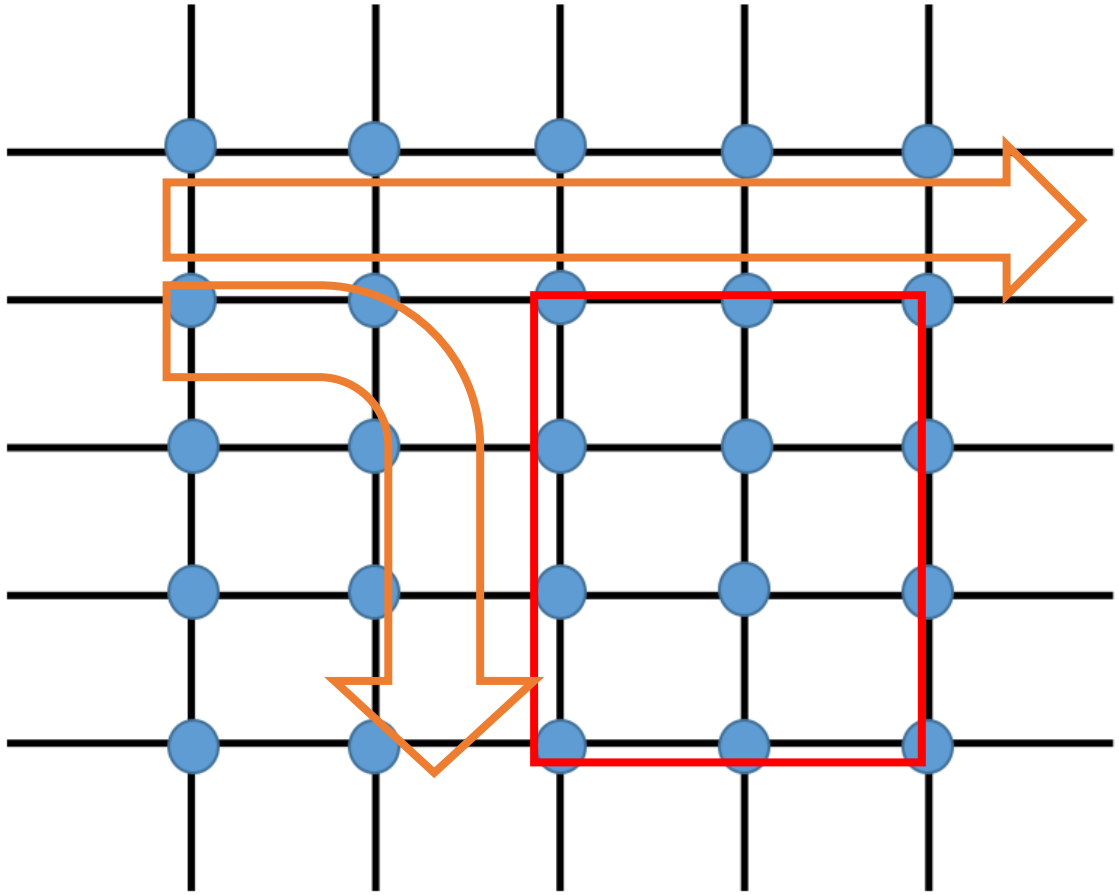
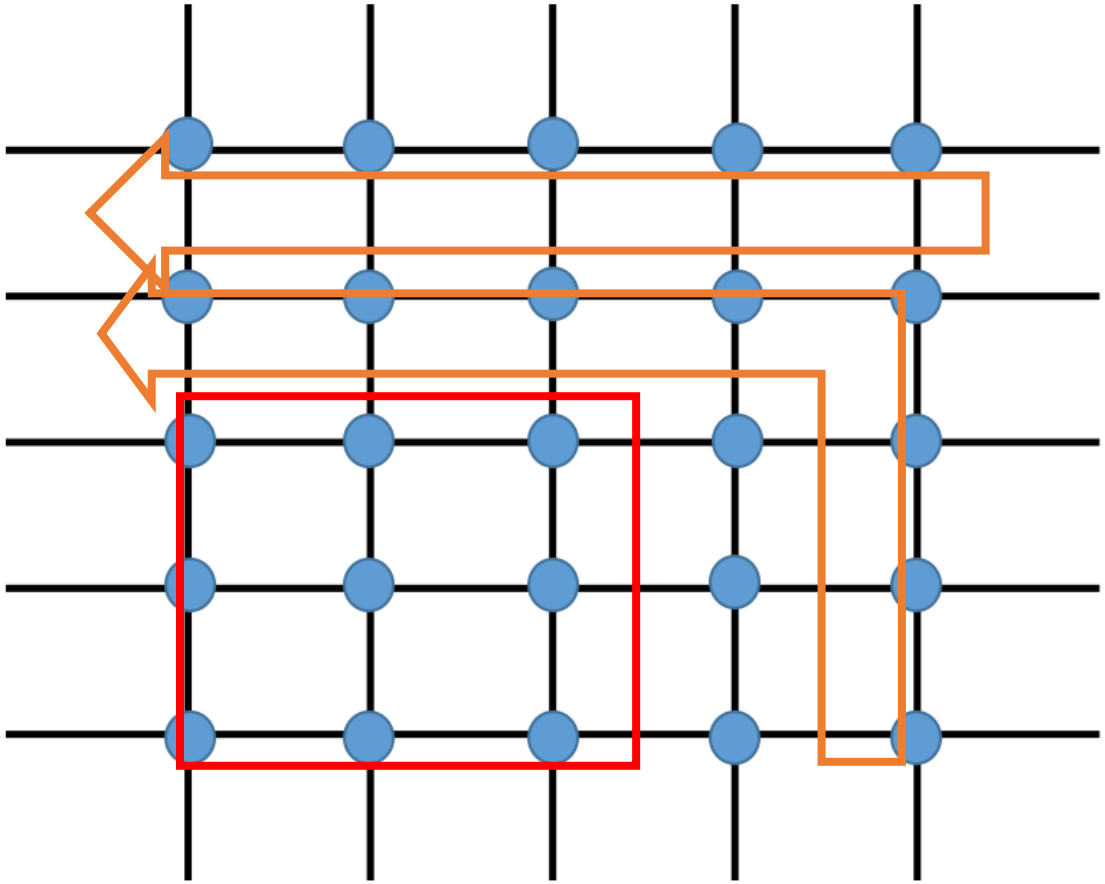
Current State of the Art: Corridor Optimization

Source: Frost, Traffic Technology Today

Network Optimization: Data driven partitioning

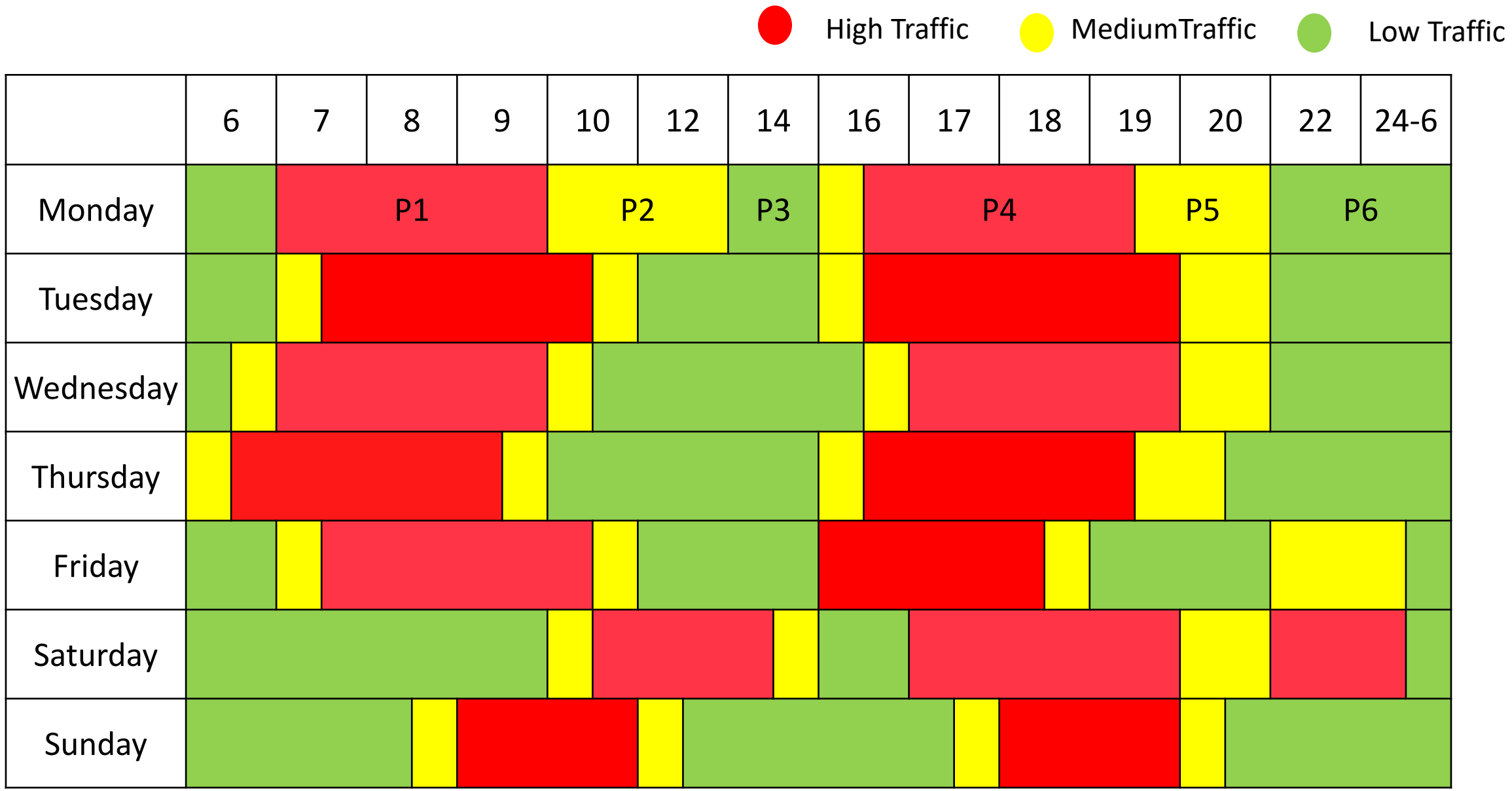


P1 (7 – 9 AM)



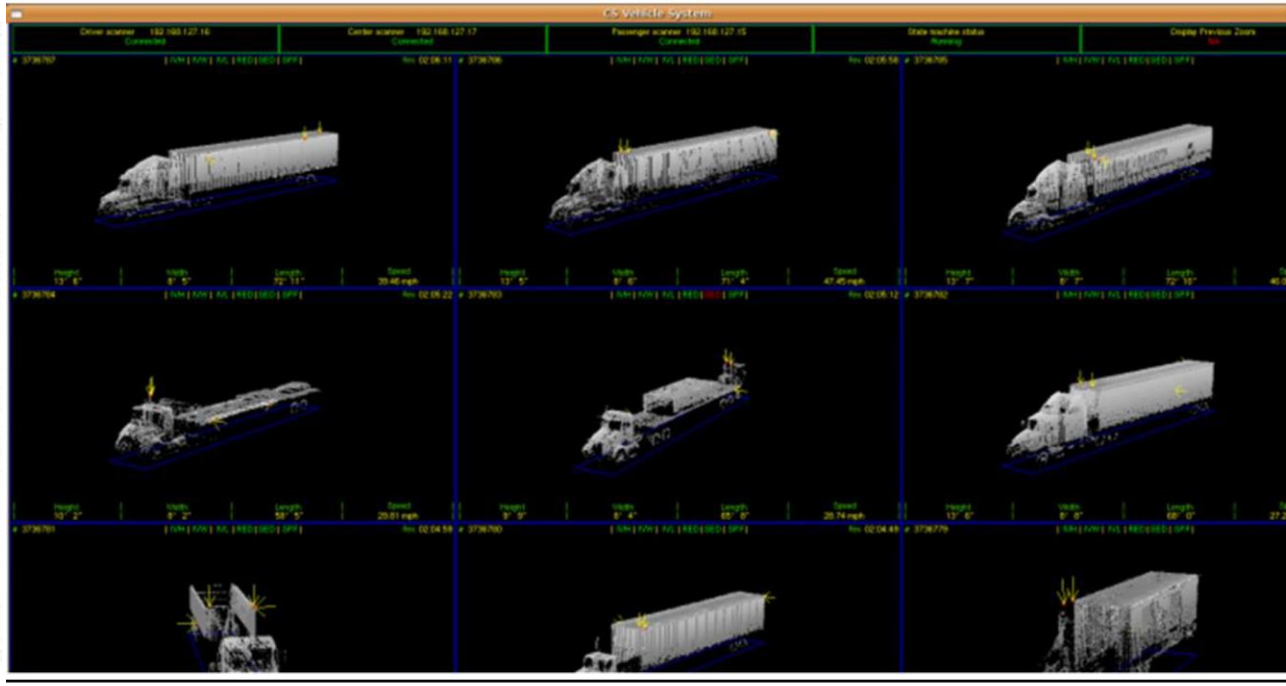
P4 (4 – 6 PM)

Network Optimization: Corridor Traffic Status



Truck and Commodity Classification Using Machine Learning

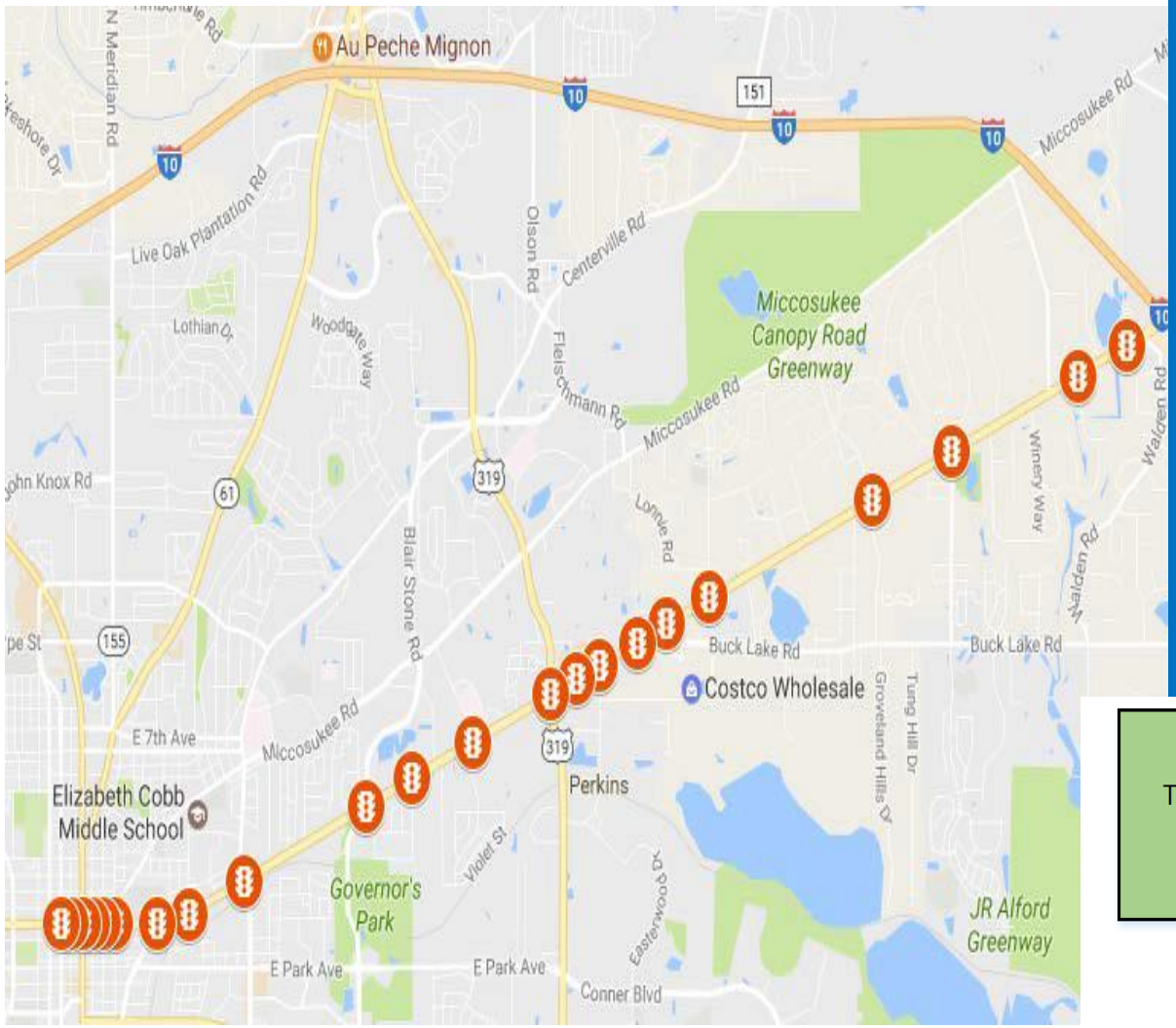
Configuration	Body type	Typical commodities	Typical industries
Five-axle tractor semitrailer, 3-S2 (59%)	Vans/reefers (63%)	• Palletized cargo • Refrigerated goods	• Retail • Produce
	Flat decks (16%)	• Equipment • Building supplies	• Construction • Manufacturing
Six-axle tractor semitrailer, 3-S3 (19%)	Hoppers (6%)	• Grain • Granular fertilizer	• Agriculture
Nine-axle turnpike double, 3-S2-4 (8%)	Tankers (4%)	• Petroleum products • Chemicals	• Petroleum • Chemical
	Dumps (6%)	• Aggregate • Grain • Refuse	• Construction • Agriculture
Eight-axle B-train double, 3-S3-S2 (7%)	Containers (2%)	• Palletized cargo • Freight of all kinds	• Retail



Machine Learning on Actuator Sensors and Video Images of Trucks passing on a highway

Text Recognition from Images

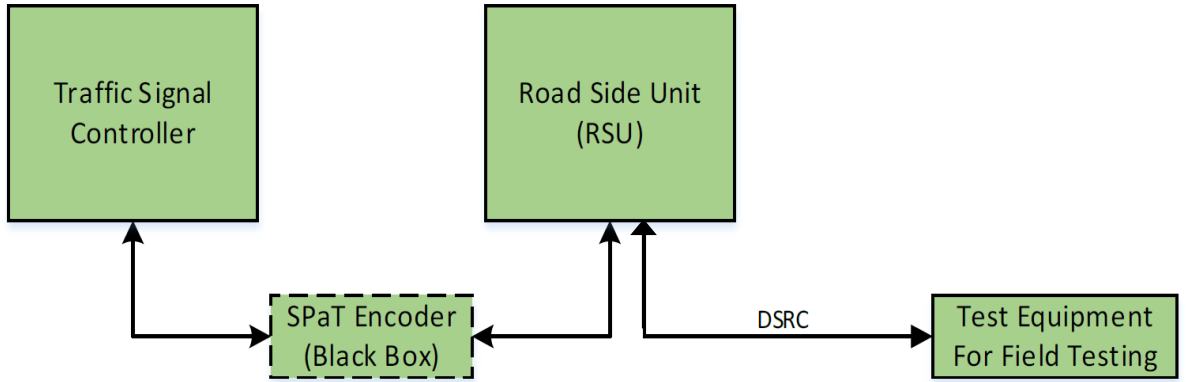
SPaT Data Analytics



SPaT/MAP message based applications (Time-to-Change Notification, Red Light Violation Warning, etc.)

Warnings (Forward Collision Warning, Emergency Brake Light Warning, Do Not Pass Warning)

TIMs - Curve Speed Warning, Speed Limit Changes/Updates, Work Zone Warning, and others (the ability these depend on which corridor is chosen for the instrumentation)



Bigdata: Predicting and preventing fatal crashes (FDOT D5)

Landuse
Geolocation
Landuse Type
.....
.....

Red Light Cameras
Geolocation
Camera Type
.....
.....

Signals
Geolocation
Signal Type
.....
.....

Construction
Geolocation
Begin/End Date
.....
.....

Roadway Characteristics
Geolocation
Median Type
Median Width
Surface Condition
Surface Width
Number of Lanes
Functional Classification
Maximum Speed
Number of Luminaries
.....
.....

Pedestrian Crash Event
Crash ID
Geolocation
Time
Injury Severity
Light Condition
.....
.....

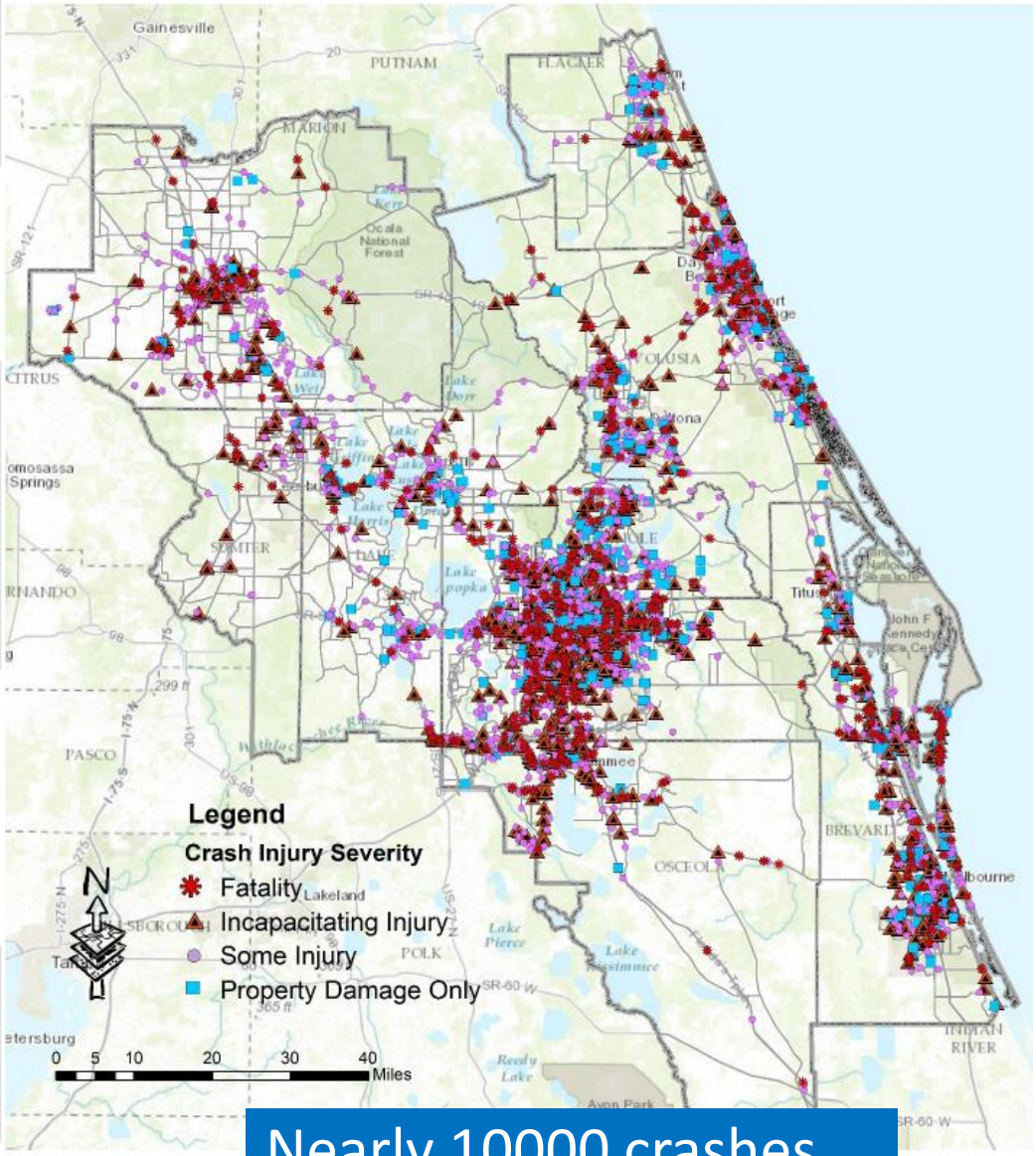
Demographic Information
Geolocation
Total Population
Minority Population
Income Status
Education Level
Vehicle Ownership Status
.....
.....

Transit Stops
Geolocation
Number of Riders
.....
.....

Transit Route
Geolocation
Number of Riders
.....
.....

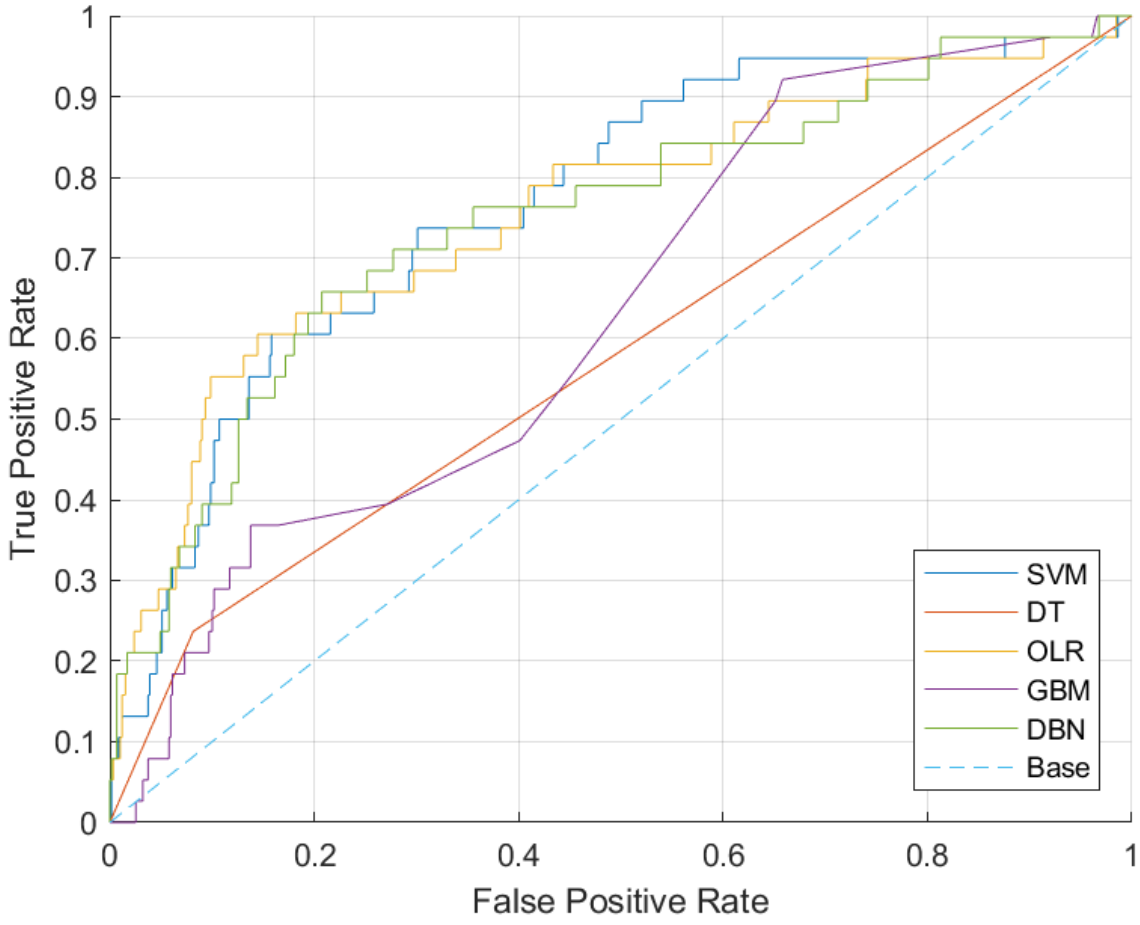
Walking / Biking
Geolocation
Trip Count
.....
.....

Sidewalks
Geolocation
Length
.....
.....

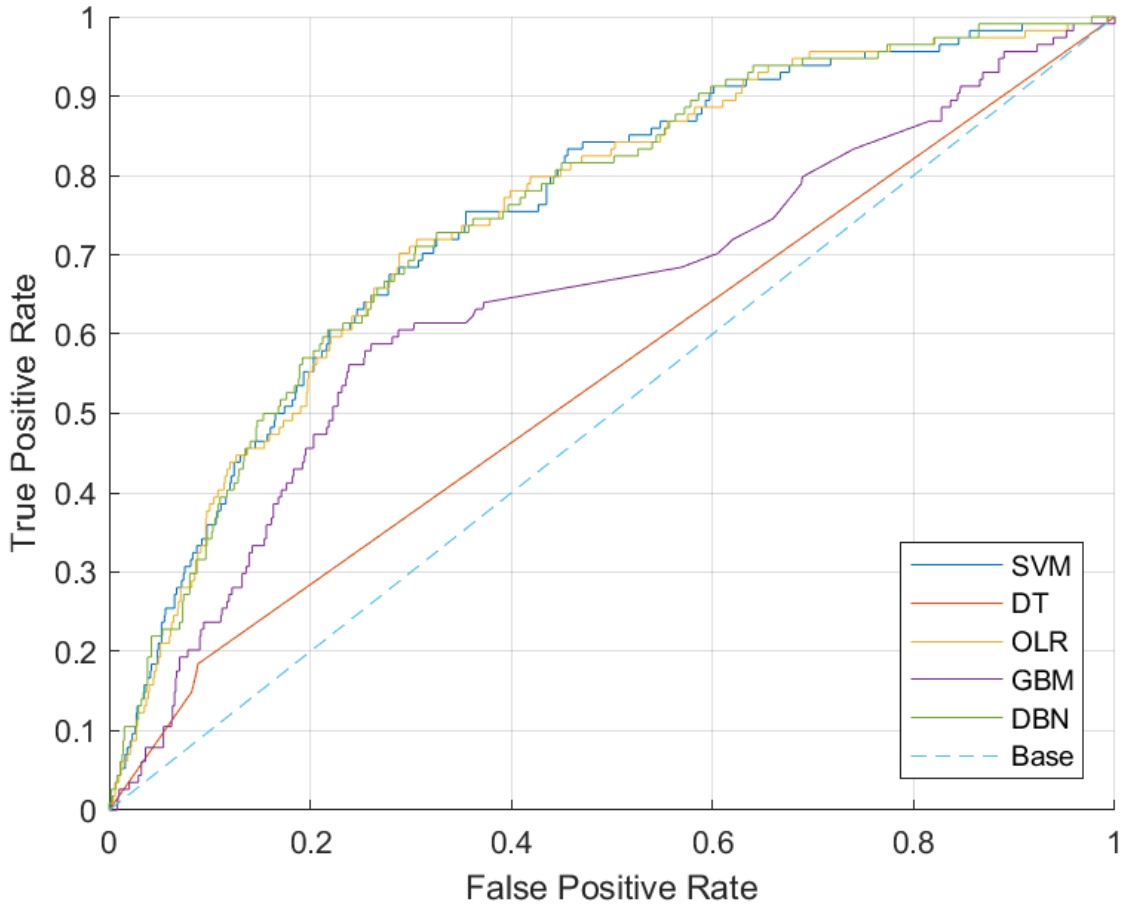


Nearly 10000 crashes

Predicting ROC Curve



Intersection



Non-Intersection

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Intersections

Data Source	Variables	LASSO Coefficient	OLR Coefficient	DT Gain
Crash Characteristics				
Pedestrian Crashes	AlcoholRelated	17.543	-0.825	1.184
Time and Weather Characteristics				
Pedestrian Crashes	LightConditionDayLight	−5.794	0.698	5.139
Pedestrian Crashes	LightConditionDarkLighted	4.465	-0.844	2.300
Pedestrian Crashes	LightConditionNotLighted	22.478	-1.560	1.431
Pedestrian Crashes	WeatherConditionRain	−1.260	0.428	0.605
Population Characteristics				
Demographics	HouseholdsPublicAssistanceIncome	1.308	-0.549	2.513
Demographics	PercentBachelorsAndHigher	−9.188	2.047	9.277
Demographics	PopulationMedianAge	8.016	-1.288	7.994
Demographics	PercentAmerican	−1.566	4.075	1.745
Demographics	PercentAfricanAmerican	−0.577	0.467	2.972
Demographics	PercentMultiRace	−1.399	0.967	3.644
Demographics	PercentOtherRace	21.044	-2.146	6.874
Demographics	OccupiedHousingWithNoVehicle	−0.936	0.319	3.886
Demographics	TransportationWalk	−1.899	1.210	2.941
Demographics	TransportationBike	−0.650	0.423	1.605
Demographics	WorkedAtHome	2.559	-1.657	3.669
Signalization Near Crash Location				
Signalized Intersection	DistanceToNearestSignalizedIntersection	0.839	-0.424	3.890
Others				
Red Light Cameras	DistanceToRedLightCameras	1.464	-0.209	6.808

Road Segments

Data Source	Variables	LASSO Coefficient	OLR Coefficient	DT Gain
Crash Characteristics				
Pedestrian Crashes	AlcoholRelated	13.945	-0.646	0.612
Time and Weather Characteristics				
Pedestrian Crashes	LightConditionDayLight	-7.471	0.479	1.893
Pedestrian Crashes	LightConditionDarkLighted	3.361	-0.949	0.559
Pedestrian Crashes	LightConditionNotLighted	23.232	-1.541	0.833
Crash Location Roadway Characteristics				
Roadway Characteristics Inventory	Speed	17.917	-1.317	2.603
Roadway Characteristics Inventory	PrincipalArterials	3.375	-0.156	0.847
Roadway Characteristics Inventory	LaneCount	10.167	-1.221	1.114
Roadway Characteristics Inventory	Ramp	3.990	-0.283	0.276
Crash Location Land Use / Population Characteristics				
Demographics	PercentBachelorsAndHigher	-1.041	1.240	1.502
Demographics	PopulationMedianAge	0.286	-0.173	1.090
Demographics	PercentWhite	2.499	-0.886	3.763
Demographics	PercentAsian	0.750	-0.474	1.322
Demographics	TransportationOther	1.502	-0.901	0.938
Demographics	TransportationMotorVehicle	-0.361	0.332	0.409
Demographics	WorkedAtHome	-1.669	1.593	1.457
Signalization Near Crash Location				
Signalized Intersection	DistanceToNearestSignalizedIntersection	1.650	-0.363	2.283
Others				
Roadway Characteristics Inventory	MedianWidth	4.273	-0.457	1.438
Roadway Characteristics Inventory	MedianTypeLawn/Turf	4.042	0.067	0.505
Roadway Characteristics Inventory	MajorCollector	-1.555	0.394	0.643
Roadway Characteristics Inventory	MinorArterialUrban	-1.249	0.254	0.376
Sidewalks	SideWalkGapPartial	0.737	-0.182	0.265

Important Predictors

Predictor Description	Coefficient
Means of transportation to work, other means	0.745
Percent of persons, American Indian and Alaska Native alone	0.390
Means of transportation to work, bicycle	0.362
Percent educational attainment, 25 years and over Bachelor's degree only	0.173

Intersection

Predictor Description	Coefficient
Percent of persons, some other race alone	0.597
Means of transportation to work, walked	0.349
Partial sidewalk gap with sidewalk missing on one of the roadsides	0.266
Distance to the nearest transit stop	0.247
No sidewalk gap, with sidewalk missing on one roadside	0.209

Non-Intersection

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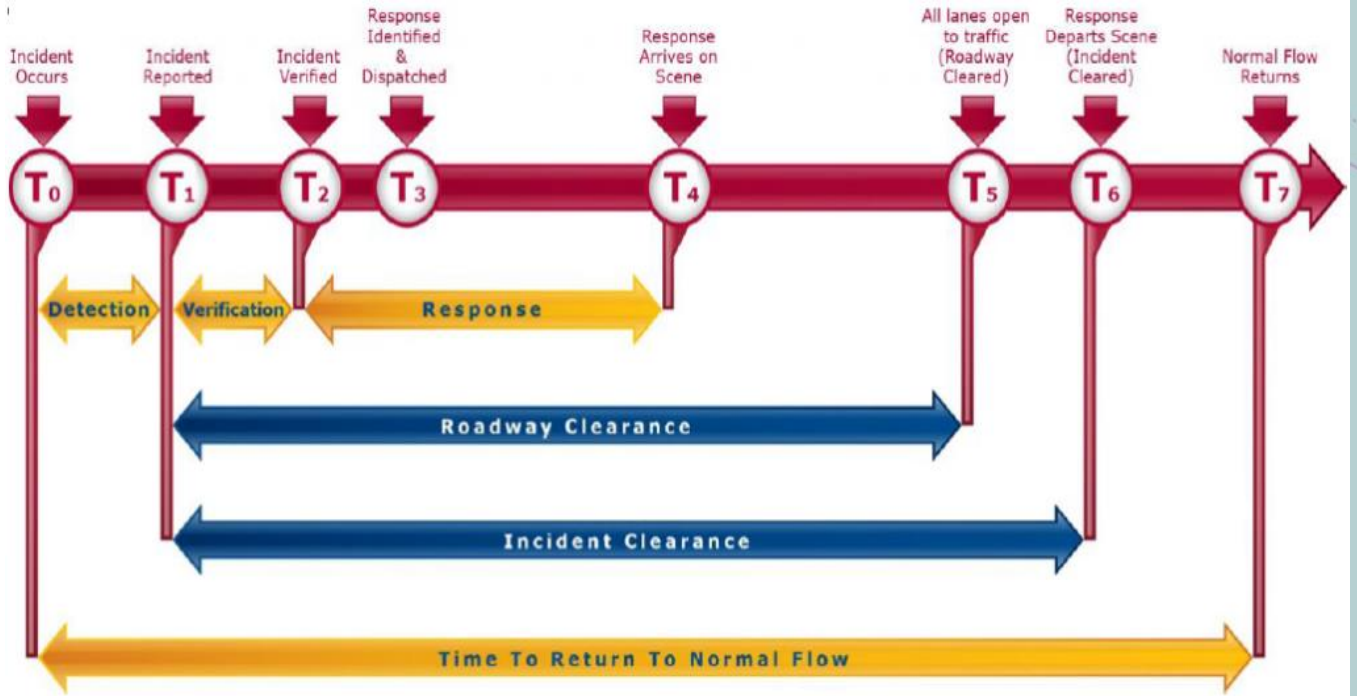
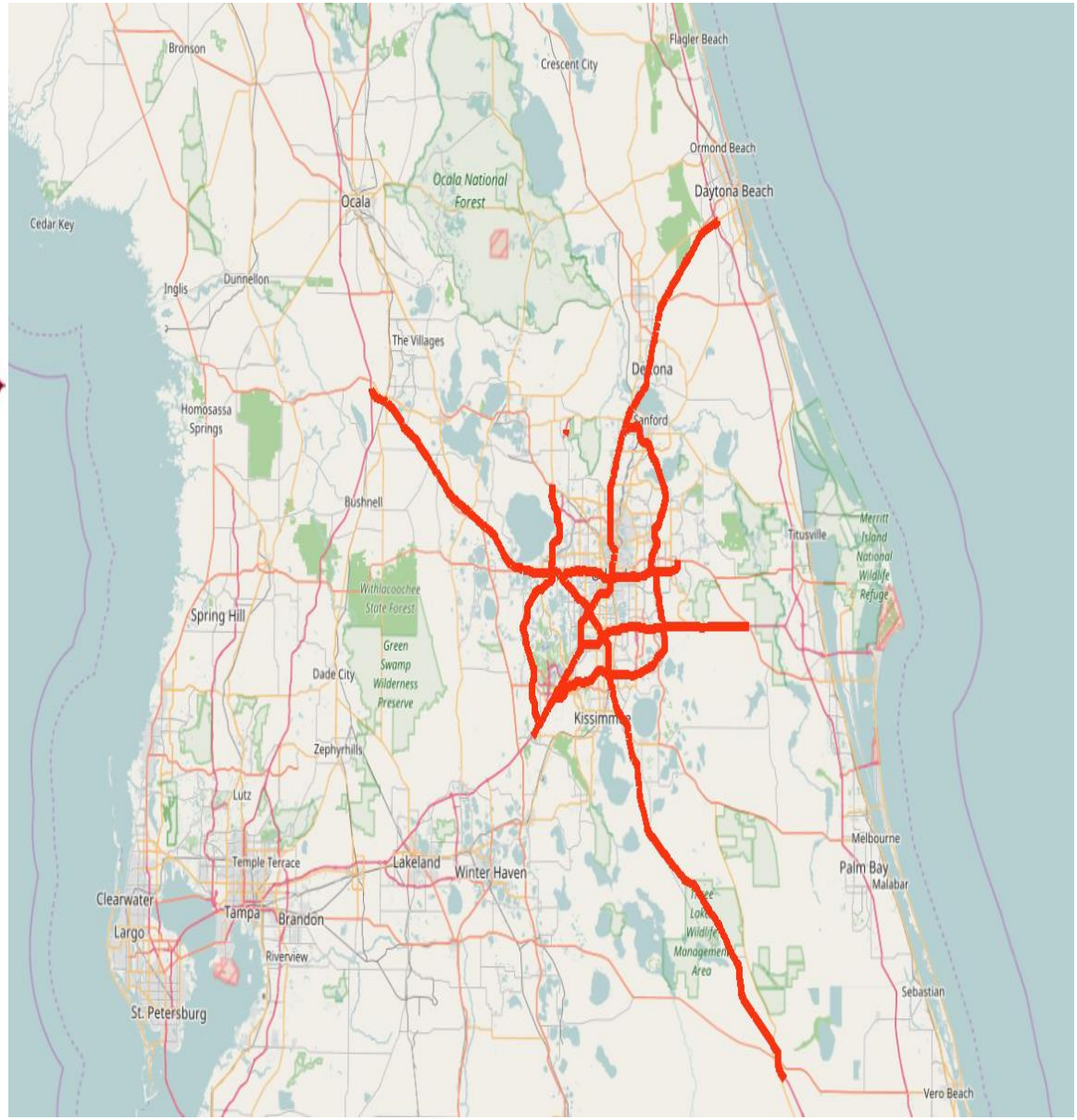
Road Ranger Analytics





Average Incident Duration

Problem Description

Objective: Optimize the average delay by advising automated vehicles and controlling signal phase and timing (in real-time)

Sensing technologies

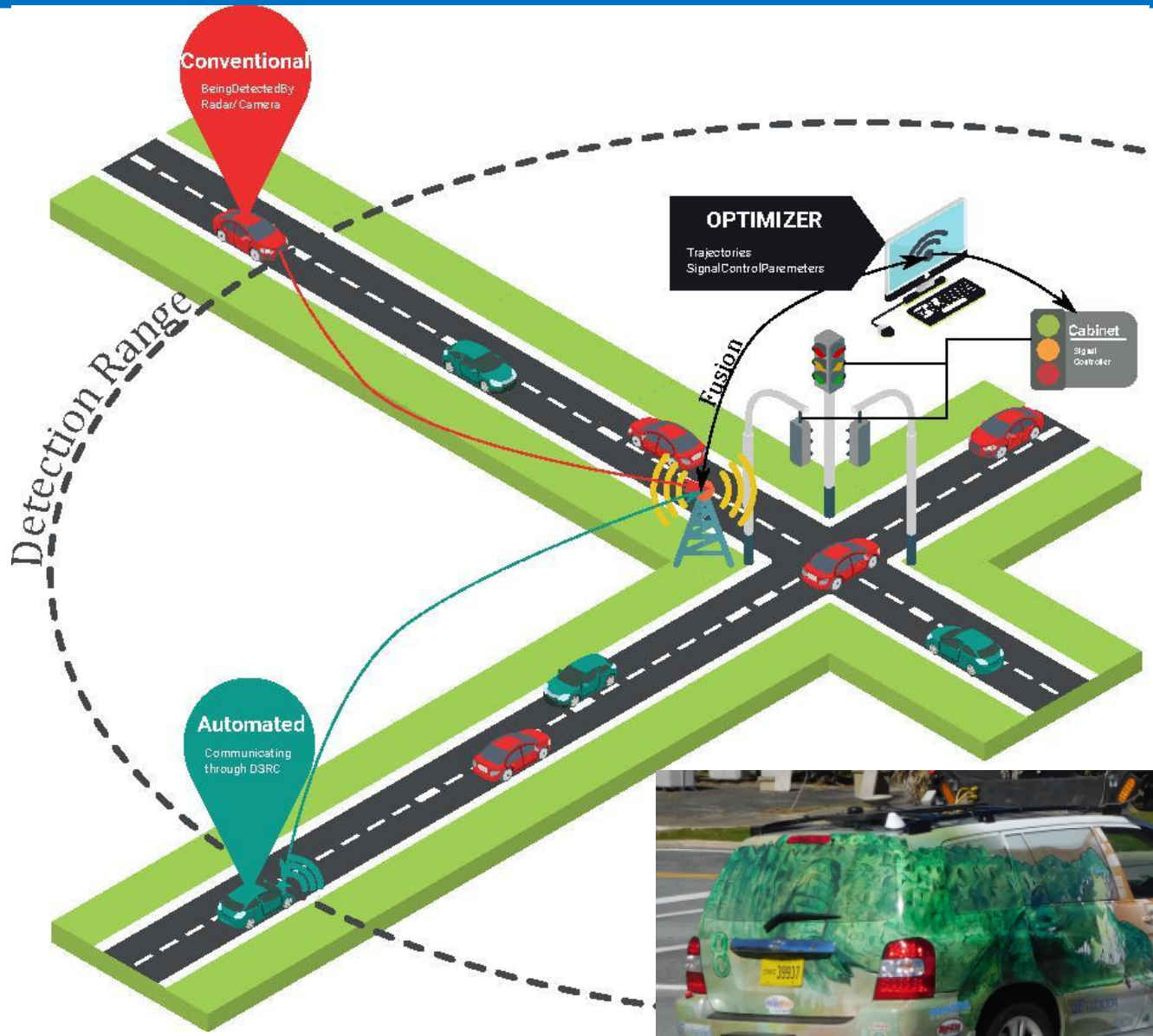
- Dedicated Short Range Communication
- Radar
- Camera, Lidar

Autonomous Vehicle Technology

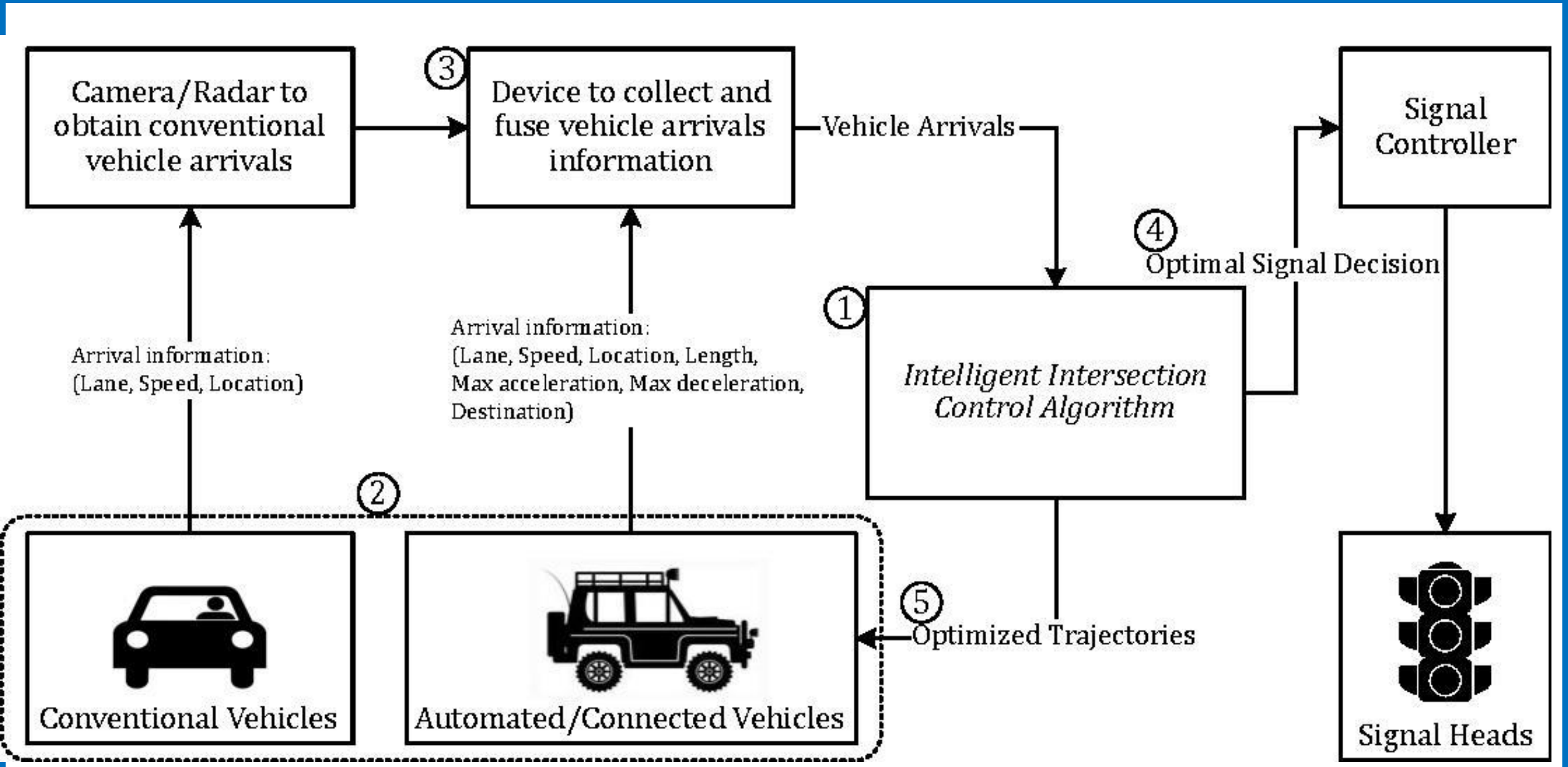
- Navigation and Localization algorithms

Optimization Algorithm

- Vehicle Path Optimizer
- Signal Status Optimizer



Intelligent Intersection Control System

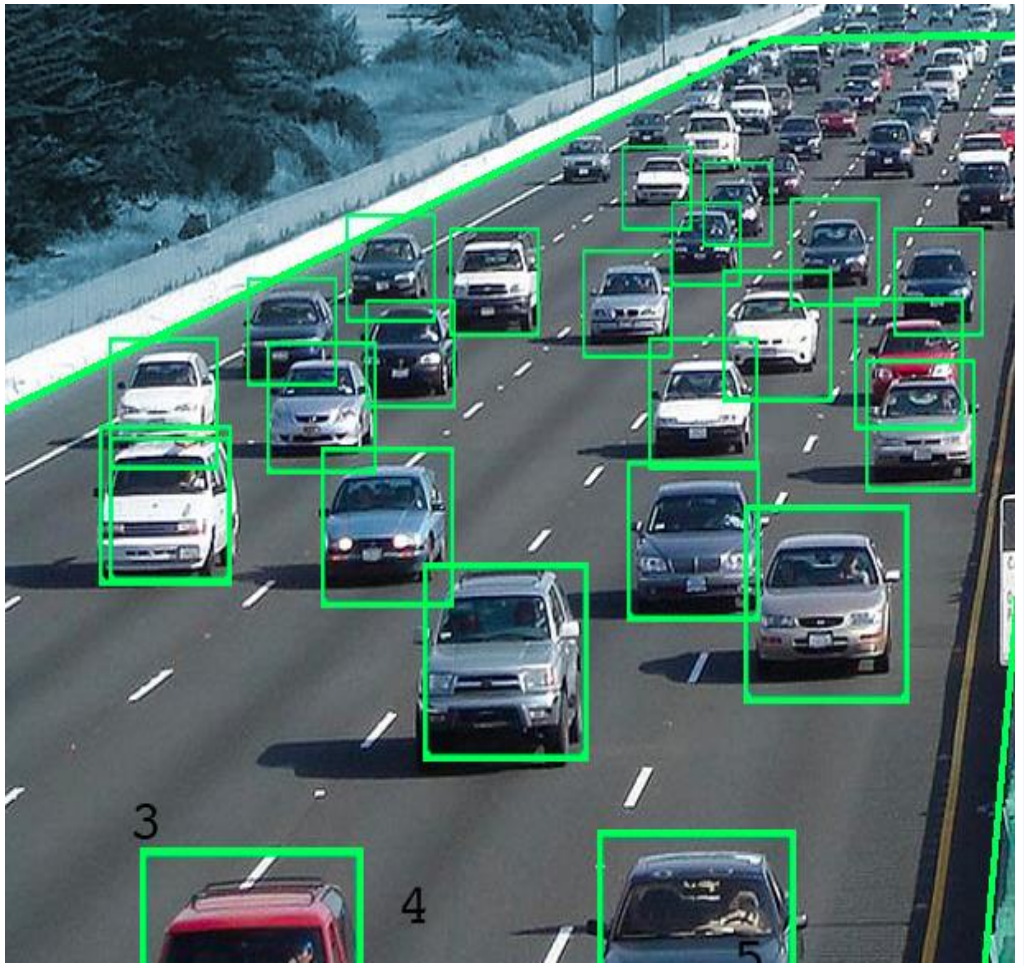


Sensor Fusion for Intelligent Intersection Control

Goal: Classify and track all traffic participants up to ~600 feet away from the intersection

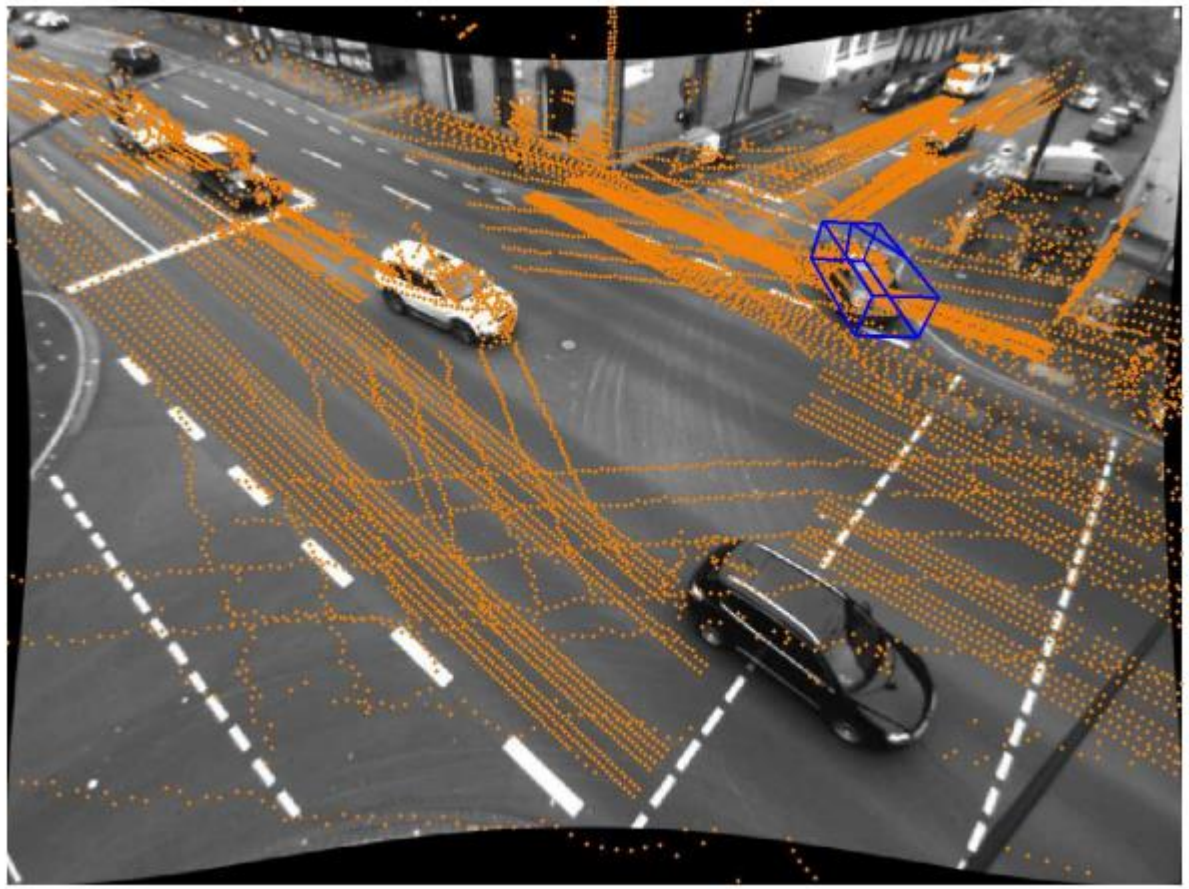
Challenging Multisensor-Multitarget problem

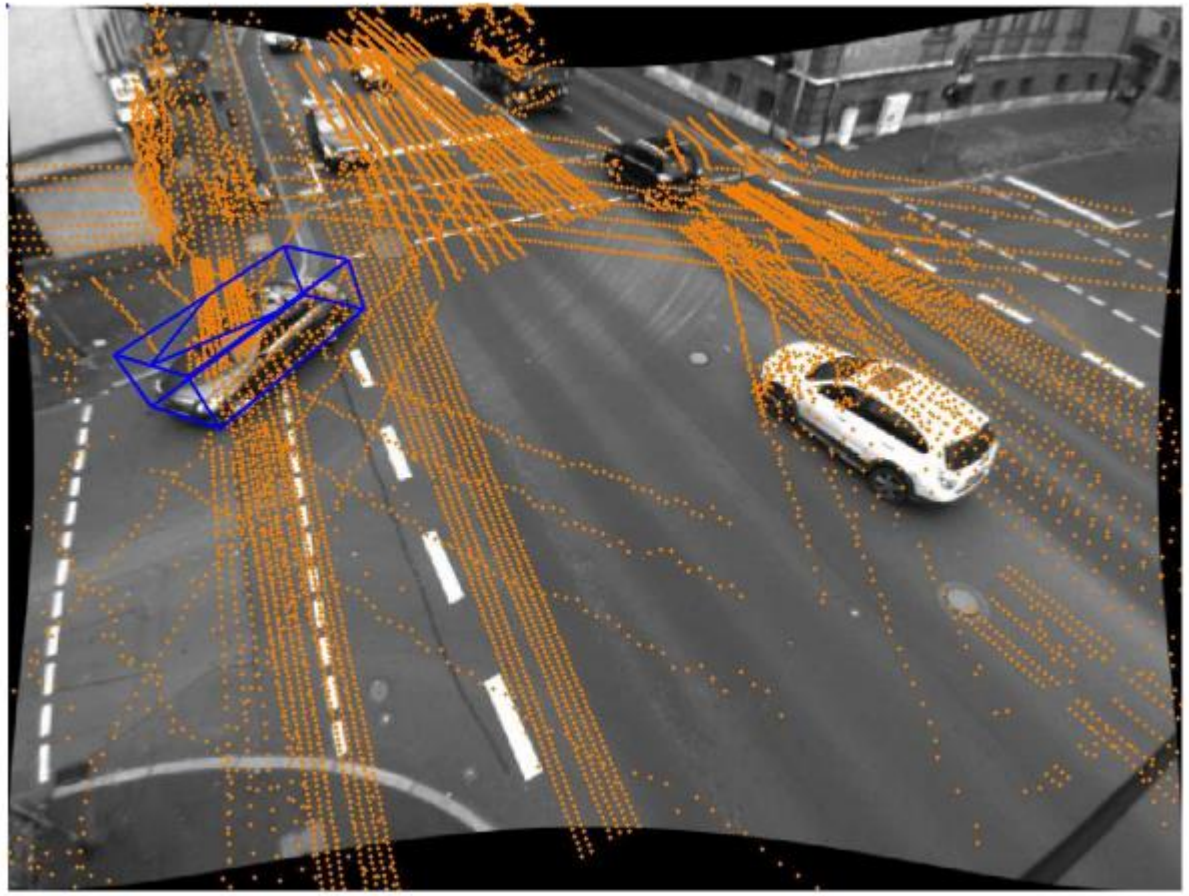
- Occlusion is common in medium-heavy traffic
- Need to synchronize and associate sensor data in real-time
- Need accurate models of uncertainty in sensor measurements and vehicle dynamics



Sensor Fusion

Assignment Problems in Multi-Target Tracking





Track-to-track Association (T2TA) and Data Association are core problems in multi-target tracking systems where sensor measurement and tracks are matched spatially and temporally

Instances of linear and multidimensional assignment problems

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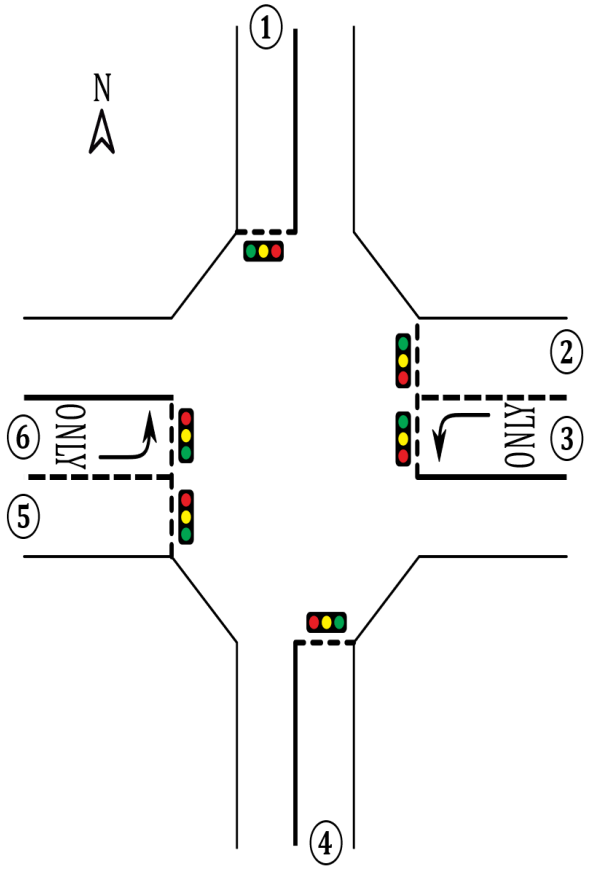
Signal Optimization Algorithm

Objective: Minimize the Average Travel Time Delay experienced at the intersection

Approach: Mathematical Programming

Description:

- Automated Vehicles Shall receive a trajectory at the time they enter the detection range
- The Trajectories Shall comply with signal status and have no conflict with other vehicles
- The joint decision on Trajectories and Signal Phase and Timing yields the minimum average travel time delay



Phase	Movement
1 SB L,TH,R	
2 NB L,TH,R	
3 WB L/TH,R	
4 EB L/TH,R	

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Conclusions

- Transportation is going through a IOT revolution
  - New Sensors (Video, Lidar, Radar, ….)
  - New Types of Vehicles
  - New Communication Standards
  - Cheap Computng and Storage Resources
- Use of Data Analytics and Real-time Algorithms is becoming increasingly important
- Significant challenges for Computer Scientists to develop real-time and offline changes
- Need for multidisciplinary approaches for solving these problems

Collaborators (University of Florida)

Faculty and Research Scientists

- Professor Lily Elefteriadou –Civil and Coastal Engineering
- Professor Carl Crane –Mechanical Engineering
- Professor Siva Srinivasan - Civil and Coastal Engineering
- Professor Anand Rangarajan - CISE
- Dr. Clark Letter –Civil and Coastal Engineering
- Dr. Tania Mishra - CISE

Funding

- NSF Award # 1446813, FDOT Multiple Awards

PhD Students

- Patrick Emami –CISE
- Pankaj Chand – CISE
- Dhruv Mahajan – CISE
- Yupeng Yan –CISE
- Xiahoui Huang – CISE
- Mahmoud Pourmehrab - Civil and Coastal Engineering
- Aschkan Omidvar - Civil and Coastal Engineering
- Marilo Martin-Gasulla - Civil and Coastal Engineering