Car Telematics: The Next Gold…

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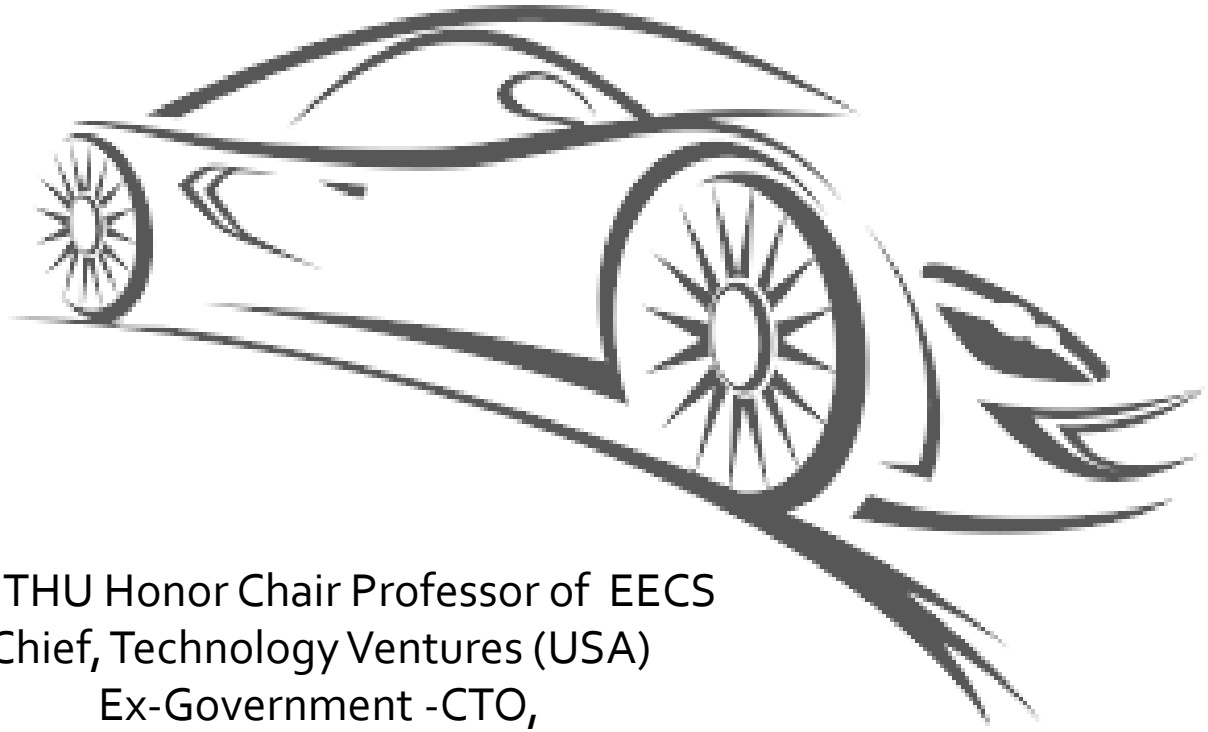

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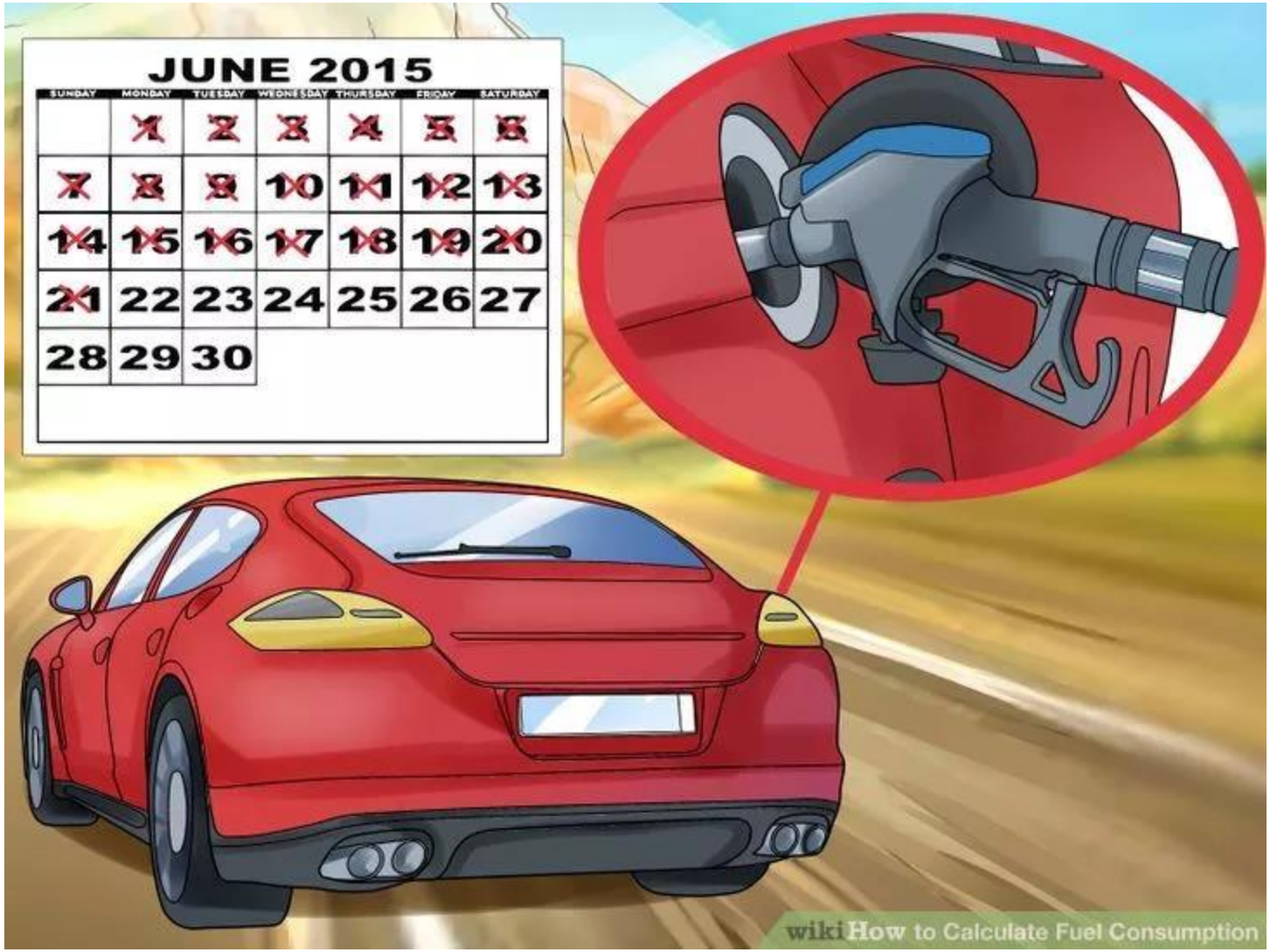
Outline of My Talk Today..

- MOTIVATION
  - Why
- PROPOSED ARCHITECTURE
  - How & What
- ANDROID APPS
  - Usage Scenarios
  - Views
- FIELD TRIALS & RESULTS
  - Driving Styles
  - Fuel Consumption
  - Greenhouse Gas Emissions
- CONCLUSION
- IMPACT & FUTURE WORK

MOTIVATION #1: ENERGY IS LIMITED



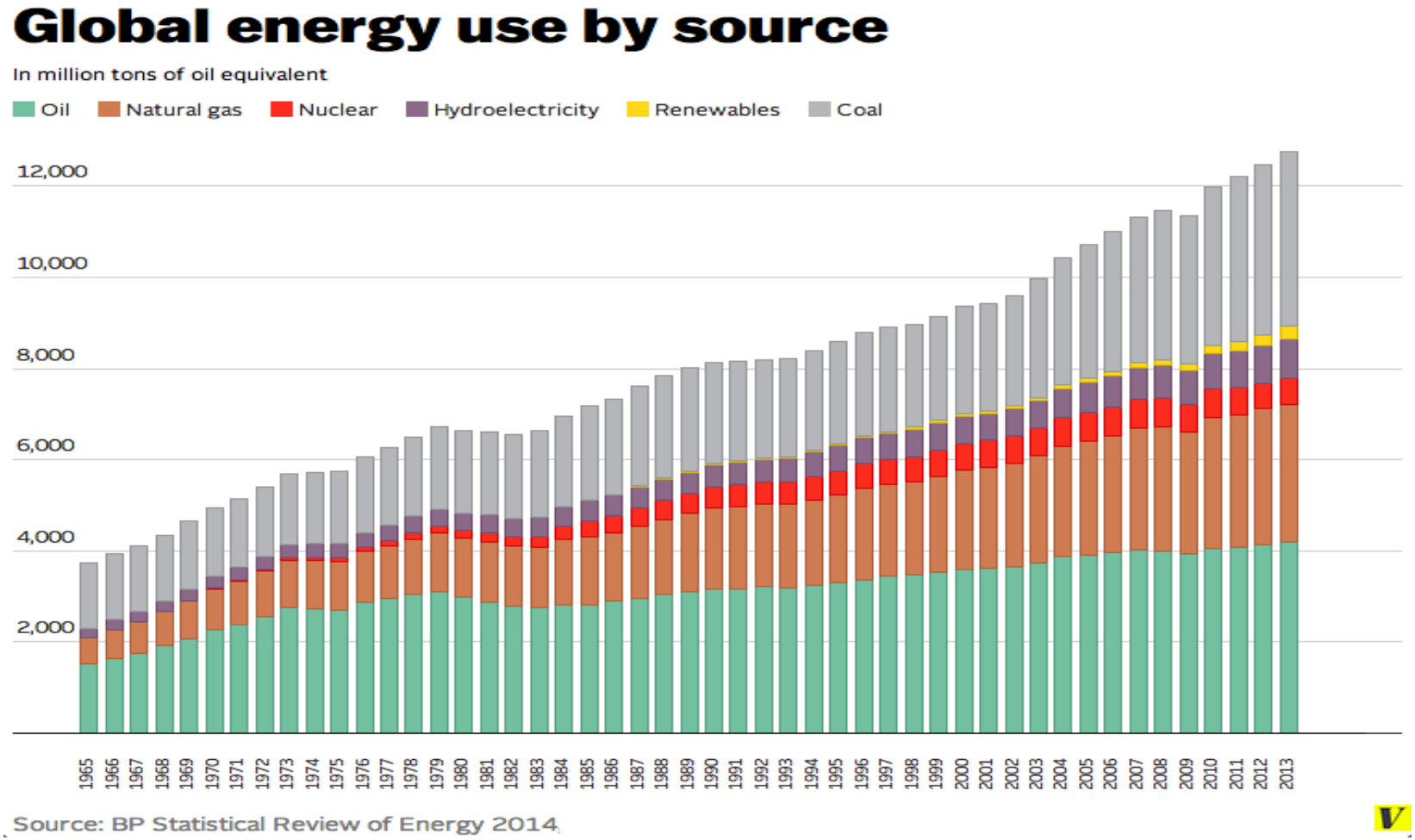
COSTLY TOO

$2.50 Per Gallon in California

A full tank will cost $40+

MOTIVATION #1: ENERGY IS LIMITED

- Car Fuel demand is increasing & energy is a limited resource
- Till Today, we don't have a good solution to this problem..



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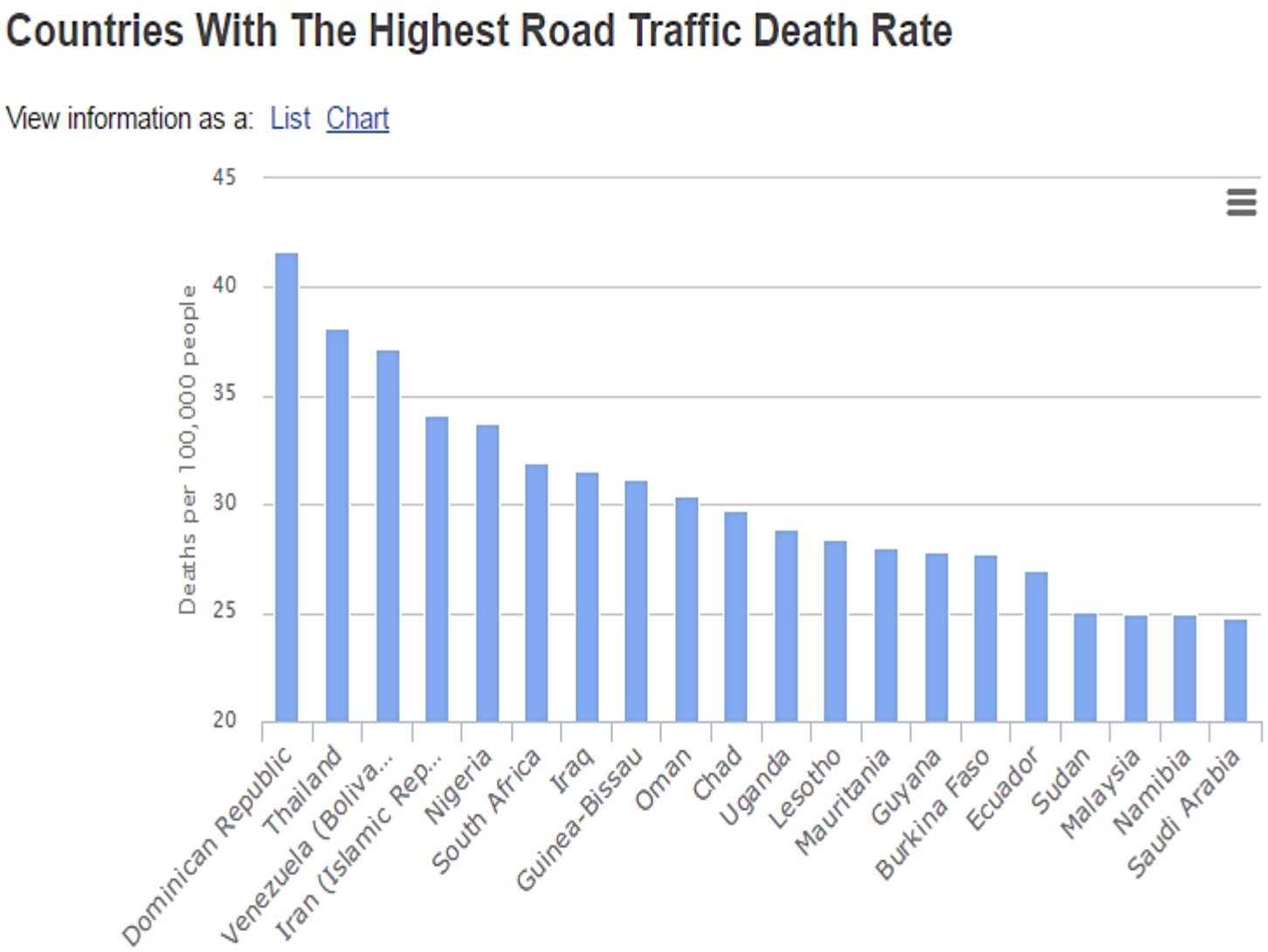
MOTIVATION #2: CAR ACCIDENTS KILL



In the USA alone,

6 Million ave no. of car accidents every year

>90 peope die in car accidents every day

3 Million People Injured Every year

THE RECENT CRASH: TELSA

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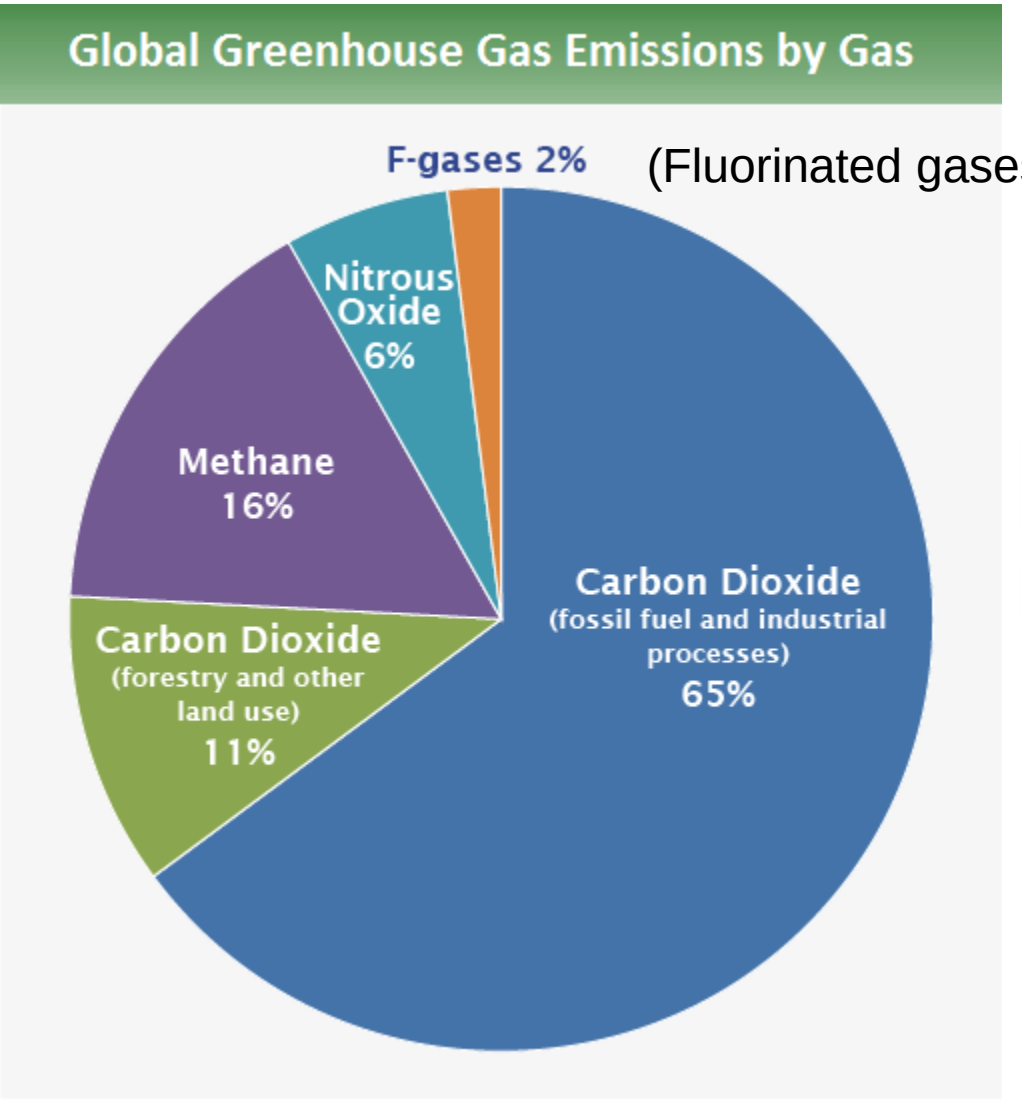
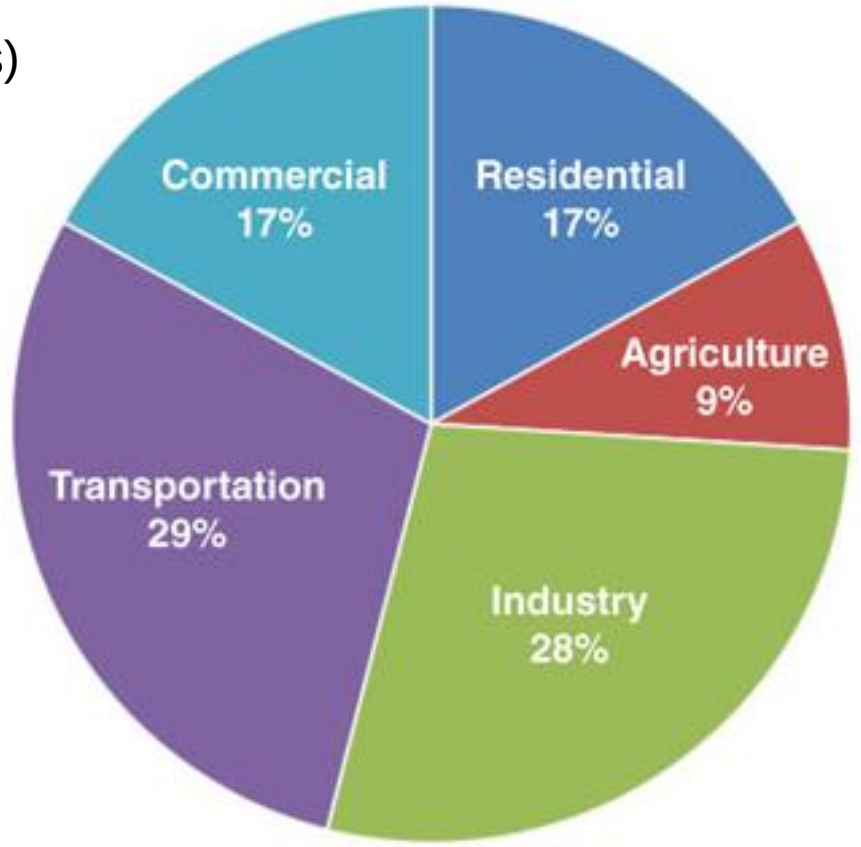
MOTIVATION #3: THE ENVIRONMENT IS POLLITED

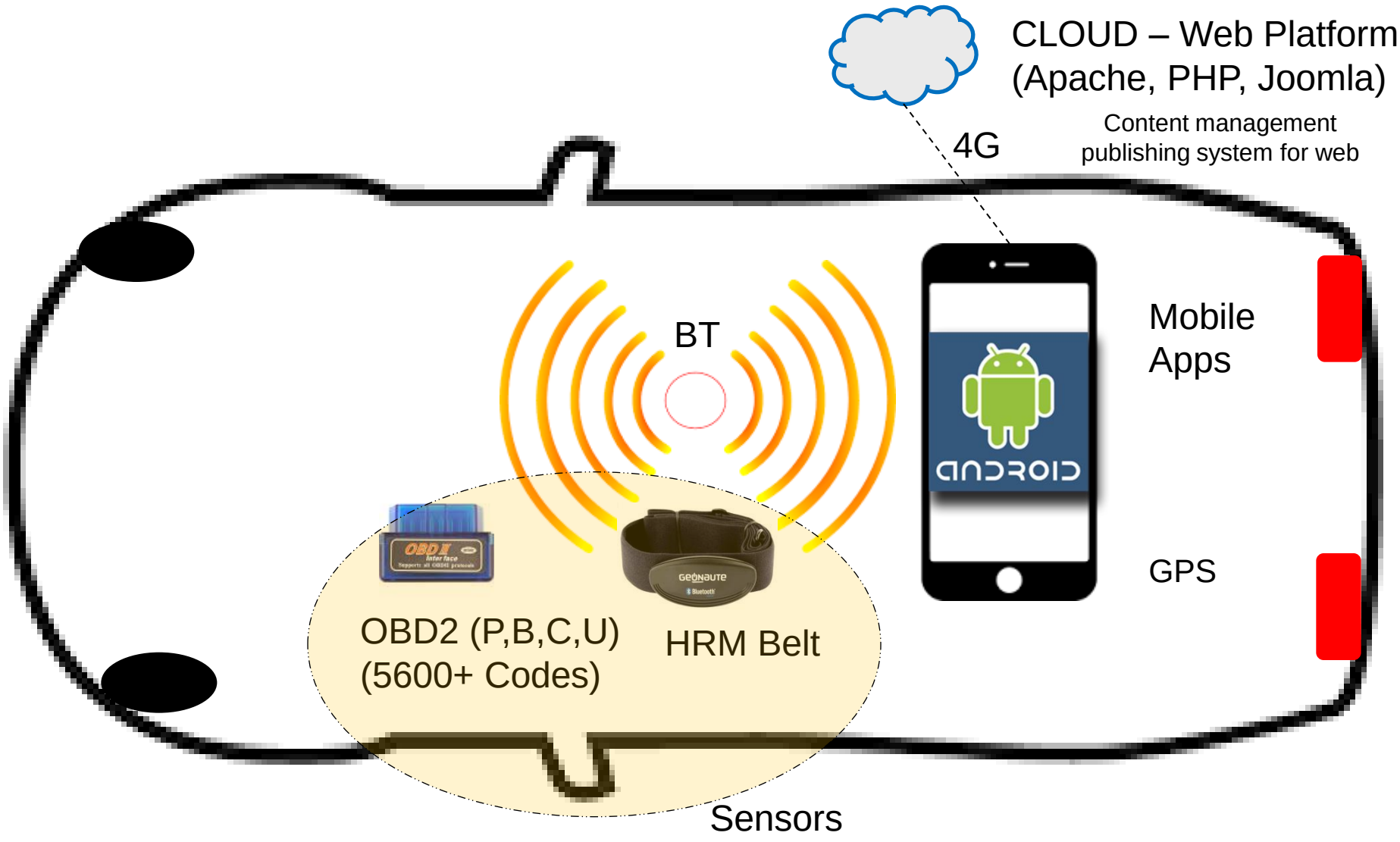




SOLUTION: POSSIBLE APPROACHES

- **STOP DRIVING!!**
  - Nope, not possible. There are over 1Billions cars on the road…
  - The car industries will collapse if that happens…
- **DON'T USE GASOLINE (PETROL), USE ELECTRIC CAR…**
  - Gasoline is not the only issue
  - Electricity is generated by turbines (using steam or coal)
  - Self driving car is NOT the solution
- **WE PROPOSED – STARTING FROM YOU……**
  - Yes, you and me – we are drivers
  - Our driving styles, our behavior
  - And its impact on fuel consumption, accidents, pollution, etc.

PROPOSED SYSTEM DESIGN



THE CAR – THE ELECTRONICS

Diagnostic Trouble Codes

B - Body
C - Chassis
P - Powertrain
U - Network

00-99 - Specific fault designation

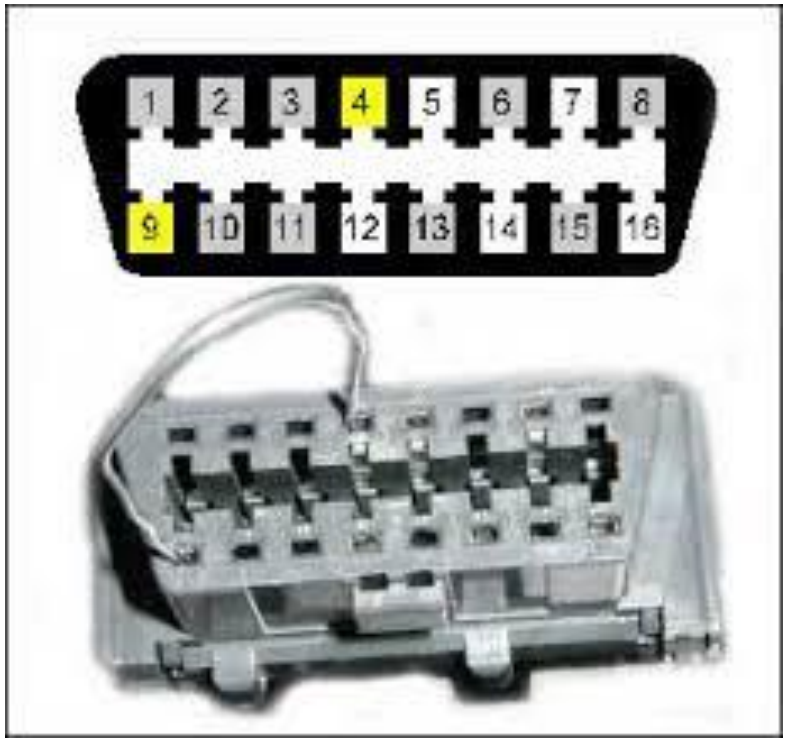
P 0 1 50 (O_2 Sensor circuit problem)

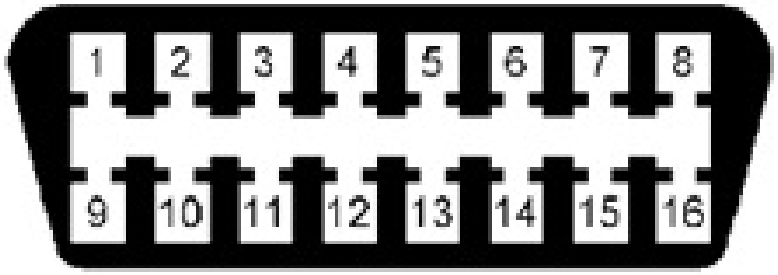
Society of Automotive Engineers

0 - Generic (SAE universal codes - same definitions for all manufacturers)
1 - Manufacturer's specific codes - not standardized

1 - Fuel and Air metering
2 - Fuel and Air metering
3 - Ignition system or Misfire
4 - Auxiliary emission controls
5 - Vehicle speed and idle regulation
6 - Control module and output signals
7 - Transmission
8 - Transmission
9 - Control modules, input and output signals

On Board Diagnostic (OBD)



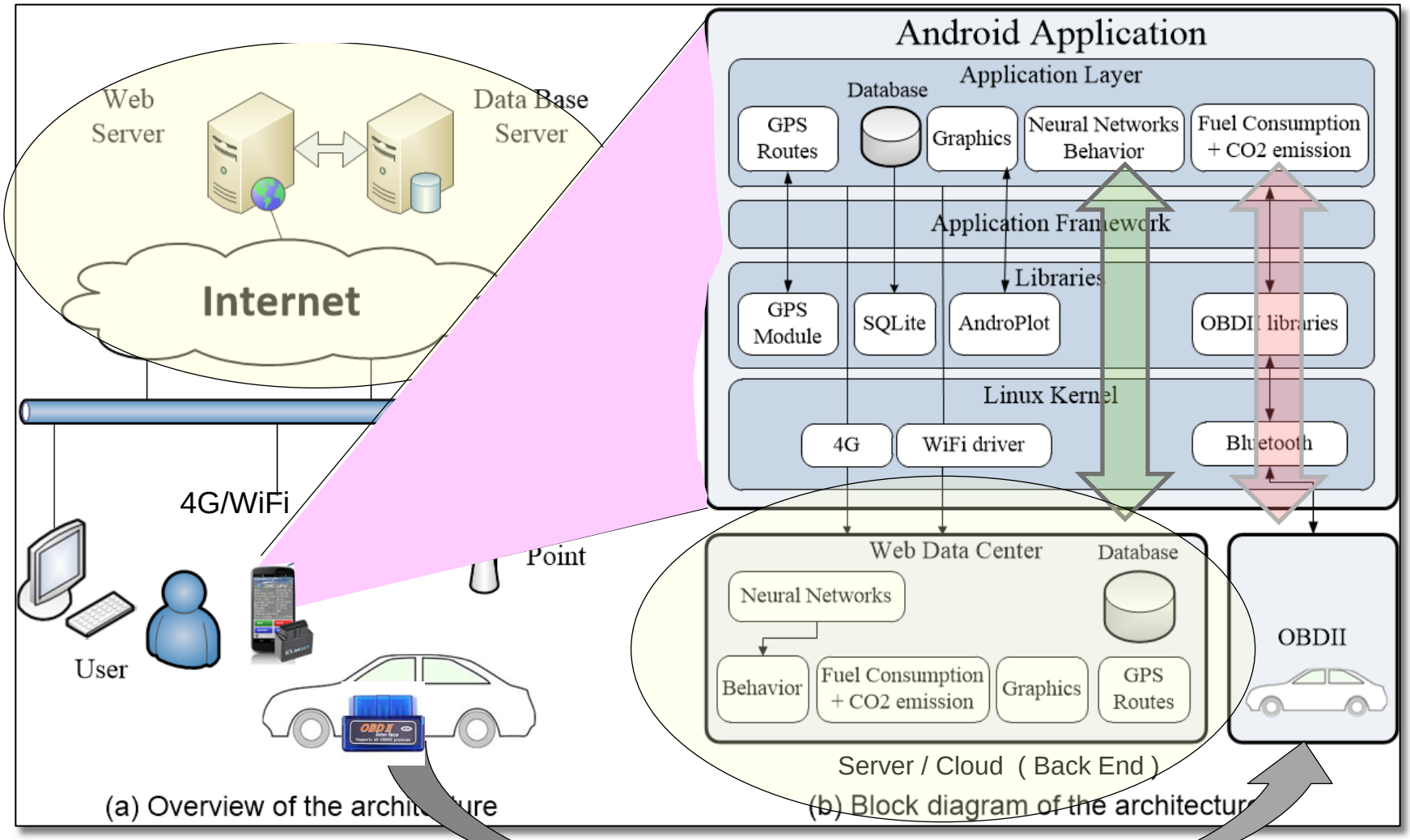


PIN	DESCRIPTION	PIN	DESCRIPTION
1	Vendor Option	9	Vendor Option
2	J1850 Bus +	10	J1850 Bus –
3	Vendor Option	11	Vendor Option
4	Chassis Ground	12	Vendor Option
5	Signal Ground	13	Vendor Option
6	CAN (J-2234) High	14	CAN (J-2234) Low
7	ISO 9141-2 K-Line	15	ISO 9141-2 L-Line
8	Vendor Option	16	Battery Power

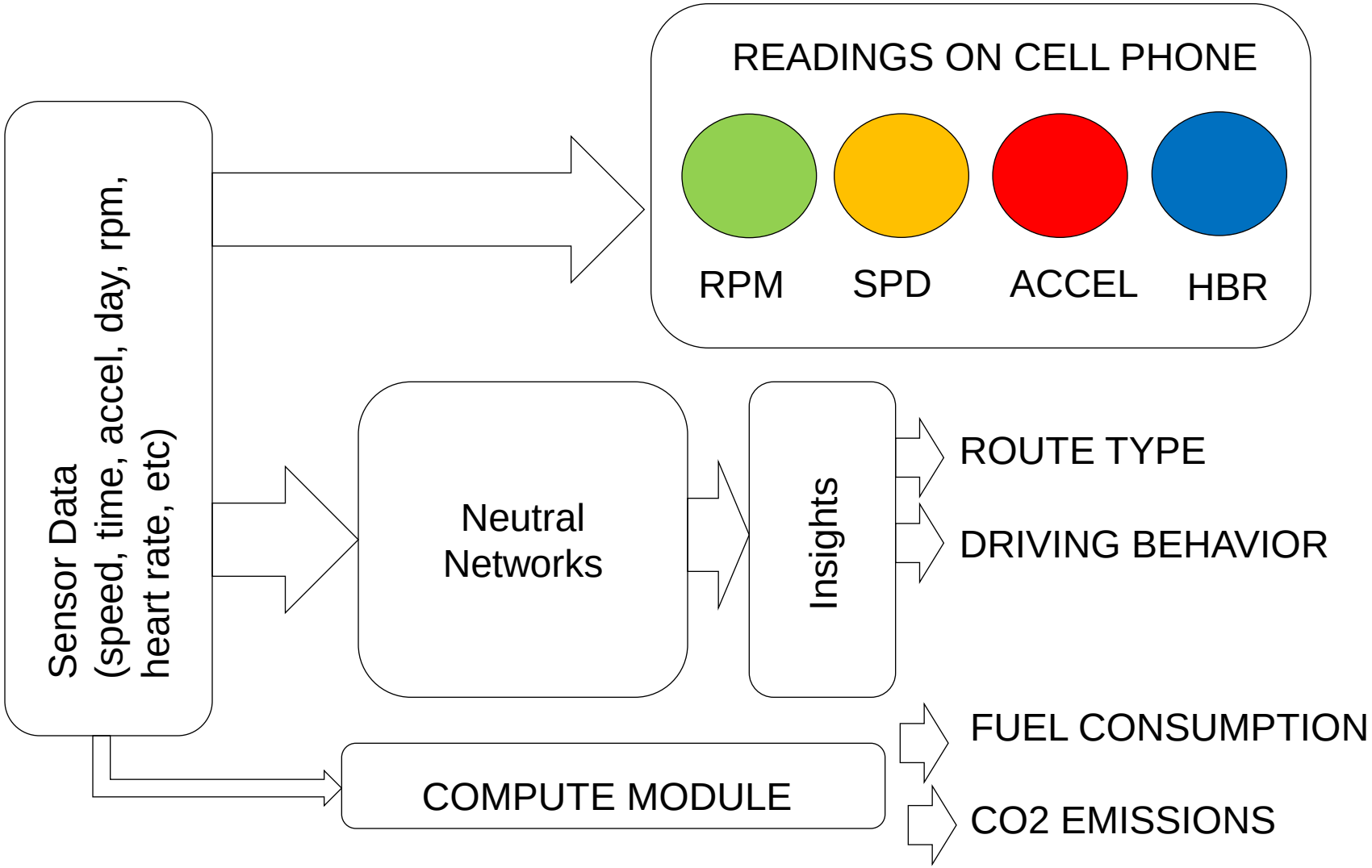
OBD-II Connector and Pinout

The OBD IN YOUR CAR

Our Proposed Systems Architecture



System Data Flow Diagram



Over 15,000 Registered Users Globally

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Our Trials Taken from Drivers Globally

- 534 drivers, 414 Routes under tests
- Routes are driven in different days
- Drivers' Age ranges from 24 – 74 years old

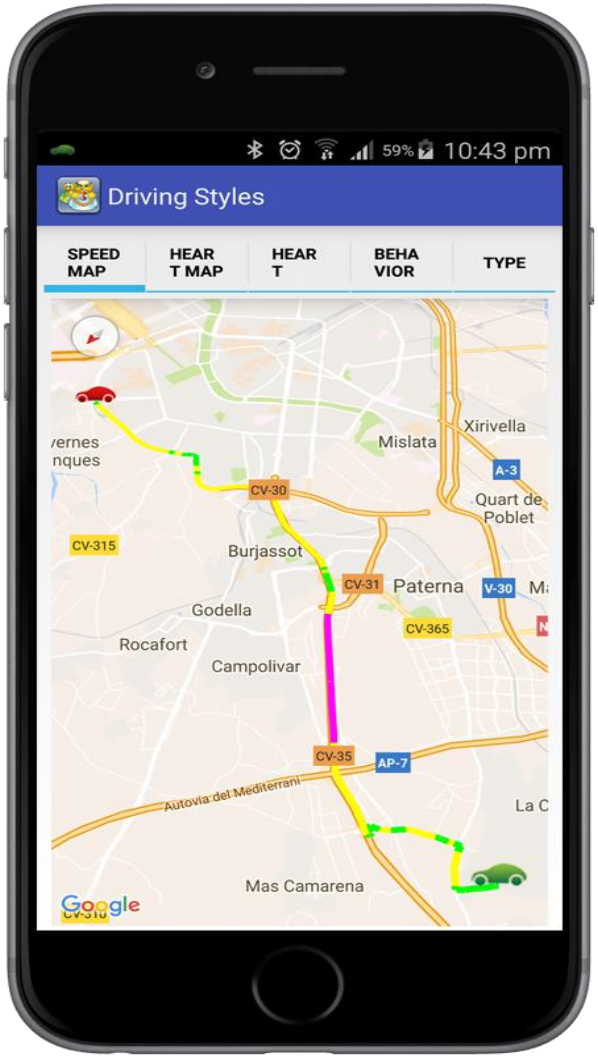
- Routes are from drivers in these countries:
  - USA, MEXICO, COSTA RICA, ARGENTINA, BRAZIL,
  - GERMANY, NETHERLANDS, SPAIN, HUNGARY
  - ROMANIA, SLOVENIA, INDIA, etc

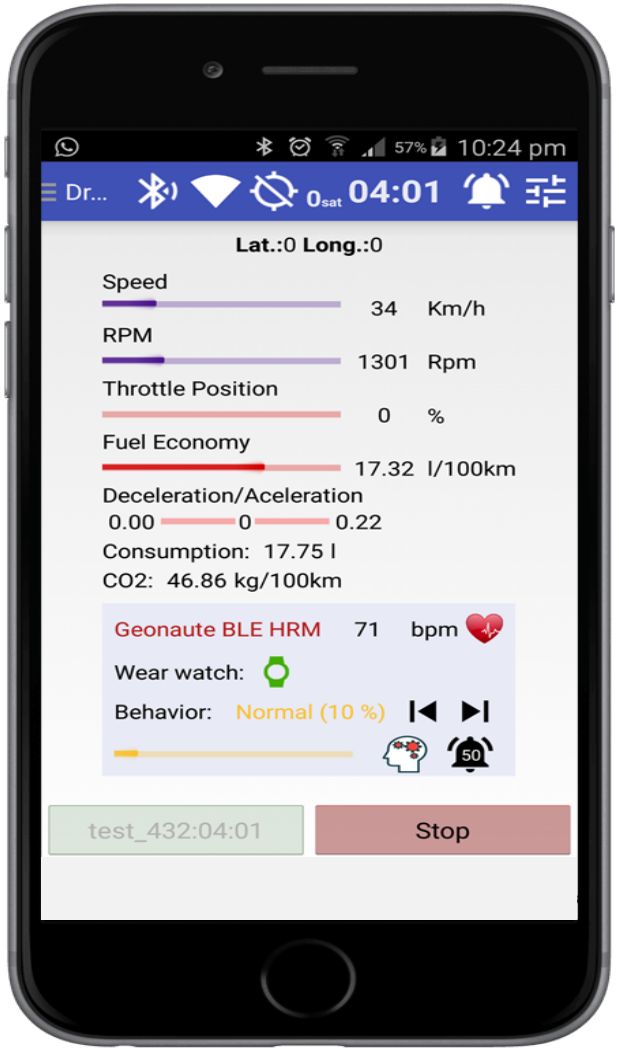
- 25 Different types of cars under tests

- Cars are from these makes:
  - Honda, Skoda, Volkswagen, Toyota, Renault, Ford, Mercedes
  - Citroen, Ford, Nissan, Suzuki, Kia, AMC, SEAT, BMW

- 16 Diesel, 7 Gasoline, and 2 Hybrid Cars under tests

Android App: DRIVING STYLES





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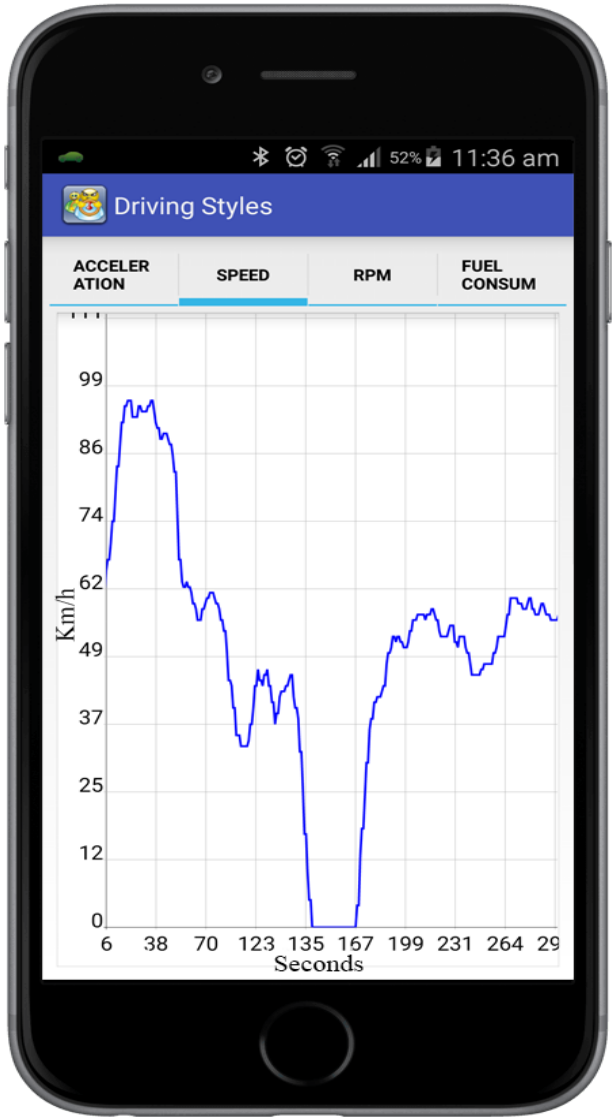
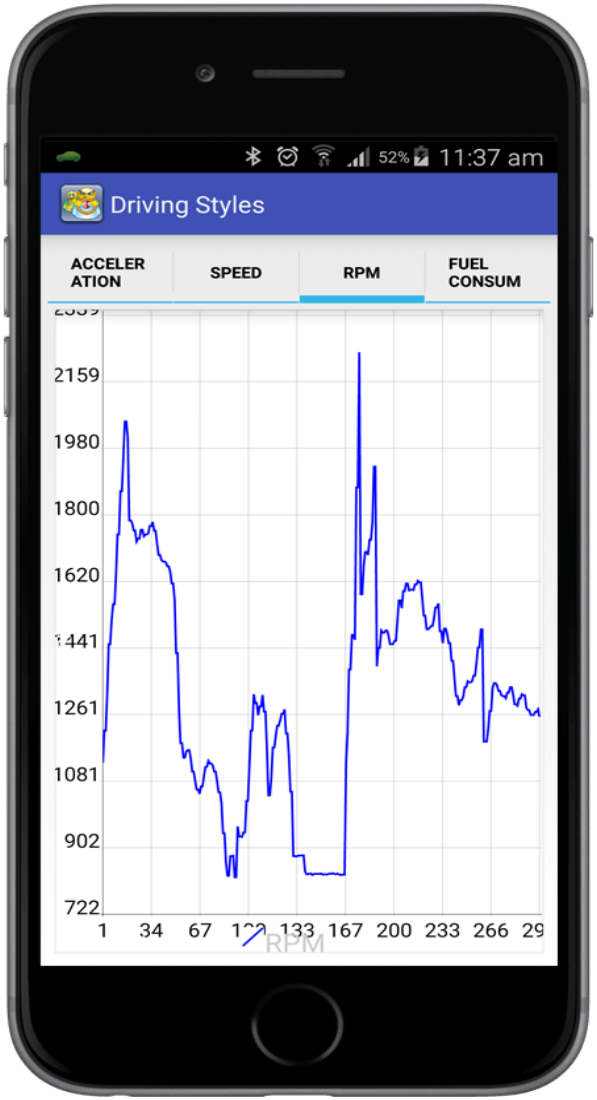
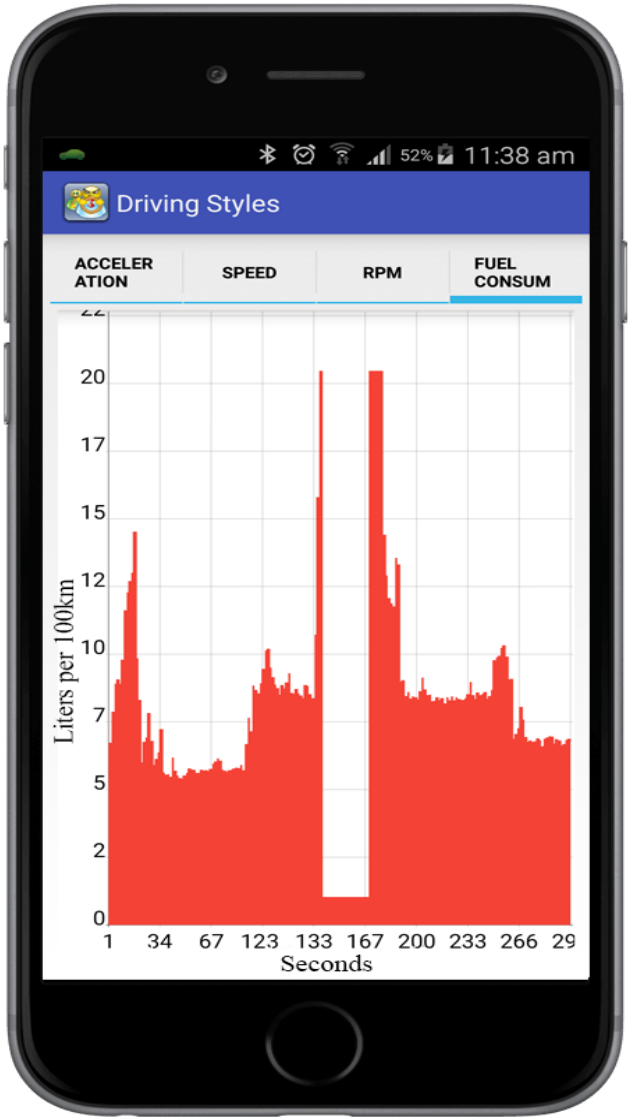
Android App: DRIVING STYLES







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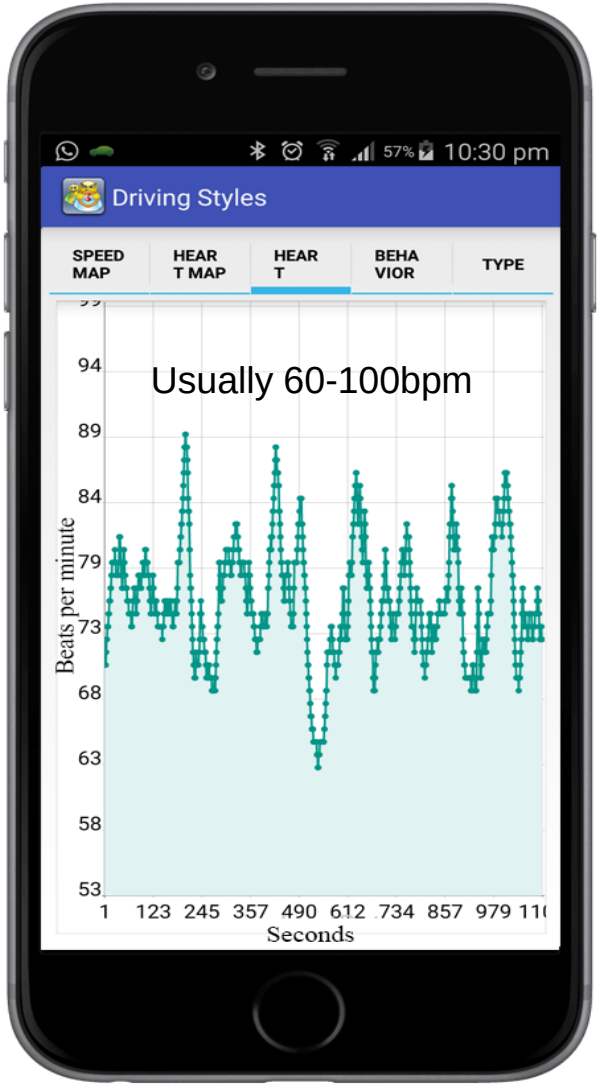
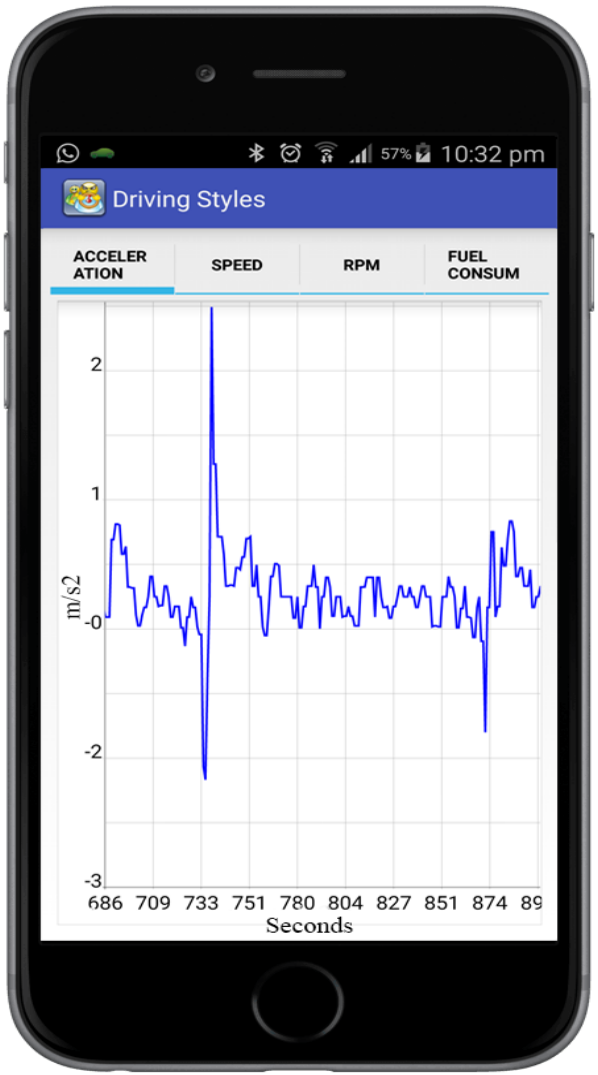
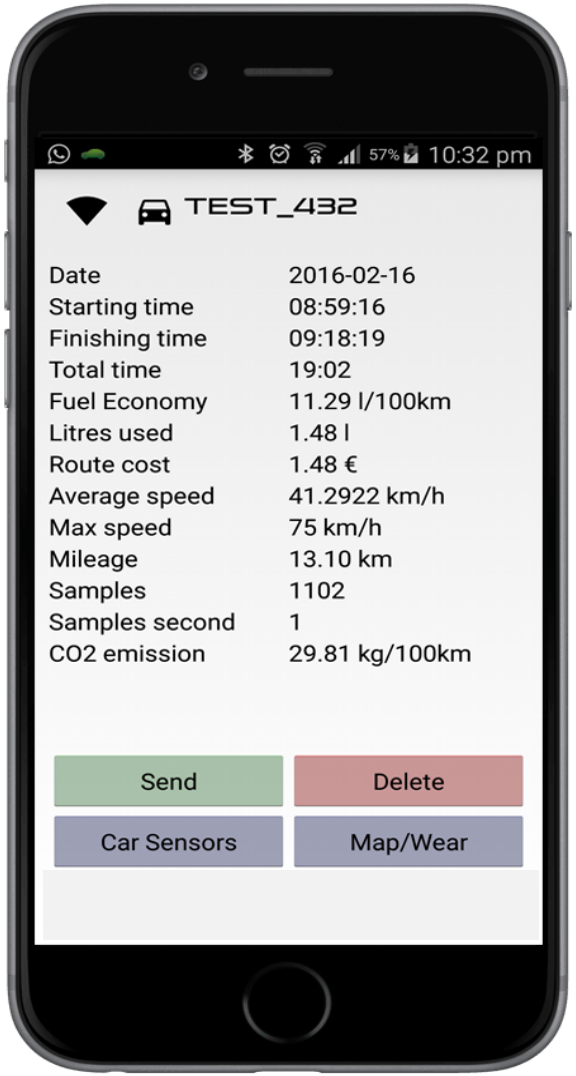
Android App: DRIVING STYLES







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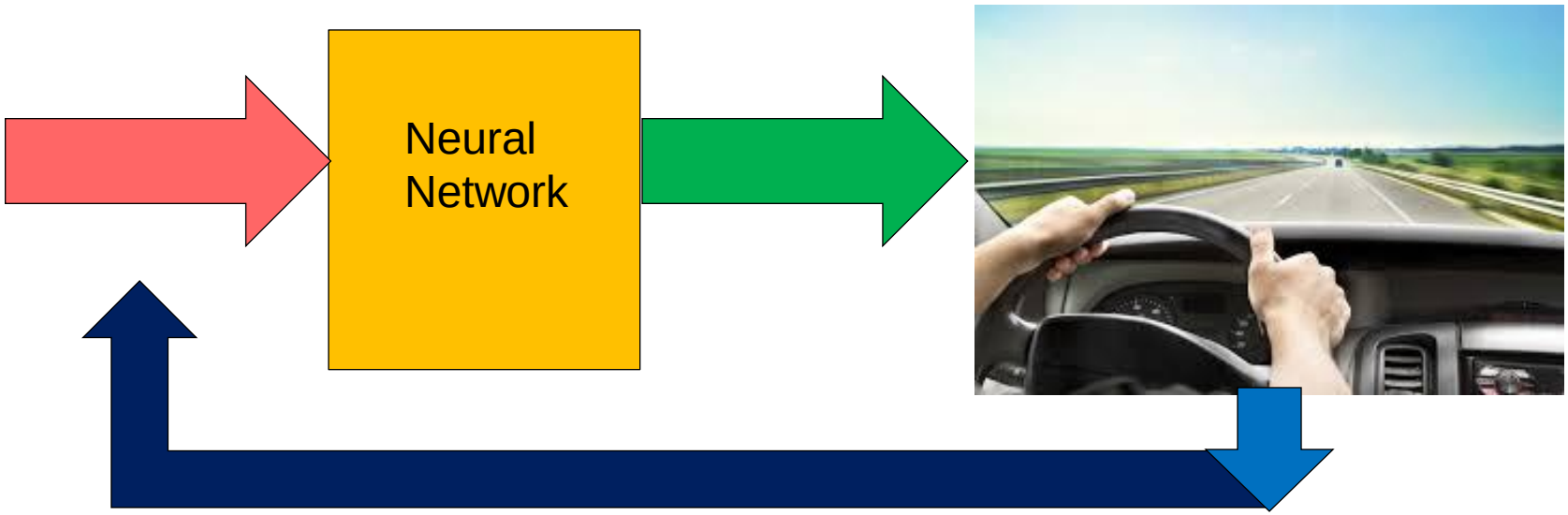
Key Characteristics We Created

- Capture a driver's driving style
  - Kept a record of his travel profiles
  - Kept a record of his car performance + health
- Understand his driving behavior
  - Help him improves his driving skills better
- Notify him - his style's impact on fuel and environment
  - Help him improves his driving
  - Help him saves $$ and prolong life of vehicle
- Promotes Good driver rating
  - Draws in advertisement
- Right now – have a pool of users in Europe…

The Neural Network

3. Neural network
   - Identifies, for each path segment, the driving style of each user.
   - Identify the ROAD TYPE : urban, suburban or highway.
4. Integration of the neural networks in the data center
   - Dynamically and automatically analyzes user data
   - Serve QUERIES by users to find out their profiles as well as their fuel consumption



BACKWARD PROPOPAGATION

- INPUT
- OUTPUT
- WEIGHTS
- LAYERS
- ERRORS

- ACTIVATION FUNCTIONS

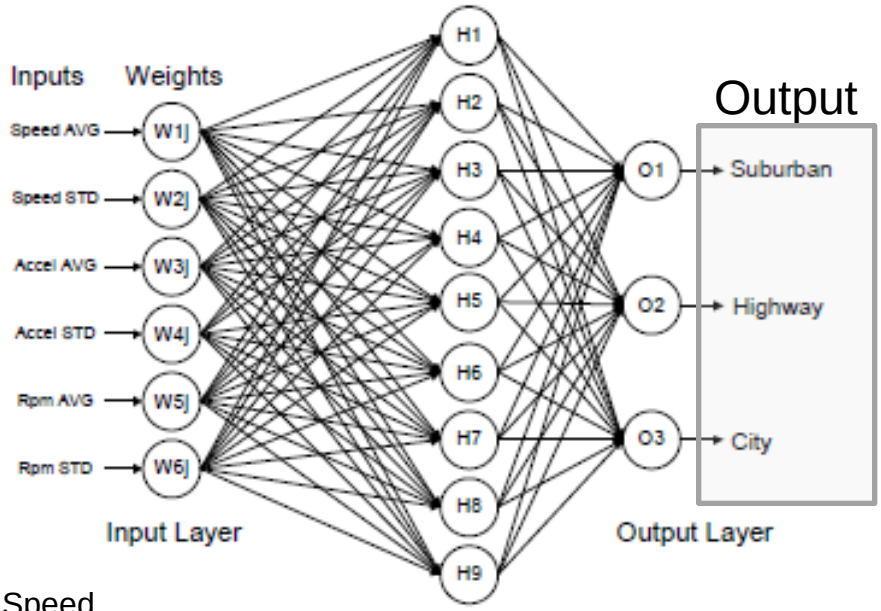
$$S(t) = \frac{1}{1 + e^{-t}}.$$

- *Sigmoid*

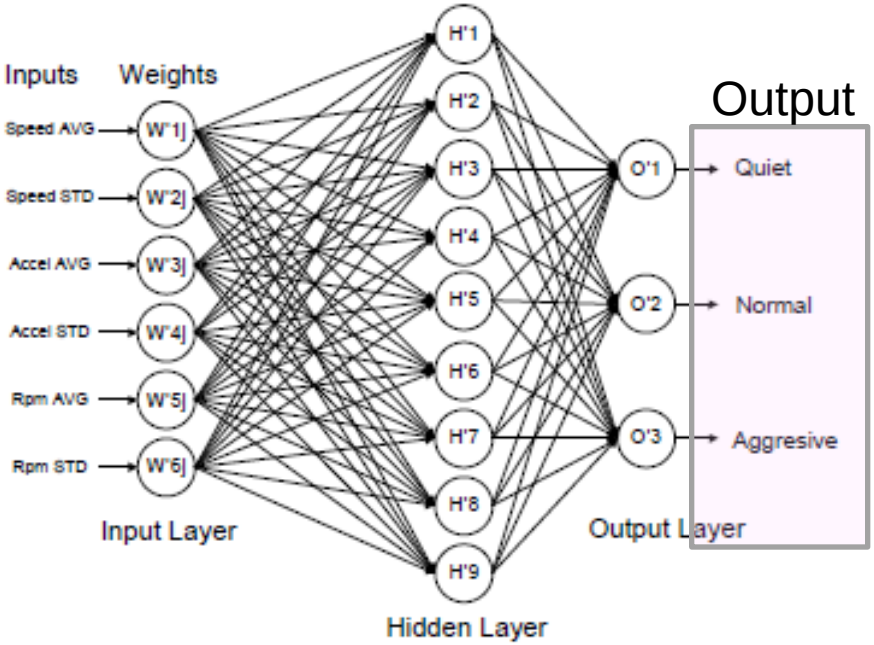
- Gaussian: $\phi(v_i) = \exp\left(-\frac{\|v_i - c_i\|^2}{2\sigma^2}\right)$
- Multiquadratics: $\phi(v_i) = \sqrt{\|v_i - c_i\|^2 + a^2}$
- Inverse multiquadratics: $\phi(v_i) = (\|v_i - c_i\|^2 + a^2)^{-1/2}$

USING NEUTRAL NETWORKS

Supervised Learning, Classification Problem, Backward Propgation Method



(a) Three-layer Neural Network Route Type



(b) Three-layer Neural Network Driving Style Type

- Speed
- RPM
- Accel

- Identify, for each route, the driving style of driver
- Identify the route as suburban, city, or highway

- We use the backward propagation algorithm that yields least sum of squared errors of prediction

JavaNNS

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RESULTS: DRIVER'S BEHAVIOR

(a) Confidence interval of the neural network Driver Behavior corresponding to the route analyzed.

RESULTS: ROAD TYPES

(b) Confidence interval of the neural network Route Type corresponding to the route analyzed.

0% confidence interval ► No faith at all. Results not indicative.

OUR RESULTS .....

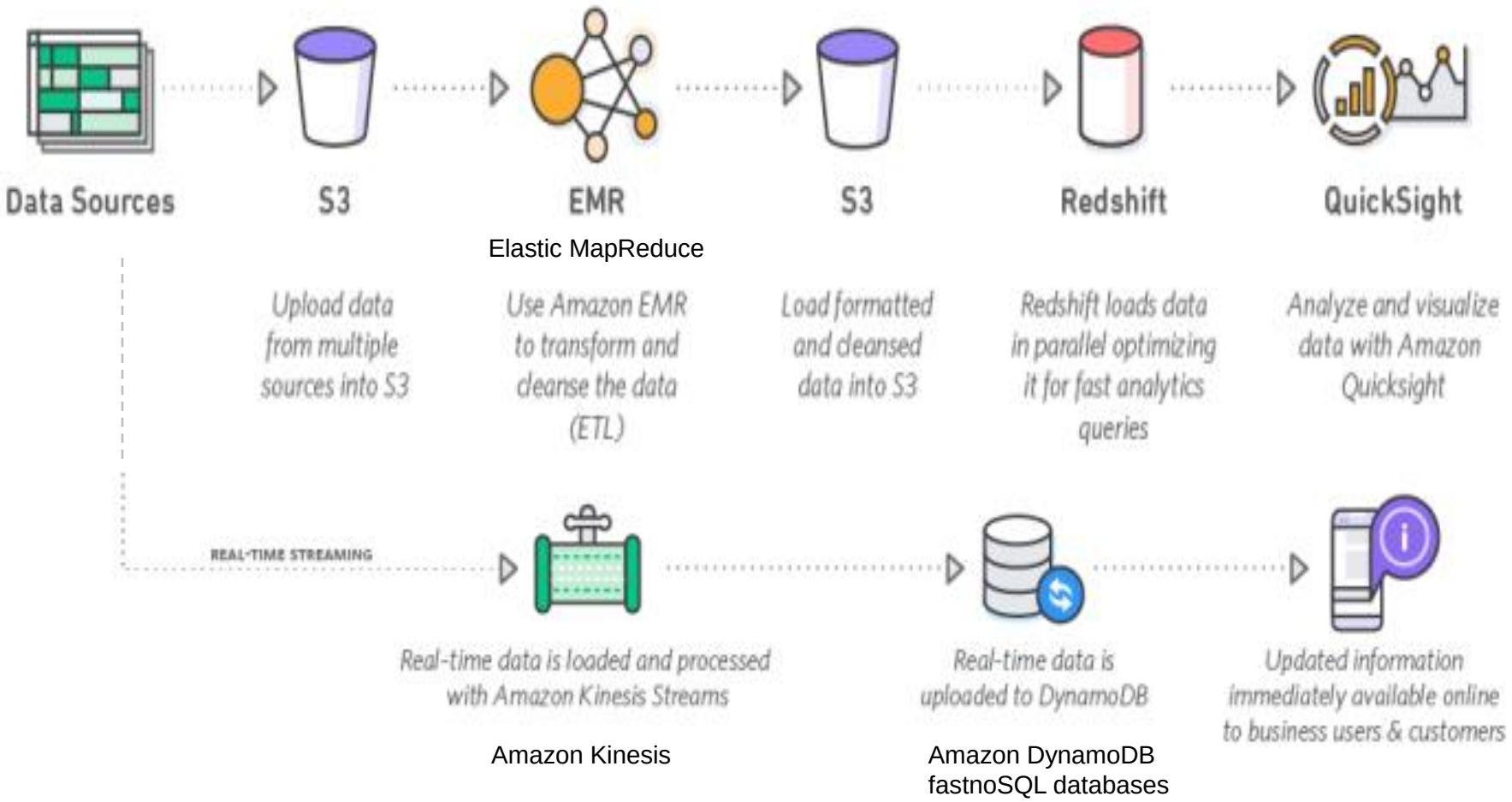
- Our 3-Layer Neural Networks are able to:
  - Predict well **on the type of roads** the user has driven given inputs and sufficient training
  - We need to know “ROAD TYPE” to yield insights on what is behind the “driving styles” and “fuel consumption”

- Our 3-Layer Neural Networks are able to:
  - Categorize well the BEHAVIOR of the drivers based on given inputs
  - BEHAVIOR: **AGRESSIVE** | NORMAL | **QUIET**
  - We use HEART RATE as an input, in addition to car OBD parameters such as “speed”, “rpm”, “accel”, etc.
  - **This is new in the sense that we combine:**
    - HUMAN body vita data with
    - VEHICULAR motion real-time data
    - To relate and explain the cause of serious of actions
    - This is analytics and insights applied to Telematics

• THIS MEANS…MORE ANALYTICS WORK NEEDED

- 1 Billion + Cars on the Road
- 214 Million licensed drivers in the USA alone
- Over 6 Million km of roadways in USA
- Imagine BIG DATA
  - Driving style records (about the commute)
  - Driving profile records (about the driver)
  - Time of Day, Speed, Location, Road Type, Fuel, etc
- **Analytics & Insights can help to:**
  - Ease traffic congestion
  - Deal with pollution
  - Understand cause of accidents, etc.
  - Make better driving decisions

DATA ANALYTICS IMPLEMENTATION – AMAZON



RESULTS: FUEL CONSUMPTION

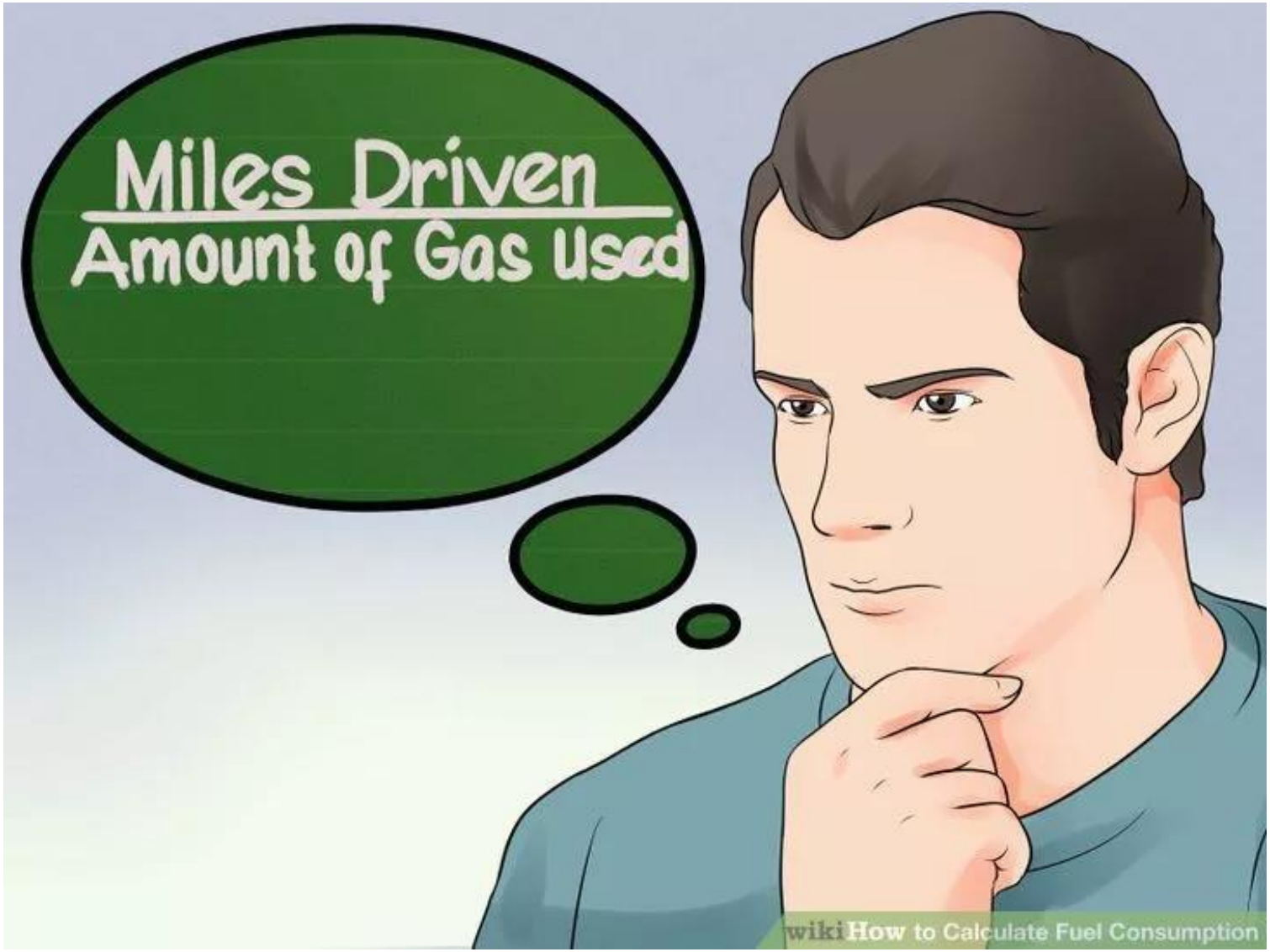
- Using OBD data collected, how do we calculate:
  - Fuel consumption
  - CO_2 emissions

- Evaluate the impact of Driving Behavior on Fuel consumption and on Greenhouse effect

Recall: 4-Stroke Car Engine

1. INTAKE
2. COMPRESS
3. COMBUST
4. EXHAUST

WHAT IS MILEAGE?



WHAT IS FUEL CONSUMPTION?

- Fuel consumption = ratio of fuel consumed over distance travelled (litres per 100 kilometres or inverse of MPG – miles per gallon).

$$Fuel\ Consump.\ [l/100km] = \frac{Fuel\ Flow\ [l/h]}{Speed\ [km/h]} \cdot 100 \qquad Instanta.\ Fuel\ Consump.\ [l/km] = \frac{Fuel\ Flow\ [l]}{Speed\ [km]}$$

- The OBD does not have a fuel consumption parameter. But, it provides other values that enable its calculation.

$$Fuel\ Flow\ [l/h] = (MAF \cdot 3600)/AFR_A \cdot FD$$

- MAF - Mass Air Flow (g/s)
- AFRA actual Air-to-Fuel Ratio
- FD – Fuel Density (g/l)

Obtained from OBD

Fuel Type g=dm3	Ratio by mass	Density
Gasoline	14.7:1	820
Diesel	14.5:1	750

Ideal air/fuel ratio (grams of air to 1 gram of fuel) - Density (g/dm3).

RESULTS: Greenhouse Gas Emissions

Greenhouse gases are generated from direct combustion carbon dioxide *CO2*, Methane (*CH4*), and Nitrous oxide (*N2O*), among others.

Burning 1Kg of Carbon ► 3.67Kg of CO2

C02 Emission

Fuel Carbon Content

Mass of Fuel will burn

$$m_{CO_2} = 3.67 \cdot C_c \cdot m_{fuel}$$

$$m_{CO_2} = 3.67 \cdot 0.857 \cdot 1\,[kg] = 3.15\ [kg/1kg\ fuel]$$

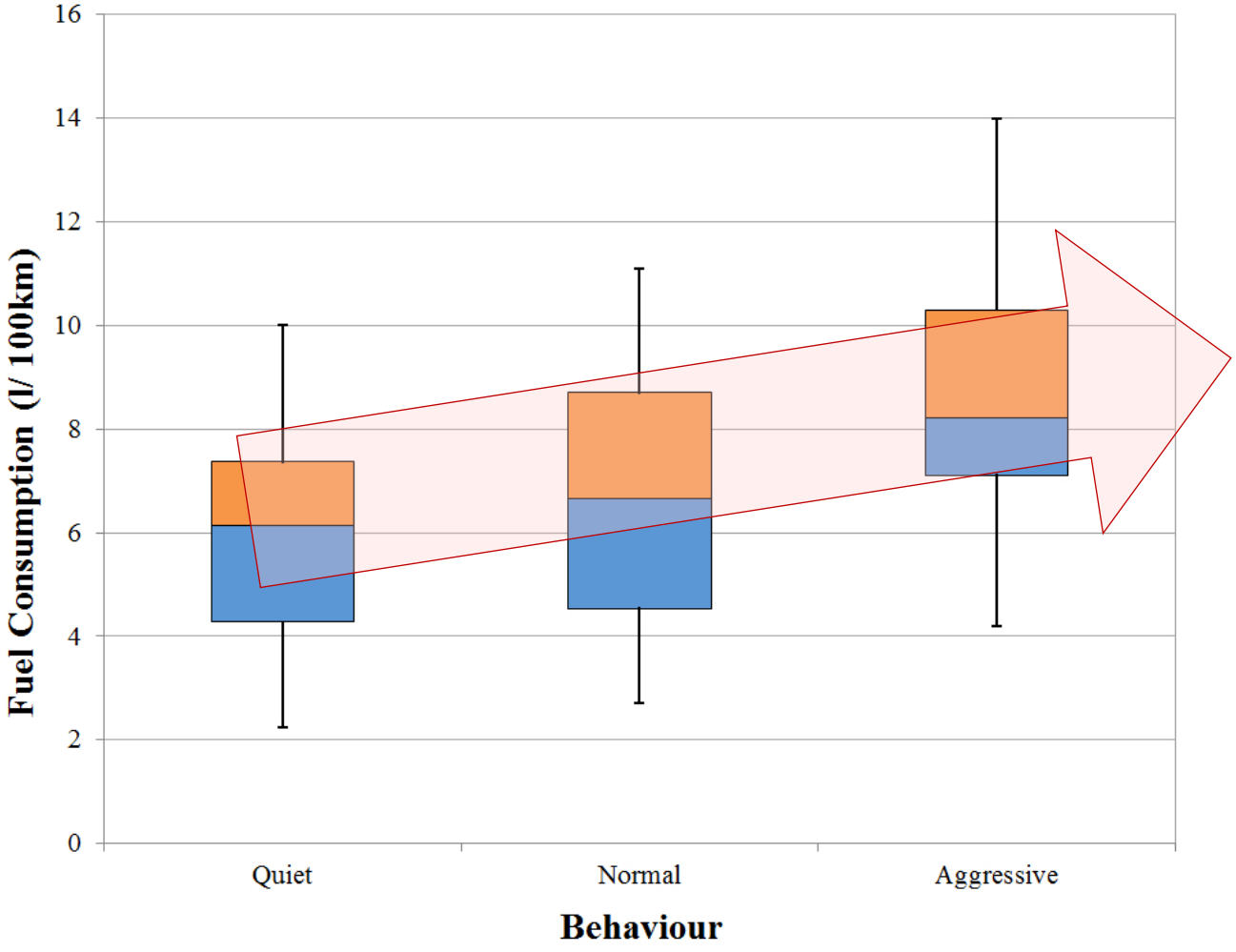
$$Density\ of\ diesel\ fuel\ is\ 0.84\ [kg/l]$$

$$m_{CO_2} = 3.15\,[\mathrm{kg}] \cdot 0.84 = 2.64\ [kg/1l\ fuel]$$

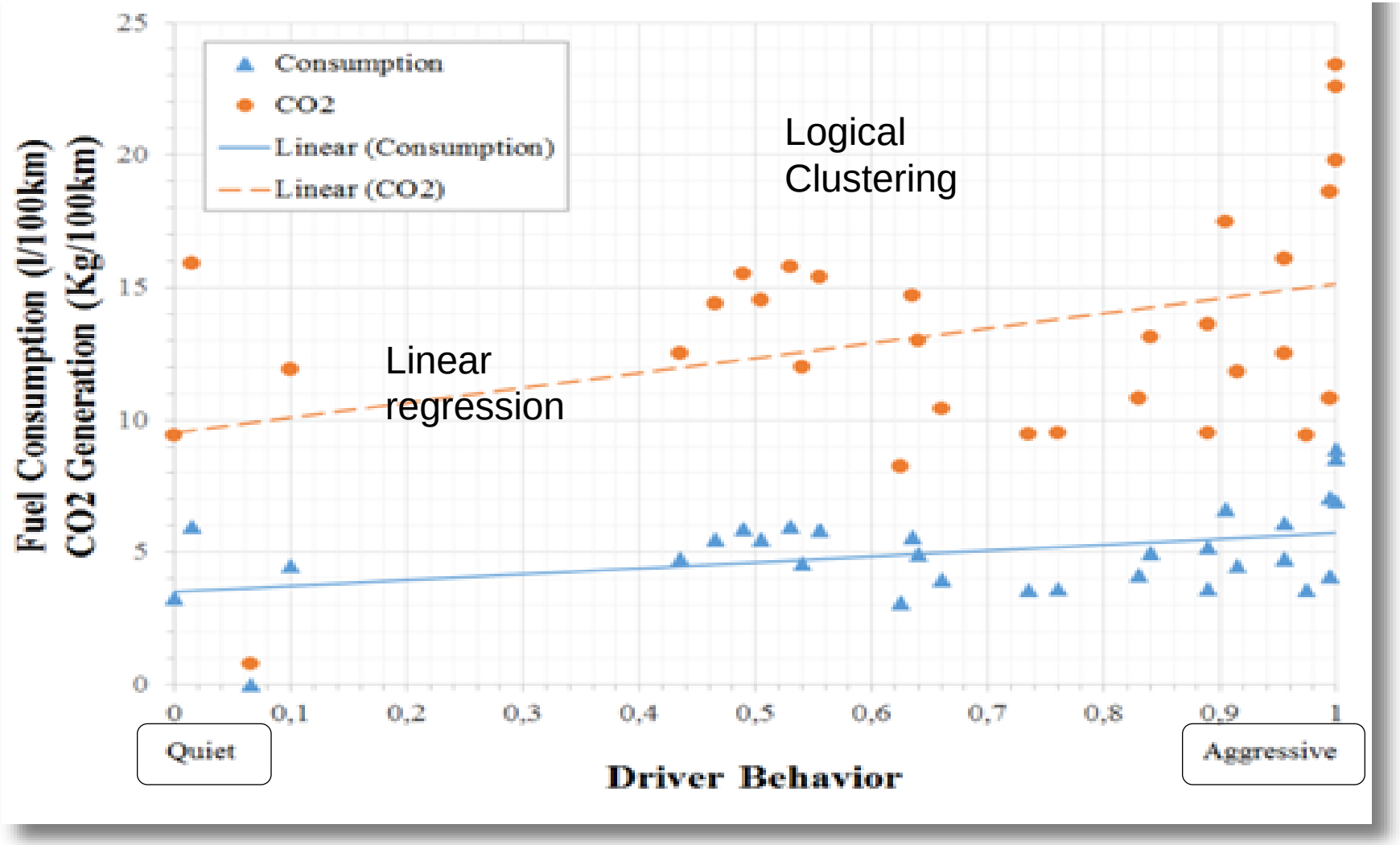
Factors that can affect fuel consumption:

1. Vehicle age and condition
2. Outside temperature, weather
3. Traffic conditions
4. **Driver behavior**

FUEL CONSUMPTION vs. DRIVING BEHAVIOR



RESULTS: CO_2 Emissions & Fuel Consumption



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Experimental Results and Evaluation

1. **AGGRESSIVE DRIVING – results in greater fuel consumption, cost, and pollution. And it adds to danger in driving (accident prone)**

2. **Making drivers aware of their behavior is important**. Allows for:

   - Self correction
   - Better and safer driving
   - Do not pollute or use fuel excessively

WHY OUR WORK IMPORTANT? = UBER

FORTUNE magazine

June 2016

UBER

Uber Is Starting to Monitor Drivers For Bad Behavior

Uber (uber) wants drivers to know why they're getting bad ratings.

The transportation company will begin testing new software this Friday that monitors driving behavior. The Wall Street Journal reports that Uber will be able to track a driver's speed, whether they're stopping short, and other unfavorable habits. The test will start out in at least nine cities including New York, Los Angeles and Chicago. Fortune previously reported that Uber began running a similar test in Houston last November.

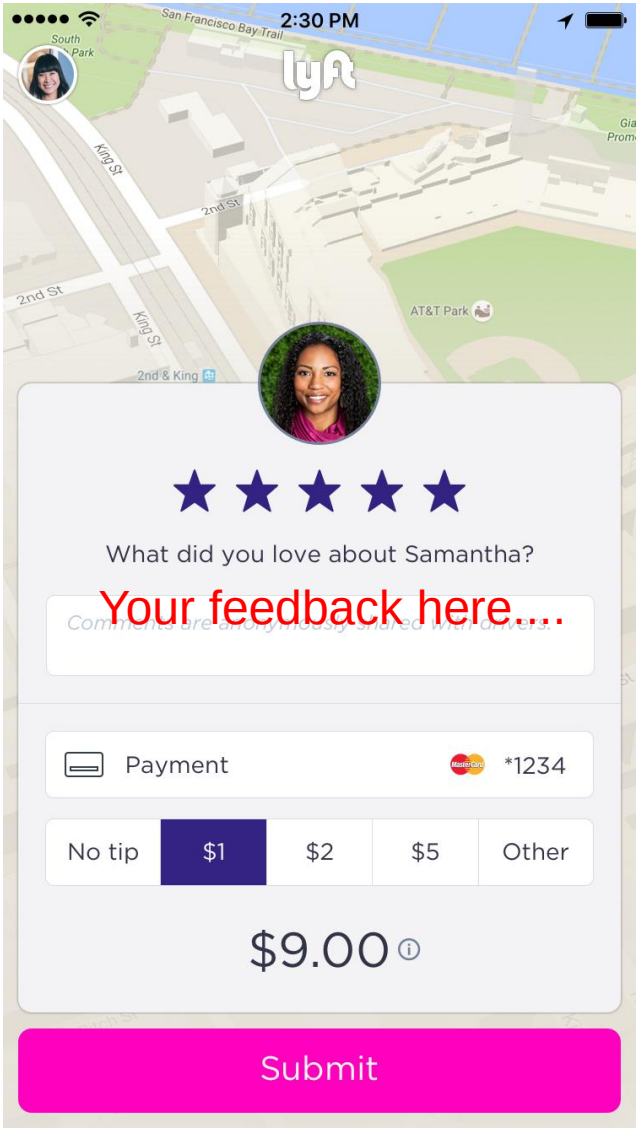
WHY OUR WORK IMPORTANT? = Lyft

- Even Lyft wanted

To know how their

Driver is behaving…

- METRICS:
  - Friendly?
  - Safe?
  - Good navigator?



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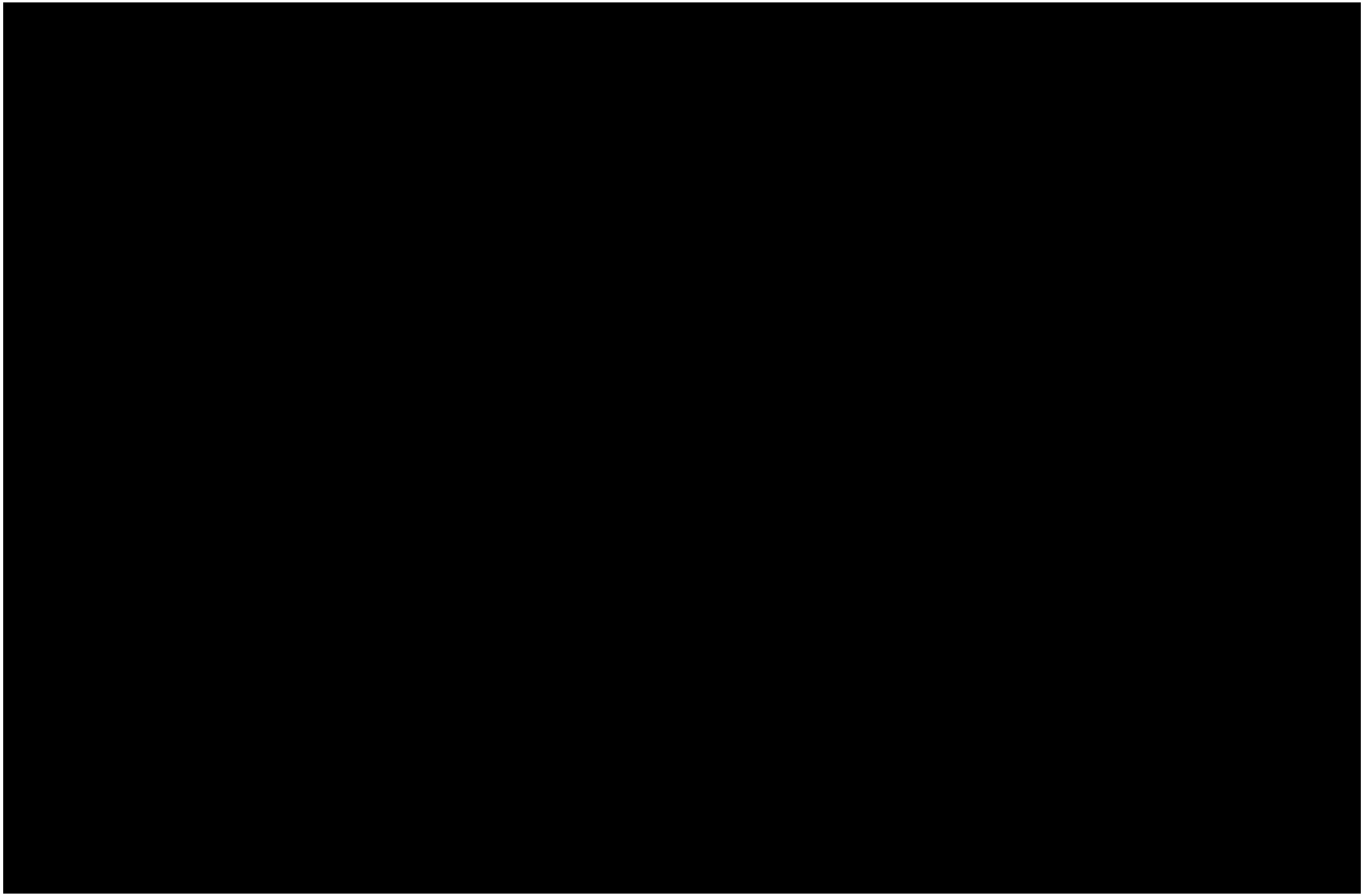
CONCLUSIONS

- **TODAY's WORLD has to embrace FUSION TECHNOLOGIES:**
  - Wireless, Sensors, Location, and Analytics
  - Web, Neural Networks, Databases, Electromechanical System

- **WE HAVE SHOWN THAT:**
  - Drivers' driving styles can impact fuel (gas) consumption
  - Reckless driving can be identified and rectified (driving schools)
  - Good drivers can be rewarded (lower insurance)
  - Good drivers reduce accidents on the road
  - Drivers now know how well or badly they drive (do u know???)
  - Driving profiles can be archived (as in car black box) and use in court cases
  - Good driving saves fuel cost and avoid accidents

- **FINALLY, TRANSPORTATION INDUSTRIES TAKING A TURN:**
  - Towards more self awareness
  - Better understanding of the underlying dynamics
  - Plenty of room for future research

VIDEO: SEEING IS BELIEVING .....



FUTURE WORK

- QUESTIONS?
- THE END

Talk (V2V)

Sense

Extended Vision

Reason/AI