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The 27th INTERNATIONAL ELECTRIC VEHICLE SYMPOSIUM & EXHIBITION.

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Dynamic Range Prediction for an Electric Vehicle

João C. Ferreira[1,2], Vitor Monteiro[2], João L. Afonso[2]

[1]ISEL, Lisbon, Portugal; [2]Centro Algoritmi, Univ. Minho, Guimarães, Portugal

jferreira@deetc.isel.ipl.pt , vmonteiro@dei.uminho.pt, jla@dei.uminho.pt

Universidade do Minho

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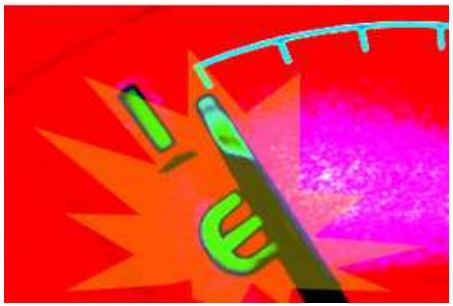
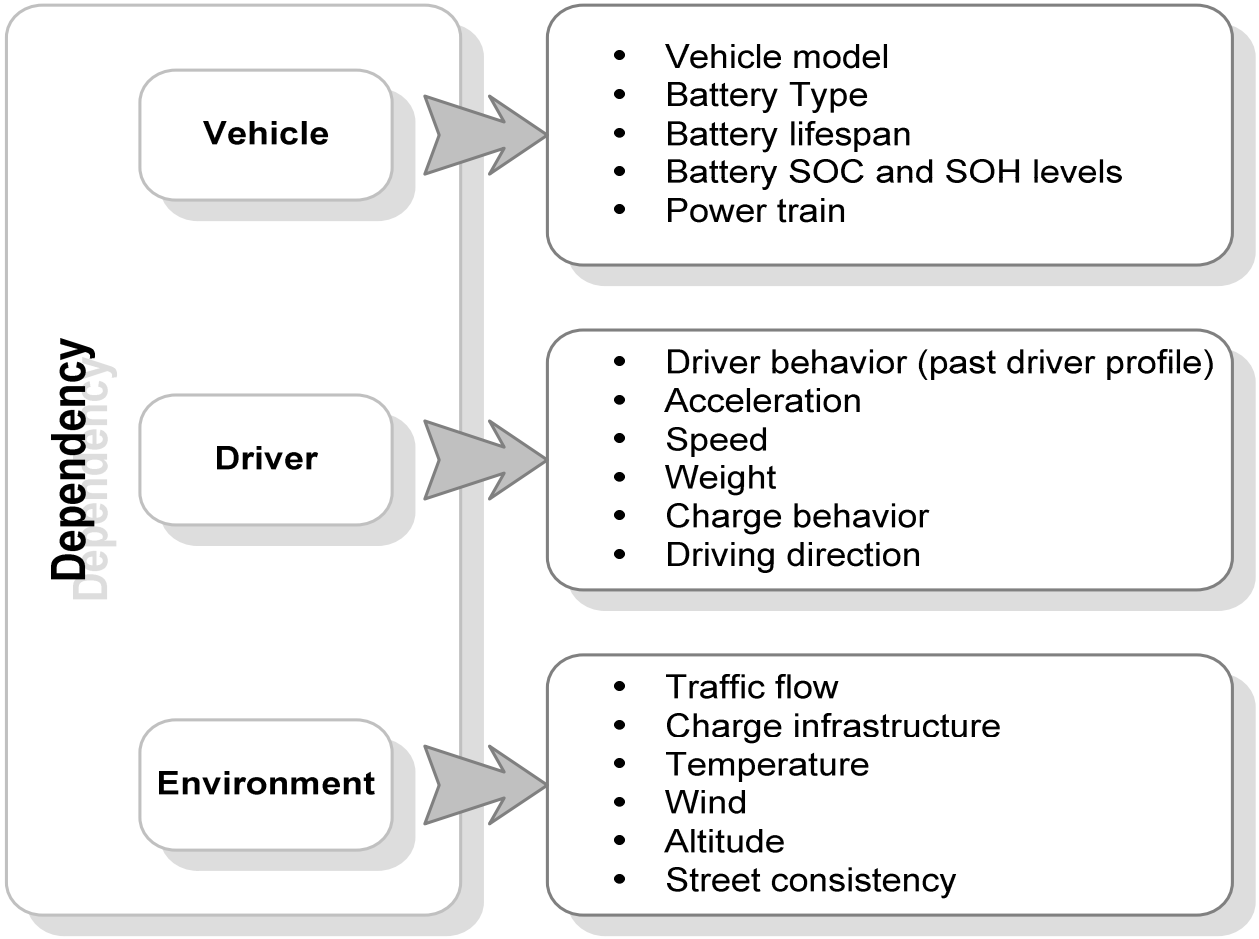
The Problem

- EVs have limited autonomy (e.g., 160 km)
- EV charging process is slow
- Missing EV charging infrastructures



Range Anxiety Problem ⟺ fear that an electric vehicle (EV) will run out of charge before it reaches its destination

Range autonomy is based on



Main Idea

- Personalized Range Prediction
- Range Presentation on a Map
- Information in Real Time on a Mobile Device
- Creation of a Driver Profile

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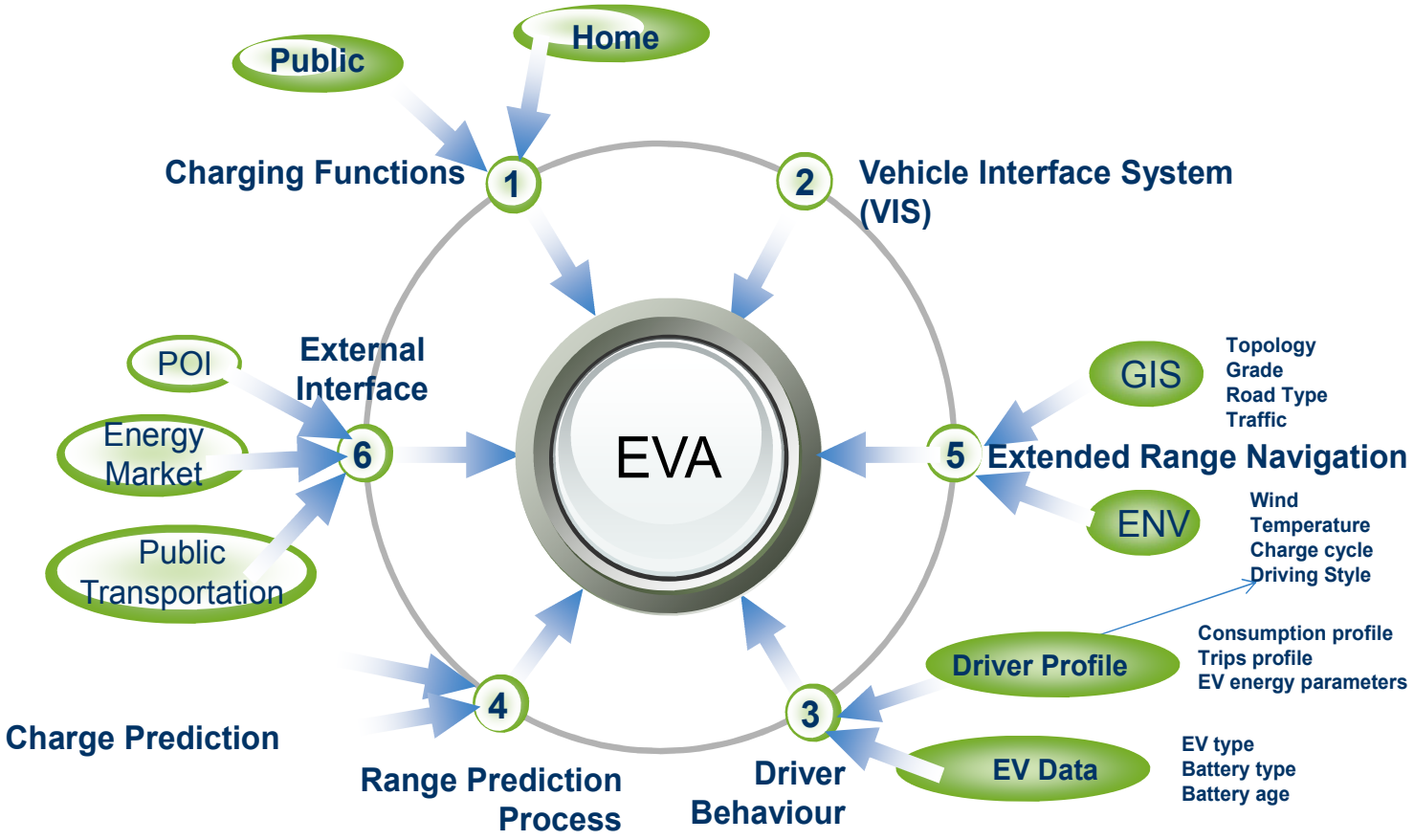
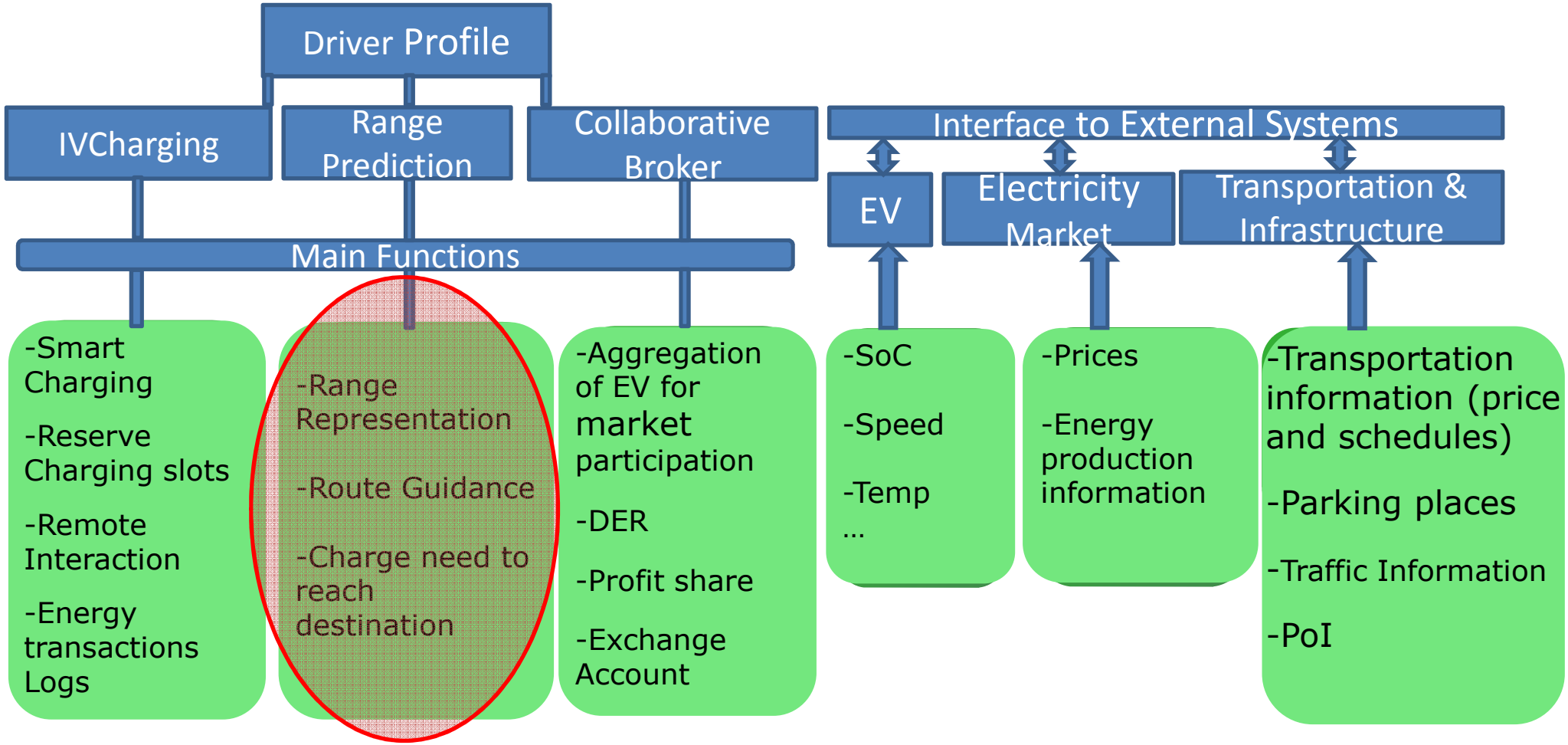
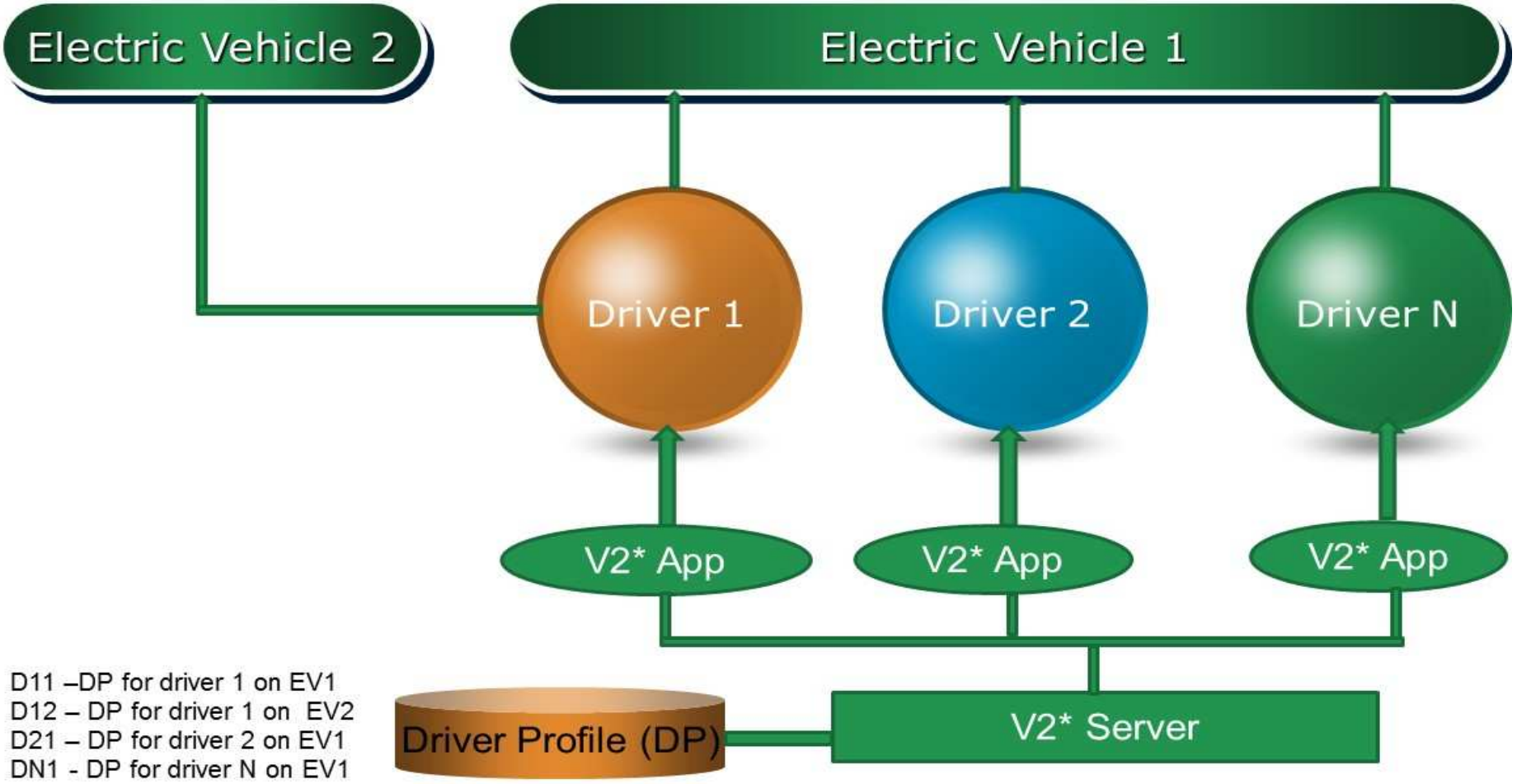
Proposal



General Overview



Driver Profile



D11 –DP for driver 1 on EV1
D12 – DP for driver 1 on EV2
D21 – DP for driver 2 on EV1
DN1 - DP for driver N on EV1

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Information Extraction from EV and Charging Device

Charging Log File	- Charging Point - Start Date - Finished Time - Total Cost
Information from EV	- Battery SoC Level - Voltage and Amperes - Battery Temperature - Speed
Control to Charging Device	- Start Charging - Stop Charging - Program Charging - Discharging

Analyses of transactions data can be useful information for future charging or discharging processes, taking into account a smart charging strategy to combine distribution network limitation and low prices. All of this information is stored on the information repository on the central server. If internet communication is available, the driver can check remotely the home charging process, and interact with it, if he wants to.

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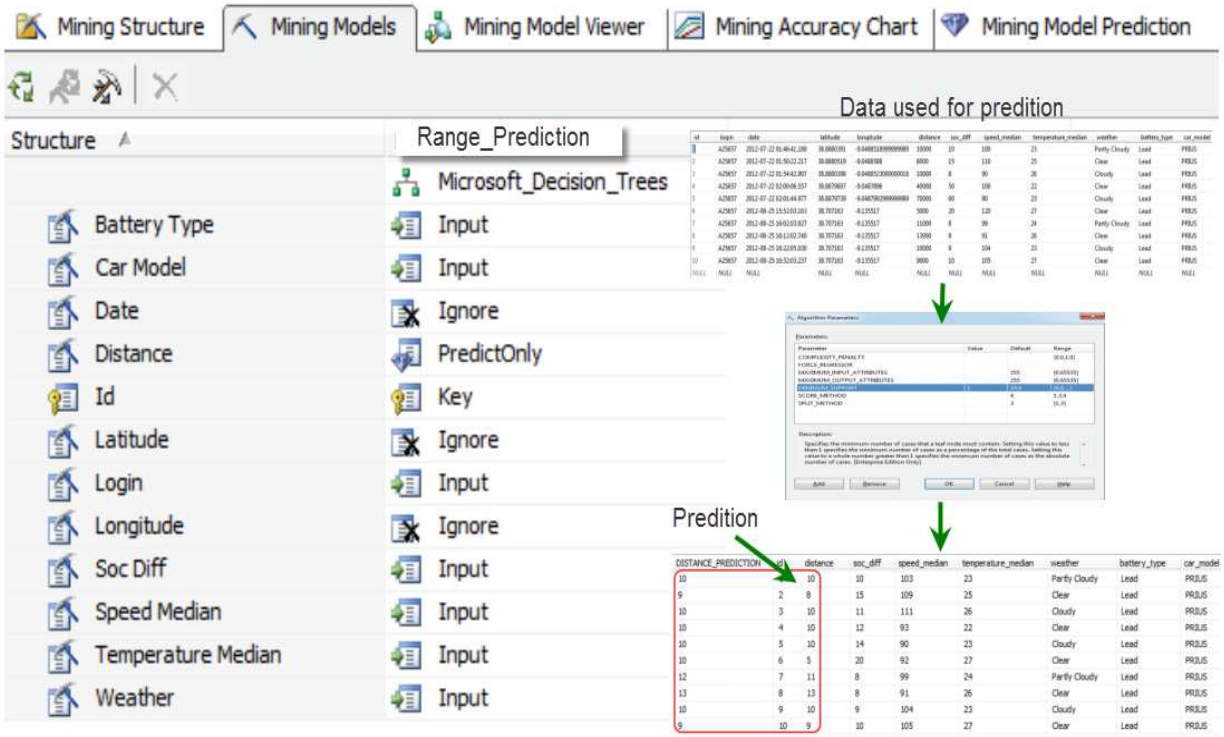
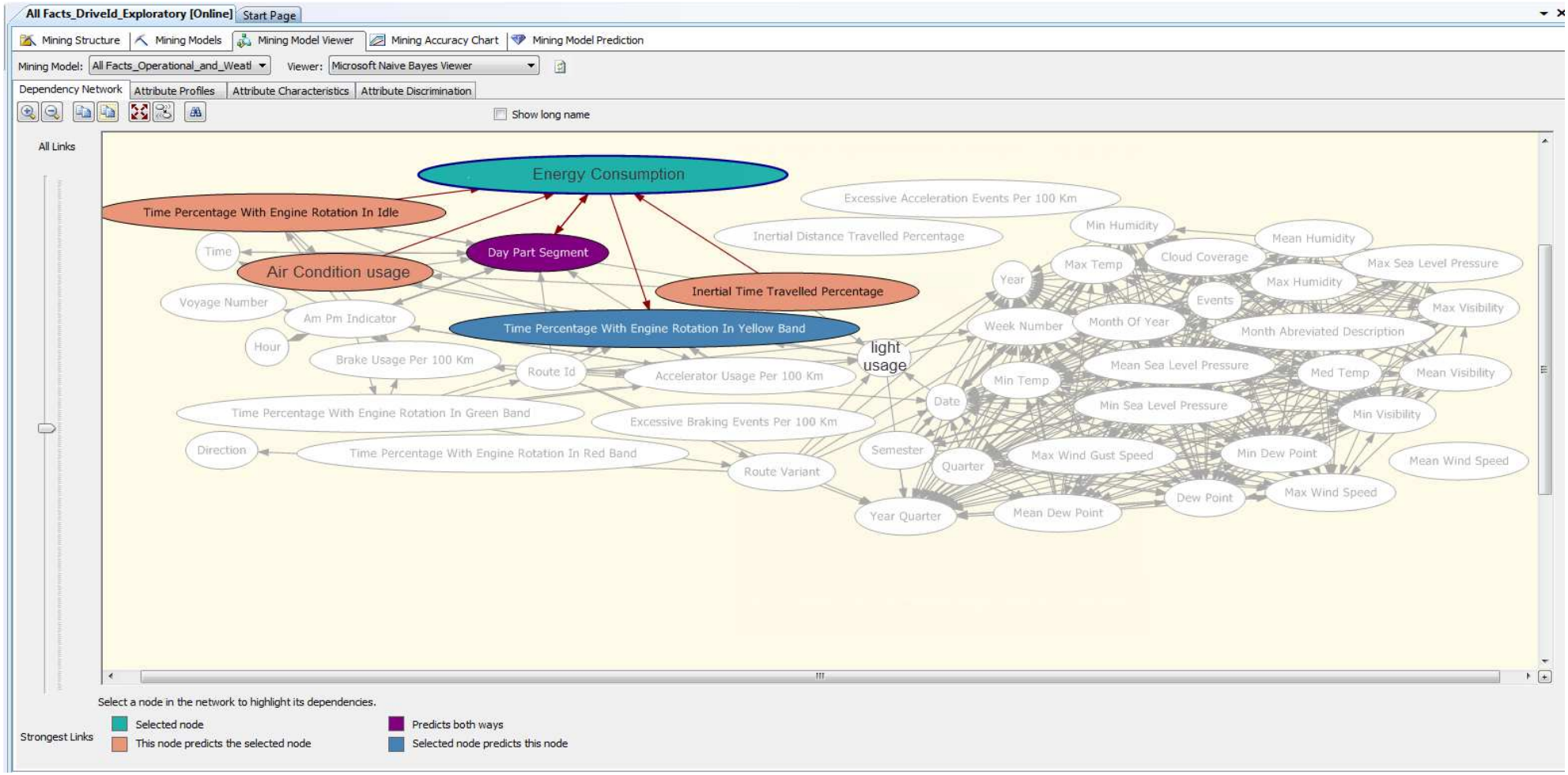
Range Prediction Process



Data mining approach combines past data of driver profile, with current information of EV (speed, SOC level), weather information and traffic.

Average Energy Consumption key influencing factors



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Data from ICE engine

Attribute: Average Fuel Cons. Value: 44.74324 - 55.7322

Characteristics for 44.74324 - 55.7322

Attributes	Values	Probability
Clutch Usage Per 100 Km	< 276.5929	
Time Percentage With Engine Rotation In Yellow Band	< 1.764227	
Clutch Usage Per 100 Km	276.5929 - 604.5859	
Inertial Time Travelled Percentage	5.639054 - 9.320704	
Time Percentage With Engine Rotation In Idle	24.22572 - 31.11111	
Time Percentage With Engine Rotation In Idle	< 24.22572	
Day Part Segment	Daytime	
Day Part Segment	Morning rush hour	
Inertial Time Travelled Percentage	< 5.639054	
Time Percentage With Engine Rotation In Yellow Band	1.764227 - 8.485124	
Time Percentage With Engine Rotation In Idle	31.11111 - 36.81707	
Inertial Time Travelled Percentage	9.320704 - 14.88833	
Day Part Segment	Post afternoon rush hour	
Day Part Segment	Afternoon rush hour	
Day Part Segment	Nightime	
Time Percentage With Engine Rotation In Yellow Band	>= 28.48299	
Time Percentage With Engine Rotation In Idle	36.81707 - 43.21214	
Day Part Segment	Pre morning rush hour	
Time Percentage With Engine Rotation In Yellow Band	8.485124 - 19.31218	
Time Percentage With Engine Rotation In Yellow Band	19.31218 - 28.48299	
Inertial Time Travelled Percentage	>= 23.44407	
Inertial Time Travelled Percentage	14.88833 - 23.44407	
Clutch Usage Per 100 Km	604.5859 - 976.6519	
Time Percentage With Engine Rotation In Idle	>= 43.21214	

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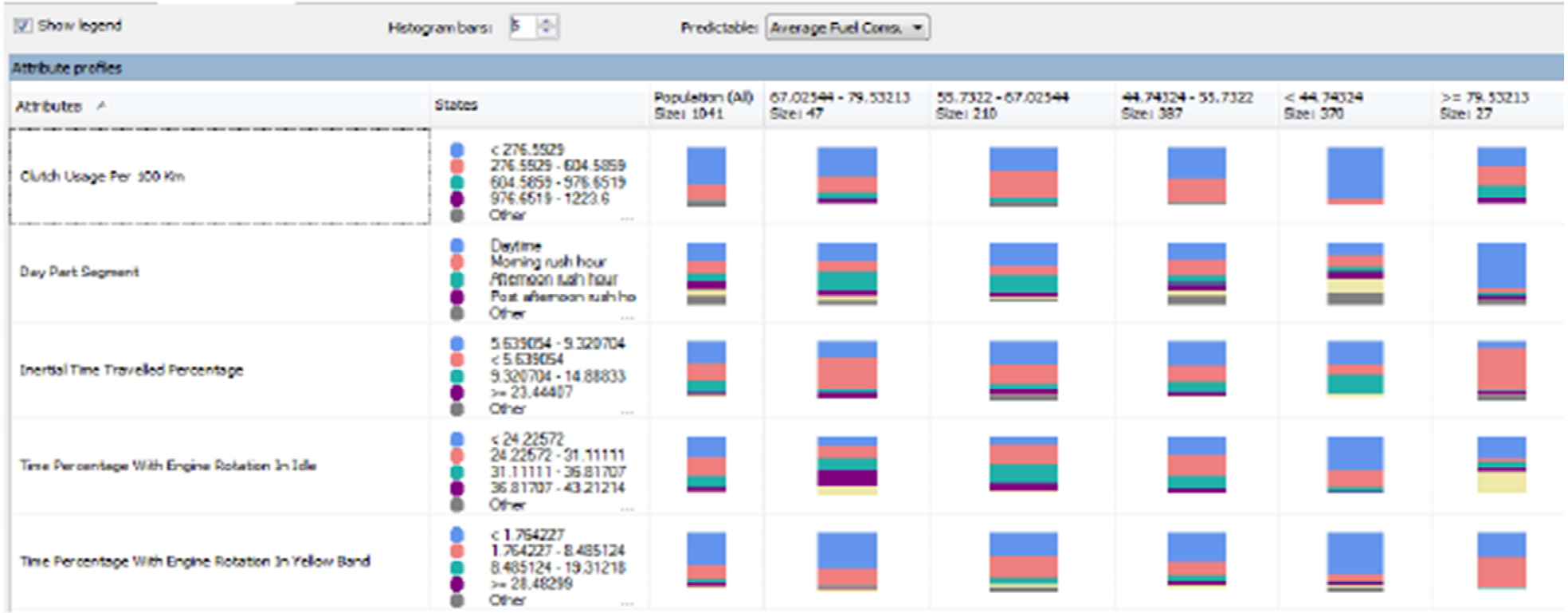
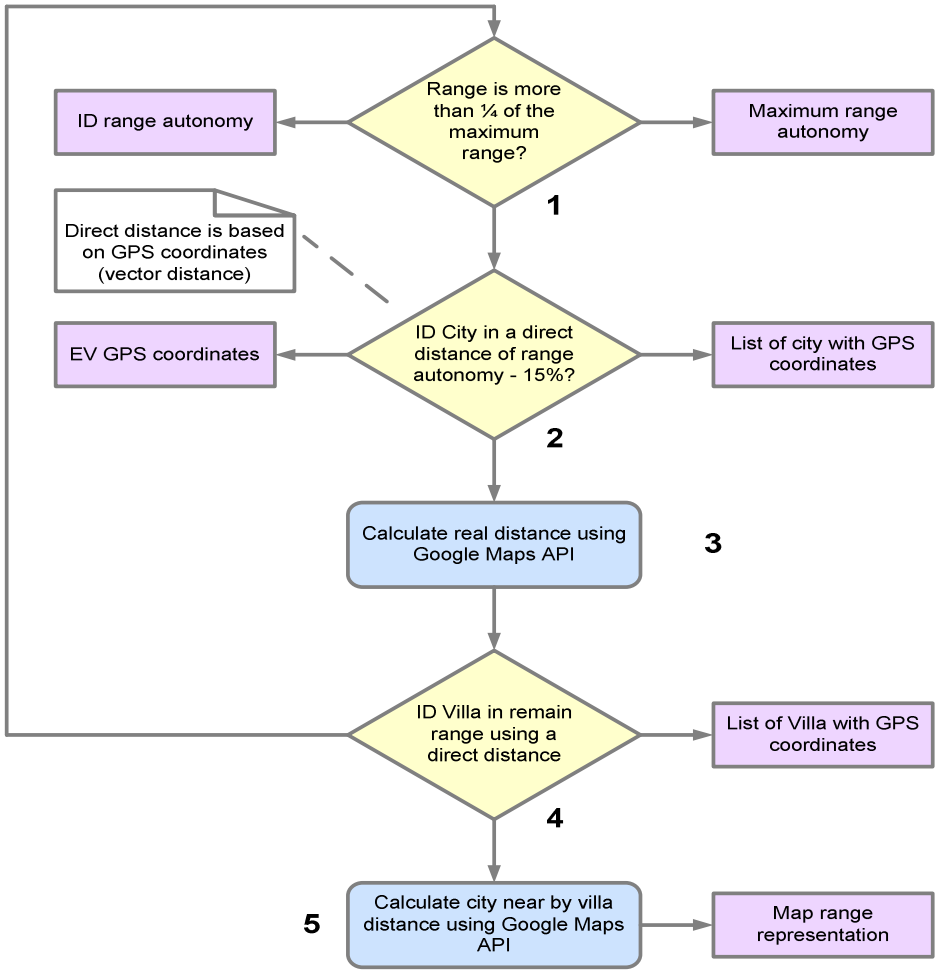
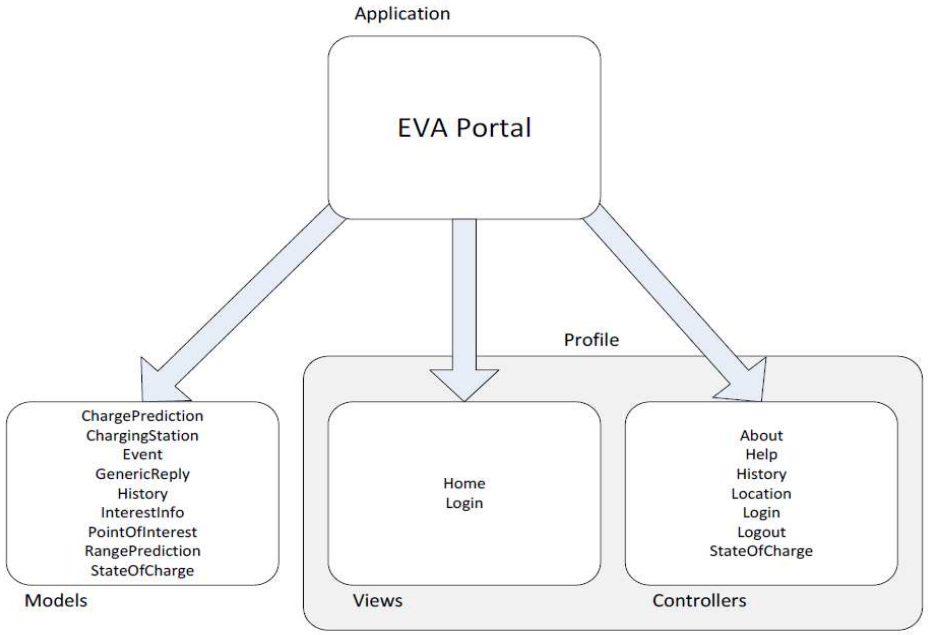
Data from ICE engine



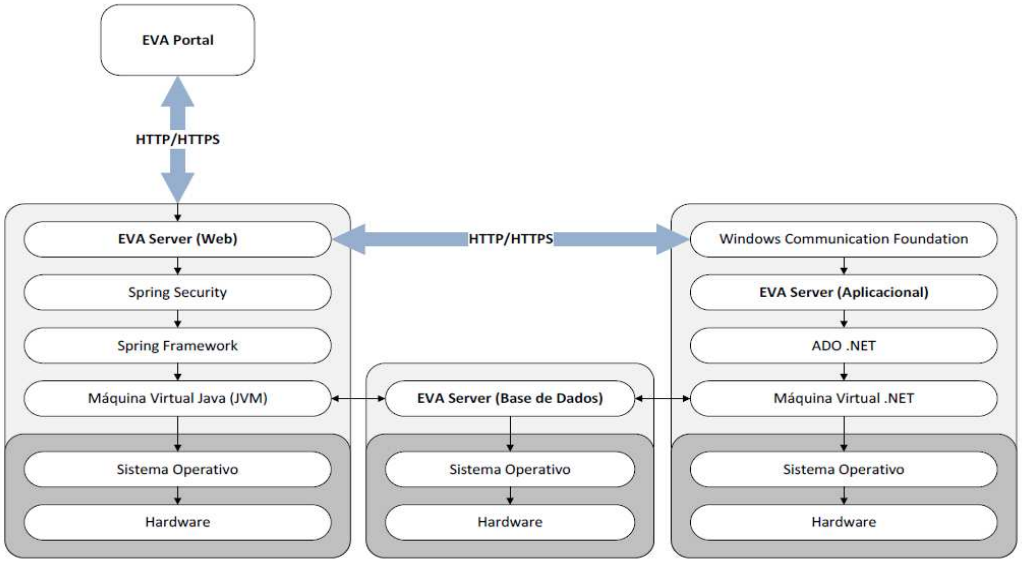
Range Representation Process



EVA Application



EVA Portal in MVC (Model View Controller) approach.



EVA Server and Application architecture.

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Results

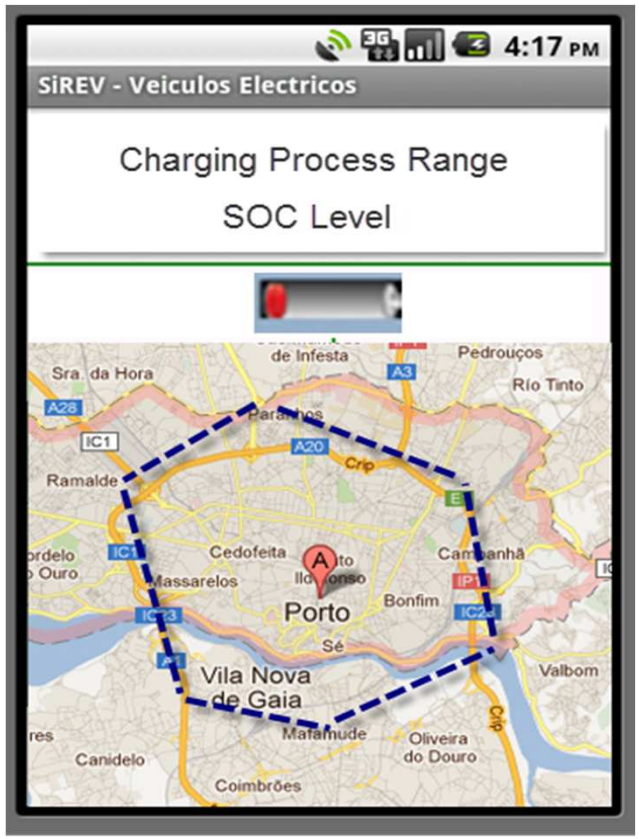
Range Representation in a trip:

1) Starting point of the EV with full charge
2) After 25 km of trip
3) After 100 km of trip
4) After 150 km of trip

Range estimation based on the uncertainty factors

The red shadow is a range that is possible to achieve, but for which the driver needs to perform driving optimization (with air conditioner off and avoiding big accelerations). This could be a helpful information, because the driver can customize his behavior in function of the range he needs to achieve in his trip. This process can be continuously updated, and thus, when the S0C level is low, this uncertainty is also low.

Range Representation on a Charging Process



Range Representation with SOC level in 5%

Range Representation with SOC level in 80%

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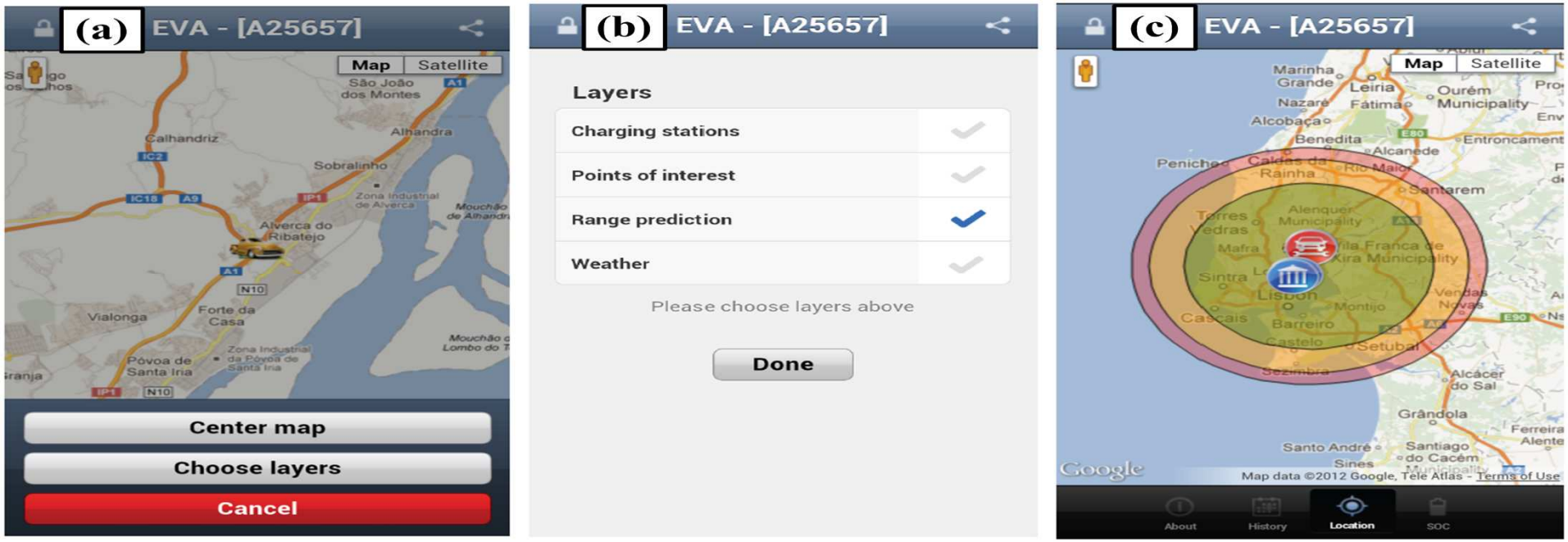
Results - Range prediction interaction process:



(a) EV position; **(b)** Available functions; **(c)** Range representation.

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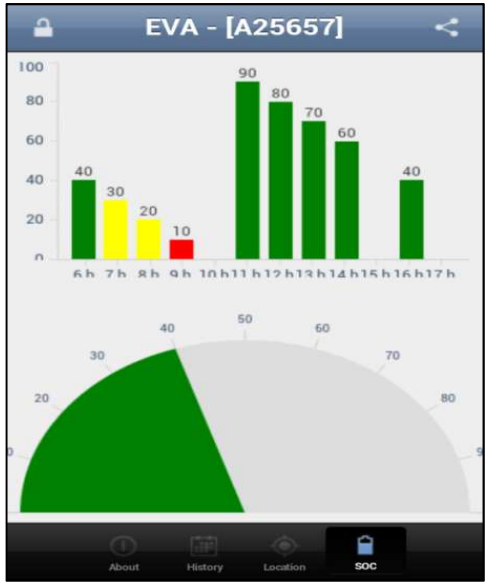
Results



Screens of the EVA mobile application of the route paths near the limit of the EV range autonomy.

Screens of the EVA mobile application related with details about Charging Stations (CS) and Points of Interest (POI).

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Results

Screens of the EVA mobile application:
(a) Guidance to Charging Stations (CS) and Points of Interest (POI);
(b) Alert of insufficient charge to reach a desired destination.

Screens of the EVA mobile application getting past information from historical events data.

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Conclusions

- The current work has as main goal to minimize the driver range anxiety problem by:

(1) an accurate EV range prediction based on past driver behavior, batteries SOC level and external parameters, like road characteristics, traffic conditions and weather;

(2) range representation on a map taking into account current driver position with an uncertainty associated with driver behavior.

- Other important work output is the historical driver profile data that can be used to establish driver communities profiles (drivers with similar behavior), and from this information start driver education towards energy savings.

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Thank you for your attention.

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