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iSHARE – Car Sharing Concept Vehicle

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Abstract

iSHARE is an Electric Vehicle (EV) designed and implemented by IDIADA Automotive Technology, based in functionalities assessment, stakeholders requirements and state-of-the-art technologies. With the complete integration of ICT technologies, the iSHARE concept vehicle enables cutting-edge fleet management services and friendly user interaction through an open, comprehensive and reliable interface with the objective of supporting new mobility business models and a higher acceptance of the EV by private parties, institutions and final users.

Keywords: Car Sharing, Mobility, Electric vehicle, sustainability, smartphone, ICT

1 THE iSHARE PROJECT

The European Commision [1][2] identified that road transport is at the heart of some of the most significant societal grand challenges. The importance of energy, security and sustainability, climate change, environmental issues and road safety are increasingly well understood; the need for accessible, affordable and robust mobility is acknowledged by our growing urban populations. Three main reasons make new concept vehicles essential:

1. Vehicle development based on citizen demands: There is a growing market for pure electric vehicles in the urban environment. The automotive industry needs to put electric vehicles into the market. However, these vehicles need to satisfy the consumers' expectations.
2. Specific areas transformation into "carbon free communities": 80% of European citizens are living in urban areas; more than 1000 European cities have more than 100.000 inhabitants; nearly 10% of Europeans reside in areas that could potentially be transformed into "carbon free communities" in a few years.
3. Innovative and green public purchase: Electrified mobility is a priority for many local authorities and national governments public administrations are purchasing 17% of vehicles.

Figure 1. iSHARE Technical specifications

Current EVs are built using the same layout than internal combustion engine vehicles, replacing the thermal engine by the batteries used in the electric vehicles. The powertrain differences between this two power sources and the especial characteristics of electric vehicles permit a complete new vehicle structure design improving aspects like passive safety, vehicle dynamics, crash compatibility, ergonomics and interaction with vulnerable road users (VRUs) [3].

Table 1: iSHARE Technical Specifications

Structure and trims	Tubular structure and plastic trims
Motor	1x electric induction motor
Peak power	140 Nm
Kerb Weight	530 kg
Energy	7 kWh
Battery	4x modules; European Batteries Oy Nominal voltage: 102.4 V Nominal energy: 9.36 kWh
Onboard charger	6 kWh
Length	2000 mm
Width	1400 mm
Height	1585 mm
Wheelbase	1340 mm
Track (Front & Rear)	1220
Tyre size	155/60 R15
Passengers	2
Luggage capacity	117 L
Max speed	80 Km/h
Range	95 km
Restraint system	Driver & Passenger front airbag Integrated Child Restraint System in passenger seat for >3-yo children
Other	SIM card for communication with control centre Contactless door opening and closing Bluetooth system for music play

A complete new design of the vehicle was focused on the concept of MOBILITY ON DEMAND, following previous experiences in the market [4]. MOBILITY ON DEMAND aims to offer non-fixed route transportation to users, supplementing public transportation systems. The iSHARE project developed and implemented an electric Heavy Quadricycle for use in car-sharing [5] fleets with enabled compatibility with advanced car-sharing business models (e.g. open car-sharing [6][7]), and devices for mobility (smartphones and tablets). For this purpose, a specific communications architecture was defined and implemented.

2 iSHARE CONCEPT

The iSHARE concept is defined by different components, both inside and outside the vehicles, and with defined interfaces between them. The main elements involved in the mobility car sharing concept are the following:

- *Back office platform*: General management system that controls all vehicles, charging spots, energy, commercial transactions, user IDs and profiles.
- *Web interface*: The web interface will be used by users to access to electromobility management and booking systems. When a user books a service, the Backoffice sends them a specific PIN and CodeBar to their computer or smart device and the same one is assigned to the rented vehicle.

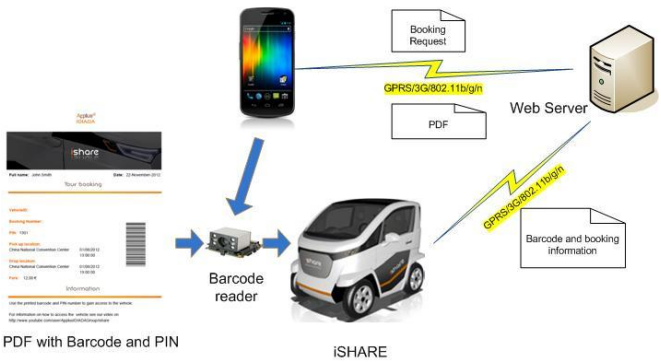

Figure 2. iSHARE Architecture

- Smart Devices: Smartphones and tablets are included in the platform with specific applications designed to make it easier for the final user to book and authenticate themselves, enabling access to the service. Displayed barcode can be directly used with the vehicle barcode reader to get access to the car.
- *On board units*: a bidirectional on-board system, integrated in the vehicle

architecture Electronic Control Units (ECUs) that manages all internal and external data (from backoffice) in order to authenticate the booking, arrange the driving service and close the session when the booked trip is finished. After the user passes the barcode to the vehicle, the ECU will unlock doors and proceed to the authentication phase through a visual interface placed in the vehicle Dashboard. This dashboard manages the user interactions regarding the booking starting and finishing processes, and turns into a HMI with the vehicle critical driving information during the trip.

The iSHARE project constitutes itself as an advanced electric car-sharing concept open platform, ready to fulfil future mobility business models and easily adaptable for different needs and requests of their potential stakeholders. IDIADA Automotive Technology, has implemented this vehicle in all its phases towards functional excellence, making use of our state-of-the-art development capabilities and engineering team know-how.

3 ELECTRONICS ARCHITECTURE

The iSHARE Electronics were developed for fulfilling the needs of the vehicle in terms of performance and functionalities. Some of the components have been designed and developed from scratch and some of them have been appropriately chosen and integrated in the vehicle.

Figure 3. Electronics Architecture

In Figure 3 we can see the components taking part in the system to accomplish the functionalities defined for the car sharing concept.

Four different ECUs were integrated in the vehicle: BCM (Body Control Module), BMS (Battery Management System), Inverter and VIU (Vehicle Interface Unit). BMS and Inverter were part of an Electric Engine Kit and BCM and VIU were designed and developed specifically for the vehicle. These four ECUs were connected through CAN bus where an extra module was also connected, Keypad and DNR Selector.

Other components taking part in the system are the IC (Instrument Cluster), Barcode Reader, GPS and Server where the car booking Applications run.

In this document we will describe the whole electronic system related to communications. The BMS and Inverter, which are part of the power train of the vehicle, are out of the scope of this paper.

4 iSHARE PROTOCOL

The iSHARE protocol is managed from the Server. This Server will be waiting for a booking request through its website. In the moment a request is received and a vehicle is booked for a specific user, a PIN and a Barcode is assigned for those vehicle and user. The process to book a vehicle is shown in **Figure 4**

Figure 4. Booking protocol

In the vehicle side, when a Barcode is received (**Figure 5**), the VIU analyze it (in collaboration with the Server) and, if it is the correct one, the VIU sends an *Open Doors* request through the CAN Network. The vehicle will be opened by the BCM and the Instrument Cluster will switch on.

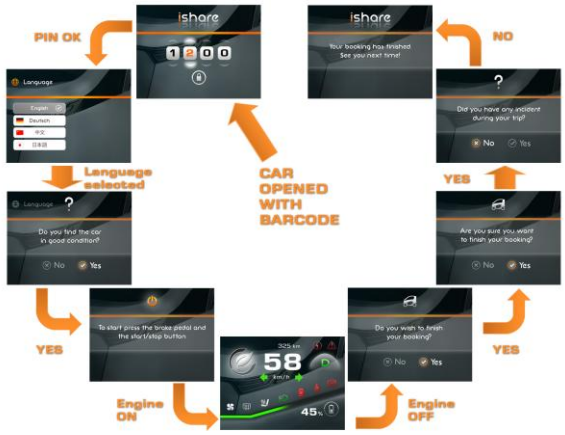

Figure 5. iSHARE Protocol

At this moment, the system will be waiting for the PIN number assigned for the booking. The driver is expected to introduce the Correct PIN number in the Instrument Cluster. Once the PIN is written, it is sent to the VIU to be analysed (in collaboration with the Server) and, in case the PIN number written by the driver is the same one assigned to the vehicle, the VIU will send a *PIN Correct* message to the CAN Network. Once the BCM has received the *PIN Correct* message, the system will enable the vehicle and a questionnaire will be shown in the Instrument Cluster. At this moment, the booking is considered to be *Open*.

With the booking *Open* and the questionnaire filled, the vehicle will be ready to be cranked and the driver will be able to drive it in a normal way. While the booking is *Open* we will have two options for closing the vehicle: 1) closing the vehicle finishing the booking or 2) closing the vehicle keeping the booking *Open*. Every time we switch off the engine, the Instrument Cluster will ask us if we want to finish our booking. In case we want to finish it, the VIU will close the booking and the Server will be informed, making the vehicle available for another booking. The user will not be able to crank the vehicle again if a new booking is not arranged through the website. If the user does not want to finish the booking, the VIU will keep the booking *Open* allowing the user to crank the vehicle again, even if we close the doors with the Barcode while leaving the car parked.

5 ELECTRONICS COMPONENTS

5.1 Vehicle Interface Unit

The Vehicle Interface Unit (VIU) is the interface between the vehicle and the infrastructure for connecting the car to the network. This ECU is running under Embedded Windows and three Java [8] Applications were developed to control the system, *Barcode Reader*, *Booking Management* and *CAN to Ethernet Gateway*.

The *Barcode Reader Application* is the one in charge of reading the Barcodes coming from the sensor. This application also decodes the Barcode and communicates with the Server to check if the Barcode is the expected one, if so, it sends the *Open Doors* request to the BCM.

The *Booking Management Application* is the one in charge of exchanging data with the Server when a booking has been arranged and informing it about the state of the vehicle. This application is also interacting with the vehicle in order to manage the state of the booking, i.e. checking barcodes and PINs. This application and the *Barcode Reader Application* work concurrently.

The *CAN to Ethernet Gateway application* is the one in charge of reading all the data coming from the CAN Network and forwarding it to the Ethernet network, in a correct format, in order to reach the Instrument Cluster where all the vehicle data is shown to the driver.

5.2 Body Control Module

The BCM was designed and developed specifically for the iSHARE vehicle from scratch. This ECU was developed to be in charge of controlling some functionalities of the vehicle like locking/unlocking system, windows, wipers, comfort, etc.

A PCB was designed and built with an automotive processor installed on it. Firmware was developed for controlling the functionalities listed below:

- Scheduler
- CAN Communications
- iSHARE Protocol Functionality
- Locking/Unlocking Functionality

- Push Start/Stop Button Functionality
- Wiper Functionality
- Window Functionality
- Comfort Functionality
- Lights Functionality

In this BCM we want to highlight the *iSHARE Protocol Functionality* and the *Locking/Unlocking Functionality* which are the ones in charge of managing the iSHARE Protocol.

The iSHARE Protocol Functionality controls the interaction with the user managing the state of the vehicle. This functionality is based in a state diagram we can see in the Figure 6.

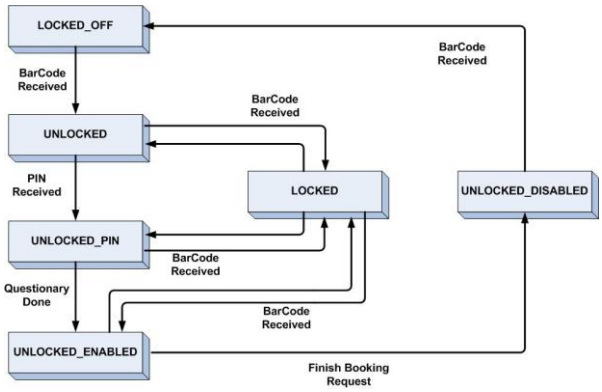

Figure 6. State Diagram

This state diagram enable/disable functionalities of the vehicle in every state. The state of the vehicle is changed through the user interaction with the Barcode Reader or the Keypad. The VIU is in charge of reading the Barcode and in case the Barcode is the expected one, the VIU sends the *Open Doors* or *Close Doors* requests to the BCM.

The state diagram has 6 different states, according to the locking/unlocking process of the iSHARE Protocol. These states are: LOCKED_OFF, UNLOCKED, UNLOCKED_PIN, UNLOCKED_ENABLED, LOCKED and UNLOCKED_DISABLED. In each state, the driver interacts with the vehicle to change from one state to another.

- LOCKED_OFF: The vehicle is completely locked, waiting for an order to *Open Doors* coming from the VIU. The only action the user could do in this state, is open the vehicle through the Barcode Reader.
- UNLOCKED: Once the Barcode is accepted and the VIU has sent the *Open Doors* request, the BCM changes to the UNLOCKED state and opens the doors. In this state, the Instrument Cluster is switched on and the vehicle waits for the PIN number.
- UNLOCKED_PIN: Once the VIU checks that the PIN received from the Instrument Cluster is the correct one, a *PIN Correct* message is sent to the CAN Network. The BCM changes to the UNLOCKED_PIN state once the *PIN Correct* message is received. In this state, a questionnaire is shown to the user. Once it is filled up, the BCM will go to the next state.
- UNLOCKED_ENABLED: In this state the driver will have the possibility of cranking the vehicle and driving it.
- UNLOCKED_DISABLED: The System will go to this state if the driver switches off the vehicle and accepts finishing the booking. Once the vehicle is in this state, the only option available is closing the vehicle with the Barcode.
- LOCKED: The vehicle can reach this state from the states UNLOCKED, UNLOCKED_PIN and UNLOCKED_ENABLED, closing the vehicle with the Barcode keeping the Booking *Open*. Once the vehicle is in the LOCKED state, the only option available for the driver is opening the car with the same Barcode assigned for the Booking.

An important feature of the iSHARE Protocol Functionality is the communication with the VIU because is the ECU in charge of receiving the driver interaction, analyze it and inform the BCM about its decisions. Once the VIU receives the events generated from the driver, it sends its decision to the BCM through the CAN network, after quering the Server.

BCM and VIU receive also from the CAN network the data coming from the KeyPad related to the interaction with the driver about PIN, questionnaire and Booking.

The second important functionality of the BCM is the Locking/Unlocking Functionality, which is in charge of locking and unlocking the vehicle when the iSHARE protocol requires it. This functionality

is internally related to the iSHARE Protocol Functionality.

5.3 Instrument Cluster

The Instrument Cluster (IC) is a LCD screen with a Linux Embedded developed to show data to the driver, working as a HMI (Human-Machine Interface). It also interacts with the driver in the process of introducing the PIN and the End-Of-Booking. This Instrument Cluster is controlled from the Keypad and DNR Selector as well as data coming from the CAN Network.

The Instrument Cluster is connected through an Ethernet Connection to the VIU. The VIU works as a gateway, forwarding the information coming from the CAN Network towards the Instrument Cluster.

In Figure 5 the sequence of the Instrument Cluster is shown, changing from one screen to another following the BCM states and the user interaction. We may find three main parts in this sequence: The first one is the PIN request and the initial questionnaire. The second one starts once the vehicle is cranked. In that moment the IC shows the relevant information for the driver such as speed, state of charge, vehicle odometer, seatbelt reminder, light beams, turning lights, warnings, etc. The last starts once the vehicle is off . At that moment, another questionnaire is shown in the screen, asking the driver if he/she wants to finish the booking as previously described.

Is important to notice that any time the vehicle is connected to a charging station, the screen will automatically change to a charging icon with the state of charge shown, as can be seen in Figure 7.

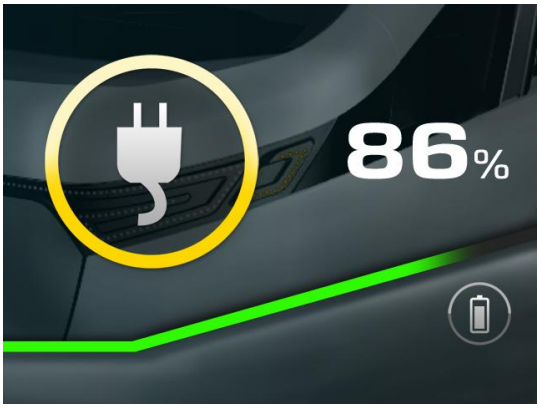

Figure 7. Charging Screen

5.4 Keypad and DNR Selector

KeyPad and DNR Selector are placed on the front side of the dashboard, where it is easy to be accessed to the driver to control it. These KeyPad and DNR Selector are in charge of managing the driver interaction. To achieve this, a PCB was developed with an automotive processor connected to the CAN Network, allowing two different functionalities:

- Keypad: it is a set of 5 buttons (four arrows and one OK button) for the driver interactions. The information is sent to the Instrument Cluster through the CAN Network.
- DNR Selector: it is a set of 3 physical buttons for the gear selected (Drive, Neutral and Reverse). In case the Drive button is pushed twice, the ECO function will be selected. The gear selected will be sent to the CAN Network.

5.5 Server and Smartphone Application

The Server acts as a booking centre of the iSHARE system, with two different applications running: *Web Application* and *Booking and Database Management*. This Server has been implemented following an open software solution [9].

5.5.1 Web Application

The Web Application is the responsible of managing the html, php and sql files in order to build the website in the Hypertext Transfer Protocol (HTTP).

The Web Application has been designed both to be seen from a personal computer and a mobile phone. The target of this website is to allow the user to book a vehicle, delivering a pdf with a Barcode and a PIN number once the booking is done.

The main feature of the application is the *Adaptive Pricing* according to the flexibility of the user. Taking vehicles out of the iSHARE charging point and bringing it to one of this charging point, will make discounts in your billing, as well as returning the vehicle to those same charging points.

5.5.2 Booking and Database Management

This application communicates with the VIU and checks if the barcode received and the PINs are the correct ones.

The application waits for a connection coming from the client (VIU in this case). When the server receives the first connection from the VIU, receives the VIN number of the vehicle and the barcode red, after that the Server checks if the barcode is correct, informing the VIU about the result. Once the Booking is *Open*, the VIU informs periodically the Server about its state until the user *Closes* the Booking and the information about the last connection is recorded for invoicing.

6 CONCLUSIONS

iSHARE is an Electric Vehicle designed and implemented by IDIADA Automotive Technology, which targets the latest mobility concepts in response of new societal challenges in sustainable urban environments.

With the complete integration of ICT technologies, the iSHARE concept vehicle enables cutting-edge fleet management services and friendly user interaction through an open, comprehensive and reliable interface with the objective of supporting new mobility business models.

This project has addressed functional design and implementation leaving issues like timings, data transmission, safety and security as subjects to be analyzed and improved in future evolutions of the platform, together with the integration of new technology developments (e.g. NFC, Mirrorlink, etc…).

The target of the project is achieved thanks to the merging of Mobile Technologies, Communications Technologies, Electric Vehicles and new Mobility concepts in the same vehicle. This prototype sets the base for future development of this type of vehicles and infrastructures following the car sharing philosophy.

Some of these strategies have been taken as a basis in its initial implementation, leaving enough flexibility for future development of new approaches that will define the future of this kind of platforms. iSHARE stands as a robust, multi-technology development platform for future implementations addressing mobility challenges and innovations.

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