SMART DEVICE CONNECTIVITY IN CAR RADIO

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ABSTRACT

Smart Device Connectivity (SDC) is a trend setting invention in the automotive industry. Now we are in the era of connected cars where the presence of devices in an automobile that connect the devices to other devices within the car. So, now connecting our favorite applications to the car head unit is really interesting functionality. Till toady we have seen automobiles with AM / FM, Audio, Video, CD player, USB, Bluetooth in their entertainment block. The usage of mobile Internet accesses and applications in the mobile has increased enormously within the last year. Keeping this factor in account smart device connectivity feature is developed to control the applications of our smart phone through the car radio head unit.

Keywords: Applications, Connected Cars, Internet Accesses, Radio Head Unit, Smart Device Connectivity.

I. INTRODUCTION

Nowadays In-vehicle infotainment, which is a combination of entertainment and information, is flourishing in the automotive industry. The higher end, luxury automobiles incorporate safety and connectivity along with the advanced audio/visual entertainment. With the advances in technology, the auto motive industry is moving towards the radios with more integrated features on them. Since drivers want to use their Smartphone's also while driving, automotive technology has to allow seamless integration of various brought-in personal devices based on various software and hardware standards [1]. It should enable safe completion of non-automotive tasks that users usually perform on their mobile devices, such as shopping, social networking or communication. In order to help users deal with an ever growing number of tasks of increasing complexity automotive UI has to be simple, intuitive and flexible. In order to be "always connected," people tend to use their Smartphone's Internet access manually while driving.

According to the recent study the most common usage of Smartphone apps in the Car are listed below Driving-related apps and music apps most frequently accessed

- 61% have accessed smart phone navigation apps while driving
- 44% have accessed music apps
- 36% accessed weather
- 38% US smart phone owners use apps while driving
- Almost 40% send and/or receive at least one SMS daily behind the wheel.

The growing variety of in-dash systems and Smartphone integrations are making the traditional AM/FM radio hard or harder to find.. A study released earlier this year by Digital Radio UK intended to assess the usability of digital radio and the future for radio in connected cars found:

- 30% of the cars (in the study) had a system to integrate the Smartphone with the dashboard
- 100% of manufacturers have developed their own proprietary connected system
- 100% of manufacturers are working with Apple on CarPlay, Google on Android Auto, or both
- 50% of manufacturers are working with Mirror Link

Since usage of Smartphone's and their applications in the car are increasing therefore Smart Device Connectivity introduced to the automotive market to provide flexibility between the Smartphone and car radio.

SDC (Smart Device Connectivity) uses a template-based approach to HMI (Human Machine Interface) and application design. Each mobile application starts with a home screen which can then be navigated via an associated menu structure. Additional HMI elements, such as pop ups, sliders, dialogs or images are accessed via additional RPCs (Remote Procedure Calls).

II. SMART DEVICE CONNECTIVITY

SDC enabled applications communicate over a known transport layer, exchanging messages in a pre - determined protocol and format. These messages include (but are not limited to) command and control information, as well as other program data, such as writing to a display, accessing buttons, creating menus, using voice controls and outputting audio to the vehicle speakers.

SDC is an extensible method for a head unit and a mobile application to communicate and present data to each other in an effort to present a mobile application to a driver inside a vehicle.

The SDC software consists of two distinct parts, one that is integrated into vehicle and the other that is integrated into the application inside the mobile phone. The following are the features of these two parts of SDC software:

- It Can support multiple functions in a single application but not multiple applications
- The state changes of the mobile applications are managed, maintained and notified
- The capabilities of in-vehicle head unit interface are understood by providing an interface
- The physical discovery and connection to a mobile application is managed
- Wraps in-vehicle services such as buttons, displays, audio controls and other common vehicle inputs and outputs
- Creates a template based User Interface which provides consistent developer experiences using vehicle's HMI
- The SDC enabled mobile applications interact with the IVI system by a common interface provided by the SDC software
- The SDC software is supported by android and iOS phones only
- The mobile phone is connected to the head unit over either USB or BT
- It provides a simplified approach device detection and connection

III. SDC ARCHITECTURE

SDC is an extensible method for a head unit and a mobile application to communicate and present data toeach other in an effort to present a mobile application to a driver inside a vehicle. Each RPC (or API offered to developer on a mobile application) has a corresponding function or result on a head unit inside a vehicle.

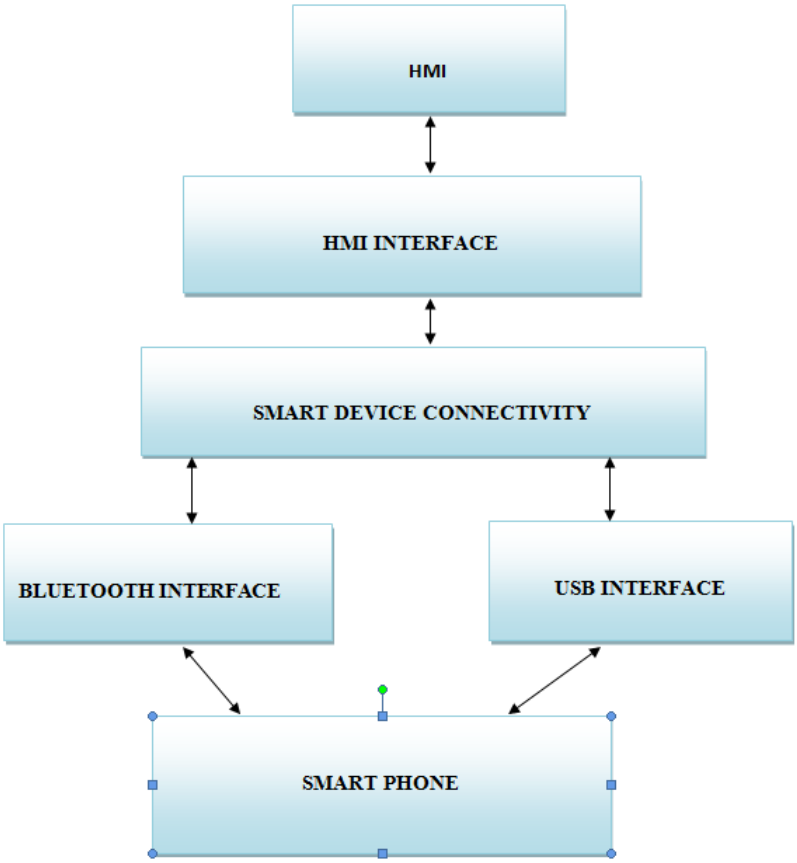

Fig.1 Architecture of a Vehicle Head Unit Integrated with SDC

The infotainment system of the vehicle has to be integrated with the SDC. The discovery of the device and the end points are done by the transport mechanism of the integrated head unit. The applications in our mobile phone (android devices) are supported by the head unit over USB and BT connections and the iOS utilizes the iPod Accessory (iAP) protocol over USB.

3.1 Step by Step Flow for the Above Diagram

- The mobile phone can be connected to vehicle head unit via USB or Bluetooth (BT)
- The USB connection is provided by the USB stack and the BT by the BT stack
- These stacks provide the interfacing between the mobile phone and the vehicle head unit
- The HMI (Human Machine Interface) is the uppermost part of the architecture which is visible to the user
- The core of the architecture is the SDC manager. It further consists of various layers named:
  Application layer: the decision making is done here
  Transport layer: the handling of data flow from upper to lower layer and vice versa
- The interfacing between the SDL manager with the HMI is provided by HMI_Message_Handler
- Whereas the interfacing with below layer is provided by Transport Adapter layer
- The HMI message handler converts the data into a format which is supported by the layers to which the data is to be sent.
- Similarly the transport adapter layer does the same at the lower level.

IV. SDC CORE

4.1 Step By Step Connect

- Mobile device is connected to car radio.
- Application will make requests to the vehicle and the vehicle responds (Remote Procedure Calls). Application appears to be running inside the vehicle, but all business logic is contained on mobile device.
- User interacts with their vehicle and vehicle notifies application of any system or user events.
- Application reacts by sending requests to modify application behavior or appearance in the vehicle.

4.2 Transport Layer

- Each application is responsible for establishing a transport (Bluetooth, USB, iAP)
- Head unit and mobile device may have a separate connection already for existing features (i.e. hands - free profile, mass transport, etc.)
- Currently supported transports
- Android(Bluetooth):RFCOMM
- Android(USB)
- iOS(USB):iAP

4.3 Remote Pocedure Calls

SDC APIs are request/response driven. Notifications are asynchronous

- Requests/Responses
- Add Commands
- Add Submenu
- Delete command
- Register App Interface
- Set Media Clock Timer
- Perform Audio Pass
- Notifications
- On App Interface Unregistered
- On Button Event
- On button Press
- On Command

4.4 Vehicle Notifications

The existing system events or state changes of the vehicle which might impact the mobile application must be notified to the mobile .The following are few examples of notifications:

- Changes in the power state of the vehicle like ignition ON/OFF
- Higher priority applications
- Loss or attenuation of source, change in audio state of the head unit
- Subscribing to the changes in the vehicle data

V. HMI DESIGN IN SMART DEVICE CONNECTIVITY

As Smartphone growth continues, more consumers will accept and expect touch screen input and also expect touch interaction to be same as Smartphone's. A human machine interface (HMI) is an interface which permits interaction between a human being and a machine [2]. HMI's are widely used, from control panels of nuclear power plants to the screen and input buttons on a cell phone. Designing such interfaces is a challenge, and requires a great deal of work to make the interface functional, accessible, pleasant to use, and logical.HMI is a part of the system visible to users. The presentation and behavior of HMI shapes users' understanding of the system and their perception of its performance. As generally applied, the HMI has been around since the time when machines were invented, the underlying thinking being how to make the human use of the machine more efficient. HMI has become the most attractive component for all areas, and automotive is one of the challenging areas. The way drivers interact with their cars is evolving, driven by changes in a number of related domains – personal mobile devices, car technology, consumer electronics, demography and economics.

5.1 Input/Output Components of Hmi

HMI consists of Input and Output components. A human user needs some way to tell the machine what to do, to make requests of the machine, or to adjust the machine. Examples of input devices include keyboards, toggles, switches, touch screens, joysticks [3].The interface also requires an output, which allows the machine to keep the human user updated on the progress of commands, or to execute commands in physical space. On a computer, for example, users have a screen which can display information. The greatest advantage of an HMI is the user-friendliness of the graphical interface. The graphical interface contains color coding that allows for easy identification (for example: red for trouble). Pictures and icons allow for fast recognition, easing the problems of illiteracy. HMI can reduce the cost of product manufacturing, and potentially increase profit margins and lower production costs [4]. HMI devices are now extremely innovative and capable of higher capacity and more interactive, elaborate functions than ever before. Some technological advantages the HMI offers are: converting hardware to software, eliminating the need for mouse and keyboard, and allowing human interact

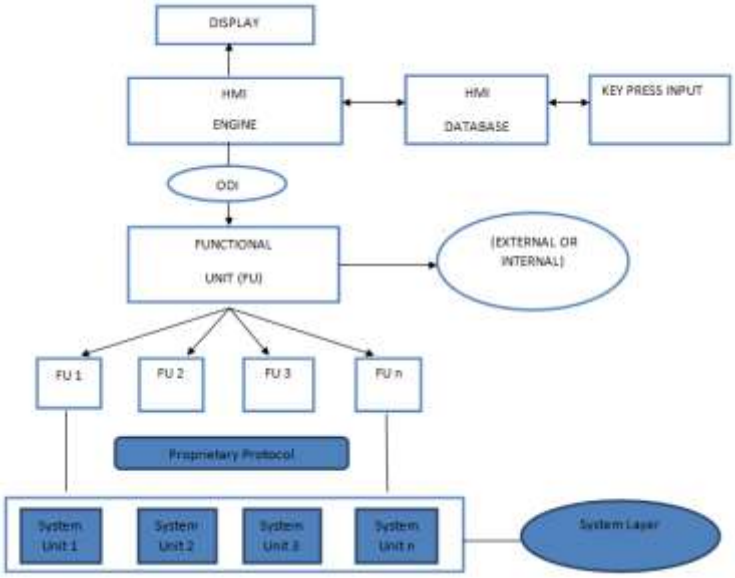

Fig.2 HMI Inputs and Outputs

5.2 Main Blocks of HMI

- HMI Model- Model includes drawing screens and transitions between views – done using HMI Tools. Exported as database (includes images, fonts…) Tools – EB Guide, Populus, QT, Altia, TAT etc.
- HMI Framework or Engine
- Middleware to understand the tool output and do the functionality on hardware.
- HMI Adaptor-Used to decouple HMI from subsystem.
- Widgets and Graphics Library

HMI design for the Smart Device Connectivity is common for all different applications even though graphical user interface is differing from application to application.

The user inputs directly on the screen (In Touch-screen devices) and the input is recognized by the HMI and passed on to the below layers with an appropriate ID for each event. This event is then handled by the corresponding FU (Functional Layer) and it formats it as needed by the System layer (where the actual processing of the data is done) before passing further.

Once the System is done with the processing as needed, it would publish the appropriate result and the same is received by the middle layer and again decodes and aligns it as expected by the HMI layer. The HMI displays the updated data to the user. Fig.2 above is the block diagram of the same.

HMI is scattered across all modules of the radio like media, tuner, Bluetooth, diagnostics etc.

VI. IMPLIMENTATION

SDC is developed to serve as an intermediary between vehicle's Head Unit and an application that runs in any of the mobile devices:

- A mobile phone can be connected via Bluetooth or USB
- The application should be SDC enabled one

The mobile device might be any of:

- iOS
- Android

The SDC system allows the application to:

- Use vehicle HMI: Voice Recognition, Text To Speech, buttons (physical and touch screen), vehicle display, audio system etc.
- Operate with Vehicle Data (seat belt position, transmission shift lever position, airbag status, etc.).

VII. CONCLUSION

Safety concerns are met here. The only data which sent by the applications is displayed on the HMI, this means the driver distraction is minimized to a very large extent. It is independent of the graphical user interface of application in phone. Smartphone's can be connected to radio head unit via USB, BT and Wi-Fi. SDL provides easy approach for controlling the Smartphone's applications through car radio head unit.

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