Abstract - One of the prominent application segment of Internet of Things framework is in Automotive Sector. It is important to arrive at a unique low cost solution to enrich the user experience at the driver’s seat with minimal distraction. The Internet of Things Layered Architecture based design approach assists the system designer to conveniently differentiate the system component requirements distinctly at various layers. Human Machine Interface approach in the proposed solution makes the application smarter, providing ease of operation. USB Webcam C170 design unit for voice processing in this model interacting with the Google API provides accurate voice interface processing unit to the Raspberry Pi IoT Infrastructure. The Google Voice API with a built-in Semantic makes the proposed design solution distinct in handling Human Machine Interface namely, voice. This new model allows the development of the Human Machine Interface tool suite for Smart Infotainment System in cars. The precision of the output response obtained in this model to the voice commands is overwhelming.

Keywords - Raspberry Pi, Voice Processing, Internet of Things, Inter-Car-Communication, Automotive Electronics, Human Machine Interface.

-I. INTRODUCTION

Internet of Things (IoT), based application development has gained popularity in recent years and it is predicted that by 2050 there are going to be around billion smart objects connected together. These smart objects can be application specific sensors and actuators in the systems developed. Automotive sectors foresee a large number of application possibilities in near future. Research is being done to develop system prototypes for a low cost vehicle. Presently manufactures are equipping the vehicles with high end Engine Control Units (ECUs) to enhance safety and comfort. Clearly there is a need to develop feasible solutions for the low end car sector, so that advanced technology reaches the common population. Need for Information and Entertainment Services in an automotive sector is growing on an exponential scale.

The role of IoT infrastructure in the development of smart infotainment devices is significant. The comfort of the driver acts as a fore runner in the development of such systems. The primary focus of a driver must be in the road which is possible only by developing voice assistant system models. If the driver gets an environment which does not demand his/her physical attention, the distraction will decrease and the driver focusses more on the road. Safety through increased drivers focus on the road and providing a hands free experience to ease the pressure of distraction is important. The design solution in IoT systems is multidisciplinary and scattered through various domain specific challenges.

In [1], Ovidiu and Peter discuss the progress of IoT based design systems in the near future. Common architectural approach for IoT empowerment is presented in detail. The authors give an IoT layered architecture illustration which is useful for the IoT system designer. During the system level integration of IoT, networking infrastructure and protocols need special attention. The forecast [2] about using Human Computer Interface (HCI), Human Machine Interface (HMI), and Machine to Machine Communication (M2M) in the networking layer to establish communication between source node and target node. The converse of HCI in IoT is discussed in [3]. The roadmap of HCI and IoT is discussed till 2030, depicted a five yearly advance in technology. The role of Plug N Play (PnP) smart objects foresee a great demand by 2025. The PnP have evolved from home and personal environment in 2010 to a prominent prediction in utility, transport and automobile sector beyond 2025. In [4] American Industrial Systems (AIS), gives the HMI utility in IoT based system design. The need for multidisciplinary interaction between telecom, hardware and software sectors in emphasized. The key features of interoperability and dependability are illustrated. Charles describes the M2M concept and applications using IoT based design in [5]. The platform used in various mode of communication for M2M IoTs is discussed. The various sectors of M2M applications are discussed in detail with high priority given to automotive applications. The future trends like pay-as-you-drive insurance are forecasted in remotely traceable smart car systems. Through [6] HMI is discussed for smart infotainment systems through an Advanced Driver Assistance Systems (ADAS) based
approach. ADAS safety has been addressed through Controlled Area Network (CAN) protocols, Embedded Automotive Radar Technologies, etc. Multipoint Control Units (MCU) are an integral part of it in establishing communication using the concept of IoT. MCU has varied applications in the field of videoconferencing, as it bridges the connections and establishes communication. The radar houses multiple Direct Memory Access (DMA) units which facilitate the storing of data and providing commands. Further the system being enhanced with Advanced Packaging Technology reducing the size of the chip used. [7] has the report which indicates the development of Smart Infotainment System in high end cars. The Infotainment System deals with In Car Entertainment (ICE) or In Vehicle Infotainment (IVI). This approach makes use of the concepts like Car Audio, Computer and In Car Internet. There are a few existing designs similar to this one, but only in most expensive in segment cars. BMW iDrive, Sync/MyFord, IntelliLink by Buick, GMC. BlueLink by Hyundai, Connect by Mazda, Comand by Mercedes Benz, Nissan Connect Infiniti in Touch, Subaru StarLink, Toyota Entire/Lexus Enform, Volkswagen MIB are a few to name. Voice operated systems are designed for ICes in the present state of art ECUs.

Leo Sun discusses about voice operated Intelligent Personal Assistant (IPA) systems with highest priority to Google API, which is a software interface [8]. This is used for voice processing, being compatible with the three OS platforms namely iOS, Windows and Android. Towards the end of the year 2013, Google Now was launched which is supported voice commands. Logitech Inc. has launched a webcam with Fluid Crystal Technology. This webcam has a microphone to support voice inputs which is used in intelligent voice assistant systems. The main merit of this webcam is that it supports internet connectivity. Hence this webcam C170 [9] is appropriate for IoT based system design units. In an IoT based design which is voice operated in the Smart Infotainment System an appropriate voice data acquisition unit is needed. The device choice should be compatible with Google API to interface the hardware and software component. IoT infrastructure design requirements are very unique and distinct. Raspberry Pi a standalone minicomputer with its own OS environment was chosen as the processing unit. A two way decision in now needed to choose an appropriate voice sensor unit. In one side, there should be a hardware interface design possibility to connect to the voice sensor and on the other side the Google API component should be able to acquire the input voice data from the sensor. An appropriate device decision made in this system integration is the unique choice of webcam Logitech C170 voice sensor. The system design for this multidisciplinary approach should support the IoT architecture salient features.

II. IoT LAYERED ARCHITECTURE FOR SMART INFOTAINMENT SYSTEM

The IoT Architecture has four distinct layers, embedded in it. They are the Application Layer, Information Services Layer, Networking Infrastructure Layer and Smart Objects Layer. The smart objects layer consists of the sensors and the actuators that are used in the IoT system as data acquisition modules and data deployment modules respectively.

![Fig. 1. IoT Layered Architecture](image)

The Smart Objects Layer in IoT architecture consists of sensors and actuators that interact with the real world. Fig. 1 illustrates the IoT layered architecture. Choice of the sensors and actuators in an IoT based system design makes them smart objects. Their capability is enhanced to make them programmable devices using appropriate internet supported software modules. Since they are programmable they can be precisely and specifically used to provide user services. In the IoT layered architecture Information Services Layer has Software as a Service (SaaS) as the main design attribute. SaaS is an internet based system designer's mode to reach the customer end typically using internet. The customer specification governs the designer's model approach. The model by which Google API extracts information from its server is a SaaS based approach. The salient features of SaaS is Global Accessibility and Automatic Update to the latest version. To establish the communication between the Smart Objects and the Information Services in IoT architecture, Networking Infrastructure Layer is required. For the data transmission between the human voice input and the Raspberry Pi, Webcam acts as an intermittent node. The Google API installed in Raspberry Pi interprets the input signal locally. Further the speech to text conversion is done using networking infrastructure which plays a vital role in obtaining the output response in the proposed solution model. The Application Layer is customer specific design feature. It supports various application in transportation, energy, home automation and automobiles. SIS is designed and developed cod automotive sector. The state of art technology updates in automotive sector have paved a way for smart assistance
system design to the driver in providing minimum distraction. The present IoT based systems can use HMI technique in establishing connectivity through the networking infrastructure layer of IoT architecture. Fig. 2 illustrates IoT Layered Architecture in Smart Infotainment System.

![IoT Layer Architecture in Smart Infotainment System](image)

**Fig. 2. IoT Layer Architecture in Smart Infotainment System**

### III. HUMAN MACHINE INTERFACE IN SMART INFOTAINMENT SYSTEM

Human Machine Interface design feature comes in the data acquisition phase from the Smart Objects. The HMI platform was developed for IoT based Smart Infotainment System. The HMI design feature is implemented in Mercedes and BMW cars in 2015. Prototyping a cost effective HMI model for low cost automotive sector is an interesting area to investigate. Earlier this investigation was in Artificial Intelligence (AI) domain using Natural Language Processing (NLP). With the advent of technology the hardware interface designs have grown smarter and are capable of interpreting the meaning of human voice. The HMI has a very stringent design requirement factor like system reliability, accuracy, efficiency, user satisfaction and quick response time. The design procedure to construct HMI in SIS needs a systematic design approach which is developed as an algorithmic model. The two phases of this model are: i) producing a sequence of steps to perform the HMI interface. ii) Implement the HMI model using software modules (Google API) interfacing with hardware units (Webcam, Raspberry Pi). Steven Hickson created a software code for Google API which is used in HMI system development. Integrating this voice processing command onto Raspberry Pi is a prerequisite before invoking the voice operations.

![HMI in Smart Infotainment System.](image)

**Fig 3. HMI in Smart Infotainment System.**

The flowchart in Fig. 3, illustrates the initialization process to invoke the webcam and put it in active mode. The steps followed by IoT infrastructure to reflect the output response are also shown. The human voice input which is read by the Raspberry Pi is processed, i.e. converts it from voice to machine level language. It then connects to the internet and transmit data (to Google Server). The response obtained from the server is the required information which is in low level language. Raspberry Pi reprocesses it to convert it to high level language. The output response then appears. The above algorithm is repeated every time a voice input is sensed by the webcam microphone. The system thus functions with a procedural approach towards the voice commands.

### IV. SMART INFOTAINMENT: AN HMI TOOL SUITE DESIGN FRAMEWORK

The methodology adapted for making the system function is divided into two important phases. Namely:

**A. Voice Recognition/Detection**

A voice recognition module generally consists of a microphone device which captures Analog Audio signals from human voice. It must have a sound card which can be configured by the Raspberry Pi. The microphone device here is a webcam peripheral namely Logitech C170, which can capture sound and relay it further for voice based controls. After capturing the voice signals from the microphone device, it is given to the Raspberry Pi for voice processing. In order to configure the external microphone device, we have to override the default sound card of the Raspberry Pi by using ‘alsabase.conf’ which is
ALSA (Advanced Linux Sound Architecture), a software framework and part of the Linux kernel that provides an Application Programming Interface (API) for sound card device drivers.

B. Voice Processing

After successfully capturing the audio from the device, the input has to be processed for the output to be reflected. While we have chosen the processing method which is built in the Raspberry Pi, there are a few other methods as well. The Primary and the Best Applications are:

Firstly, Conversion of Speech to Text: When connected to the Internet, Raspberry Pi can be used to convert a given input speech into the text format, provided that the language used is English with further possible extensions to other languages.

Secondly, to Use the Device as a Google Personal Assistant: The Striking Feature of Raspberry Pi is that it is completely User friendly with support to various APIs that can be used as personal assistants. This feature enables the user to explore and access the most powerful aspects of Google and hence providing a privileged hassle free driving experience by synchronizing directly with all the Google applications such as Google Web Browser, Google Maps, YouTube and if needed Gmail. The advantage of this feature is its ability to trace the route to a particular location by including the traffic that the driver will approach, the alternate routes that are available for him/her to drive, just by using voice commands. This depicts the future of inter car communication wherein they interact with each other to exchange information regarding their current position, the momentary speed at which they are travelling, etc., all for the driver's convenience.

Lastly, Driving the Appropriate Actuators: The final phase is to redirect the voice signal to carry out a specific function like driving a motor of a power window or sending signals to control the navigation of the car or to monitor the interior lights of the car. According to the voice command assigned, the necessary function is called and hence the outputs i.e., the actuators are driven to carry out the operations. The various Actuators being:

- Navigation System
- Stereo Controls
- Call Monitoring System

The software programming platform is developed using Python system call feature. When the voice command is initialized, the operational feature of the design model are invoked. The built-in features of ALSA model includes the libraries of voice processing in the design. These commands are user friendly and when invoked using the Voice HMI Bach Commands perform the required task. Playing the music, invoking Facebook, Google and other internet services. The HMI voice processing model is Semantic, interpreting the command language.

Example: Voice Command
- Q: What is 2+2?
- Q: 2+2?
- Q: Answer 2+2?

Displays the answer on the monitor as 4, and also spelling it out, in audible voice as four.

The various Bach Commands used are:

arecord: - To capture audio signals from the external microphone device, duration of the recording can be set.

aplay: - To play the recorded wave file stored in the Pi.

These user friendly commands play a prominent role in interacting with the system and act as a basis for communication.

V. SMART INFOTAINMENT SYSTEM DESIGN MODEL RESPONSE

Table illustrates the response chart of the processing model. Record and Play an Audio file: The first attempt made was to record and playback an audio file using the properties of ALSA, thus achieving the initiation step. The audio files of formats ‘.wav’ and ‘.mp3’ were recorded and replayed using OMXPlayer. Later the same was achieved using aplay, an inbuilt command in Raspberry Pi. This basically concerns with Stereo Controls inside a car.

Speech to Text Conversion: Achieved through Google APIs where in, any voice input will be converted into text format. The smartness of the system lies in the fact that it connects to the internet (if available), provides the value of the given input viz., reads out the location of a particular place, performs ALU operations, Google’s a few words, etc. Further it makes use of Google Apps Script (a JavaScript used for manipulating the APIs) for services such as Calendar, Docs, Drive, Gmail and Sheets and create Add-Ons as well. User Registrations, Drive Apps, Custom Search, Search Engine Apps, Gadgets are a few fields where they find prominent applications. An effort of implementing a system along with the hardware and testing for its functionality and working was made.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Design Feature</th>
<th>Design Module</th>
<th>Specification</th>
<th>Design Response</th>
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<td>Driver</td>
<td>Arithmetic and Logical Operations, Location Search, Text</td>
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<td>2</td>
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<td>OMX Player</td>
<td>.wav &amp; .mp3 files</td>
<td>Preloaded Music &amp; Preloaded data</td>
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VI. CONCLUSION AND FUTURE WORK

An IoT enabled design framework is presented for automotive sector. The HMI model developed for the IoT based Smart Infotainment System has been built using the fundamentals of IoT layered architecture feature. The proposed, ALSA based voice command interpretation, introduced achieves a cent percent precise response. When cost parameter is considered for this system, it observed that this design can be implemented in low segment cars, making the high technology affordable. The successful implementation of the proposed design solution for IoT based Smart Infotainment System, with the projection of 21 billion smart objects by 2020 advances the knowledge during system integration. Future work is on, with a similar approach in developing a prototype for power window and interior automotive lighting. The concept of connected cars using IoT and Cloud based approach for both car safety and road safety would be a major leap in the future. Automotive Electronics clearly depicts the safety based approach for connected cars with interfaces to all the safety concerned modules which exist today.

REFERENCES