Advanced Intelligent Vehicular Analytics (AIVA) using IMS Architecture

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Abstract

Technology if left alone can't evolve, merging of technologies leads to creation of a hybrid which paves the way for the future. This paper elaborates the convergence of a system which measures mechanical parameters and a telecommunication network. AIVA stands for Advanced Intelligent Vehicular Analytics which will record all the vehicular diagnostic data using OBD-II scan tool program and then wirelessly transmit the data to a central server thereby creating a database of the vehicular data. The database created will be used from the business point of view to generate applications using Web 3.0 architecture. An Interactive Graphical Interface (IGUI) for a cellular phone will be developed so that the owner of a particular vehicle will get real time live update of the vehicle's health. A semantic web of data would be generated to facilitate further progress in this field. This way the owner will know the fault in the vehicle and when to take the vehicle to the service station.

Keywords: *DSP; IMS; CAN; ECU; Web 3.0; Semantic Web.*

1. Introduction

Few decades ago when we used to think about automobiles, the first thing that came into our minds was that they were fully mechanical systems which only used to take us from one place to another. The current scenario is that an automobile has many features incorporated due to the innovation and improvisation of technology which provides: Quality, Comfort, Performance, and Satisfaction. We can take a step towards the future by incorporating this technology in the automobile sector and generate applications which will facilitate progress in other sectors too.

Most of the modern vehicles now days are equipped with ECU [1] (Electronic Control Units), now the ECU is nothing but an onboard car computer which monitors all the system running in the vehicle and measures all the parameters via sensors. These sensors which relay the data back to ECU of the car form the Controller Area Network [2] (CAN). The ECU then gets the signal about the working condition of different system of the Vehicle. Almost all the data which is going to the ECU goes to waste as it is not being relayed or very little being utilized. We plan to tap in all the signals been sent by the sensors to the ECU and then utilizing those raw data and generating a database. This raw data will be wirelessly transmitted via a wireless network to a server from where the data can be accessed for different purposes. Incorporation of additional sensors will help in generating secondary applications, which will be discussed in the paper. Regarding communication networks, the IP multimedia subsystem (IMS), which is the networking architecture for next generation networks, is a promising solution. IMS makes it possible not only to provide access to all the Internet services through cellular networks, but also to offer network capabilities and functionalities, such as charging features, identification and authentication and messaging or conferencing. Higher transmission speeds are obtained so relaying of data is fast and efficient.

2. AIVA Architecture

The general architecture of Advanced Intelligent Vehicular Analytics considers four main elements in the overall system: the vehicle, the wireless network, the server and the semantic web portal (see Figure 1).The vehicle is equipped with a cellular phone which performs the task of data acquisition and transmission. Controller Area Network of the vehicle relays sensor data to the ECU. The cellular phone equipped with an interface and acquisition software which will record the diagnostic data and transmit it to a central server. Remote information, services and capabilities are also available through the network infrastructure. IMS core and capabilities are also included. Block diagram architecture of AIVA is given below (see figure 2).

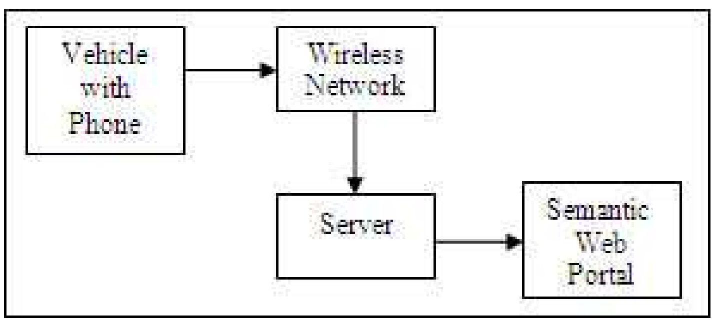

Figure. 1. Main elements of AIVA.

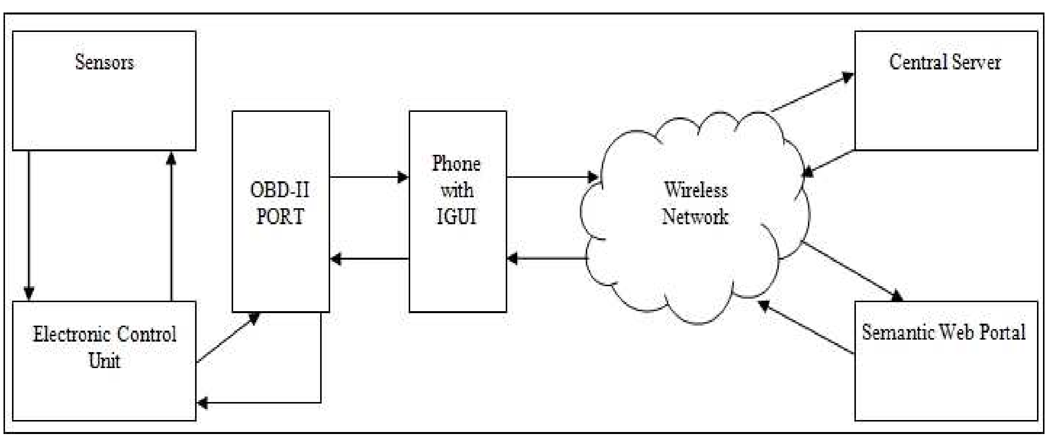

Figure. 2. Block Diagram Architecture of AIVA.

3. Vehicular Diagnostics

3.1 Engine Diagnostic:

An engine diagnostic [3] is a test which is performed to learn more about engines. It is used to gather data which can be utilized in the repair of the vehicle. Performing an engine diagnostic starts with the incorporation of a diagnostic tool connected to the vehicle's OBD-II port. The diagnostic tool is nothing but a data logger with a display. The device interfaces with the vehicle's ECU returning a diagnostic trouble code (DTC) which can be referenced against a list of codes for vehicles from that manufacturer. If the engine is in good working condition, the device will inform the user. If there is a problem, one or several codes may be displayed. Codes can mean a wide variety of things. During an engine diagnostic, the mechanic determines what is causing each code to display, for the purpose of developing an estimate to let a driver know how much it will cost to address a problem. Sometimes, the issue is simple, while in other cases, it can be very complex. People usually bring cars in for an engine diagnostic when the "check engine" light is displaying, or when they are experiencing car problems. It can be helpful for the mechanic to know which kinds of problems are being experienced, and how long the driver has noticed the problems. For things like the check engine light, sometimes the light goes off when nothing is really wrong; for example, some cars will display the light when it is time for an oil change to goad drivers into going to the mechanic, and the mechanic can clear the alarm so that it will stop displaying.

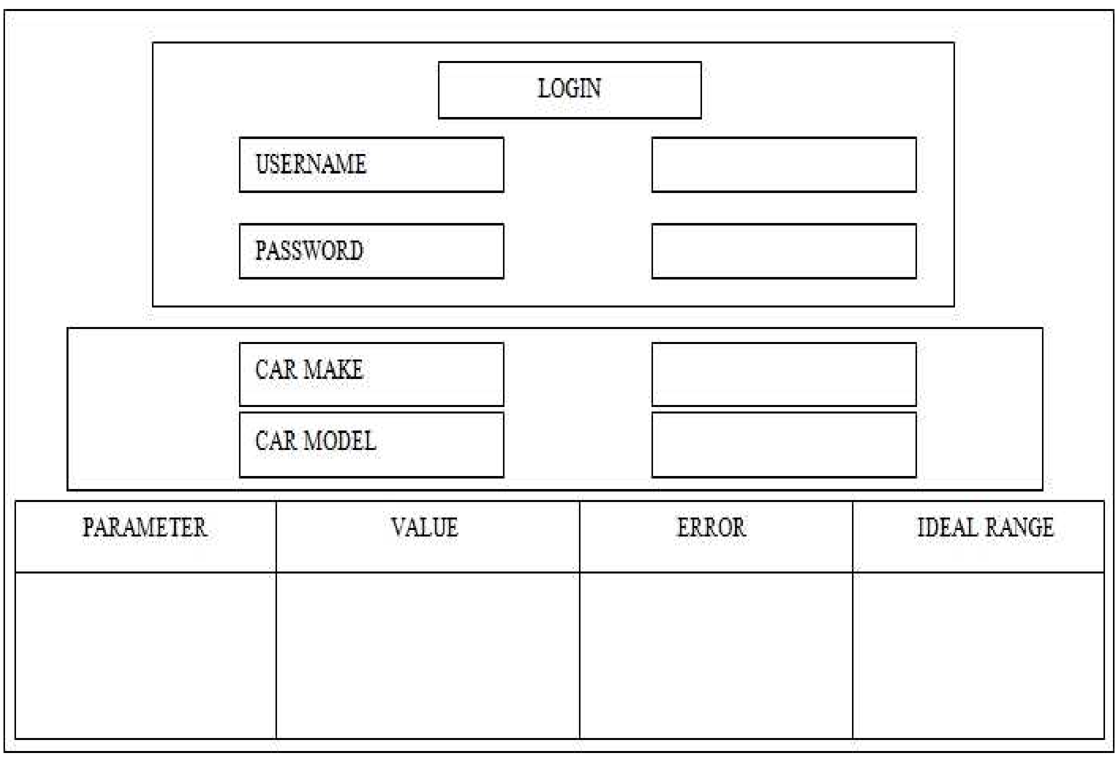

Figure. 3. Diagnostic Scan Tool Program Interface.

3.2 Working of the Diagnostic Scan Program (DSP):

Diagnostic trouble codes, known as DTCs, are alphanumeric codes that a vehicle's computer outputs when it detects a malfunction. These codes are transmitted by a vehicle's on-board diagnostics (OBD) system and can be accessed using a diagnostic tool that plugs into the OBDII connector. Diagnostic trouble codes don't only communicate with individuals, they also communicate with the vehicle. For example, certain diagnostic trouble codes tell a vehicle when to turn on the "check engine" light. Sometimes, the "check engine" light is triggered by a trouble code that indicates serious car troubles. In other cases, the trouble code that caused a "check engine" light might merely be indicating that a fuse needs to be replaced. Thus, having a personal diagnostic scanner can go a long way in helping an individual car owner figure out whether a "check engine" light actually necessitates a trip to the car shop. A diagnostic scanner can also give a car owner the option of turning off the "check engine" light after assessing the diagnostic trouble code. Automotive diagnostics software interfaces with your vehicle's engine control unit (ECU) to provide real time diagnostics and troubleshooting data. Auto diagnostics software can reset the check engine light (CEL) in the dash, pull trouble codes stored in the ECU, and narrow down potential causes for problems. It can also be a useful tool for automotive maintenance. The diagnostic scan program or DSP is nothing but program running in a cellular phone, which is plugged into the car’s OBD-II port. The DTCs generated are interpreted by the program and corresponding values of the parameter are displayed on the screen. The schematic view of the DSP interface is shown in figure 3 (above).

4. Transmission of Data

After the recording of diagnostics data by the IGUI is done, it’s time to transmit the data. 3G services will aide in transmission of data from the vehicle to the central server. Technically, 3G is a generic term that covers a variety of wireless standards and technologies including: CDMA (Wideband Code Division Multiple Access), CDMA2000, UMTS (Universal Mobile Telecommunications System), EDGE (Enhanced Data for Global Evolution), HSPA (High Speed Packet Access, including HSDPA & HSUPA).

This paper considers the internet protocol multimedia subsystem (IMS) technical architecture and its importance in adapting to various applications. IMS is a person-to-person service that enriches the way people communicate with each other by combining voice, image and video into a single session. IMS uses session initiation protocol [4] (SIP) and session description protocol (SDP) underneath architecture to communicate between various IMS components. IMS is defined as a new subsystem, i.e. a new mobile network infrastructure that enables the convergence of data, speech and mobile network technology over an IP-based infrastructure. The carrier is the internet. IMS was designed to fill the gap between the existing traditional telecommunications technology and internet technology. This will allow operators to offer new, innovative services that shareholders and end user expecting. The architecture of IMS specially helps enable and enhance real-time multimedia mobile services.

4.1 IMS Architecture:

IMS Architecture [5] (see figure 4) is described below. IMS is classified into three component layers namely, Transport layer, Core layer and Application layer. Transport layer connects all networks on an all IP domain. Core layer is the main layer which also houses the HSS. Application layer contains the servers which executes all the application requests.

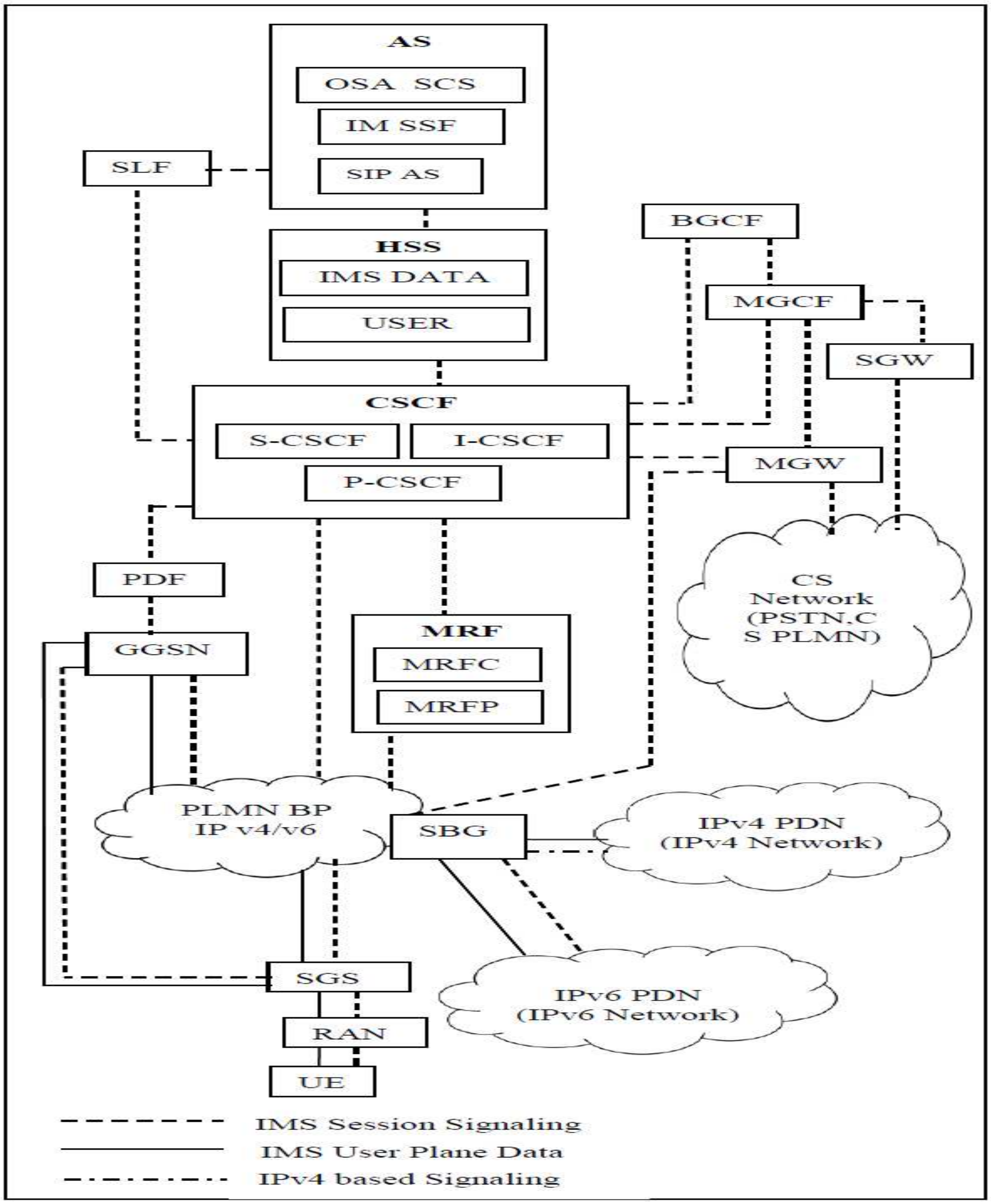

Figure. 4. IMS architecture

4.1.1 Proxy Call Session Control Function (P–CSCF): This is the first point of contact in the IMS for a user. The P-CSCF may be in the home or visited network. SIP register/invite methods are initially terminated to P-CSCF, and it ensures that registration/session requests are passed to the correct home network or that SIP messages are passed to the correct serving CSCF (S-CSCF).

4.1.2 Interrogating Call State Control Function (I–CSCF): I-CSCF is the entity of the home network that is able to determine the S-CSCF from which the user should register. I-CSCF queries a home subscriber server (HSS) to get the name and capability of the S-CSCF. Once S-CSCF begins identifying, I-CSCF could be removed from signaling.

4.1.3 Serving Call Session Control Function (S–CSCF): The S-CSCF is the function that registers the user and provides service to them. The S-CSCF is acting as the SIP registrar for all the users of IMS. It performs routing and translation, provides billing information to mediation systems, maintains session timers, and interrogates the HSS to retrieve authorization.

4.1.4 Media Gateway Control Function (MGCF): IMS is designed to integrate with PSTNs. MGCF is used to transfer non-SIP packetized voice to SIP user agent (UA) and vice versa. If the calls are originating or terminating on the PSTN, the MGCF converts the PSTN time division multiplex (TDM) voice bit stream to an IP real-time transport protocol (RTP) stream and direct it to the IP address of the corresponding IP phone.

4.1.5 Media Resource Function (MRF): MRF is divided into two parts: multimedia resource controller (MRFC) and multimedia resource function processor (MRFP).
Tasks of MRFC are as follows: (1) Control the media stream resources in the MRFP. (2) Interpret information coming from an application server (AS) and (3) Generation of data records (CDR).
Tasks of MRFP are as follows: (1) Control the bearer on the MB reference point (2) Provide resources to be controlled by the MRFC (3) Mix incoming media streams (4) Determine media stream source (5) Handle media stream processing (e.g., audio transcoding) (6) Manage access rights to shared resources in a conferencing environment.

4.1.6 Home subscriber server: HSS is a master database for users' subscription-related information. It supports the IMS entity to establish the registration/call control. HSS is the superset of the Home Location Register (HLR) and provides users' physical location. HSS is operated in IP core networks and can be contacted through diameter protocol. As such SIP AS is connected to S-CSCF through an IMS service control (ISC) interface. The ISC interface is also connected to IP multimedia service switching function (IM-SSF) and open service access service capability server (OSA-SCS).

4.2 Working of AIVA:

CAN network relay the sensor data to the ECU. If any error is encountered then ECU corrects them and relays analog pulses to the actuators. The sensors again interpret the data and relays signal to the ECU. The IGUI developed for the cellular phone would be equipped with scan tool software which will perform the task of a diagnostic scan tool. After selecting the car make and model PID's are generated and their corresponding DTC's are monitored, which are generated by the ECU. The errors will then be displayed in the interface. Data will be continuously monitored and stored in a log file. Transmission of the data will be via 3G network. Real time relational databases of the uploaded data would be created based on Web 3.0 architecture using semantic agents.

5. Integration of Web 3.0 Architecture

The semantic web [6] is a web of data that is able to describe things in a way that computers can understand. Statements are built with syntax rules. The syntax of a language defines the rules for building the language statements. Semantic web is all about making this syntax semantic, describing things in a way that computers applications can understand it. The semantic web is not about links in web pages, it describes the relationships between things and properties of things. Semantic agents work through the created relational databases to take decisions innovatively. The RDF (Resource Description Framework) is a language for describing information and resources on the web. Allocating information to RDF files, makes it possible for computer programs ("web spiders") to search, discover, pickup, collect, analyze and process information from the web. To search the semantic web, we will need some software called "Semantic Web Agents". These "agents" will help us to find what we are looking for on the semantic web. We plan to generate product ratings, brand ratings and a dedicated web portal based on Web 3.0 using semantic agents.

5.1 Product Rating:

Product rating is nothing but a score card on which two or more products are compared across different fields and parameters, which is bought by the customer. Any product new or old is judged across different fields and parameters to award them with individual score on respective parameters.

Based on the vehicular diagnostic data which will be uploaded, the semantic web agents will analyze the same and build relational databases. We plan to develop a meticulous and extensive product rating system especially for automobiles, to help the prospective and present customers in buying, selling and to get better after sales service. Since the automobile segment is a vast segment under which the cars are again classified into different segments, which again attracts customers from different sectors of society thus, becoming one of the most complex, cluttered and confusing segment for the customer to make buying decision. On top of that, there is lack of relevant information about the product and its competition.

Vehicles can be classified in different segments according to the fields on which it is rated; on a whole a vehicle can be compared with the other vehicle of same class or can be compared with the vehicles from different classes, on a common field or parameter. The scores are assigned to a vehicle over comparison of performance in different fields and sub fields, And rating it from 1 to 10, 10 is given to a vehicle with the best performance on that field and 1 to the vehicle with worst performance. After this all the sub scores are added and average is calculated and the average is the rating or the score of the field, in the same way all the field scores are added and average is taken out and thus that score becomes a Vehicle's Product rating.

Some of the data related to vehicle performance, handling, fuel efficiency and reliability are coming from the vehicle's onboard diagnostic system, which is then uploaded for real time data analytics, thus we get real time data from different vehicles and the data analytics program can compare and make different classes and segregate the vehicles, before comparing them again and rating them. Rest of the data can be gathered from the World Wide

Web, manufacturers, voting, survey and testing. All the above tasks can be accomplished by semantic agents. The introduction of a new vehicle, ever changing performance figures of a vehicle all affect the product rating and ranking thus making it dynamic in nature. All these factors are taken into consideration and real time analytics is done to keep up with the market and keep the customer up to date.

As no two customers are the same and keeping that in mind they also have different priorities in their mind, thus the system helps the customer to get an extensive comparison between two or more vehicle of same or different segment easy, according to their taste. The filters can be set by the customer while comparing, the filters only shows the parameters or field selected and shows the comparison between those selected field, and will show overall product rating based on the filters applied. Priorities are the sequence of the desired parameters that the user seeks in a vehicle, and those defined priorities are taken into consideration and relevant product ratings are calculated and displayed for the vehicles of the same class or different class. Thus simplifying the decision making process.

6. Conclusions

AIVA architecture will surely help in vehicular communications and various applications related to the same. People will come to know their cars much better, and the cars life will improve drastically. By using 3G/4G network better speed can be achieved. IP–based service architecture would be a key element in communication networks, and SIP will be a standard protocol to cater to all 3GPP multimedia applications. It ensures that future multimedia services will be truly IP–based. All the key components for IP convergence are commercially available today, and IMS infrastructure equipment is also available. Integration of semantic web applications in the proposed analytics is going to revolutionise the way customers are served.

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