



Advance Vehicle and Driver Profile Management Using Cloud Frameworks

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| Article History | Abstract |
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| Received: 06 June 2023 Revised: 05 Sept 2023 Accepted: 29 Nov 2023 | <p><i>Advancements in semiconductor technology, embedded automotive computing, AI/ML computing and cloud computing has recently helped automotive industry to reach to provide the next generation vehicular experience such as self-driving cars, advanced safety features, cloud-based fleet management, highly efficient automotive manufacturing, connected cars, telematics and many more. Automotive or vehicular industry also started focus on providing better driving experience, in vehicle connectivity, entertainment, remote vehicle diagnostics and driver assistance, etc. Automotive cloud computing is one such domain which helped automotive industry to scale itself to connect the vehicles to cloud and remotely manage and control the vehicles, provide emergency assistance, data science and analytics services to dealers, insurance companies, car manufacturers, fleet management, etc. In this paper we present the research of recent advancements of automotive industry especially using cloud computing and how the cloud computing frameworks are making huge impact on auto industry such as advance driver's profiles management using cloud framework. This paper also discusses the implementation approach for electronically managing the vehicle and driver's preferences for their next generation electric and hybrid vehicles. And the paper proposes the smartphone's NFC or BLE based driver's profiles management approach.</i></p> <p>Keywords: Cloud Computing, Fleet Management, Vehicle to Vehicle Communication (V2V), LiDAR, Artificial Intelligence (AI), Machine Learning (ML), Long Term Evolution (LTE), 5G, Original Equipment Manufacturer, NFC (Near Field Communication), BLE (Bluetooth Low Energy), Ultra-Wide Band (UWB).</p> |
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1. Introduction

Cloud computing has been the pioneer technology and created a solid foundation across different industries. This paper focuses on impact of cloud computing in auto industry and how the customers, dealers, vehicle manufacturers and related service domains can leverage the advantages of cloud computing. This paper is divided into three major sections. Following subsections discusses how the auto industry is surrounded by cloud computing and multiple service domains around it are interconnected using cloud. The section two focuses on primarily on cloud framework-based drivers profile management implementation approach and how efficiently the vehicles and drivers get benefit of cloud frameworks for variety of cloud services.

A. Cloud Computing in Auto Industries

In recent years cloud computing has been very popular in many industries such as healthcare, medical, manufacturing, retail, ecommerce, education and automotive industry is no exception of using cloud computing. In recent years, automotive sector is going through massive revolution and thanks to Amazon, Microsoft and Google for their highly advanced, scalable, multi-zone, ubiquitous cloud computing platforms and solutions which are used without having massive infrastructure upgrade requirements or investments by auto industries. The entire cloud resource management can be outsourced and seamlessly managed by auto industries without being involved in massive infrastructure deployment.

Today's vehicles have become smart and intelligent with advance computing engines, highly advanced infotainments, advanced LTE/5G based telematics, GPS, and collisions detection techniques using LiDAR sensors for object detection and AI/ML, Computer Vision algorithm-based imaging devices and sensors for autonomous vehicles. Many auto industries pioneers have been deploying the cloud platforms as vehicles will be dependent on data and assistance from the cloud platform solutions as in paper [11].

B. Connected Vehicle Cloud

As shown in figure 1 the connected vehicle cloud once deployed it has been interfaced with various entities such as car drivers and owners, automotive OEMs, dealers, media agencies, insurance companies, content providers, energy utility companies, support centres, repair shop, network operators, fleet management companies, vehicle themselves can connect to the cloud. Connected vehicle cloud is explained in very simplified way by Connected Vehicle Cloud model as shown in figure 1 below. The entire automotive industry ecosystem is connected using the common cloud solutions as shown below model in [4].

The connected cloud transforms the vehicle networks and provide quality in terms of high speed, low latency network connectivity using advance 4G/5G mobile communication networks and high-speed cloud framework. Thus, the manufacturers, dealers, service centres, vehicle and drivers always have connected and they can utilize the worlds latest cloud-based technologies, such as automated emergency assistance, efficient fleet management, in vehicle high speed entertainment support, fast remote assistance, quick repair history, on mobile vehicle management services, etc as in [4].



Fig. 1. Connected Vehicle Cloud.

Following are the vehicle connected cloud features in website [4]:

- Cloud framework-based execution engine: framework to execute complex data analytics and machine learning based functionalities for driver and vehicle performance, services, repair, maintenance, insurance, etc.
- High speed vehicle communication platform to connect to any kind of vehicle or device.
- Secure storage and database engines for high-speed data access, data recovery and database management in case failures.
- Security framework security algorithms and framework to establish secure connection between cloud and vehicle including the carrier networks, using identity and access management framework, single sign on using unique vehicle identity.
- Vehicle and driver preference profile a cloud-based framework to create secure vehicle and driver profiles.
- Access to service centres using mobile device-based applications to connect the cloud to easy access for service history and vehicle maintenance alerts.
- Location based services for drivers' favourite destinations and alerts for geo-fencing, parked and remote mode vehicle tracking, remote vehicle immobilization.
- Dealers and manufacturers network management framework to establish the vehicle manufacturing and dealership network interface to efficient vehicle delivery scheduling.

- Fleet management framework for the rental car services to manage the driver's profiles, rental services and connect with vehicular services.
- Insurance framework to keep track of vehicle insurance for data analytics and offers to drivers for easy and discounted insurance offers.

C. Telematics and Cloud framework-based driver's efficiency and safety

A cloud-based framework is required to manage the driver's profile in next generation hybrid/electric vehicles where entire automotive components like engine, IVI, clusters, telematics is controlled using compute power.

And a cloud service model is required including the cloud interface with vehicle manufacturers, dealers, fleet management, rental services, road side assistance and the owners of vehicles. This service model uses the telematics network connectivity on vehicles to connect to cloud network. The telematics provide always on network connectivity to vehicles where there is mobile network connectivity is available. The LTE/4G and 5G is advance network connectivity can be used to connect the vehicle to cloud, emergency assistance, road side assistance in case of emergency, etc as in paper [3].

As shown in figure 2 the telematics module connected in vehicles will provide seamless connectivity, safety and remote assistance features. It provides connectivity to mobile applications, Bluetooth, Wi-Fi, GPS location base services, anti-theft alarms, etc as in [9]. The vehicular connectivity features are hardware based and most the hybrid and electric cars have these features inbuilt. The telematics modules can be also fitted into vehicles inside the OBD ports of the car which then gets connected to vehicles internal engine framework using CAN interface.



Fig. 2. Vehicle Telematics Connectivity.

Following are some of the cloud-based features provided for vehicles using telematics paper in [8]:

Safety Features:

- Automatic accidental notifications and services to emergency services, road side assistance, emergency contacts
- Road side assistance in remote areas where there is breakdown
- Panic notification to save emergency contacts
- Tracking stolen vehicles and immobilization Remote

Vehicle Management Features:

- Remote engine and climate control starts
- Remote door and boot lock
- Remote vehicle status check
- Find the car location

Location/GPS based services:

- Real time traffic information
- Geo fencing and last location
- Frequent destination alert services

Telematics and cloud framework plays vital role for vehicle and driver profile management and in section 2 the focus is how the driver profile management framework enabled in cloud.

I. CLOUD FRAMEWORK-BASED VEHICLE AND DRIVER PROFILE MANAGEMENT DESIGN & IMPLEMENTATION APPROACH

Vehicle owners and car drivers always have their own preferences while driving and if the vehicle is shared between multiple drivers, the very efficient and automatic vehicle preferences management system can be implemented using secure cloud. These features can help drivers for ride sharing, vehicle rental services companies to maintains the profiles details, car drivers easily customize and manage it on the secure cloud at minimal cost.

Recent years vehicle network communications and connectivity options are increasing and hey continue to grow, hence the vehicle and driver can be customized based on preferences. Since there are vehicle sharing and rental services it is highly anticipated that personalized driver preferences to be enabled for vehicle and drivers and these features are already available locally withing vehicles. And the focus of rest of this paper is basically enable cloud framework to securely store the vehicle and driver's preference to cloud storage which can be accessible from anywhere as in website [5].

Drivers can preserve driving preferences such air conditions preferred temperature, seats positioning and height, outside and internal and mirror angles, drivers recommended radios stations, infotainment applications such as maps, dialers, messages and other more personalized preferences. The vehicle cloud sync manager syncs all of preferences to the cloud, and hence the drivers can access these preferences anywhere from world using web or mobile application or using infotainment system.

For profile management driver needs web-based application or infotainment system with unique identify created while purchasing the vehicle. When driver switched to another vehicle, the driver needs to connect to secure cloud framework using his vehicle or mobile application to authenticate himself using the in-vehicle login system. This service is useful not only for loaner cars, but also when purchasing a new vehicle. Since some of the preferences may not be applicable when driver changes the vehicle, those will be simply ignored and only new vehicle supported preference will be applied, but the old preferences will be still backed up in secure cloud storage for future access and usage as in website [5].

With the help of cloud-based driver profile service, multiple “driver profiles” can be maintained per vehicle. Examples of personal settings that can be configured in the cloud are:

- Vehicle exterior preference – outer rear view mirror angles and height, head light adjustments, etc
- Vehicle interior preference – driver seat height, cabin AC, inside rear-view mirror angles, head rest height, seat alignment,
- Infotainment preferences – customized music, FM radios, home screen, displaying favourite stations or types of content
- Location based preferences - recent and frequent navigation destinations, cloud-based network alerts, etc.

A. Cloud based vehicle and driver profile management system architecture

The cloud framework-based vehicle and driver profiles can be managed by fleet management or vehicle manufacturer auto industries.

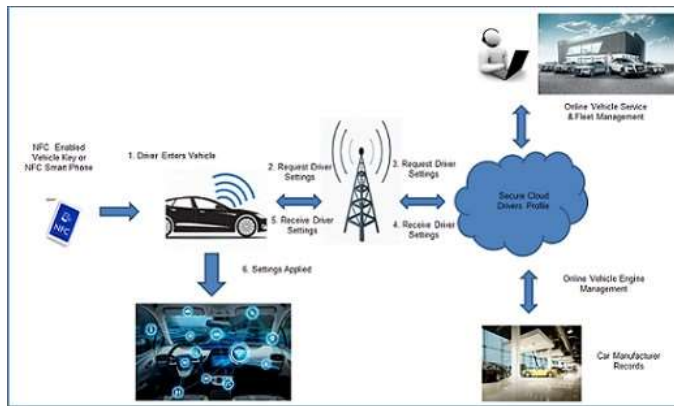


Fig. 3. Secure cloud framework for driver and vehicle profile management.

Figure 3 shows the architecture of cloud framework-based profile management framework which is highly secure as it's administered by fleet management companies and secure access to vehicles using NFC Secure card emulation or Bluetooth Low Energy on the smart phone to authenticate and access the cloud framework. The fleet management cloud framework and access interface are going enable the authentication and authorization of vehicle driver profile access based on unique ID's created and shared only using trusted and certified driver.

As shown in figure 3 NFC in Smartphones provide unique secure ID which is available only with cloud framework and the driver's mobile or NFC tag. The key is encrypted and highly difficult to encode and hack as the secure element in NFC controller is only storing the keys on the smartphone or NFC cards. This unique ID is nothing but the unique profile ID for the driver and vehicle which will be maintained and managed by cloud framework.

Key architectural components of the vehicle and driver profile management system includes:

- **Vehicle's cloud sync manager:** A vehicle with mobile network connectivity of telematics module is key for profile management and synchronization using cloud. A profile sync manager component is a software component part of vehicle cloud framework interface. The sync manager component as soon as receives request from profile manager framework of the vehicle system, it retrieves the unique ID of the driver and vehicle and connect to secure cloud framework where driver profiles are synced. It authenticates the driver based on the unique ID received over NFC or Bluetooth based secure communication. This helps the sync manager to establish the secure connection with the cloud framework.
- **Cloud ID and Access Management Framework:** The cloud framework can be divided into multiple framework and ID and Access management framework is crucial for key management. Based on the unique ID received from the cloud sync manager, the ID and Access manager component will authenticate the driver and helps to establish the secure connection between cloud and the vehicle.
- **Profile Download Manager:** Once the vehicle and driver are authenticated the profile download manager will download the profile on vehicle and then store in secure storage of the vehicle compute memory.
- **Profile Updater:** Once a profile is downloaded from cloud to the vehicle the profile will be applied on car's infotainment, clusters, interior and exterior of the vehicle. Any change by the driver in the preference of the interiors will be immediately updated to the cloud sync manager framework.

B. Vehicle and driver profile management connectivity interfaces

An architecture of simplified vehicle connectivity is shown in figure 4 below



Fig. 4. In Vehicle Cloud Connectivity Architecture.

The Vehicle infotainment and cluster system software as discussed in section above has cloud sync manager framework which connects to the cloud for profile management. The driver's authentication and connectivity to the system is authorized using the unique ID based on mobile application which uses the NFC or BLE based unique secure IDs.

C. In vehicle and driver profile management system architecture

Figure 5 below shows system software architecture for in vehicle driver profile access, download and update management using secure cloud interface. The vehicle software system consists of core operating system, in vehicle infotainment software system, cluster management and cloud interface framework, physical network connectivity solutions such as Bluetooth, NFC, LTE/5G and CAN interface for vehicle engine and cluster interface.

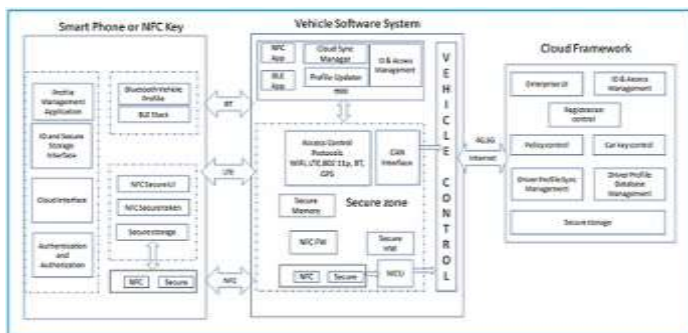


Fig. 5. In vehicle driver profile management system architecture.

The smartphone connects with vehicle using BLE and NFC with unique ID. The Vehicle software system connects to cloud using secure network and authenticates itself using the unique ID and IADM software system in cloud framework. The profiles stored in cloud framework are securely downloaded and applied over vehicle system using profile update manager which has full access and authentication to access and update the vehicle profiles for specific driver and vehicle.

1) Cloud Framework Modules for Driver Profile Management:

- **Enterprise UI:** The cloud framework provides features such as enterprise UI which helps the dealers, manufacturers and vehicle owners to access the cloud framework. The UI can be simplified view for access control, history, record and other vehicle data. This UI can be accessible from any internet-based device after authentication using owner's credentials.
- **ID and Access Management:** To securely authenticate the drivers and authorize them the services provided by dealers and manufacturers owners are entitled for. The ID and access management framework also enforces certain security policy control and vehicle key control enforces certain security policies for drivers' services and key management. This framework is also utilized to provide services like single sign on and use different cloud-based services. The security policies and access level should be different for vehicle owners, dealers, service centres, fleet management services features mentioned in [12].
- **Registration Management:** The cloud framework also provides easy access and process for registering and deregistering the vehicles as per the request after authorization from dealers and owners after new vehicle purchase. This registration is required to create a new set policies and preferences database for new vehicles.

- **Vehicle Key Management:** The vehicle key control is secure manager which keeps track of the keys and associates unique IDs created for each vehicle. These keys and corresponding certificates, unique ID are never accessible to vehicle owners and dealers and they are managed by vehicle manufacturers. This is to guarantee to avoid hacking of the vehicle using software tampering.
- **Driver Profile Sync Manager and Database Manager:** The drivers profile sync management and profile data base management system enable the secure storage and profile sync based on driver's vehicle access and services. The secure storage is scalable and the driver subscribes the cloud framework access and services during vehicle purchase and obtains the keys and unique ID. These credentials are used during vehicle and cloud framework connections and helps to manage the profile.

2) *Vehicle Software System:*

- **Cloud Sync Manager:** The vehicle software system includes the cloud sync manager which connects securely to cloud using the secure protocols. This component is back-end component and keeps running in background to sync profile and preference from cloud. The sync manager uses the driver's unique id and vehicle unique id to connect and authorize with cloud. Based on this authentication certain cloud services access is granted as mentioned in [16].
- **Profile Updater:** The profiler updater component in vehicle software systems sends and receives the preference and other information related to vehicle and driver and updates to vehicle accordingly. Typically, the preference gets updated as soon as driver enters vehicle and access the system using secure keys like NFC or Bluetooth based smartphone [18-24].

3) *Smartphone Software System:*

- **Mobile Application:** The vehicle dealers provide a simple application with rich UI to register and access the cloud-based services to drivers. This application can be used for accessing remote cloud services, safety features, remote assistance, maintenance alerts from cloud, location-based services and notifications, etc. The application uses the NFC and Bluetooth low energy to create the secure key and unique ID based on secure element in device and that helps to authorize the drivers and vehicles.

Thus, the vehicle and driver preferences can be easily managed with these three different software subsystems and cloud-based framework. The usage of telematics and cloud computing for rich driving experience for vehicle owners can certainly achieved and cloud computing plays a key role here. With connected cloud between smartphones, vehicles and dealer, manufacturer this becomes a connected vehicle ecosystem with many more advance analytics features. Vehicle owners can use these cloud-based analytics features for improving their driving experience and analyse the vehicle performance and at the same time manage the vehicle at the fingertips using seamless cloud connectivity.

II. ADVANTAGES OF NFC/BLE BASED DRIVER'S PROFILE UPDATE APPROACH

Harman and Tesla have implemented the driver profile management in their vehicle ecosystem which is based on cloud and local vehicle software management. But this paper presents the new approach for vehicle's driver profile management which using smartphones capabilities of having short range wireless technologies such as NFC, Bluetooth or UWB. The driver's preferences are activated as soon as driver enters vehicle using his NFC, BLE or UWB based unique key authentication.

- NFC controllers provide secure element which stores the secure keys and certificates and authenticate the driver detection which is considered as highly secure transaction mechanism and used in many transit and payment systems.
- Ride share becomes easily possible between family and friends by creating a new unique key based profile and updating the preferences for specific driver
- Since profiles are securely stored in cloud, accessing and managing the profile becomes very easy using smartphone applications.

- Connected vehicle cloud helps for easy data analytics as dealers, service centres, insurance companies, fleet management shares the same cloud framework

III. FUTURE SCOPE OF IMPLEMENTATION WORK

The current prototype implementation shown in figure 4 is based on raspberry pi, NFC controller and ThingSpeak cloud. The ThingSpeak cloud has limited number of interfaces though it's secure cloud. And NFC controller doesn't support the secure element to store the keys and security certificates for authentication. Hence, following are some of the implementation improvements are possible for recommended implementation: Use Automotive Linux, QNX based software system for real time and automotive requirements for infotainment and vehicle software system.

- Implement the BLE based system for unique key generation and driver's authentication.
- Use automotive CAN commands to control the components in vehicle to update the profile settings. Implement the cloud interfaces and storage with the AWS or Azure cloud interface.
- Design and develop mobile application to connect to ThingSpeak cloud and driver detection using NFC and BLE.
- Real time synchronization of driver profiles with cloud database whenever there is an update in profile settings by driver.

4. Conclusion

Cloud computing plays very crucial role in auto industry and is going to transform the entire industry with advance features and solutions, which involves entire auto industry software and hardware development on cloud frameworks, supply chain management, artificial intelligence and machines learning based face detection, driver detection, etc. These solutions can be easily managed on vehicle and on cloud. The platform providers provide scalable software solutions, and saves lot of cost for auto industry.

Real time driver and vehicle profile management is one such area which is going to streamline the multiple drivers for same vehicle who has different preferences while driving he vehicle and doesn't want the preference to be changes when another driver occupies the car. The driver also expects that the vehicle maintains his favourite music, radio and location tracks. And storing these profile preferences in vehicle may not always possible due to limited amount of secure storage in vehicle system and the driver may change the vehicle and expect that the same preference to be applied in new vehicle as well. So, maintaining the profile preferences in cloud network over secure storage gives advantages as its secured and can be accessed only the same driver using the ID and authentication management system. This paper focus on the same driver profile management in cloud and focuses on key technologies and interface required to design and implement same. NXP Semiconductors already have NFC based solutions for smartphone based key detection and this paper extends that to manage the driver's profile management using cloud framework when the particular driver's NFC based key is detected.

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