International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Leveraging Cloud Computing for Advanced Applications in the Automotive Industry

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Abstract:
With the growing demand for vehicle connectivity, data management, and computation power, the automotive industry has recently started recognizing cloud computing as a transformative technology. Traditionally, all industries stored their data on their personal devices, and to use that for any computing tasks, they were wholly dependent on their own IT infrastructure, but now the times have changed, and industries have started taking advantage of cloud services for computation and data storage. With the adoption of Cloud computing, many industries have seen a considerable difference in their business operations and Customer experience **[1]**. Automotive is no exception. This article details about the advantages of using the cloud and several use cases where the cloud services are being used in automotive applications.

Keywords: Cloud Computing, Automotive, Connected and Autonomous Vehicles, Over-The-Air (OTA), and Data Analytics.

Introduction:

Vehicle sensing and actuation have multiplied, with modern cars incorporating hundreds of sensors and dozens of computers. These technologies facilitate local sensing, inference, and action – proximity sensors pre-tension seatbelts in the event of an imminent collision, accelerometers vary shock damping to improve comfort, and vehicles predict common destinations. However, a significant opportunity exists to connect vehicles to one another and with infrastructure. For example, connected vehicles aggregate data will improve vehicle longevity by helping to optimize time maintenance. The insight and control facilitated by extra-vehicular data sharing will improve transportation safety, efficiency, comfort, and convenience and reduce operating costs by allowing distributed sensing, remote computation, and action at scale.**[2]**
With the rise of connected and autonomous vehicles in the automotive industry, the adoption of cloud computing has seen a considerable difference in business operations and customer experience. This paper lists the benefits of using cloud computing by organizations and then details several use cases being realized in the automotive industry using cloud computing.

Benefits of adopting cloud services and computing:

Low Cost:

Managing one's own IT hardware costs in terms of labor, power consumption, and hardware repair and upgrade is an overwhelming task. With Cloud computing, all these things can be managed by a third-party company. An additional benefit of cloud computing is that one can define requirements clearly and pay only for what is absolutely required.

Automotive industry complex needs

Auto companies' needs revolve around large engineering simulations, analytics, data, and dealers' networks. These consolidated demands require a very powerful infrastructure whose maintenance can prove to be a technical challenge even for the best **[3].** Cloud computing can help overcome these challenges.

Connectivity features:

Cloud can be used for various services, such as remote vehicle operations, tracking the car's current location, enhancing the performance of the GPS system, entertainment, and real-time traffic updates. This connectivity improves the overall driving experience and safety.

Low risk and highly secure:

Cloud service providers provide round-the-clock support to ensure the systems' security. Relying on cloud services can also reduce the risk of failures and cyber hacks. Data stored in our own infrastructure is vulnerable to natural disasters. On the cloud servers, the data is safe if there is a natural disaster, such as a storm, cyclone, or earthquake.

Use Cases:

OEMs and suppliers are taking advantage of cloud services and computing; below are a few of them:

Personalization and Customer Experience:

Cloud is being used for convenience functionalities like driver profile management through which preferences like interior temperature settings in a car, music settings, and frequently navigated destinations can be synchronized between the mobile app and car through a cloud server. In the 2018 CES, Tier-1 suppliers demonstrated how the personalization features can be made portable with cloud integration. Remote lock, unlock, remote engine start, Personalization, and Infotainment features were demonstrated. For example, in the picture below, the driver first creates his profile along with a picture and settings on the phone and uploads this data to the cloud through the Cloud vehicle app. When the driver pushes the start button in the car, one of the apps on the Head unit retrieves the driver profile and adjusts the settings (Temp, music, and seat adjustments) in the car accordingly. This use case demonstrates how the driver profile can be made portable across the phone and owner's vehicles and applied instantaneously.

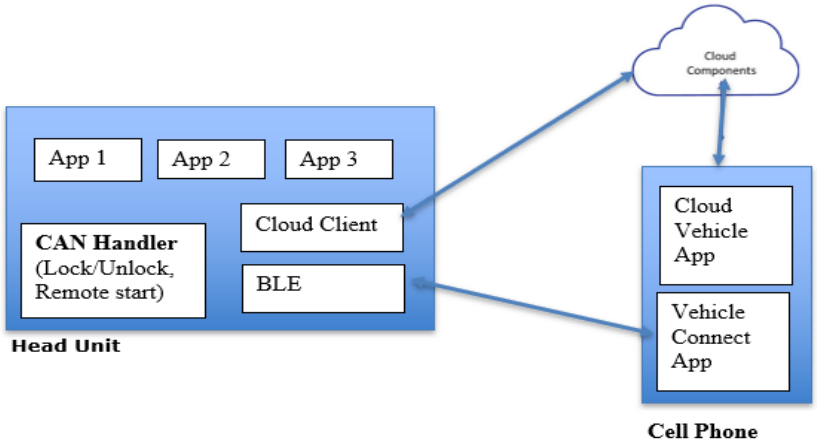

Figure 1: Profile management between phone, cloud, and car.

Data analytics:

OEMs and suppliers have started taking advantage of cloud analytics during the software development cycle (Pre-SOP) and Post-SOP to debug the issues and identify the root cause. In the case of the high-end vehicle, this data is uploaded to the cloud directly using Wi-Fi in the car, and in the case of low/mid-segment cars, where Wi-Fi is not an option, OEMs are considering capturing the logs from Head Unit to USB and then upload the logs from USB to the cloud's micro portal for data analysis.

Also, with the help of a query engine and micro portal, data can be ingested, stored, analyzed, and represented in interactive dashboards, charts, and graphs that can help analyze trends for manufacturing, marketing, and customer behavior. A simple representative architecture

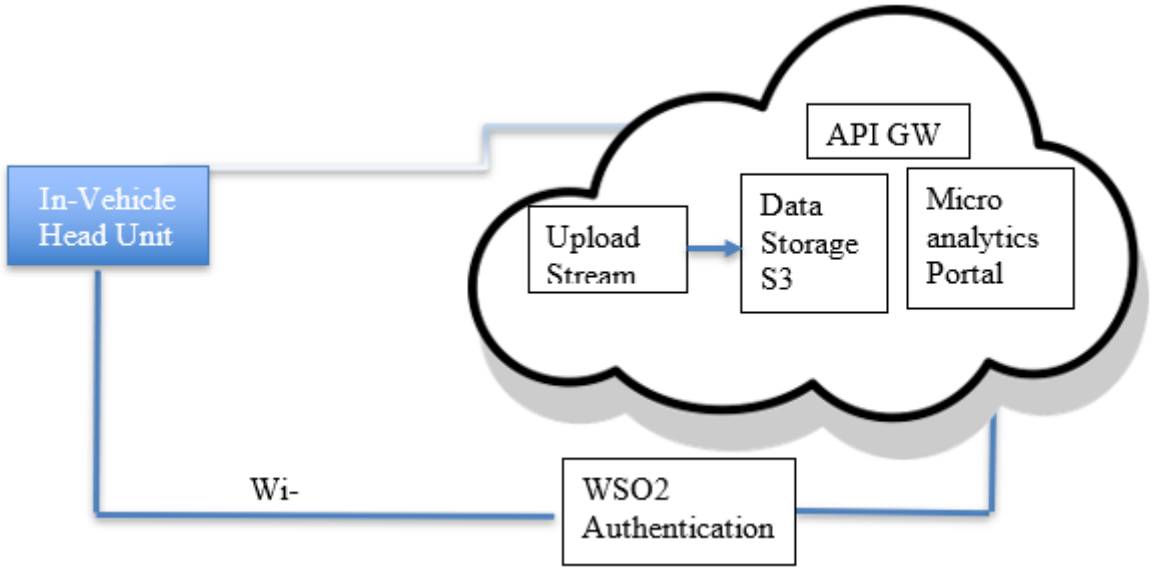

Figure 2: Cloud data analytics

Over the Air Updates:

In the past, when new car owners drove vehicles out of the dealership, they would be stuck with the same technology until they either visited the dealership again or bought new cars. This isn't the case anymore. Cloud services allow remote vehicle updating (OTA) of firmware and software easily without requiring a visit to the dealer. OEMs realize remote vehicle updating services (OTA) improve the relationship between the car owner and manufacturer. The typical architecture of the OTA framework is depicted in the picture below. Update management, device management, and campaign management are part of the OEM backend system, where the OTA updates are triggered. Campaign management will be handling the actual updates on the vehicles. In this case, TCU (Telematics Control Unit) is the gateway module that updates other ECUs' (Electronic Control Unit) software in the car. OEM backend pushes the data through the OTA manager, which is the leading software component in the TCU and is responsible for flashing the software on all other ECUs. MQTT is used for command and control, and HTTPs is used for actual data transfer. The OTA manager notifies the Head unit about updates' availability and seeks permission to initiate the updates.

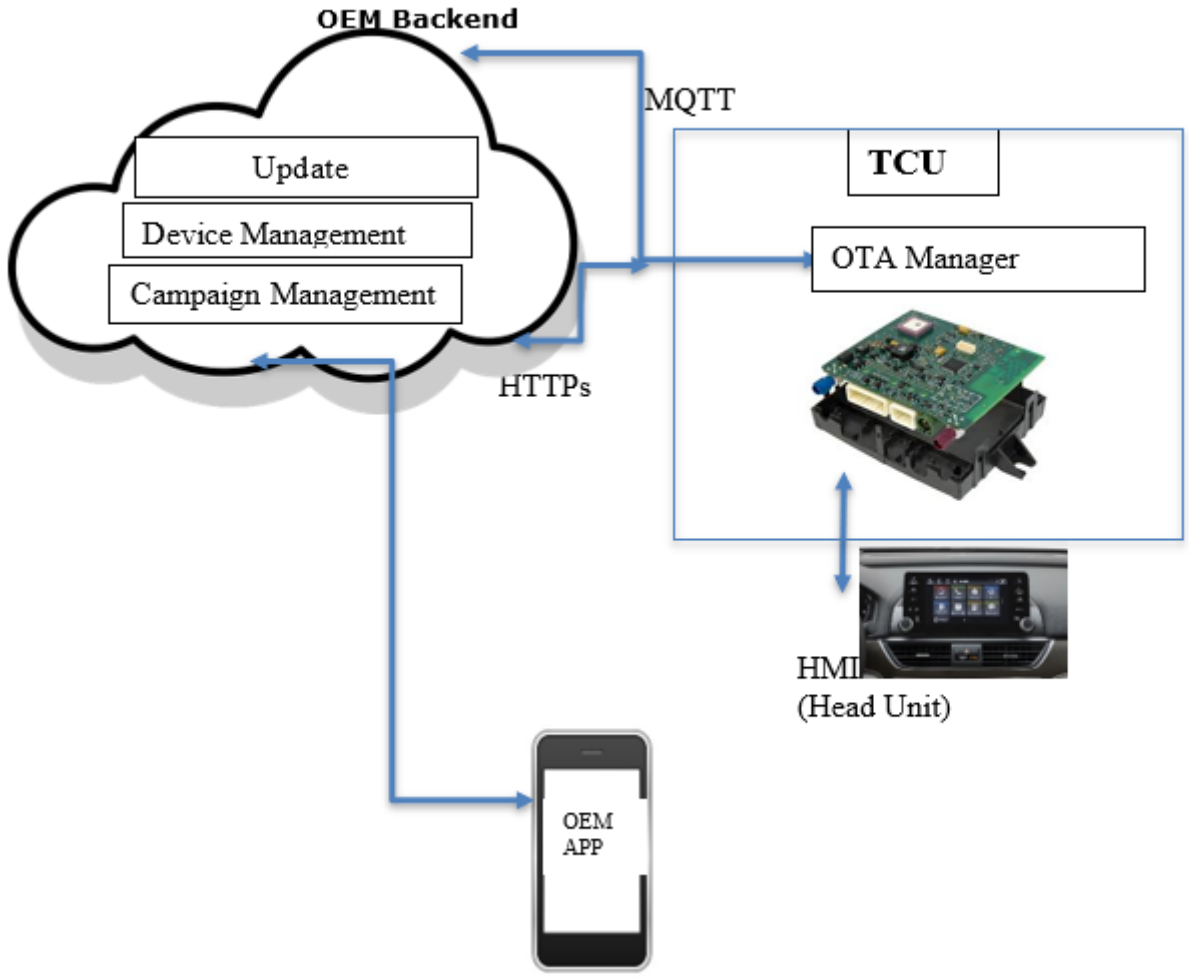

Figure 3: Basic architecture of OTA (Over the Air) updates

Subscription management:

OEMs are considering using cloud services for map subscription management, through which users can purchase maps and update them on the vehicle's Head unit. For this solution, OEMs and suppliers integrate third-party payment gateways like Stripe/Adyen and Avalara for tax computation based on region.

Autonomous driving and ADAS

Cloud computing helps develop autonomous and connected driving technologies. The massive data sets from sensors and cameras are processed and analyzed using high-performance computing resources in the cloud. One study **[4]** proposes a cloud-connected autonomous driving system (CCADS) in terms of traffic networks. Self-driving vehicles share data with all other running self-driving cars via a traffic network cloud, and the traffic network plays a central role in the CCADS. It analyzes traffic data and manages all self-driving vehicles to achieve high efficiency and safety in the traffic environment. Self-driving vehicles remain locally autonomous but globally controlled.

Manufacturing efficiency

By integrating cloud-based solutions, manufacturers can improve production efficiency, optimize their supply chains, and reduce downtime. Cloud platforms facilitate excellent collaboration between stake-

holders, ensuring a more streamlined manufacturing process.

Conclusion:

Due to several benefits listed in section 3, the auto industry is quickly adopting cloud services to realize several use cases. Cloud computing and its service's ability to provide scalable, flexible, and cost-effective solutions help automotive companies address the growing demands for connected and autonomous vehicles. Automotive OEMs and Suppliers are busy realizing several use cases, including updating the software in the car using Over-the-air services, debugging the issues reported during the SW development (Pre-SOP), and diagnosing the issues reported from the field (Post SOP) using analytics capabilities of cloud and for data-driven decision making in ADAS (Advanced driver assistance systems). Cloud computing will play a significant role in future advancements in the automotive industry as it continues to evolve.

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