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The Future of Automotive Mobility: Integrating Cloud-Based Connected Services for Sustainable and Autonomous Transportation

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Abstract

Automobile mobility is evolving rapidly and dynamically with the integration of numerous new devices and technologies. A connected vehicle is one kind of intelligent computer that requires long-term software updates and maintenance. To meet the demand of automobile manufacturers and enhance the user experience, cloud-based connected services can integrate vehicular data clouds, Internet of Vehicles applications, and mobile cloud computing for shared benefit.

The concept of vehicular data clouds are described, and their benefits, components, functionalities, and formal architectures are delineated. Future work includes the development of advanced algorithms to optimize the system design of vehicular data clouds, the modeling of user mobility to efficiently support mobile cloud computing in the automotive environment, and the development of an innovative business model. A connected vehicle is a complex intelligent computer that includes many interconnected devices such as sensors, actuators, wireless communication modules, vehicle control units, processors, and human–machine interfaces. These devices allow vehicles to provide semi- or fully autonomous services. For the long-term efficiency of vehicle operation, such intelligent devices are developed based on long-term software updates and maintenance. This connected vehicle technology abstract is a connection platform that can be integrated with many applications to enhance the driving experience and improve the safety of vehicle operation. At the same time, it can help the automobile industry to understand the desire of drivers so that they can promote business retention and the continuous improvement of intelligent vehicle technology.

Keywords: Vehicle, car, communication, smart, technologies, innovation, future, cloud, cloud computing, infrastructure, services, hybrid, infrastructure-as-a-Service, industry 4.0, assisted, proof, connected home technologies, connected house, proof of concept.

1. Introduction

This paper investigates the future of automotive mobility, which is envisioned to encompass a sustainable, efficient, and pleasant road transportation that permits increasing the duration of non-disturbed driving, actively reduces the number of road accidents caused by human errors, and enables private vehicle ownership to persist in the next decades without significant impacts on the environment. The Future Internet is featured by important advances related to the concept of users being connected to the Internet most of the time. The fusion of the Future Internet with the automotive industry will make possible the availability for the automotive cloud server of a huge amount of real-time data vectors, which taken collectively, will comprise the integrated vehicular big data feed. These data vectors hold a detailed imprint of the driver, passengers, road infrastructure, and of the surrounding environment, which allows the establishment of a reliable signature for driving at any specific time instance. To serve mobility-related goals, several automotive cloud service providers are envisioned to compete in maintaining a constantly updated copy of the automotive cloud, in charge of estimating the future state of the automotive cloud. The competitive players will offer different cloud-based connected services over a set of vehicular platforms, while being strongly interconnected among them and with the evolving infrastructure. The huge number of cars in the system together with the high accuracy of the driving signature will limit the predictability of the drivers' action, which can positively impact the safety and sustainability of the automotive mobility.

In recent years, the asynchronous utilization of the vehicular platforms to access the most advanced stream of cloud-based connected services can change the mobility behavior. Aggressive drivers trying to surpass other vehicles due to their delayed trajectory or speed decisions are easily identified. The patent free areas of the driving routes allow the car to bypass competitors and with good likelihood, some of them should radically modify their decisions instantly to avoid collisions. Unavoidable and costly

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micro-changes in the travel routes result since the time in advance for receiving information is short. The implemented proof-of-concept consists of three Roadside Units and three On-Board Units which includes an Openmote-cc2538 and a Raspberry Pi, surrounding an intersection enabling remote monitoring of the traffic light configuration. The experiments and simulations show that the intended micro-changes in the driving trajectories caused by the cloud-based connected services cannot be inferred, especially during low vehicular density.There are challenges: real-time and low-latency remote monitoring and management of air quality, noise level, and autonomous transportation.

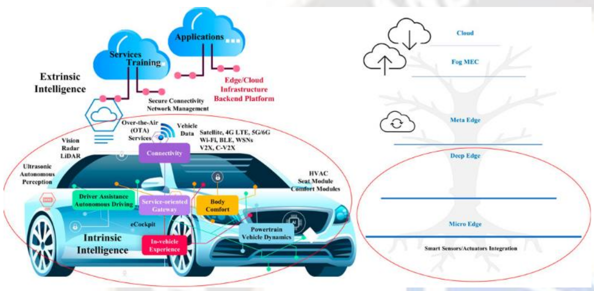

Fig 1: Automotive Intelligence Embedded

1.1. Background and Significance According to the World Health Organization, every year about 1.35 million people die in car accidents worldwide, and about 50 million are seriously injured. With a vision of reducing the number of accidents to almost zero by 2040, many automobile companies, startups, researchers, and government bodies are exploring various safe and smart mobility solutions around the world. There are 5 levels of vehicle automation defined by SAE, and full self-driving automation (level 5) is expected to arrive in a few decades. Autonomous car technology has two parallel paths towards the development of the technology: sensing and perception and decision and control system study. The entire car and road structure, traffic management center and urban surveillance infrastructures, autonomous cars can safely and efficiently drive, park, and charge, and air quality and noise level around car can be remotely monitored and managed by utilizing the home IoT platforms and cloud-based engine, equipment, and trucks in sustainable transportation environment.

Equ 1: Customer Segmentation (Clustering) Using Machine Learning

$$J = \sum_{i=1}^{k} \sum_{j=1}^{n} 1_{(x_j \in C_i)} \left\| x_j - \mu_i \right\|^2$$

Where:

- k is the number of clusters,
- n is the number of customers,
- x_j is the feature vector of the j-th customer,
- C_i is the set of customers in cluster i,
- μ_i is the centroid of cluster i,
- $1_{(x_j \in C_i)}$ is an indicator function that is 1 if x_j

2. Regulatory Framework and Standards

For a few years now, automotive is living in transformative times, facing a disruptive revolution in the way people and goods are going through urban areas and rural zones. A lot of things like new vehicle shapes or energy sources, and the usage of them will deeply change. Just imagine major players getting in the game, far after the automotive construction pioneers, but potentially transforming it much more. Their views look at transportation in a totally different way, deeply connected to digital patterns and smart services, again all that far after the premature failure of a major phone constructor. The need for a bunch of cloud-based services appears, for a safer and more sustainable transportation, based on emerging solutions from vehicle-to-vehicle, vehicle-to-infrastructure, vehicle-to-pedestrian, and vehicle-to-cloud communications, and a regulatory framework waits for that to make it all grow harmoniously.

As a matter of fact, traditional car manufacturing is only a part of the emerging connected car market. The automotive industry is progressively changing from a set of isolated products to a global interconnected mobility system, in which smart vehicles are one of the most important pieces. The emerging investments on smart applications and services for cars are likely to revolutionize their use and their actual shape to a point where manufacturing cars could be the last and less profitable part of the chain. The challenges go from better road safety to more effective automotive fuel use, going by the vast set of congestion levels. There is a broad set of technologies now flooding the market that are starting to make the connected systems a viable infrastructure. There are at least three major related fields of innovation into automotive design and manufacturing, heavily determined by today's digital big players. The first one is located at the computational units in cars. The use of additional sensors and processing systems in already running vehicles is increasingly seen as a decisive option for a number of aftermarket installations, but also directly into cars as standard set up. Traditional in-dash car systems are now in obsolete position relative to mobile phones computational power, and as such, or the one links himself to the cars, they will likely disappear. The other two fields on which big investments are being done come as an obscure hybrid set of enabling technologies, being a combination of manufacturing process and finished products, and also the regulators and standardization entities, determining both technical background for infrastructures and for car-to-car communication, as well as the legal framework in which it is all going to happen. Just imagine on that note a car reminding you not to forget your parking ticket not because an already excessive fee, but because it will likely call the police if you do so, then skipping the last part, you would positively run to the nearest store, spend money buying whatever in the need of the day, thus finally serving their true and only purpose.

2.1. Current Regulations The automotive industry is at the confluence of new challenges related to the concept of Mobility as a Service, the transition to car sharing instead of individual car ownership, market saturation, and the growing role of IT content enforcing sophisticated cybersecurity counteractions to protect the vehicle integrity and passengers safety. By 2025, it is expected that more than 250 million of the new cars will be shipped as connected with V2X embedded capabilities, so a further acceptance of the new type-approval scheme in regulation is crucial. In this scenario, the concept of the vehicle is intended evolvable as a system not only of display and sensors but of working in cooperation with other entities, also being, or utilizing, connected data, thus it looks like an IoT device. The future vehicle will be an increasable distribution of event driven data and will be able to act on an environment; currently it is designed to fall into the scope of a closed item. However, testing and controlling in an effective way a complex system as the vehicle is almost impractical, hence the scope is to move towards a more holistic approach, up-leveling the concept of vehicle as an open system. In this future the V2X communication, in its different flavors, will play a key role optimizing the traffic management specifically by the realization of efficient and sustainable transportation systems, or by the optimization of the logistic chain in the city environment. In a coordinated manner, vehicles equipped with communication devices would be interconnected between them and with a central Control Centre, having access to large amounts of data information. On a high level control would be composed of two main functionalities: Events Detection and Control Strategy Planning, a local strategy regarding acceleration and safety data would be followed. Both commands would be displayed to the Human Machine Interface, vehicle or user embedded. On the other side, an enriched stream of information would be returned to the vehicle/user from a subset of the vehicles equipped with specific sensors or capabilities. Once the action took place the new vehicle configuration would be communicated to the surrounding environment in a species of confirmation, thus realizing a dedicated feedback loop. In this scenario hence there is an implicit request of open dialogue and communication, and eventually, in the enforcement as a penalty mechanism, of diversity of communication devices modeled as different architectures open to analysis.Basic control functions such as driving modes control, traffic flow regulation, and primary safety are automated. Two sharing contexts: microtransit and fixed routes. Total demand for each context changes under various automated modes. Ridership approximated using an assignment model that considers heterogeneous demand distribution and dominant factors. Fleet operations based on load factor tradeoff curve strategy, with empty autonomous repositioning to service areas without trips.

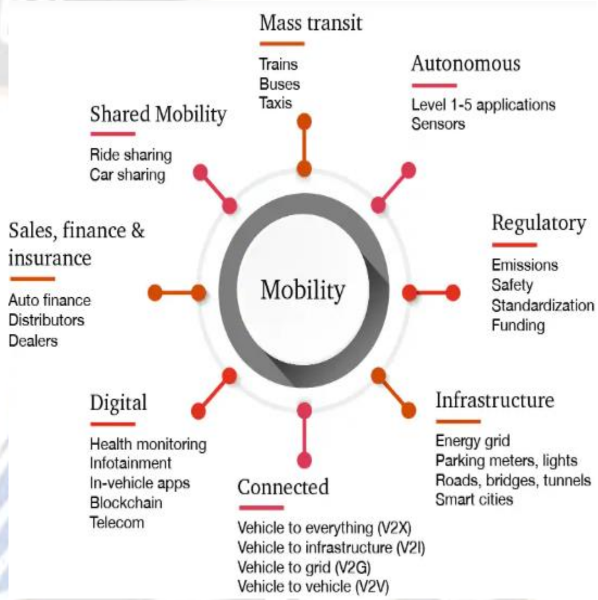

Fig 2: Current Regulations

2.2. Future Policy Considerations Urban transportation is crucial because 50% of the world population lives in cities. Additionally, the Urbanization trend is expected to grow, so Urban Mobility should be able to cope properly. The investment and the overall way of handling the transportation system is included in the Urban Mobility in cities. A city can be called smart if the built environment manages to create, with the use of technology, infrastructure, and telecommunications, an operative and sustainable environment able to provide for the demands of urban growth. The goal is to upgrade the quality of life, the adequacy of public services, and the operative management of the city. A very important part of the Smart City concept includes the smartness of the transportation system. Automated vehicles correspond to the ultimate industry in road transport, concerning both public and private transportation. An Automated Transport System refers to a road transport system. Urban areas would make particular use of it.

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3. Cloud Computing in Automotive Industry

In today's consumer electronics and IT world, automakers are increasingly focused on integrating electronic equipment, services, and advanced technology in vehicles, leveraging cloud computing and the IoT. Furthermore, automakers use engineering services that allow them to keep track of the vehicle's condition, thus being able to anticipate and solve potential failures. Although these systems can operate independently of the driver, user demand remains essential for automatic fault resolution. Anomaly in cars can come from different parts of the vehicle, and the services that come with the car are typically related only to critical parts. Vehicle on-board diagnostics (OBD) platforms are equipped with an engine control unit (ECU) that manages the air-fuel mixture and onboard diagnostics system, so the ECU possesses a detailed set of data on the engine and its performance. OBD-II, a standard for extracting this same information, was introduced over twenty years ago; today, it is mandatory in the US to connect this platform to the standard J1962 connector. ECU data can then be retrieved using one of the many OBD scanners available in the market. However, the same information can also be fetched using a smartphone equipped with a Bluetooth interface and a dedicated app. Hence, as a proof-of-concept of the potential of sensing data in cars for providing services it is proposed to build a system that integrates the sensing data taken from the car's engine and that verifies through data processing if it is possible to address anomalies on the car engine. It is then to verify if the same data can be processed in the cloud to address anomalies on different vehicles. Car selected is a Kia Rio 1.1 CRDi driven for about 50 km on three different days; no problems with the car were noticed in the period. On each trip, data on real-time observations and statistical aggregations are collected through a smartphone app, while the car is connected to an ELM327 Bluetooth OBD-II reader and the Torque app.

Fig 3: Cloud Computing in Automotive

3.1. Overview of Cloud Technologies In the era of the Internet of Things (IoT), modern vehicles will be applied in many aspects of life, and they will be linked with verities of environments such as family, office, traffic, and grounds. By the integration of various services and resources in the vehicles, the vehicle owners can get services to improve the capability of life, security, and avoidance of car accidents, as well as comfortable driving. On the other hand, the vehicle can search other services or resources in the environment. These services must be secure and controllable, and the control is realized by accessing the vehicle through the cloud.

There is an urgent requirement to connect homes and cars, and the application of IoT technology in the automotive industry is very broad. This technology is applied to vehicular infotainment, external devices and the near-communication of vehicle electronics, etc., and it has been demonstrated that it can obtain much more detailed data than can the old code reading method. In this work, an IoT system is developed to connect new devices and home appliances with a vehicle. An extended household domain is controlled by the vehicle and the car is used as a local storage scheme for the convenience of vehicle owners. A case study confirms its usefulness. Generally, in most cases, due to the vehicle's rigid fossil fuel or electric-driven engines, this energy is typically unaccountable stacked or used in an essential matter. However, the proposed plug-in driving cycle helps in rationalizing the energy recovery and utilization programmatically thereby transforming it into a clean low carbon energy source.

3.2. Benefits of Cloud Integration The automotive industry is experiencing a variety of trends such as cloud services, mobility on demand, and car sharing. This presents the role and the future of internet-based connected services, vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), vehicle-to-device (V2D), and vehicle-to-home (V2H) applied in everyday life. It presents considerations and challenges for implementing the 'automotive cloud' and integrating various devices, systems, and services with the automotive cloud. It also presents a couple of use cases and example scenarios showing cloud-based connected services for future sustainable and autonomous transportation in an urban environment. Protection is essential to ensure data privacy, security, confidentiality, and data authenticity. The new Proof of Concept (PoC) system includes numerous applied technologies, techniques, and algorithms for intelligent vehicle-to-vehicle, intelligent vehicle-to-infrastructure, and an intelligent service for connected vehicles. There is an expectation that the intelligent automobile service PoC implemented and proven in a real environment will continuously lead initiatives as a unique technology for an intelligent automobile service system which is successfully applied to future connected vehicles, autonomous driving, vehicular clouds, and the intelligent automobile transportation service model.

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Equ 2: Sales Forecasting Using Time Series Analysis

$$Y_t = \mu + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \cdots$$

Where:

- Y_t is the sales at time t,
- μ is a constant,
- $\phi_1, \phi_2, \ldots, \phi_p$ are the autoregressive parameters,
- $\theta_1, \theta_2, \ldots, \theta_q$ are the moving average parameters,
- ϵ_t is the noise at time t.

4. Connected Services in Automotive Mobility

The connected services paradigm refers to the integration of various automotive applications and services into the global computing environment using Cloud computing and Internet of Things (IoT) technologies. However, implementing such services intelligently based on secure and affordable vehicle connectivity remains an ongoing research issue. In this chapter, the issue is investigated in the context of Smart Cars and P-Cloud, a vehicular data cloud built using vehicle-centric IoT and cloud technologies. Intuitive use of car data is made possible by developing different systems utilizing such services in Smart Cars. P-Cloud-enabling systems encompass vehicle data acquisition systems, GSM modules, a smartphone-based OBD-II interface, and V2X systems. In order to ensure the security and privacy of car data movement in the P-Cloud paradigm, cloud-to-vehicle encryption and vehicle data usage policy systems are introduced. Intelligent car dashboards and a vehicle data cloud broker facilitating the incorporation of numerous third-party mobile car services are also developed and presented.

Fig 4: Automotive Connectivity Trends

4.1. Definition and Importance

The world is experiencing the 4th industrial revolution, which is characterized by smart, interconnected devices that generate large amounts of data. Hence, spot on real-time analytics using this data is a key to innovation. With the advent of new technologies, cars and data centers are getting connected. This enables multiple functionalities such as monitoring the state of the car, reading error codes, e-Calls, breakdown telematics, retrieving statistics about the car usage, configuring the car, offering predictive maintenance services, and many other cases. This paper discusses the introduction of a pervasive service platform to expose connected vehicle's services as Web APIs.

To create the overall pervasive service platform in alignment with Industry 4.0 paradigms, a system has been created that is able to: (i) orchestrate the custom platform's components, (ii) offer advanced real-time data analytics for the connected cars, and (iii) offer model-based development letting users iterate through the development of the APIs. Additionally, its overall architecture is designed to leverage CloudFoundry® components to ensure scalability and flexibility for new developments by following the micro services architecture. To support the pervasive service platform usability, a vehicle simulator is used to replay historical vehicle data streams. This platform, integrated with real auto OEM platforms, is in use in the PasTime project.

The proliferation of vehicles and the increasing advancements in cloud computing and wireless communication have led to the era of big vehicular data processing. Vehicular data clouds are envisioned to enable a wide variety of cloud-based services, resulting in the improvement of transportation mobility, sustainability and safety. To implement the concept of vehicular data clouds, a traffic management system has been developed for traffic signal violation detection based on real vehicular data and vehicle-to-infrastructure communication. The system was evaluated in terms of detection and communication reliability and service quality with both real and simulated vehicular data.

4.2. Examples of Connected Services

Connected cars generate a significant amount of data outside and inside the car. This data can be used for many useful services, such as road navigation, traffic management, remote monitoring, urban surveillance, information, and business intelligence. In the upcoming decades, the automotive industry will rapidly change its shape. Two prime-principles leading this change are - electric vehicles to ensure sustainable development by reducing the fossil fuel dependency of transportation - self-driving vehicles (also called as Autonomous Vehicles AV's) with advanced driver assistance systems to dramatically increase road safety (and traffic safety around the world) and traffic efficiency. Many vehicle manufacturers, technology suppliers, and added-value service providers are already investing significant efforts into developing different aspects of the future automotive mobility. For integrating these innovative and disruptive functions into future automotive mobility the crucial requirement is extreme dependence on the various implementations and realizations of the ubiquitous

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communication techniques provided on the frame of the so-called Vehicular Ad-hoc NETworks (VANETs) (and also in a broader context of Vehicular Communication Systems). Furthermore, the most effective way to make widespread penetration in vehicle networking is an active usage of the Internet to support intelligent vehicles networked together to communicate both to each other and to the network. In such a perspective, this paper outlines the path to steer the automotive industry into a new era, thereby shaping the future of automotive mobility on a sustainable, intelligent, and safe foundation.

5. Sustainable Transportation Solutions

INTRODUCTION OF WRITING: The Future of Automotive Mobility: Integrating Cloud-Based Connected Services for Sustainable and Autonomous Transportation How people get from point A to point B in urban areas is ever-evolving and ripe for technological innovation. Current modes of transportation such as personal vehicles, buses, trains, ridesharing and biking are transitioning into more sustainable forms powered by electricity, renewable resources, and micro mobility services. To future-proof strategies aimed for sustainable transportation, urban planners need to take advantage of existing technologies and new, developing ones like cloud-based connected services. By improving the distribution systems of energy, air quality, and transport in a smart city, a mobility platform can seamlessly connect varied forms of transportation while managing the intensity, congestion, and use of each mode. This multifaceted efficiency can ensure transportation networks are better managed for urban sustainability, opening new opportunities for integrating smart transportation solutions. This creates a unique position and charging paradigm for electric vehicles that has been identified in urban environments across various regions, and is suitable for urban residential areas, regular parking spaces, bus stations, airports and train stations. For vehicles that park for longer periods, brief descriptions of an inductive and a wireless power transfer system are given. Given the future importance of energy management in interconnected services and the practical challenges in implementation, a parallel architecture is then proposed that is highly dynamic and predicts energy needs throughout a system of connected services.The current car vehicles are moving away from individual L1 electrical functions, soft and hard keys, knobs, and dials with a few words or icons on paper in one to two rows on the center stack and are moving toward new features, in particular QXGA resolution and with full glass cockpit displays integrating many individual display screens.

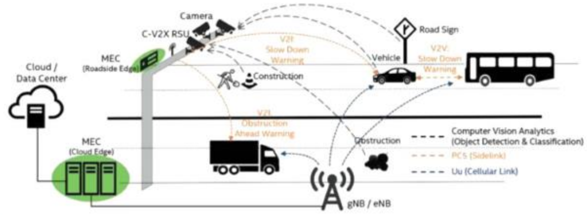

Fig 5: Sustainable Transportation Solutions

5.1. Electric Vehicles and Their Impact With their support to protect the environment and battle climate change, governments worldwide have agreed to reduce the emissions of road transport vehicles. An important step is planned vehicle digitalization, the goal being an improved traffic flow by carefully planned routes, reduced stops, enhanced safety, and balanced charging/discharging of the driven vehicles. Unfortunately, the classic Internal Combustion Engine (ICE) vehicles have large and harmful emissions of NOx, UHC and CO, meaning that it is too expensive to build and operate the infrastructure for a volume as large as the number of cars. To mitigate this problem, hybrid vehicles appeared, with the same driving conventions between the wheel and the ground but with a primary energy from a combination of ICE, fuel cell and battery. Electric Vehicles are expected to be the probable future of the road mobility, partially due to the aforementioned laws restricting the pollutant emissions of the transport vehicles, partially due to the increasing number of recharging infrastructures inside the cities, and mostly due to the huge pollution generated in the cities from both big vehicles like buses, trucks, construction machinery, etc., and from many personal cars with ICE.

5.2. Renewable Energy Integration Two key trends in future transportation are sustainable energy supply and autonomous driving. Shared, autonomous vehicles form an ideal base for mass transportation services. The long-term future may lie in autonomous public vehicles. This future approach could shift and complement current public transportation services. With lower costs and increased flexibility, on-demand minibuses could be a good alternative to fixed routes and timetables. Such services can be implemented with minibuses, cars, or motorcycles. In developing countries, motorcycle taxis are already a key part of transportation services. Sharing rides has an environmental advantage compared to private cars and taxis. However, at the moment ride sharing is also seen as a means of providing sustainable income to the underemployed. In the case of public shared services in developed countries, such a mindset causes problems with implementations. With the lowest emission vehicles seeing the smallest parts of use in transportation services and the same small share seeing the most use, public transport is mostly viewed as something used by impecunious people. Simply developing services where well-off people are seen using shared public transportation could start changing this perception. And if

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autonomous minibuses are used, they can also provide much faster on-demand services than fixed routes.

A transportation service planning system which takes into account diverse everyday scheduling constraints, such as fixed work hours, parental leaves, school times, etc, was deployed in two cities. Without a preference for transportation mode, system use for transportation planning recommended the use of bicycles for almost all distances in the small suburban city. Thus, the transportation service planning system was used only in the relatively large city. System use counted as successful if user took suggested transportation but with their own personal vehicles. In a comparison of 975 transportation possibilities in the large city, 403 times the transportation was the same as that recommended by the present system, but using the user's own car. The decision was considered to operate despite the fact that service hours and the cost of using the car exceeded those for the recommended public modes.

Equ 3: Personalized Marketing Strategy Using Machine Learning (Recommendation Systems)

$$R \approx U \Sigma V^T$$

Where:

- R is the matrix of ratings (or interactions between consumers
- U is the matrix of consumer features (latent factors),
- Σ is the diagonal matrix of singular values,
- V^T is the matrix of car model features (latent factors).

6. Autonomous Transportation Technologies

In the automotive industry, new connected services are developed and deployed by cloud service operators, such as traffic information services or real-time fleet management solutions. Instead of considering cloud services as an add-on to vehicles, an integrated deployment should be envisioned, with other connected services jointly developed by vehicle manufacturers and cloud service operators. An open prototyping platform for cloud-based connected services is introduced, enabling the provisioning of such services in a standardized way, by combining vehicle-resident applications and cloud services. Several dedicated on-board and cloud-based applications supporting P2P communication, media sharing and ride sharing are described, along with an in-depth evaluation of a specific peer-to-peer traffic information service.

Cloud computing has been proposed as the answer to global, flexible and outsourced computation. For the mobile environment this would mean that applications and all their supportive services would run on cloud, while only the display and user interface remained in the device. This approach would enable more lightweight and secure devices, longer battery life and instant access. The basic idea of cloudlets is to populate infrastructure with powerful computers upon which devices could offload applications for faster and energy-efficient execution. In reference to the automotive environment, this could be expected in service areas along heavily traveled routes. Although cloud-based service is not yet available for automotive use, there are some tendencies that already resemble the "early days" of the mobile cloud concept.

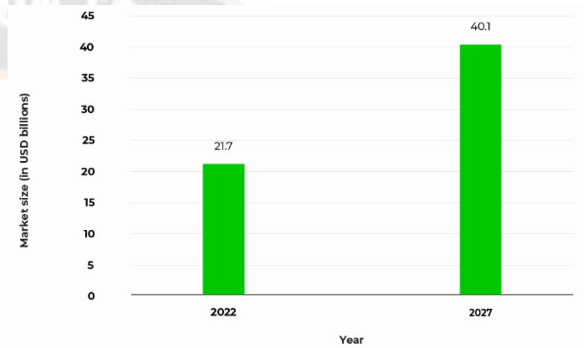

Fig : Transforming The Automotive Software

6.1. Levels of Automation

In unprecedented times like the Coronavirus pandemic, exploration of stepwise solutions involving smart transportation is pivotal. It will not only fulfill sustainable mobility demands but also encourage safety, comfort, and connectivity. Analysis of state of the art outlines a direction towards autonomous driving. With an increasing interest in Level 5 autonomous vehicles, full automation has evolved from fascinating future work to a necessity for avoiding global crisis. However, smart mobility and autonomous driving are not one-directional and require interconnected components for the realization of complete cloud-based architecture. Forward progress depends partially on the definition of the state. Levels of automation have been a good start, but without definitive regulations surrounding their placement into public, these levels still present certain ambiguities. Additional definitions herein offer a comprehensive framework of basic and advanced automation types, with an emphasis on how the former affect and can be made more accessible to the public. For broader analysis, it is imperative that various discussions surrounding autonomous driving are univocally agreed upon. In the interest of contextual clarity, the term 'autonomous driving' refers to the operation of a vehicle in controlled environments without direct human supervision. These levels are as follows: Level 0: No Automation; Level 1: Driver Assistance; Level 2: Partial Automation; Level 3: Conditional Automation; Level 4: High Automation; Level 5: Full Automation.

6.2. Key Technologies Enabling Autonomy

Modern automotive mobility has been an element of the world's

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infrastructure and culture for more than a century and offers unparalleled personal independence and freedom of movement. The flourishing of automotive industries, most notably in Europe and North America, since the early 20th century led to an over-reliance on automotive transportation and highways for intra-city movements creating urban congestion, pollution, and similar significant drawbacks. Consequently, there is a pressing need to re-evaluate the automotive mobility concept and its relative merits and drawbacks. Looking to the future, how can automotive transportation be re-conceptualized to be sustainable and valuable? To provide some answers to this fundamental question, a holistic view of automotive mobility is taken, transcending just transportation to include integrated cloud services, and a plethora of open research issues are posited and discussed.

There are two immediate driving forces encouraging the automotive industry to focus more on integrating cloud-based connected services: Autonomous and driverless vehicle technologies are just around the corner and will be a reality within 5 to 10 years; however, connected vehicles are exclusively data consumers and need to be integrated with cloud-based connected services to access updated local clouds to have continuous connectivity to global services; and Sustainable transportation and ‘green’ vehicles are fundamental throughout the 21st century due to a dramatic increase in greenhouse gases and other air pollutants as a result of an over-reliance on traditional internal combustion engine vehicles.

7. Conclusion

The automotive industry is developing promising opportunities using various cloud-based vehicles for mobility and ancillary services. The advances in connected vehicle technologies and the Internet of Things (IoT) aim to enhance the vehicular driving experience. Real-time two-way information exchange between vehicles and roadside infrastructures is realized by using urban and vehicular communication technologies similar to the wireless system. The vehicle and the infrastructure confirm the real-time ambient information exchange (if any events, accidents, and relevant information sharing or warning notifications) using the supporting wireless system. The vehicle further processes the obtained information and controls the automated driving mode, speeds, and direction interactively. The future vehicle technology is anticipated to have the capability of surround sensing and can develop wireless communications and form connections between vehicles similar to vehicular ad-hoc networks (VANETs) as well as between vehicles and surrounding infrastructures comparable to infrastructure VANETs with roadside units as cellular network base stations in the transport.

This special mode communication enables the end-to-end information exchanges (safety, comfort, and entertainment applications) within the connected-cloud domains, leading the new generation of automotive mobility of sustainable transportation and supporting a variety of new automotive platforms. The environment of the connected-cloud vehicle comprises the vehicle itself and several standardized domain cloud systems. At the vehicle side, the onboard “home-network” of the vehicle hosts the cloud services that can be modified and equipped with new functionalities in the automotive business. The automotive dealer can install and store in the vehicle database many configurations to enable customizable services similar to personal computing. Additionally, the hosted services connect the vehicle to the cloud via cellular communication with access notification to the designated cloud-systems. During the last decade, the upcoming cloud systems are integrated with the targeted mobile devices in the automotive business. Hence, from the vintage app approach many new automotive applications are provided in the automotive market including the industries and third-party vendors similar to Android and Apple applications for smart-phones turning the vehicle into the automotive smart-phone for connected-cloud vehicle applications. The cloud-vehicle services enable the driver and the passengers to obtain various new applications and functionalities, such as traffic and environment information, NS application for parking places, weather information, smart TV, push information services related to events, commercial ads, news, etc., and many others available on the cloud systems. True potential of cloud-based central-domains of vehicles for connecting various automotive platforms are described in terms of surrounds, onboard and home related domains and a new vehicle mode of automotive cloud-vehicle device is proposed with an architecture outlining its main components and applications for advanced services.

7.1. Future Trends

The objective of this study is to present Cloud-VANET, a novel cloud-based vehicular ad-hoc network that enables vehicles to connect to distant vehicular nodes using cloud computing. Within the proposed Cloud-VANET, each vehicle initially sends data to the global cloud gateways, which connect to the datacenter cloud computing facilities. The data are further processed and the results are passed to the recipient vehicular nodes through the cloud gateway connection and the vehicle-to-vehicle direct link. Proof-of-concept of Cloud-VANET is also presented. It consists of automated accident report dissemination and traffic-based swarm control use cases. Proof-of-concept is presented as (i) the off-the-shelf cars communicate with the proposed roadside communication unit and cloud components; (ii) the sequence of events concerning a vehicular accident is detected and confirmed, and (iii) location specific storm warning message is disseminated from the connected car to off-the-shelf car.

407.7 million mobile connected vehicles with embedded connectivity to the cloud will be equipped with vehicle-to-vehicle,

vehicle-to-infrastructure, and vehicle-to-mobile applications by 2023. Due to the continuous external platform and ecosystem growth, a potential aftermarket ecosystem will emerge for carrying apps and services onto the connected vehicle platform. To ensure safe cloud-based integration of services and data, security issues such as vehicle penetration, data authentication, remote intervention, reputation, and blockchain will need to be addressed. These connected services are based on an open worldwide API platform. Seventy five per cent of all OEM and retaining connected vehicles are forecasted to use an open platform based on software development by 2019.

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