Future Automotive E/E Architecture

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In the industrial revolutions of the late 18th and early 19th centuries, it was one new force that created the revolutions. The world is currently undergoing a dramatic transformation, and this transformation mainly due to the confluence of 4 main megatrends.

Mega Trends

1. Urbanization

The residence of the human population, locus of economic activity and dynamism is shifting from rural areas to the cities all over the world. As per the UN, Today, 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050. This, combined with the overall growth of the world's population, could add another 2.5 billion people to urban areas by 2050. Many countries are likely to face challenges in meeting the wants of their growing urban populations. The needs for housing, transportation, energy systems, infrastructure, employment, education, and health care will intensify.

2. Digitalization

Technologies like Artificial intelligence, Internet-of-Things, etc. have been disrupting the industries all over the world with scale and scope as never before. These technologies are bringing in rapid digitalization of the world and the digitalization is primarily shaped by faster and cheaper computing, reliable interconnectivity, and pervasive cloud functionality. Moore's Law, Metcalfe's Law, and Bandwidth Law are together defining how fast and efficient our computing devices can become, why more digital connections mean greater value for everyone on the network, and how much data we can collect, manage, and process. All the above three are rapidly transforming the world we live in.

3. Aging Society

Ageing Society — the inevitable increase in the share of older persons that results from the decline in fertility and improvement in survival —is occurring throughout the world. This demographic transition is more prominent in developed countries. Many countries like Japan have started to see a falling population. The European Commission expects that by 2060, Germany's population will shrink by one-fifth, and the number of people of working age will fall below that of France. The demographic change results in a shift in the social and economic behavior of the population and thus will have an impact on all sectors in the economy.

4. Sustainability

Sustainability focuses on meeting the needs of the present without compromising the ability of future generations to meet their needs. The world's ability to sustain billions of more people who are driving carbon-emitting automobiles, consuming more and more food that is derived from dwindling food basket, is creating an imbalance in the equation of the sustainable existence of mankind.

Enablers

To master the challenges ahead due to the 4 megatrends, the mobility industry is developing the technology enablers that are most easily remembered by the acronym CASE

1. Connectivity

The cars are becoming nodes within the internet-of-things. This has transformed the car from being a mere mode of transport to a pod that delivers a new user experience to all its occupants. Connectivity adds to the safety and comfort of a car and has opened new avenues of businesses for all incumbent players. Connectivity has also created vents in the entry-barriers through which Tech giants like Apple and Google have made their entry to the industry.

2. Autonomous Driving

Autonomous Driving has the potential to make the commute time more productive, reduce accident rates, increase the mobility for the physically disabled and the elderly, optimizing the traffic on the road.

3. Shared Mobility

An excessive number of private cars on the road leads to problems in all urban areas. Traffic congestion, lack of parking space lead to loss of productive time. Shared shuttles and Robo-taxis will likely become more popular in urban areas and there will be several service innovations in this space.

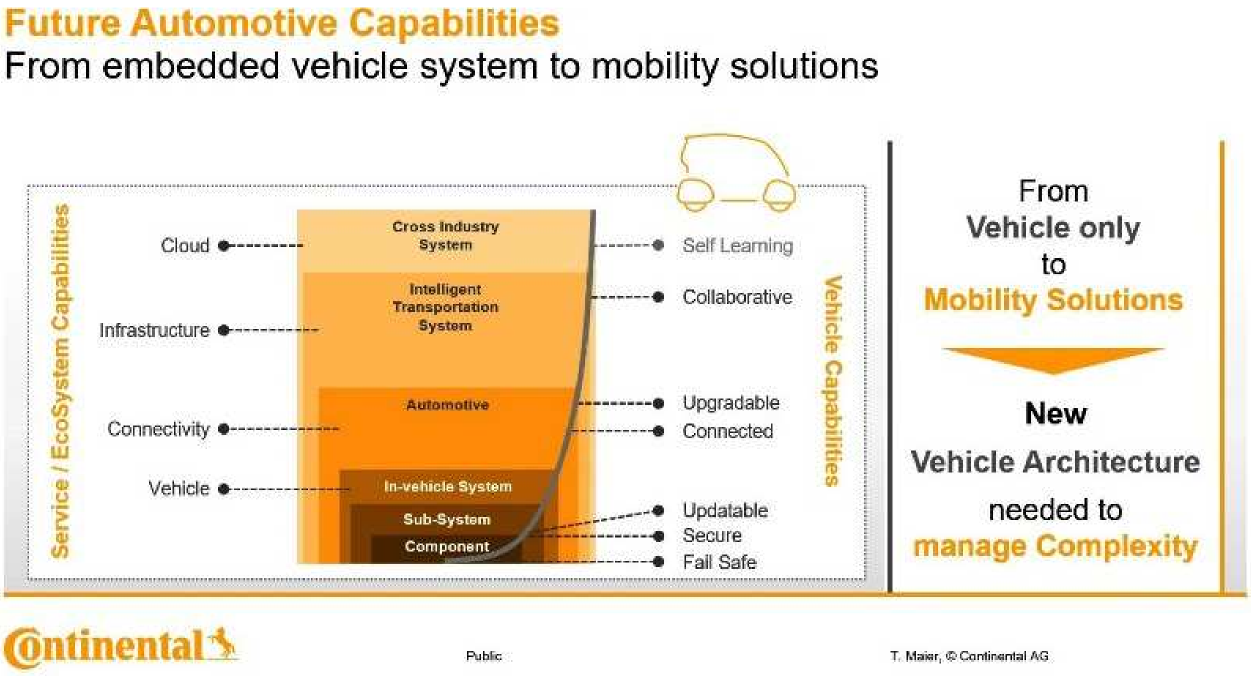
4. Electrification

Electric vehicles have the potential to reduce greenhouse gas emissions, and more importantly reduce dependence on petroleum which is a depleting natural resource. Ever tightening emissions standards in all markets around the globe are pushing vehicle manufacturers to plan for more electric vehicles.

Solutions

While the mobility ecosystem is expanding more and more, the traditional market players in automotive space have focused on improving the vehicle capabilities and are more prominently focusing on mobility solutions. Software will play an important role in mobility solutions. The future vehicles must be

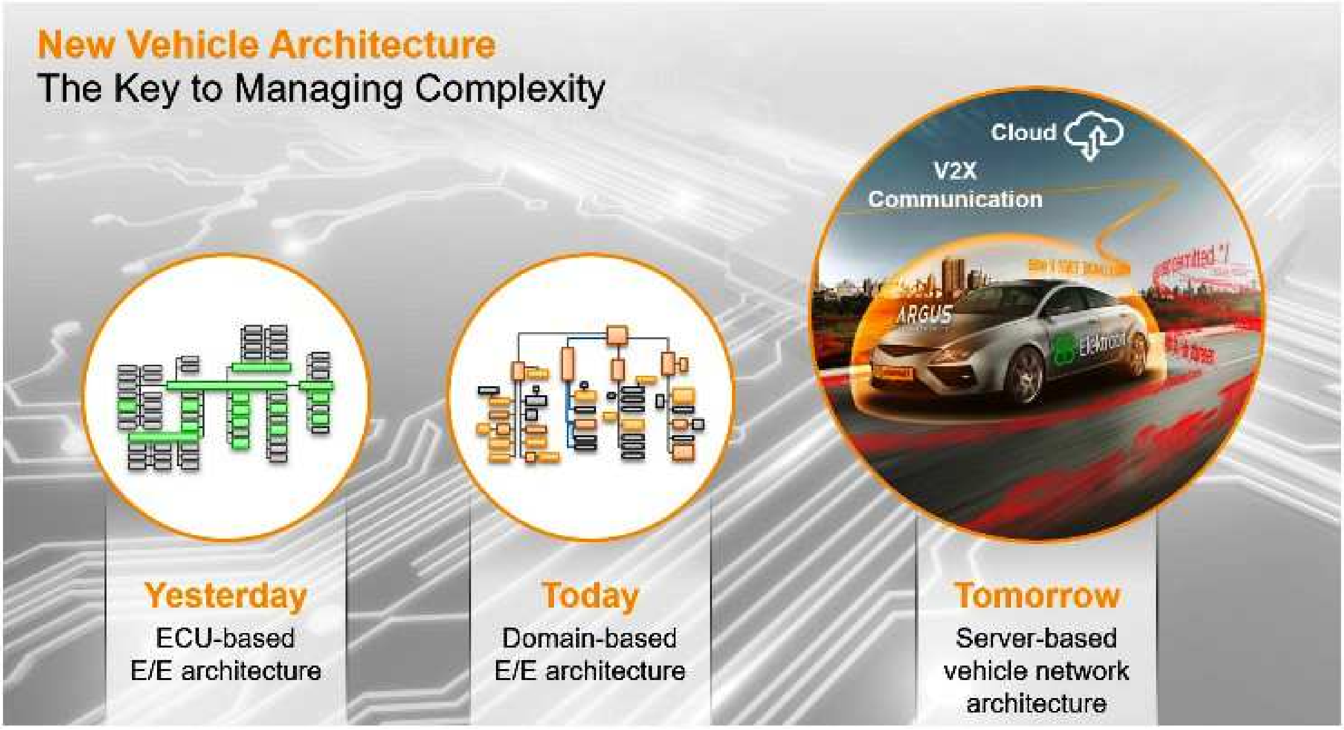
- **Failsafe**, by being capable of completing its key function even if part of it fails.
- **Secure**, by anticipating, avoiding, detecting, and defending against cyberattacks.
- **Updatable**, by being capable of over-the-air (OTA) updates of the software.
- **Connected**, to the infrastructure, internet, mobile devices, …
- **Upgradable**, in both software and hardware.
- **Collaborative**, to interact with the Intelligent Transportation System for optimized seamless transportation.
- **Self-learning**, by being artificial-intelligence-enabled.



The Evolution Of Automotive E/E Architecture

Consolidation of electronic control units (ECU's) is an important trend seen in E/E vehicular architecture. New mobility solutions will require a centralized architecture with fewer individual ECUs. The consolidation is driven primarily by mainly 2 factors

1. Optimality of algorithms for automated driving: The environment-sensing and environment-modeling algorithms for automated driving is most optimal if data from a variety of sensors are fused in a single computing unit.
2. Costs: Consolidation results in decreased costs of computing, less common components (e.g., power supply), less wiring harnesses and consolidated software functions



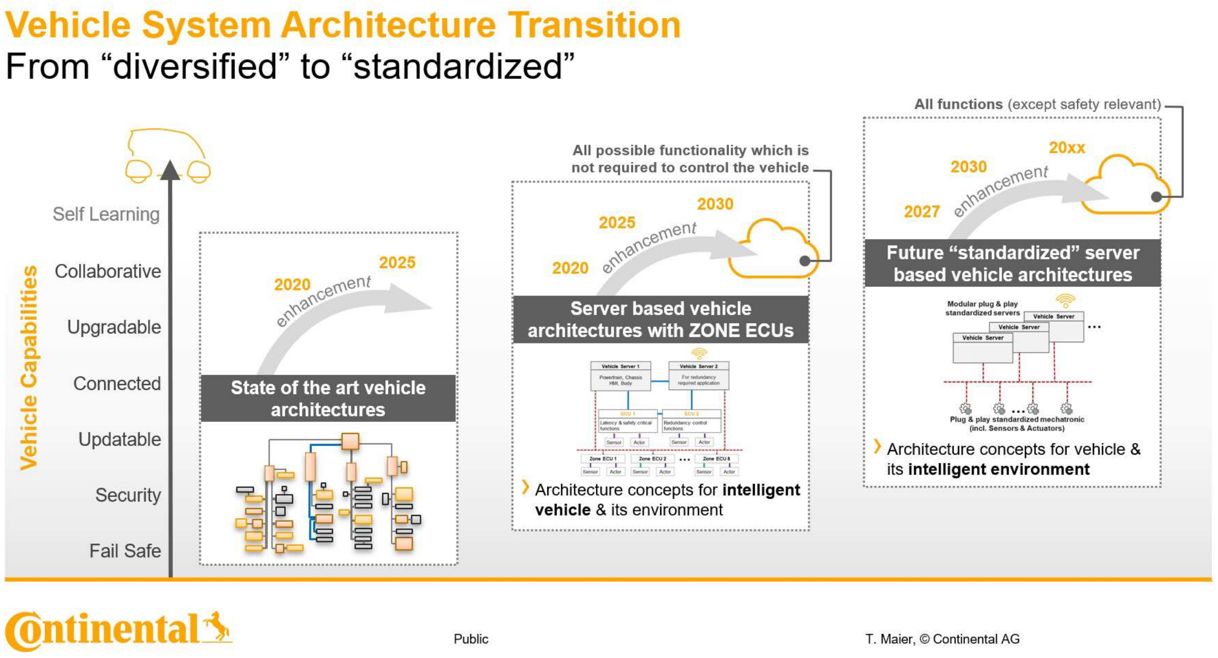
Past:
Vehicle E/E architecture of the past had up to 150 electronic control units (ECU's). Most of this ECU's had an embedded microcontroller which controlled actuators, processed sensor signals, controlled mechanical operations (like ignition/injection control) and executed electronic functions (like auto-parking, air-bag trigger). Each function had its own electronic control unit. These ECU's were connected by wiring harnesses and there existed limited interactions between the different ECU's. There was high software-to-hardware integration. This often resulted in vendor locking.

Present:
Vehicle E/E architecture of today has moved towards more centralized systems with dedicated domain control units (DCUs) or Domain ECU's. Several functions are combined into a domain ECU's to reduce the number of individual ECU's, consolidate functions and simplify the wire harness (e.g. for infotainment, body control). While this evolution will occur across all vehicle domains over time. Infotainment and driver assistance are expected to be the forerunners, as areas of high performance and/or low safety or latency criticality are easier and/or more beneficial to transform.

Future:
The future server-based vehicle architecture is characterized by a few servers for centralized high-performance-computing. These servers will be closely connected and to the cloud for regular updates as well as for off-vehicle computations. Sensors and actuators are controlled by the central vehicle servers through standardized interfaces. However, this change from today's architecture to the server-based architecture cannot be done in one step. Therefore, an intermediate step will be the server-based vehicle architecture with additional ZONE ECU's and some remaining ECU's for safety-critical applications with strong real-time or latency requirements. (e.g. for Braking or Airbag Control Systems). The Zone ECU's bridge the sensors and actuators of today to the vehicle servers and thus help to reduce the wire harness as they are placed at different zones of the vehicle (e.g. front/rear, side).

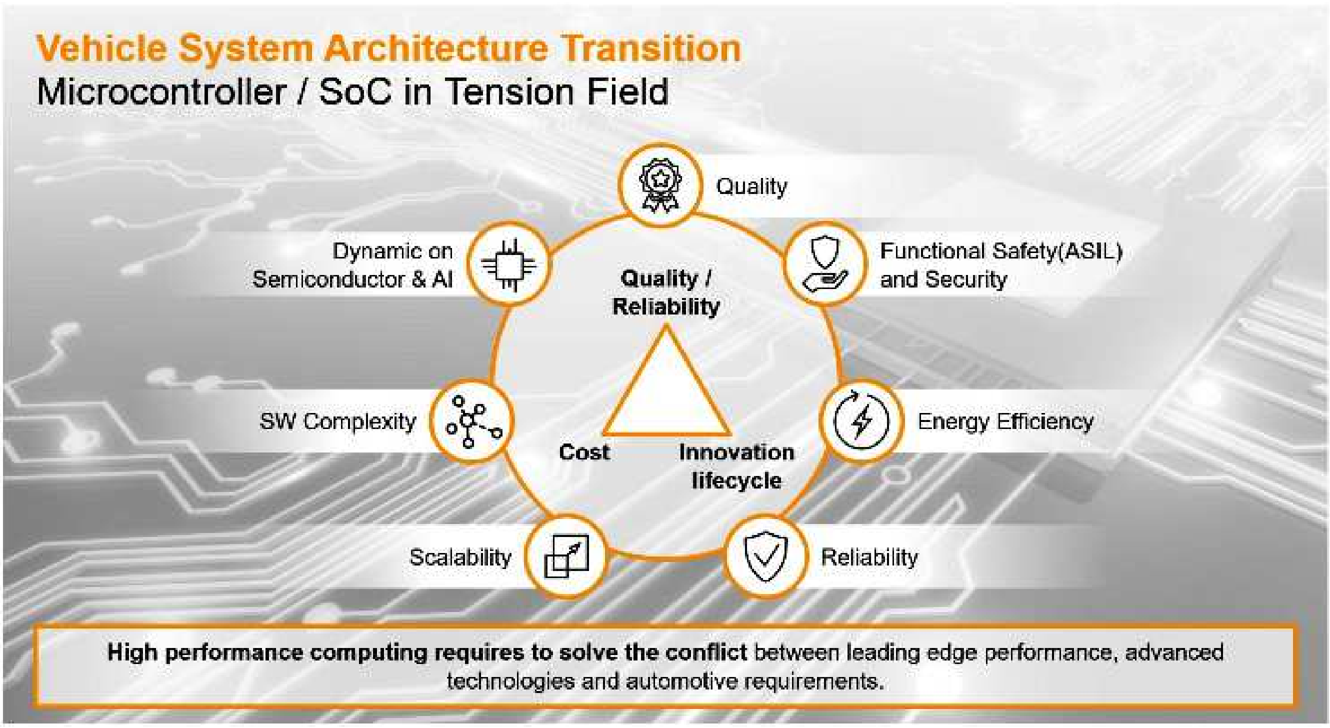
The new server-based vehicle E/E network architecture will have 3 main levels:

A. **Actuator/Sensor level**, which provides pressure, acceleration, position, image, … data to the computing level and the driver modules for the actuators like valves, motors, inverters, ….
B. The **computing level** which does the sensor fusion, analytics, planning's and execution of function and services
C. The **backend** for off-board computing, big data management, AI training, services, …



Technological Challenges To Evolution Of Automotive E/E Architecture

Automotive-qualified embedded processors of today, do not have enough compute-power to process algorithms like multi-sensor-data-fusion needed for automated driving. The current demonstrators of automated-driving (Level-3), use a combination of high-performance CPUs and GPUs from the consumer industry, and automotive-qualified master ECUs. However, to take these systems to mass-production, there is a need to replace the consumer-class computing engines with automotive-grade eHPCs (embedded HPCs). The need for processing capacity will increase further in future, since moving from Level 3 to Level 4 vehicles needs larger compute power (x2), and even greater (x1.5) while moving from Level 4 to Level 5. eHPCs cannot evolve in computing power as in the classical-HPC world. This is due to the numerous special requirements governing the microcontrollers/Systems-on-chip that are mandatory to be suitable for future automotive applications. These special requirements are depicted in the below picture.



eHPC - Moving Closer To Reality

Several premium automakers and their suppliers (so-called tier-1's), are already active in ECU consolidation. The European Processor Initiative (EPI) is one effort to build exascale HPC, with automotive being one of the target applications. Currently, 23 partners from ten European countries are in this consortium. The members range from automakers to semiconductor suppliers, corporates doing advanced-developments to researchers-in-academia, thus ensuring diversity. They aim to bring a novel low power eHPC to the automotive market. This eHPC is aimed to be fail-safe, automotive grade, real-time and powerful to be able to address even Level-5 automated driving. The first family, codenamed "Rhea", will come to market in 2021. ARM, RISC-V, and external IPs will be a part of it. It will include a proof-of-concept of an automotive eHPC. EPI plans to deliver the second family, Cronos, in 2022-2023. It will include an automotive eHPC.

Sectorial Implications Of The New E/E Architecture

- **Standardization** and **commoditization** of sensors, harnesses, computing hardware like ECU/DCU/Server, and other electronic hardware components likely to happen.
- **The software** will become increasingly prominent. The functionality will be realized through software instead of additional hardware i.e. 'appification' will be seen (e.g., ADAS functions enabled on-demand based on a standardized set of electronic hardware).
- **Service-oriented-architecture** (SOA) will emerge. The architecture will likely be more scalable and reusable across classes of vehicles, applications, and features.
- **Frequent over-the-air** (OTA) updates will become common.
- **Separation of hardware and software** development cycles will happen, thus helping auto-companies speed-up software development.
- **New sourcing models** emerge due to the separation of hardware and software. This will avoid vendor lock-in. For the digital-natives in the market, this can mean that the entry barrier into the automotive industry is lowered further.
- **Further opening of eco-system** with increased co-operation among the players, to share costs and speed up development. We have already started to see happen. Even traditional competitors in the mobility sector are partnering together in the transformational journey.
- **Continuous agile transformation** of organizations will be seen. Generally, automotive companies lag those from other sectors in adopting modern organization models. This will change soon. In a move to make themselves more agile, a leading European automotive-OEM, for example, has embraced a swarm organization, and another major car-OEM underwent a large-scale agile transformation.

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About the author

Mr. Arun Shankar is Chief Manager at Continental Automotive India Pvt. Ltd, an Indian arm of Continental AG. He manages the Microelectronic-Integration department within Technical Center India, the in-house R&D Center of Continental globally. His department delivers digital ASICs to various internal businesses of Continental. Before this role at Continental, Mr. Arun Shankar started, built and established the Advanced Engineering (AE) department in Bangalore, for Continental's Advanced Driver Assistant Systems (ADAS) business unit. The department strongly contributed to innovation projects related to automated driving and grew to become the largest AE department within the whole business unit globally.

Mr. Arun Shankar has more than 17 years of diversified work experience, spanning across consumer electronics, communication, and automotive electronics industries. During this span, he gained technical expertise in several digital technologies such as digital signal-processing (all of image, video, audio, speech), computer vision, machine learning, multisensor fusion techniques, and embedded software. Mr. Arun Shankar is a lead inventor in several of the 17 US/German patents that list him as one of the co-inventors.

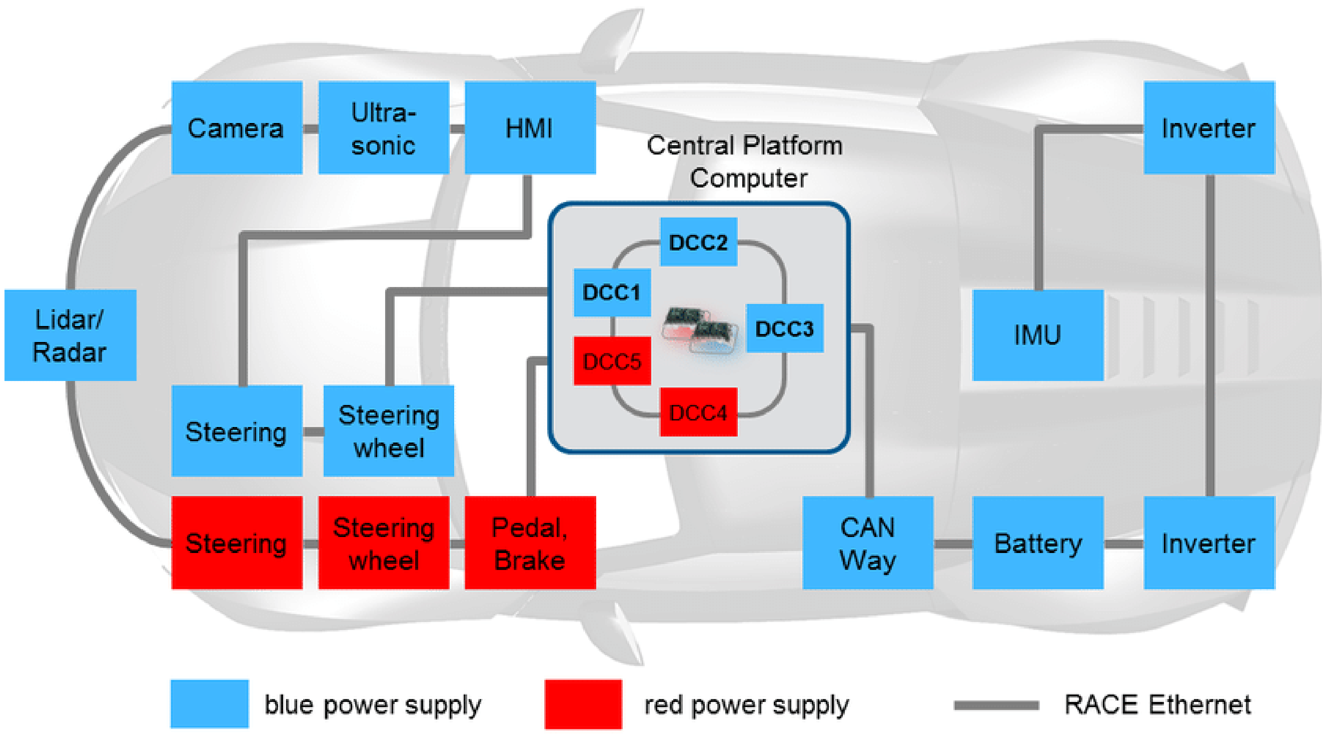
Mr. Arun Shankar was elevated to Senior member grade by IEEE in 2018 and is serving as the Chairman of IEEE-Consumer electronics society for 2019 under the IEEE-Bangalore-Section. Since 2017, Mr. Arun Shankar is also one of the invited business mentors for the India Innovation Challenge Design Contest, which is the country's largest innovation challenge hosted by Industry-Academia-Government collaboratively.

Mr. Arun Shankar is an Electronics and Communication Engineer from the University of Mysore and has also completed an Executive General Management Program from Indian Institute of Management, Bangalore.

Related Readings

An Automated Electric Vehicle Prototype Showing New Trends in Automotive Architectures

Abstract—The automotive domain is challenged by the increasing importance of Information Technology (IT) based functions. To show the possibilities of modern IT systems, a demonstrator car was developed in RACE (Robust and Reliant Automotive Computing Environment for Future eCars) based on a completely redesigned E/E architecture, which supports the integration of mixed-criticality components and offers features like Plug & Play. This paper presents the architecture and components of this vehicle prototype, which is equipped with modern systems such as Steer-by-Wire without mechanical fall back. It was designed to support future driver assistance systems, e.g. to carry out autonomous parking maneuvers onto an inductive charging station, a task, which is hard to achieve accurately enough for a human driver. Therefore, a special emphasis lies on the description of the sensor set for automated operation



E/E Architecture with Central Platform Compute

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[*https://www.researchgate.net/publication/307804303_An_Automated_Electric_Vehicle_Prototype_Showing_New_Trends_in_Automotive_Architectures*](https://www.researchgate.net/publication/307804303_An_Automated_Electric_Vehicle_Prototype_Showing_New_Trends_in_Automotive_Architectures)

Amazon has placed an order for 1,00,000 electric delivery vehicles with Rivian. The order follows a $440 million (approx Rs 3119.18 crore) investment made by the online shopping giant in the EV start-up earlier in the year. Amazon led a $700 million (approx Rs 4962.34 crore) investment round in Rivian in February 2019. The online retailer says that this massive order is the largest ever made in electric delivery vehicles. Rivian has attracted high-profile investments from other firms as well, including Ford – with which it is working to develop future electric vehicles.