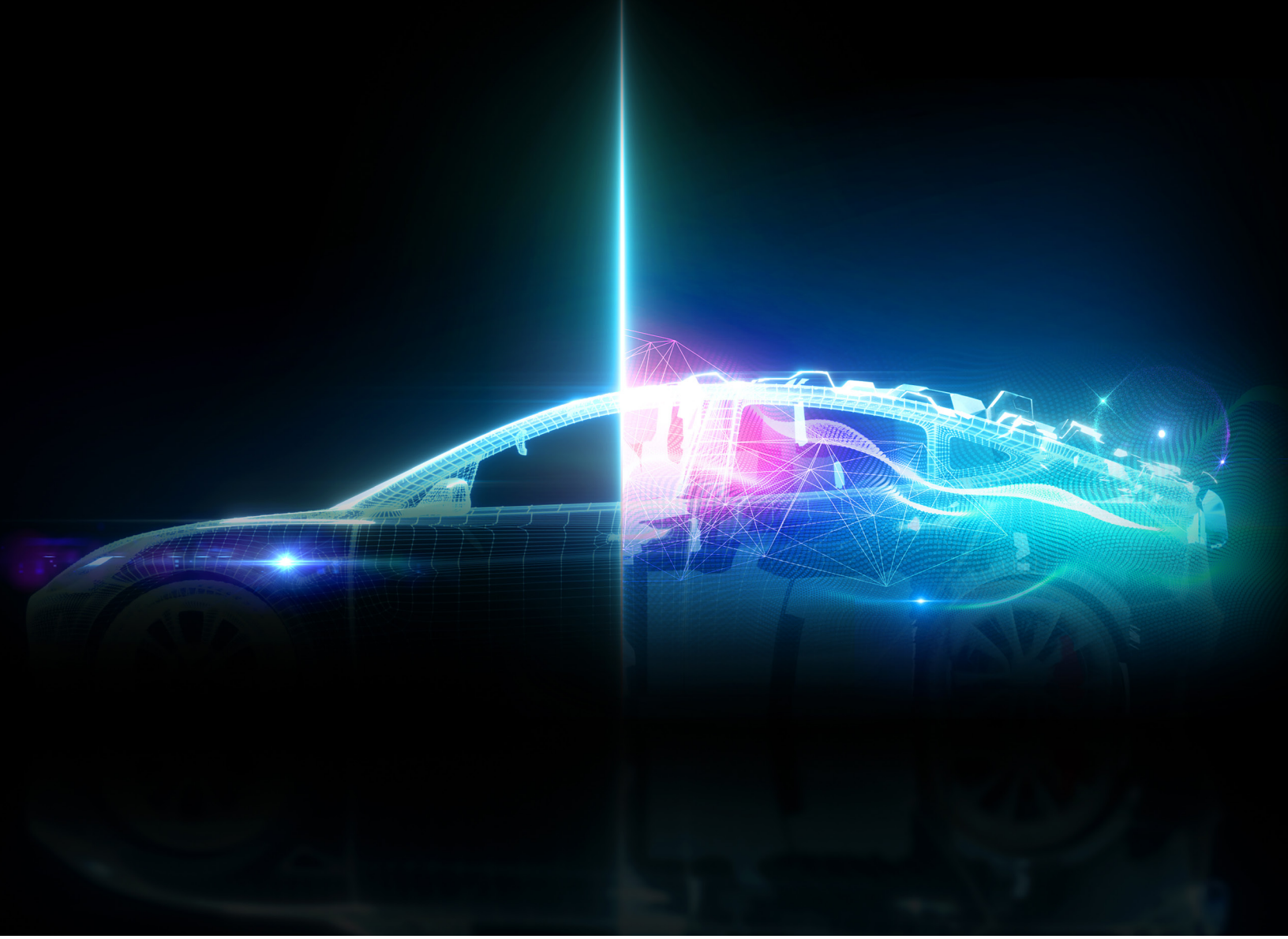

WHITE PAPER

Gearing up for Automotive's Next Frontier

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Accelerating Automotive Into The Digital Future

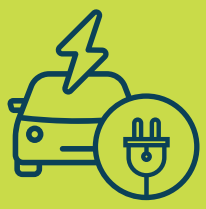
From the advent of the Model-T to the promise of self-driving cars, the automotive industry has changed drastically in the past century. As technology continues to become more sophisticated and consumers expect vehicle digitalization, there's mounting pressure to transform from mechanical-centric to software-defined vehicles. To stay relevant and withstand disruption, manufacturers and suppliers will have to implement innovative, software-based solutions.

How exactly companies will approach the delicate balance between quick adoption and successful execution remains cloudy as several factors will affect the outcome, including regulatory software development and social acceptance of several emerging trends. But one thing is certain: the automotive industry is facing another monumental wave of change. Looking ahead to 2030, **connected, autonomous, shared** and **electric (C.A.S.E.)** mobility services are expected to dominate the automotive market, offering quicker, safer, more efficient, more cost-effective and more customized transportation opportunities. We already see evidence that these trends will be at the core of the industry and that they must operate synergistically to be a successful part of automotive's future. In order to truly understand how this new frontier might look, let's examine each trend's current state individually.

CONNECTED

AUTONOMOUS

SHARED



ELECTRIC

CONNECTED

It is predicted that around 98 percent of new cars will be connected by 2020, enhancing the driving experience with driver-assistance, real-time vehicle information and entertainment services.[1] In the next decade, the industry will have no choice but to implement a customer-centric business model, leading companies to take a software-first approach. If automotive companies fail to look holistically at the software-defined vehicle as a component in the automotive cloud ecosystem, they will struggle to stay relevant.

Keeping up with consumer expectations can be challenging given automotive's extensive production cycles. Companies should accelerate their time-to-market while continuously analyzing consumer behavior, addressing current business requirements, building a roadmap for future-ready innovations and rapidly responding to change. By innovating existing connected vehicle technologies and adding new offerings, companies can redefine vehicle experiences, offer new types of services and create new services-based revenue streams.

The applications for entirely connected vehicles are vast, and the connected car of the future will be able to efficiently execute services for usage-based insurance (UBI), driver wellbeing monitoring, predictive maintenance and so much more. Soon, advances in connectivity, like 5G, and the proliferation of cloud edge capabilities will enable an easy and seamless way of using the vehicle as an integrated part of cloud-based services.

AUTONOMOUS

The dream of autonomous vehicles transporting people and goods quickly, without accidents or a huge environmental impact, could eventually be a reality. By 2030, autonomous cars will account for an $84 billion dollar market globally. While meaningful, it is a relatively small portion of the anticipated ~$2 trillion global shared mobility market projections.[2] This clearly indicates that mainstream self-driving cars won't happen anytime soon, but companies are vigorously testing the technology required to bring them to market as quickly as possible.

When autonomous vehicles do become mainstream, taxi drivers, truck drivers and transportation services will be significantly impacted. Instead of overseeing a single vehicle, drivers may transform into owners and operators of autonomous fleets. For example, a taxi driver could lease or buy several robotaxis and must be capable of using a software-defined vehicle to successfully run their business.

[1] https://www.statista.com/statistics/275849/number-of-vehicles-connected-to-the-internet/

[2] https://www.prnewswire.com/in/news-releases/digital-transformation-of-the-automotive-industry-set-to-pave-way-for-new-revenue-streams-618312083.html

SHARED

Today, most people own their private vehicle, but actual vehicle usage rates are incredibly low. In fact, cars are parked 95 percent of the time, according to a 2016 Fortune article.[3] Even without autonomous vehicles in the mainstream, consumers are already shifting from a private model toward shared mobility as they look for more sustainable, cost-effective and convenient transportation options. Taking connectivity and software-defined vehicles into account, service companies can more easily integrate and aggregate shared car fleets so that customers can plan, book and pay for their journeys entirely on their mobile device.

Disruptors have delivered shared mobility services, such as Uber, Lyft, Arro and MyTaxi, and they will continue gaining widespread acceptance as connectivity, software-defined vehicles and autonomous technologies improve. According to a 2017 Frost & Sullivan report, more than 40 million people use app-enabled carpooling services, and the usage of ride hailing apps has grown rapidly to over 70 million users.[4] It may be true that people view new mobility services solely as an additional transportation option, but the decline in vehicle sales (0.3-2% in 2018[5]) and in new drivers (15% among 20-24 year olds[6]) is hard to ignore. It's becoming more evident that perceptions of private vehicle ownership are shifting. Since OEMs cannot simply do everything by themselves, like develop every possible car service, they must better equip third parties to do so by offering a software-defined vehicle.

ELECTRIC

While drivers won't entirely rely on shared mobility services for the time being, the individual mobility model must change to become more environmentally sustainable and more reliable for private owners. One prominent push, for example, is to create an emissions-free vehicle and this endeavor wouldn't be possible without electrifying the powertrain. In internal combustion engine (ICE) vehicles today, local components emit harmful substances and noise. But with emissions-free vehicles, the electricity will come from renewable resources. Looking at reliability, the powertrain in an ICE vehicle is usually comprised of 2,000+ moving parts, while the powertrain in electric vehicles only has around 20, eliminating many costly repairs and maintenance.[7]

As battery costs continue to go down and battery capacity continues to go up, it's expected that 55 percent of all new car sales will be for fully electric vehicles by 2030.[8] Electric vehicles are inherently less mechanically-focused, making it the next logical step for OEMs to more easily implement the software-defined offerings that are steering automotive's future.

[3] http://fortune.com/2016/03/13/cars-parked-95-percent-of-time/
[4] https://www.prnewswire.com/in/news-releases/digital-transformation-of-the-automotive-industry-set-to-pave-way-for-new-revenue-streams-618312083.html
[5] https://www.forbes.com/sites/neilwinton/2019/01/03/healthy-global-auto-sales-growth-looks-doomed-in-2019/#339e8dbb55a6
[6] http://www.marginalia.online/is-riding-the-new-driving-for-the-under-24s-thanks-toride-sharing-apps/
[7] https://cleantechnica.com/2018/09/28/forbes-electric-cars-the-future-gasmobile-killers/
[8] https://www.pwc.com/gx/en/industries/automotive/assets/pwc-five-trends-transforming-the-automotive-industry.pdf

Software-Defined Vehicles

With C.A.S.E.'s reign over the industry, it's time for automotive companies to think beyond their traditional service offerings. After-market startups are creating true automotive IoT programs impacting many use cases, including breakdown assistance, car locator, advanced diagnostic alerts, auto insurance shopping, access to repair shops, jobs dispatching, expense creation apps and more. Given automotive's complex development environment, it's not currently possible to use vehicles as part of the connected services ecosystem.

Before apps, before interfaces, before code, manufacturers must think about how the vehicle interacts with other software and platforms. The point is to open the vehicle to the shared economy, which means providing generalized access to the vehicle via software. This, in turn, enables new business concepts and capabilities that may include many types of user and business experiences.

This is why the basic thinking and architecture of a fully connected vehicle needs to be structured around connected services, rather than just driver-facing applications. Connected services are computer programs that run invisibly for a driver or passenger. There are many connected services behind virtually every mobility business with any kind of online presence. Connected services store data, pre-process data, handle eCommerce payments, ensure compliance with policies and laws, track advertising, deliver messages and much more.

With connected services, mobility companies can run complex software on the vehicle itself with no additional hardware required. For example, both a Usage Based Insurance (UBI) service that tracks driving behavior and a predictive maintenance monitoring can run purely as a service on the local computing hardware. These services can start and run silently in the vehicle, provide useful data to other cloud systems, and execute service-specific logic on the vehicle onboard computer. With this approach, the vehicle effectively becomes a software platform, significantly simplifying service development, integration and deployment. When the vehicle is software-defined, the service is always upgraded, always relevant and always controlled by the service producer without compromising the vehicle safety and security.

FROM CLOSED HARDWARE TO OPEN SOFTWARE PLATFORM: FOLLOWING THE SMARTPHONE EVOLUTION

If the automotive industry needs any framework to model after, just look at the evolution of the smartphone. Over the past 15 years, smartphones have developed into a platform where businesses can quickly implement services themselves that have exceptional user experiences and business value without relying on phone manufacturers. For automotive, this transformation has yet to occur, but there's no other choice for the industry but to model after the smartphone revolution, as enabling third-party vendors to create and implement connected vehicle-as-a-service ecosystems is essential to surviving in a connected and shared economy.

The Keys To Unlocking C.A.S.E.

Modern automotive engineering innovations have paved the way for smarter and more environmentally-friendly cars. But automotive's lengthy development lifecycle and traditionally mechanical-centric focus for vehicle software development and management cannot keep pace with innovation and change in the marketplace. Today's complex connected vehicle services and applications lead many to question how we can enable and accelerate the ideation, design, development and deployment of mobility services.

CLOUD & EDGE COMPUTING

The answer to automotive's long-standing stall in innovation has, of course, been to adopt a software-defined vehicle. Today, designing, building and managing new types of business solutions and experiences for connected vehicles is largely enabled by modern cloud technologies.

Cloud has become a huge part of everyday life. From the virtual cloud where people can access photos and music via their smart device, to the Internet of Things (IoT) where people can connect to a range of devices, mobility companies now have the tools to create connected services and a new way of running business.

When looking at the software-defined vehicle and the many services that can stem from it, such as shared mobility, it's critical to look at the entire picture:

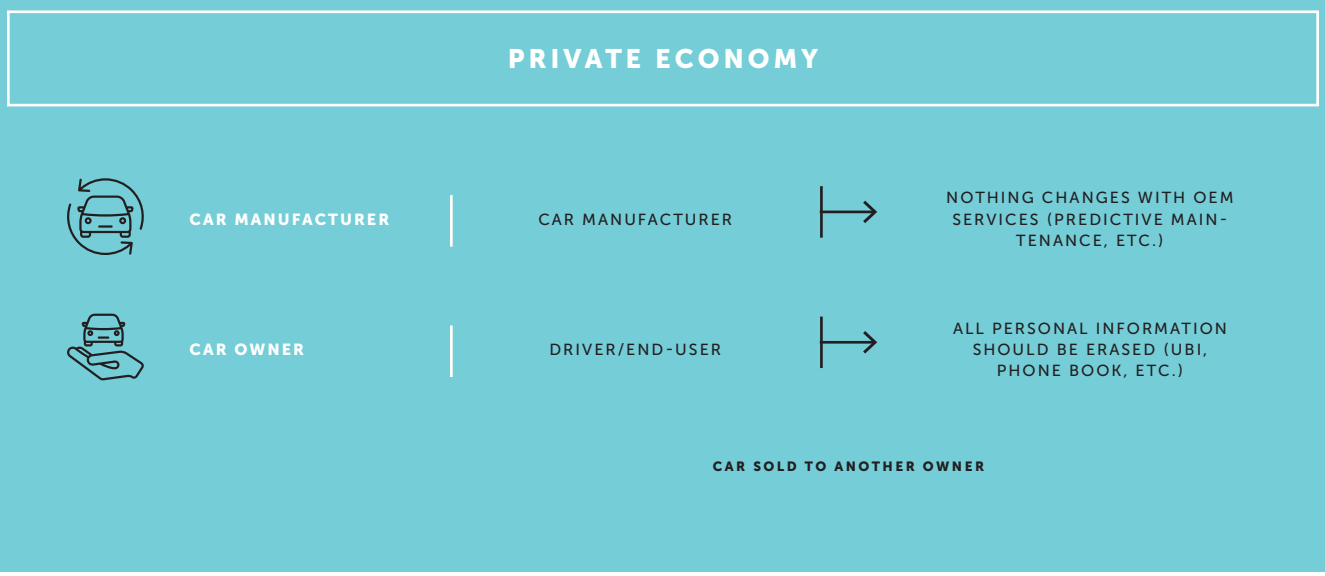
OWNERSHIP MODELS FOR CONNECTED SERVICES

For each stage in a vehicle's journey, it has different connected services vendors. For example, the OEM produces the vehicle, someone owns the vehicle, another company operates the vehicle, and then there is usually an end-user or customer. This chain of services has to be customized, even as operators and end-users in the vehicle change. Ultimately, the vehicle's system must be set up to manage each of these relationships and the endless possibilities they produce.

SHARED ECONOMY

CAR MANUFACTURER	OEM SERVICES: PREDICTIVE MAINTENANCE, ETC.	OEM PRODUCES THE VEHICLE AND WON'T CONVERT
CAR OWNER	ASSET MANAGEMENT SERVICES	ASSET MANAGEMENT MUST BE MOVED FROM PREVIOUS TO NEW CAR OWNER
CAR OPERATOR	FLEET MANAGEMENT, CRM, ETC.	VEHICLE MUST BE ASSIGNED TO THE NEW FLEET MANAGEMENT SYSTEM
DRIVER/END-USER	UBI, DRIVER WELLBEING MONITORING, ETC.	FOR DRIVER/END USER, ALL PERSONAL INFORMATION SHOULD BE ERASED

CAR SOLD TO ANOTHER OWNER



So far, the cloud has already played an integral role in transforming vehicles from stand-alone, transportation-centric machines to sophisticated, connected vehicles. However, given the massive amount of data that connected vehicles produce, the cloud-centric approach is becoming an inefficient method to support connectivity channel stability (presence, bandwidth), and instantaneously process, analyze data and execute services for connected vehicles.

The caveat with cloud for connected services in automotive is that, by exclusively using the cloud-centric approach, there's a greater likelihood of outages caused by the connectivity between vehicle and cloud. For the automotive industry, connectivity absence or interruption impacts the entire connected service functionality.

Today, vehicles produce approximately 25GB of data per hour.[9] The data is used by onboard systems to operate the vehicle, to interact with drivers and passengers and, most importantly, to help operate safety systems. As connectivity becomes more ubiquitous and vehicles produce more data, companies will need to consider an alternative approach. The next great leap for automotive is edge computing, which enables data processing closer to its origin, as well as connected service business logic execution on the vehicle onboard computer.

For example, vehicle sensors provide the engine status. With edge computing, the sensor data wouldn't have to go to a data center to determine whether or not something is impacting the engine's operations. Localizing data processing and connected service business logic execution on the edge enable services to be functional even if connectivity between the vehicle and cloud is absent. Even with the advent of 5G and its edge capabilities, comprehensive rollout will take close to a decade and is unlikely to delivery ubiquitous connectivity, especially outside of metropolitan areas. When automotive manufacturers build vehicles as an edge for connected services, they can be transformed into an entirely new offering and open new revenue streams, similar to how existing cloud vendors provide computing power, storage space and APIs to cloud-based services.

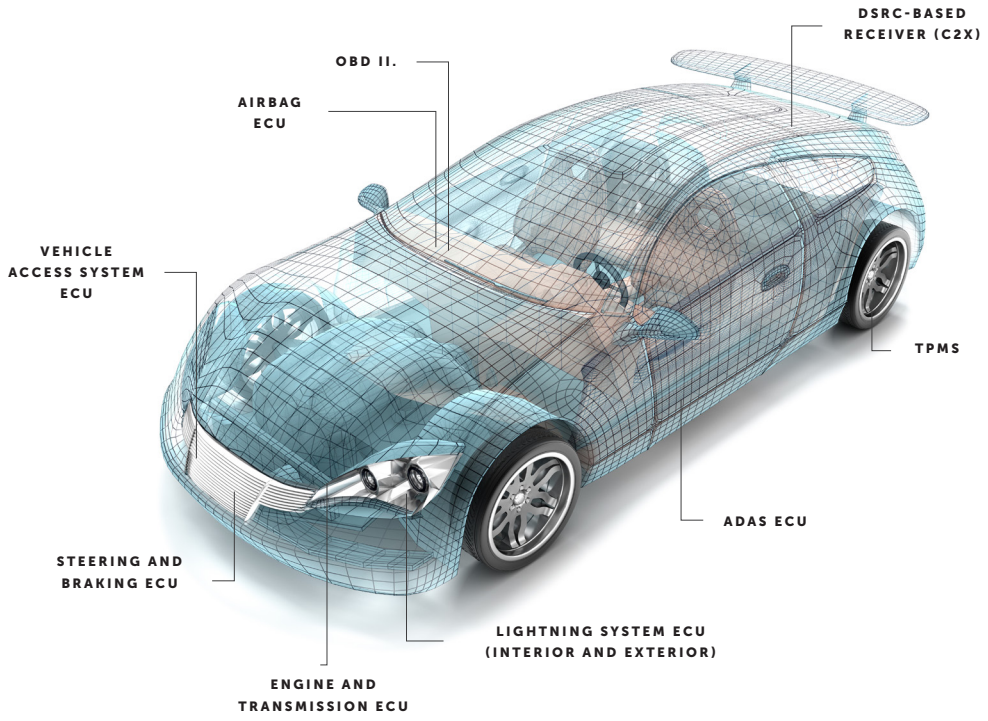
[9] https://www.siliconrepublic.com/enterprise/data-privacy-connected-cars-infographic

SAFETY & SECURITY

While the possibilities for automotive are exciting and the technologies and approaches are becoming more advanced, there's still many challenges to consider when it comes to safety and security. The rapid transformation of the automotive industry from the hardware-driven components to a software and solution-focused industry has introduced concerns around edge computing onboard systems.

The open services economy promises new business offerings, but a car's edge computing systems need to be protected against threats that would compromise vehicle safety. Ultimately, 'safety' dictates the operations that a system must carry out, and with software-defined vehicles becoming increasingly connected, cyber attackers will identify vulnerabilities. Car OEMs should follow secure design methodologies and have a set of policies and tools to granularly control APIs and data , as well as hardware access for services, and be able to take action if connected service is compromised. That's where isolation between different functions by using virtualization comes into play.

MISSION-CRITICAL SAFETY ELEMENTS: VULNERABLE AREAS OF CONNECTED VEHICLES



[9] https://www.siliconrepublic.com/enterprise/data-privacy-connected-cars-infographic

VIRTUALIZATION & OPEN SOURCE

So, how can we build cloud and edge computing solutions for shared and connected vehicles that are safe and secure? Stability and maturity are critical characteristics in automotive software, and there's a tool that has demonstrated both, providing a solid base for new innovations in connected vehicles.

Hypervisors are software that create and run multiple virtual machines on one system, which enables automotive to achieve the cloud concepts necessary for the connected vehicle. For more than a decade, Xen Hypervisor has built a legacy for being the safest and most stable hypervisor for modern data centers.

Since vehicle computers are not particularly powerful and their local storage capacity is limited compared to the modern data center servers, it's extremely important to ensure that software code is manageable and does not use too many system resources. Xen's lean architecture to partitioning software reduces the code size and lowers the potential for security vulnerabilities, making it ideal for mixed-criticality systems. Xen is a highly flexible hypervisor to control onboard peripheral assignment and hardware access control for embedded systems. Its small code base makes hypervisor safety certification possible.[10] In fact, Xen has been used to create next-gen digital cockpit solutions with mixed-safety functions.[11]

Aside from safety and security, automotive faces long development lifecycles. However, using hypervisors like Xen can help accelerate business value for the industry. Automotive companies can isolate the safety functions that require long development and verification cycles from connected service functions that must be very agile and ensure short time to market.

Out of all the challenges that the industry faces with open source, the primary concern involves third-party safety certification. Attaining third-party certification for any software project (open source or not) is difficult. However, the argument that open source software, by its nature, can't be certified or used in life safety applications is invalid. For example, open source software has been behind image-guided surgery equipment since 2006, spurring innovation and advancement in robotic-assisted platforms and improving patient outcomes. Since industry groups in automotive have a stake in certifying open source stacks and there are many factors to consider, the Xen community has been closely collaborating to ensure Xen open source safety certification.

In the coming year, the Xen open source project will become essential for automotive, especially as the whole industry refines the software-first approach as a competitive differentiator.

[10] https://xenproject.org/2019/04/02/whats-new-in-xen-4-12/

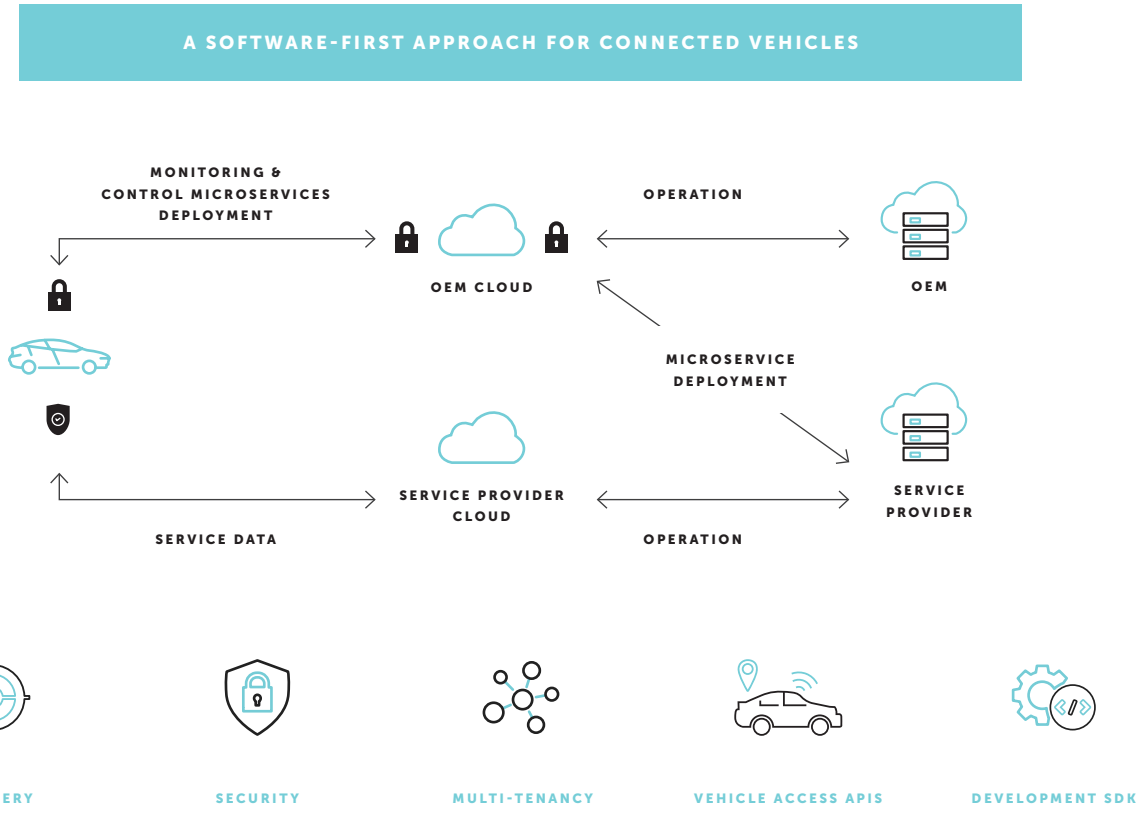
[11] https://xenproject.org/2019/03/12/revolutionizing-the-auto-industry-with-open-source-epams-xen-powered-virtual-cockpit/

Conclusion

In the age of C.A.S.E., the automotive industry needs to overcome the obstacles standing in the way of quick adoption and successful execution of innovations that will open new revenue streams, as well as offer more efficient, more cost-effective and more customized transportation opportunities.

Virtualization is the building block to isolate safety and security in vehicle software from cloud-connected services. Connected services developers using the cloud-based approach in this ecosystem can easily design services and applications for connected vehicles without knowledge of automotive and embedded software development. The industry demands a platform similar to Kubernetes to enable connected vehicle cloud-based services to use the in-vehicle computer as an edge device seamlessly and transparently by using existing modern software development frameworks.

The traditional Kubernetes is an open source platform for managing containerized workloads and services that facilitates both declarative configuration and automation. It provides a container-centric management environment, and orchestrates computing, networking and storage infrastructure on behalf of user workloads. While the vehicle acts as an edge node for cloud-based connected services, orchestration should work based on the same "kubernetes" approach, but it cannot be used as-is. Connected vehicles require a different way to control containerized microservices delivery, security and multi-tenancy. The orchestration platform should also provide a standardized approach to access vehicle-specific data and control signals by using modern software frameworks.

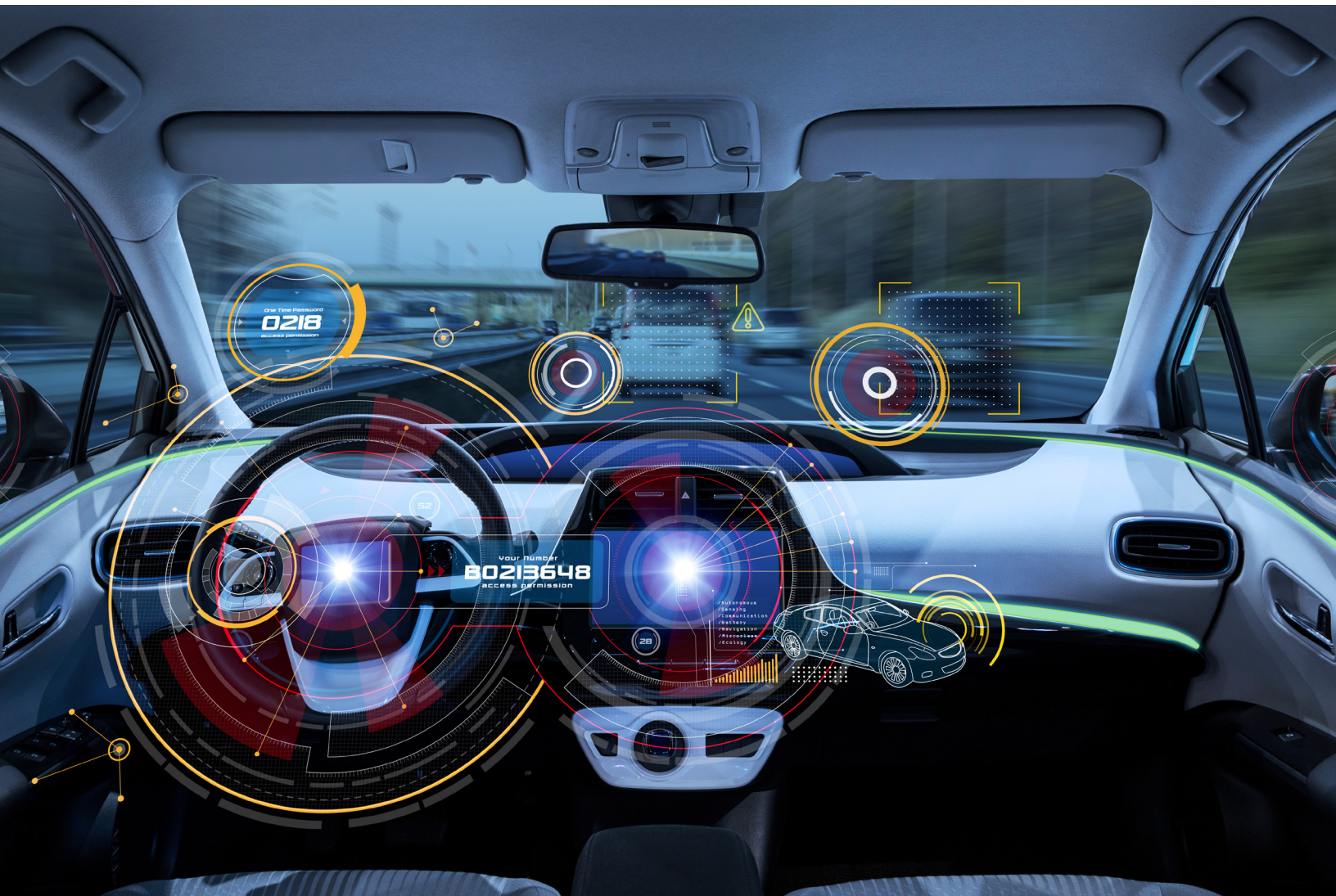


Conclusion

Implementing these systems in automotive will allow the industry to replicate the same approach to mobile services and application development. When the vehicle is an open software platform, this enables connected vehicle services producers to create and operate many different types of the future mobility services and automotive companies to develop new revenue models (similar to existing cloud vendors) and keeping safety and security level.

For example, modern fleet management systems have been deploying all business logic data to the cloud and receiving near real-time vehicle updates. However, if the cloud-to-vehicle connection breaks, the central office will no longer have visibility into vehicle status and location. In an emergency, this can greatly impact vehicle safety and security.

By using the vehicle as the computing edge, part of the business logic can be directly deployed to the vehicle onboard computer so you can perform these actions locally and implement offline actions instead of streaming information to the cloud.



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