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How DevOps Drives Software Defined Vehicles

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Introduction

With more than 200 million lines of embedded code in them modern vehicles have become software deployment platforms that just happen to move down a road. The challenge is that as more capabilities are added to these software-defined vehicles, it has become apparent automotive manufacturers will need to take the DevOps processes and workflows they currently rely on to build software to a whole new level.

As every DevOps professional knows, manual tasks make DevOps workflows less efficient. Advances in automation, however, create a unique opportunity to substantially improve productivity.

Clearly, one of the most critical decisions any vehicle manufacturer is going to make is the selection of DevOps tools and cloud platforms that enable them to modernize their software engineering practices.

The building and deploying of software across thousands of processors embedded within a wide range of makes and models of vehicles is extremely challenging for one simple reason: new vehicles only roll off the assembly line once a year. Capabilities that are not made available on schedule represent a massive amount of potential lost revenue when competitors are able to execute more adroitly.

To put it plainly, in the software-defined vehicle market, software projects can't be late.

The quality of that software needs to be of the highest order because, in some use cases, passengers are counting on that software to save their lives.

There's also obviously a lot riding on these projects. By 2030, research firms project the value of the software-defined vehicle market could reach somewhere between $58 billion to $107 billion with a with a compound annual growth rate (CAGR) between 14.8% and 17.4%.[1] McKinsey & Co. even goes so far as to predict revenue from combined software and hardware content could reach $469 billion by 2030.[2]

But no company has infinite resources. Economic downturns that result in hiring freezes, layoffs and even shortage of critical components all need to be factored into the software development lifecycle (SLDC). IT leaders, like every other business executive, must do more with less. Organizations are not nearly as keen as they once were to expand application development teams; instead, the focus now is on improving the productivity of the existing development team.

Nowhere is that pressure more acutely felt than in an automotive industry where when it comes to software engineering, there is no margin for error.

The global automotive software market will grow from $19 billion in 2021 to $58 billion by 2030

– Straits Research

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https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/mapping-the-automotive-software-and-electronics-landscape-through-2030

DevOps Challenges

A vehicle manufacturer will naturally encounter all the same challenges as any organization when embracing DevOps.

Wiring together tools and platforms is difficult. Keeping track of codebases as they move from development to production is never easy, especially across a diverse mix of IT environments. There are still far too many manual processes that introduce errors and sap productivity. Testing is also not as thorough as it should be, simply because all too often there isn't enough time.

The global automotive software market size was valued at $25 billion in 2021 and is expected to reach $107 billion by 2030

– Precedence Research

Automating software deployment also remains challenging in an era where every hardware platform has unique attributes. Change management processes, especially when it comes to remediating vulnerabilities, are often antiquated. Every application update adds more technical debt that needs to be addressed.

And observability is practically non-existent—both while applications are being built and after they are deployed.

Regardless of where any DevOps teams is in terms of overall maturity, the goal as defined by the DevOps Research and Assessment (DORA) team at Google remains the same: increase deployment frequency; reduce the time needed to make changes; improve mean times to recovery, and successfully implement changes.[3] Naturally, one of the best ways to achieve that goal is to ship smaller amounts of code during each update. However, that also means there are a lot more updates to manage over the life of an application.

Building and deploying software at scale also requires a level of orchestration that very few organizations have thus far been able to consistently achieve. The truth is that without the commitment of software engineering teams dedicated to their craft, most application development projects would simply fail.

The value of the combined software and hardware content for vehicles could reach $469 billion by 2030

– McKinsey

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https://cloud.google.com/blog/products/devops-sre/using-the-four-keys-to-measure-your-devops-performance

DevOps for Automotive

DevOps practitioners building software for vehicles face even more challenges that are unique to their industry. The ultimate success or failure of any vehicle is wholly dependent on the ability of software engineering teams to meet their deadlines. Those deadlines are determined by the year a vehicle is scheduled to be made available so it's not as if the rollout of a capability can be delayed for a few days or weeks.

The issue is that the applications being built for vehicles are among some of the most complex any software engineering team might develop. Just about every vehicle application will be based on an event-driven architecture, which enables developers to build highly scalable and reliable systems capable of digesting and aggregating massive amounts of events and information in real-time. An event-driven architecture relies on triggers to update decoupled microservices.

Event-driven architectures typically have three key components: event producers, event routers, and event consumers. A producer publishes an event to the router, which filters and pushes the events to consumers. Producer services and consumer services are decoupled, which allows them to be scaled, updated, and deployed independently.

Within the context of a software-defined vehicle, events need to trigger services residing not just in hundreds of the processors embedded in the vehicle but across also a wide range of external cloud services that add additional latency to each application.

Building these types of modern applications requires sophisticated programming and DevOps expertise.

Event-driven application architectures may have been around for decades, but the number of organizations that have the skills required to build them is today still limited. It's also worth remembering that compute resources available on each processor within the vehicle is finite, so deploying hundreds of millions of lines of code per vehicle requires a great deal of DevOps precision to continuously deploy, secure and inevitably update embedded software.

Only 27% of respondents would tolerate five or more updates per week but percentage jumps to 41% if each update only took 30 seconds

– Sonatus

The rate at which those updates are delivered also matters. A recent survey of 1,600 consumers found that tolerance for software updates is also limited. When asked how many OTA software updates they'd be willing to accept if their cars had to be turned off and inoperable for 30 minutes, only 27% of respondents would tolerate five or more updates per week. The percentage jumps to 41% if each update only took 30 seconds.[4]

.4 https://blog.sonatus.com/blog/what-consumers-really-know-about-automotive-software-survey

Finally, the reliability of the software services is critical to ensure passenger safety. Vehicle manufacturers will need to err on the side of caution when it comes to balancing innovation with safety. Unless everything from the cloud services to the code itself has been thoroughly tested and vetted, it may be prudent—no matter how economically painful —to delay introduction until the following year.

Choosing the right tools and platforms that enable vehicle manufacturers to adopt stringent and robust DevOps practices to streamline the building and development of applications and improve productivity is nothing less than critical.

Applications developed in the cloud need to be deployed across a wide range of processor classes. Just as critically important is the optimal consumption of the cloud infrastructure resources. As more applications are developed, the cost of those resources will inevitably rise.

Tools and platforms that dynamically allocate cloud resources based on real-time usage are crucial to reduce the total cost of building a software-defined vehicle.

User Applications

Software and services that interact or interface directly with drivers and passengers. These may include infotainment systems, vehicle controls, digital cockpits accessing external cloud services.

Instrumentation

Systems at the instrumentation layer include Advanced Driver Assistance Systems (ADAS) and other types of complex controllers.

Embedded OS

Real-time operating system (RTOS) processes data and events within specific time constraints that are fully understood and bound.

Hardware

The hardware layer consists of the electrical control unit (ECU) embedded in the vehicle.

Software-Defined Vehicles:
Where the Rubber Meets the Road

There is no shortage of operating systems and processors for vehicle manufacturers to choose from as they look to add more advanced services.

The VW Group, Ferrari, BMW, Renault, Mercedes-Benz, General Motors (GM), Stellantis and China's Great Wall Motors, for example, have all announced partnerships with Qualcomm. The Snapdragon Ride platform from Qualcomm will find its way into an increasing number of vehicles to enable two-way messaging via satellites.

Epic Games, meanwhile, is working on a navigation system that will include augmented reality using 800 tera operations per second (TOPS) of on-board computing power enabled by Qualcomm processors. Alternative options include Nvidia's system-on-a-chip (SoC) architecture, the Intel Mobileye platform or any one of the multiple instances of embedded Arm processors that may emerge in the years ahead.

Historically, vehicle manufacturers have relied on operating systems such as QNX from BlackBerry or Wind River Linux from Wind River Software. However, other alternatives are gaining traction.

Qualcomm is now also partnering with Red Hat to provide GM with a version of its Linux operating system that functions as a real-time operating system (RTOS) processes data and events within specific time constraints that are fully understood and bound rather than just kept as a minimum. RTOS, by definition, are designed to be event-driven and preemptive to better prioritize competing tasks.

Not every advanced capability, however, is solely dependent on the platforms installed in the vehicle.

The Amazon Web Services (AWS) cloud, for example, is at the core of a set of services being developed by Stellantis that will be made accessible via 14 different brands.

Enhanced vehicle control functions enabled by Amazon's Alexa digital assistant will allow for the development of custom experiences using AI and voice-driven technology made available via an Alexa Custom Assistant program.

A Jeep, for example, could turn Alexa into a digital off-road "coach" that would help drivers properly calibrate the vehicle and optimize performance before tackling an off-road excursion. Other capabilities would be available via a subscription to an app store.

There is even an opportunity to retrofit software-defined capabilities into older vehicles. Cerence, an automotive electronics provider, has partnered with Nvidia to develop an AI-powered voice-centric "concierge" platform using a module that can be installed by car dealers to provide access to OTA cloud services.

Apple, meanwhile, is expected to expand on the inroads it has made with Apple CarPlay to make a range of OTA services available via the cloud. Apple is likely to use an enhanced version of CarPlay to tap into a vehicle's sensors, although there is a great deal of skepticism (and some outright resistance) about such usage. Tesla, for example, doesn't support CarPlay.

Google may have a similar opportunity as its navigation software becomes more integrated with cars; it is in use on upcoming Honda Accord models and Renault is working on integration of Waze.

What's Ahead

The pressure on DevOps professionals in the automotive industry to deliver software on time is only going to increase in the months and years ahead. Software drives the most innovative features being made available in vehicles, from heads-up displays (HUDs) to advanced drive assistance systems (ADAS) that enable autonomous driving. However, those advances are only early examples and there are much more innovative applications and use cases to come.

Mercedes-Benz, for example, is developing its own Mercedes-Benz Operating System (MB-OS) that will launch next year. More than 3,000 software engineers will be working on this effort in Sindelfrigen, Germany, with additional hubs planned for Berlin, Tel Aviv, Seattle, Sunnyvale, Beijing, Tokyo and Bangalore.

MB-OS will become the central nervous system through which drivers and passengers can access a wide range of external cloud- based services. A primary goal is to streamline the driver experience by eliminating frustrating menu tiers that hinder access to more advanced features. The more cumbersome and hard-to-access, the less inclined drivers are to use these features. Mercedes-Benz has teamed up with Unity Technologies, a builder of video games, to help incorporate real-time 3D visualization capabilities to achieve easier access to some of these capabilities.

The center promises to shorten the time for single-machine full-precision model training from 276 days to 32 days

– Xpeng-Alibaba Cloud

MB-OS will also provide the foundation for a pillar-to-pillar "hyperscreen" digital display, 3D navigation and a 3D "Star Avatar" digital assistant that will function as a "digital butler" that, for example, will provide tips on how to drive more economically.

Other capabilities include audio and video streaming, messaging, gaming and augmented reality-enhanced experiences. One safety feature under development will even go so far as to show how data gathered from the vehicle, with driver consent, can identify high risk accident locations and alert drivers to potential collision spots using GPS coordinates.

Despite promising all these capabilities, Mercedes-Benz is simultaneously moving to reduce the number of electronic control units (ECUs) in its cars. That will reduce power requirements and fine tune driving modes ranging from comfortable to sporty to dynamic.

Not to be outdone, The Volkswagen Group, which includes Audi, Porsche, Lamborghini, Bentley, Bugatti and other brands, plans to reduce the amount of computing power needed inside a vehicle in favor of a system called The Big Loop. The Big Loop is being developed by Cariad, a VW subsidiary, and has two core elements.

One is an isolated, protected piece of hardware called the "blade" that handles all driving functions, including assisted driving (AD) and automated driving (ADAS) capabilities. Inside the blade is a deep neural network software package, dubbed In Situ Intelligent Data Collector and otherwise known as Instinct, that analyzes real-time sensor data. Instinct is designed to monitor for "known knowns" as well as "unknown unknowns" should an unexpected hazard suddenly appear.

The Volkswagen Group will constantly be connected to the cloud where "swarm data" will be stored. Swarm data, gathered by the all the sensors and cameras in a car, includes information about the vehicle as well as its surroundings and road conditions, providing guidance to AD and ADAS systems to enable predictive cruise control, a cornering assist function that adapts to vehicle speed and an autonomous lane-changing capability on highways. Continuous linkage to the cloud also means greater availability of more highly detailed maps.

Honda and Sony, meanwhile, are building the Afeela electric car that incorporates 45 sensors and cameras, both inside and out.

Afeela "will integrate real and virtual worlds," Honda says, with the latter viewed on a pillar-to-pillar panoramic screen across the dashboard. Novel light bars mounted on the front and rear bumpers allow communication with surrounding cars and their drivers.
A yoke-style steering wheel design minimizes obstructions to screen viewing.

Software is also going to play a critical role when it comes to personalization. A next-generation EV platform from BMW, code-named Neue Klasse (New Class), seeks to create an intelligent, almost-human-like experience in terms of people's interactions with the car.

Those capabilities could range from simple personalized greetings to an ability to use intelligent lighting to create 'facial' expressions with the car's headlights and grille.

The interface for accessing these capabilities is a HUD that spans the width of the wind screen. A slide controller allows the driver to control how much information is presented, with five levels of interaction ranging from basic driving information to a full augmented-reality projection. Another capability being touted by BMW is the ability of drivers to change the exterior color of a vehicle at the touch of a button thanks to the use of e-ink technology.

Other forthcoming advances from vehicle manufacturers include improved long-range lidar systems that can identify road obstacles and their velocity in high-resolution, sensors to monitor drivers for "eyes off the road" behavior and biometric capabilities enabled by voice recognition.

All of these capabilities are, of course, powered by the software created by developers and deployed by DevOps teams that collectively are digitally transforming the driving experience.

More than three quarters of consumers (78%) believe technology is very or somewhat important in solving driving safety issues, with 82% feeling safer with ADAS in vehicles

– PAVE-Aeye

Summary

All these innovations are just a taste of what is to come. Artificial intelligence (AI) models for software defined vehicles, for example, are becoming easier to build and deploy. In China, Xpeng and Alibaba Cloud have jointly built the largest intelligent computing center for autonomous driving, dubbed Fuyao.

The center promises to shorten the time for single-machine full-precision model training from 276 days to 32 days.[5] If 80 machines are running simultaneously, it only takes 11 hours to train an AI model. All those inference engines that run those AI models will need to be continuously updated and integrated with application code as best DevOps and machine learning operations (MLOps) converge.

Automotive companies will obviously need to build more advanced software faster than ever without compromising quality or given the current economic outlook adding additional headcount. Updates that address any critical vulnerability that is discovered in a system will need to be instantly addressed. The decisions about which tools and platforms DevOps team leaders in the automotive industry should adopt to build and deploy millions of lines of code are crucial as the fortunes of vehicle manufacturers become increasingly tied to software either embedded in their vehicle or delivered via an OTA service.

In fact, a recent survey of automotive industry experts found nearly 44% would pay extra for optional vehicle functionality after they have already purchased a vehicle.[6] Profit margins across the industry will increasing be tied to the consumption of software delivered as a service.

Consumers, of course, have no shortage of vehicle options and they are already making it clear they expect the next generation of vehicles to be safer thanks in part to technological advances. A survey of 1,095 adults found that 78% believe technology is very or somewhat important in solving driving safety issues, with 82% feeling safer with ADAS in vehicles.[7]

Software-enabled capabilities available in one vehicle and not in another will inevitably shift market share and, by extension, stock valuations. That's an enormous amount of pressure on DevOps teams that are building and deploying software for all kinds of vehicles at speeds that a Formula 1 race team might envy. The only difference is rather than having to focus on two race cars, the software engineering teams in the automotive industry are deploying software on millions of vehicles that all need to share the same road.

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