Android Automotive Transforms Vehicle Infotainment

Vehicle infotainment systems have always faced several challenges. They offer a limited number of proprietary applications. They cannot be easily updated. And they are not always as intuitive to use as other modern devices, such as smartphones.

An exciting new approach to infotainment solves these issues by taking some of the best features of smartphones and integrating them natively into an automotive environment. Built by adding automotive-specific features through the Android Open Source Project and supported by over-the-air updates and a continuous integration and deployment infrastructure, this software-defined platform vastly improves the consumer experience, creates a vibrant applications ecosystem and unlocks new revenue opportunities for OEMs.

With these vehicle-specific functions and integration with other digital systems in the vehicle, Android Automotive OS has become a first-rate automotive infotainment system. The platform continues to evolve into a full-blown cockpit domain controller with the potential to completely transform the user experience.

Android Automotive

Consumers are accustomed to smartphones and other electronic devices that receive routine updates and security patches, provide an intuitive user interface, seamlessly integrate with other devices, and showcase a robust application ecosystem. But those features have not extended to vehicle infotainment systems – until now.

With a version of the Google Android operating system called Android Automotive OS, OEMs can offer consumers an experience that meets their expectations and provides them with an experience that evolves and improves over time through over-the-air updates and connections to a larger app ecosystem – resulting in new revenue opportunities for OEMs and other third parties.

THE STATE OF INFOTAINMENT

Before the introduction of this new native Android Automotive infotainment platform, there have been two basic options for consumers: settle for the vehicle's built-in infotainment systems that run proprietary applications for features such as media player or navigation, or connect their cell phone with the infotainment system via Bluetooth or USB.

The built-in system has the drawbacks of being closed to third-party innovation and typically not allowing for updates, which essentially means the systems are often perceived by customers as obsolete as soon as the car is driven off the lot. Additionally, getting these complex systems to work smoothly and intuitively is challenging. According to a 2019 survey conducted by Consumer Reports, only 56 percent of owners reported that they were very satisfied with their car's infotainment system. Complaints included buggy software, confusing interfaces, and the inability of the system to understand verbal commands.

Using a cellphone with Apple CarPlay or Android Auto offers limited functionality, such as navigating, playing music and making phone calls. Satisfaction among consumers for these options is mildly better, according to the Consumer Reports survey, with 59% of respondents saying they were very satisfied with Android Auto and 64% expressing satisfaction with Apple CarPlay.

Many consumers still simply pair their phone to the vehicle infotainment system via Bluetooth or a USB cable – but that approach has its own drawbacks, including lack of coverage in remote areas, data plan costs, and difficulty in toggling back and forth between the cellphone and built-in features like AM/FM radio. Plus, there are security and privacy issues associated with cell phone apps that share user information and were not designed to be run in a vehicle environment.

In terms of the application ecosystem, today's vehicles might come with a limited number of apps, but even if the apps are based on an open platform, they are OEM-specific. There is no broad application development environment that encourages innovation and unlocks new revenue opportunities. That is where an open platform such as Android has the opportunity to revolutionize vehicle infotainment systems.

For example, it will not be long before drivers will be able to tap an app that finds available parking spaces, books the one selected by the driver, pays for it and provides turn-by-turn directions to the exact spot. Or they might arrive home to a garage door that opens as they pull into the driveway, lights that turn on to greet them, and a security system that automatically turns off as they exit the vehicle.

VEHICLE-SPECIFIC CHALLENGES

There are many challenges associated with building an infotainment system designed to operate in a vehicle. It needs to be built for long-term reliability, and it needs to be easily updatable. It needs to handle multiple types of audio tuners, such as AM, FM, satellite, and so forth. A vehicle has many more speakers than a smartphone, and consumers have high expectations for a rich sound inside the vehicle.

Features that contribute to safety are paramount. While the touchscreen might be the primary user interface, the system must accommodate other types of interactions, such as voice commands, or gesture activation, which uses sensors to capture the user's hand movements. It should also integrate with and manage the interplay among entertainment, navigation, telematics and other vehicle systems. For example, turn-by-turn driving directions, phone calls or lane change warnings should automatically and seamlessly take priority over listening to music. In vehicles with the technology to detect the level of distraction of the driver, the system could restrict the functions it displays if the driver is distracted or stressed.

In addition, the system has to be able to power up very quickly – usually a few seconds. Consumers expect to be able to turn on their car and quickly start driving. Regulations require that backup cameras function within 2 seconds or less. Consumers want their music on instantly and the navigation to be ready by the time they reach the end of their driveway.

At the same time, the system must avoid draining the battery and self-diagnose when it needs maintenance. And it needs to act as the interface to other functions, such as climate control and vehicle diagnostics.

All of these challenges have been addressed with the Android Automotive open-source platform, which separates the hardware and software layers, enabling the system to be designed specifically for the vehicle cabins of today, but also built for the future, as vehicles take on additional digital, connectivity and self-driving features.

VEHICLES HAVE SPECIFIC NEEDS

While vehicle user interfaces can share aspects with smartphones, automotive expertise is required for certain functions.

Audio Management

- Provide premium sound experience
- Manage various audio sources, including turn-by-turn directions, phone calls and radio
- Support wide range of different tuners that have to work seamlessly together, including AM/FM, DAB, HD audio and SDARS
- Manage audio warnings and notifications

Vehicle Connection

- Allow climate control and other car controls
- Provide information to the driver about car health
- Regulate what user can do, depending on driver workload

Power

- Allow fast start-up
- Avoid draining battery
- Indicate time for maintenance

Vehicle Diagnostics

- Insure proper function
- Provide statistics
- Update car properties

WHY IT IS A GAME CHANGER

The new Android Automotive-based platform acts as its own device, connected to the user's Google account. It does not require a smartphone to be present; instead it gets the user's contacts, music playlists and more directly from the cloud, just as a smartphone would.

Consumers can access familiar apps, such as Google Assistant, Google Maps, and Google Play Store. In fact, they can access a growing ecosystem with a variety of embedded apps and services, while OEMs will not have to devote resources toward developing and maintaining their own proprietary app store. Consumers get continuously updated security and operating system functions, and they gain the opportunity to take advantage of new after-production services.

OEMs send updates and security patches automatically over-the-air to the vehicle's telematics box. The customer receives a notification that an update is available, and, similar to what happens with a smartphone or laptop, the customer can select an upgrade option, such as performing the update while the vehicle is charging overnight.

As vehicles take on additional automated capabilities like crash avoidance, parking assistance, adaptive cruise control, blind spot assistance and emergency braking, the infotainment platform can become a primary user interface for actions and alerts that take place within the vehicle. And it connects the vehicle to external sources of information – everything from traffic and weather reports to information on where to find the closest EV charging station to vehicle diagnostics and notifications. As such, it is critical to consider these other domains during design and integration.

Over time, the infotainment system is evolving into a cockpit domain controller. In a cockpit domain controller scenario, the in-cabin computing platform integrates new functional controllers such as the instrument cluster, the interior sensing systems and other controllers for in-cabin functions, essentially transforming these hardware controllers into functional software domains. So, for example, a driver can issue a voice command to turn on the heat or adjust the seat. Deeper integration with vehicle functionality results in a more holistic in-cabin experience.

Aptiv's solution is a game changer because it delivers:

- An agile and collaborative way of working that allows faster time to market and post-production updates that deliver a progressive user experience and a high degree of personalization. In the past, it might have taken three years for an OEM to develop a new infotainment system. Using Agile software development methods, a new platform can be designed in less than 18 months.
- Continuous integration and deployment tools that provide full life-cycle, over-the-air updates, extending the operational life of the infotainment system by at least five years.
- A new, personalized application ecosystem for a seamless extension of consumers' digital ecosystem in their cars, via a first-to-market system using Android Automotive with built-in Google apps and services.
- New business models with end-to-end user and business connectivity, enhancing the safety and comfort of the driver.

UNDER THE HOOD: HOW IT WAS DEVELOPED

The first implementation of the platform is a collaboration between Aptiv and Volvo / Polestar that is deploying the new system in the OEM's latest electric vehicles, including the Polestar 2 and the Volvo XC40. Aptiv and Volvo worked with Google and led the development and integration of Android Automotive OS with the Polestar 2 and Volvo XC40, while gaining early access to Android updates and features. The teams met periodically to update the planning process, while the nuts-and-bolts development occurred in two-week increments with features constantly modified and improved.

Google made its Android Automotive OS generally available to the entire automotive community in 2017. Google delivers the code base, and the OEM and its collaborators adapt the solution to their infotainment architectures and add vehicle-specific features. OEMs could utilize open innovation as well and allow community-developed applications, since the barrier to entry for developing Android applications is low.

In the course of working with the core Android system, Aptiv developers delivered code changes and suggested enhancements back to Google as part of its open source contribution. Those adaptations focused on features such as audio, tuner, power management, diagnostics and other features, especially designed to function in a moving vehicle and to integrate with other vehicle systems.

The platform has several layers; starting at the hardware layer with a system-on-a-chip (SoC) and hardware peripherals. On top of that, Aptiv developed hardware abstraction layers (HAL) implementations, vehicle-specific libraries, frameworks and applications. Google provided the Android runtime, Android native libraries, the Android framework and applications.

Each team brought its own particular skills to the development process. Aptiv's expertise in areas of automotive hardware design and industry regulations helped Google and the OEM define and develop APIs for Android Automotive.

"Automating this massive number of tests is essential for enabling continuous improvement and continuous development."

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These vehicle APIs, part of Google Automotive Services and the Android Software Development Kit (SDK), allow OEMs to focus on differentiating applications rather than the details of making the functions work.

Aptiv's definitions of the HAL in areas of audio, tuning and power management helped the new system meet "instant-on" requirements. In other words, when a driver turns on the vehicle, critical functions are operational immediately.

Aptiv ran a comprehensive battery of tests on the device to ensure it could operate effectively in a vehicle, including tests conducted in extreme temperature conditions – from -40˚C to 75˚C – and more than 1.5 million tests required by Google for Android devices.

Automating this massive number of tests is essential for enabling continuous improvement and continuous development, as each change is quickly tested and verified.

Aptiv and other stakeholders are working on a model for lifecycle management and maintenance to ensure the longevity of the delivery platform. Since the infotainment system needed to have a user interface that was consistent with the OEM's look-and-feel, and since it also needed to integrate with all of the OEM's other systems, such as vehicle diagnostics, a close working relationship was required at all times. This was further complicated given the multi-brand implementation – Volvo and Polestar – leveraging the same system.

DRIVING TOWARD THE FUTURE

While Volvo and Aptiv were the first to market with a native Android infotainment platform, other OEMs have since announced plans to follow suit, which signals that the larger application ecosystem is off to a promising start.

The types of new infotainment, safety and vehicle performance optimization applications that might be developed in the future will certainly take advantage of emerging technologies like augmented reality. For example, when cars or commercial vehicles take on autonomous features, drivers might be able to consume additional types of media, such as streaming a movie or playing a virtual reality game.

And as 5G wireless becomes more widespread, a whole new generation of applications will emerge to take advantage of high-speed connectivity and the ability of systems to process vast amounts of vehicle diagnostic and other data in near real-time. For example, the system could apply predictive maintenance and automatically book an appointment at the dealership after checking your Google calendar.

There are also new revenue opportunities for OEMs on the commercial side. Today, when a business buys a truck to add to its fleet, that vehicle comes with a standard, non-updatable infotainment system. The business then buys additional, aftermarket hardware that attaches to the vehicle dashboard for functions such as logistics or navigation. Going forward, however, OEMs could develop applications that enable trucking companies to dispense with those additional pieces of hardware and simply download a logistics app. This creates an entirely new business model for OEMs.

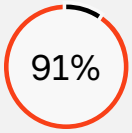
As consumers demand more from infotainment systems and connectivity becomes more ubiquitous, the on-board capabilities of the vehicle will increasingly merge with off-board capabilities in the cloud. With an automated update infrastructure and the right systems integration expertise, these software-defined platforms are well positioned to take advantage of 5G and other wireless technologies to bring a wide variety of applications to the vehicle through a broad ecosystem. As a result, powerful cockpit domain controllers fully integrated with these leading service platforms will become the digital hub of the connected vehicle.

READY FOR INFOTAINMENT

From the consumer perspective, there is clearly a strong appetite for vehicle infotainment systems that can match the features of their other electronic devices and what they experience in their increasingly digital home. In the 2019 Deloitte Automotive Consumer Study:

were interested in over-the-air software updates for their in-vehicle infotainment systems

were interested in access to real-time traffic and navigation updates



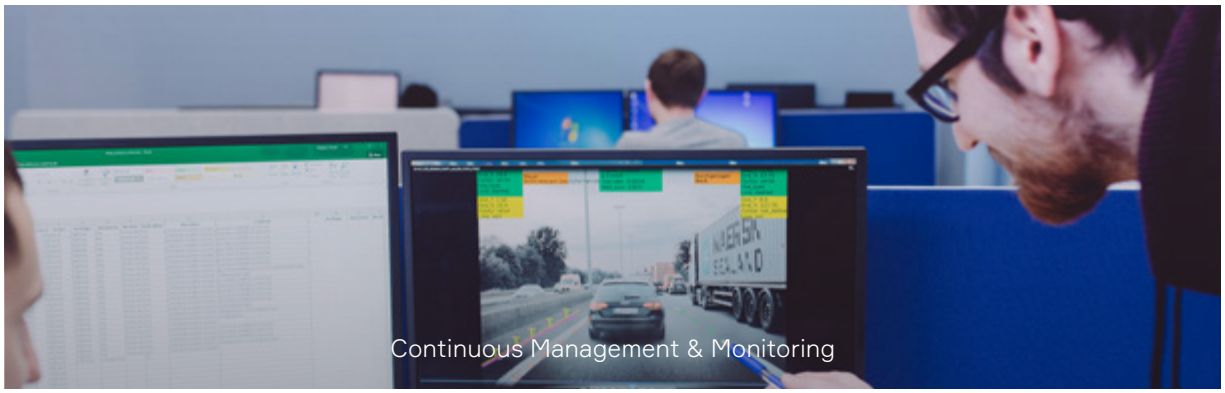
were interested in access to nearby parking

SOFTWARE FACTORY FLOW

Continuous Development

Continuous Testing

Continuous Release



HOW THE ANDROID PROJECT CHANGED APTIV

To successfully bring this ambitious project to fruition, Aptiv had to transform its own software development methods from a traditional Waterfall style to modern Agile techniques.

Instead of collecting large numbers of requirements over an extended period of time and producing one big update every year or so in a Waterfall method, Aptiv transitioned to an Agile methodology of small, incremental updates in a cycle of continuous improvement, continuous monitoring and continuous feedback.

To accomplish this, Aptiv took a “lean software factory” approach that takes into account constant feedback from all stakeholders. The key features of the software factory are a high degree of automation, fast feedback loops at all levels, high capacity and performance throughput, transparency for all stakeholders, quality that is built-in and Android certification testing. Teams also worked together on staged testing and “fail-fast” gating and instant sharing of verified code and software builds.

Aptiv can now continue to improve and refine its processes as it moves forward with additional Android-based infotainment systems in the future.

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