WHITEPAPER / ECU Virtualization

Cloud-Based Virtual Testing for Infotainment Connected Systems

Solution Approach

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1. Background

Vehicle Product Development is agile

The automotive industry is experiencing an increase in customer demand for connected and personalized experiences, resulting in a growing number of features in modern vehicles, market-specific requirements, and a variety of vehicle configurations. To manage this complexity, OEMs have established a software-focused, integrated product development process that spans the entire vehicle lifecycle. However, reducing time to market while maintaining an acceptable cost is a significant challenge in this industry, given the established agile product development process. This paper aims to identify the bottleneck in current product development and deployment methodologies, evaluate a solution to improve time to market in the context of the Connected Infotainment Domain. We will outline how this solution can be applied to achieve faster time to market for connected infotainment apps. Recognizing the key factors for a successful development process - the incremental development, deployment, and operations of one or more solutions in a value stream, the vehicle OEMs adopted agile methodologies for managing their digital products. Going even further: Like any other company transforming itself during the digital era, automotive OEMs are turning more and more into software companies. One suitable methodology, widely adopted in automotive is the Scaled Agile Framework (SAFe).

According to SAFe, continuously delivered value to customers is achieved through an established continuous delivery pipeline, consisting of continuous exploration, continuous integration, and continuous deployment [1].

Testing End-to-End is the Bottleneck

The Test End-to-End phase **(see Figure 1)** as part of the continuous integration is a notorious bottleneck in the context of the above mentioned (SAFe, or any another agile) process. As a matter of fact, testing is known to be "the bottleneck" in any DevOps pipeline [2]. This statement is especially valid for the automotive product development in connected infotainment. The main reasons for bottlenecks in this domain during End-to-End Tests are:

»» Limited infotainment hardware samples in early development phases, because of availability

»» Limited overall number of hardware test benches, because of costs

»» No practical possibility to scale the hardware test benches over a limited time at each product iteration

»» Very limited remote interaction with real hardware setups, based on video observation and control while testing.

»» The digital product is being deployed on decoupled sub systems: the vehicle, the cloud, and the mobile device with their own lifecycles and configuration varieties.

Improving these exact bottlenecks directly impacts the product delivery speed and leads to reduced development cost.
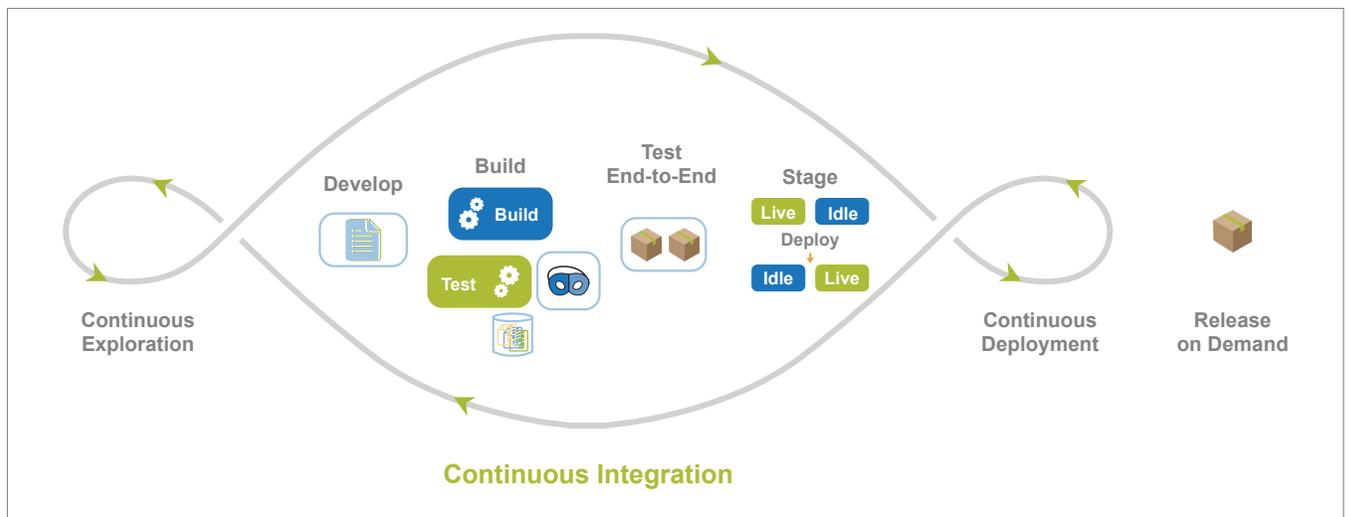

Figure 1

Continuous Integration (Source: Scaled Agile, Inc.)

2. Technology Overview

Virtualization is already here

Limited availability of vehicle electronics samples is an obvious bottleneck. How can we decrease the dependency on hardware while performing realistic End-to-End tests in the connected infotainment domain?

Hardware and software evolutions in the vehicle as a response to an increasing number of features and release cycles with new system architectures, enable running multiple software applications on a single System on a Chip (SOC). Containers – lightweight isolated domain environments have been introduced in the vehicles. Typical container separations in automotive nowadays are between the instrument cluster, the infotainment system and driver assistance systems. In modern architectures the infotainment system is already running in an isolated environment on the host OS of the SOC, making the potential migration into an emulator environment easier than ever, since the software running inside is already depending on an inter-process communication with the outer world, usually IP based.

Therefore, the first step is obvious: Virtualize the hardware and run the vehicle Infotainment Operating System like Android Automotive OS or AGL (Automotive Grade Linux) on an emulator outside of the vehicle, like a desktop PC instead of the container environment in the vehicle.

Putting an Emulator in the Cloud is the next logical Step

Together with our clients, we took next step: Integrating the emulated Operating System environment in the cloud. The cloud configurations we attempted can be grouped into different cloud environments, emulation configurations and connectivity setups. Both AWS and Google Cloud were shown to be suitable cloud providers. Emulators require the KVM Linux Kernel module. Thus, only cloud infrastructure offerings with nested virtualization or bare metal capabilities were considered as viable environments. A multitude of emulators were shown to be cloud ready. Both generalized emulators such as QEMU – open-source machine emulator and domain specific emulators such as Android's Goldfish, Cuttlefish or Trout were integrated into a cloud-based emulation setup for the purpose of our evaluation. Using containerization and cloud vendor specific features the number of running emulators can be dynamically scaled to precisely meet demands.

Connectivity to testing systems can be console-based or graphical. Both WebRTC and VNC are highly viable options for graphical connectivity. Console based standards, such as ADB, are proven options to embed emulation setups into continuous integration and testing systems.

3. NTT DATA's approach

Integration is the Key

The question we answered together with our clients was the following: How successful a cloud-based emulator can replace the hardware benches we currently use? Our conclusion is: As well as the integration you perform.

The major integration factors we identified so far are:

»» Access to the onsite network

»» Connectivity technologies enablement

»» Access to testing interfaces (in the case of Android Automotive that would be the Debugging Bridge ADB)

»» Access to the user interface

»» Dashboard and API for administration of the virtual ECU instances

The Application areas we were able to evaluate together with our clients in the integrated environment were the navigation, third party entertainment apps and basic enabling connectivity functionalities like user login.

Application areas out of scope were e.g., Apple CarPlay, Android Auto, Bluetooth connectivity.

Impressions of the PoC: Wide scaling of usable virtual Infotainment Systems on short term (and testing in parallel) is possible, connected features can be well evaluated. In addition, we detected that this environment could be used for a virtual early feature evaluation. **(see Figure 2)**
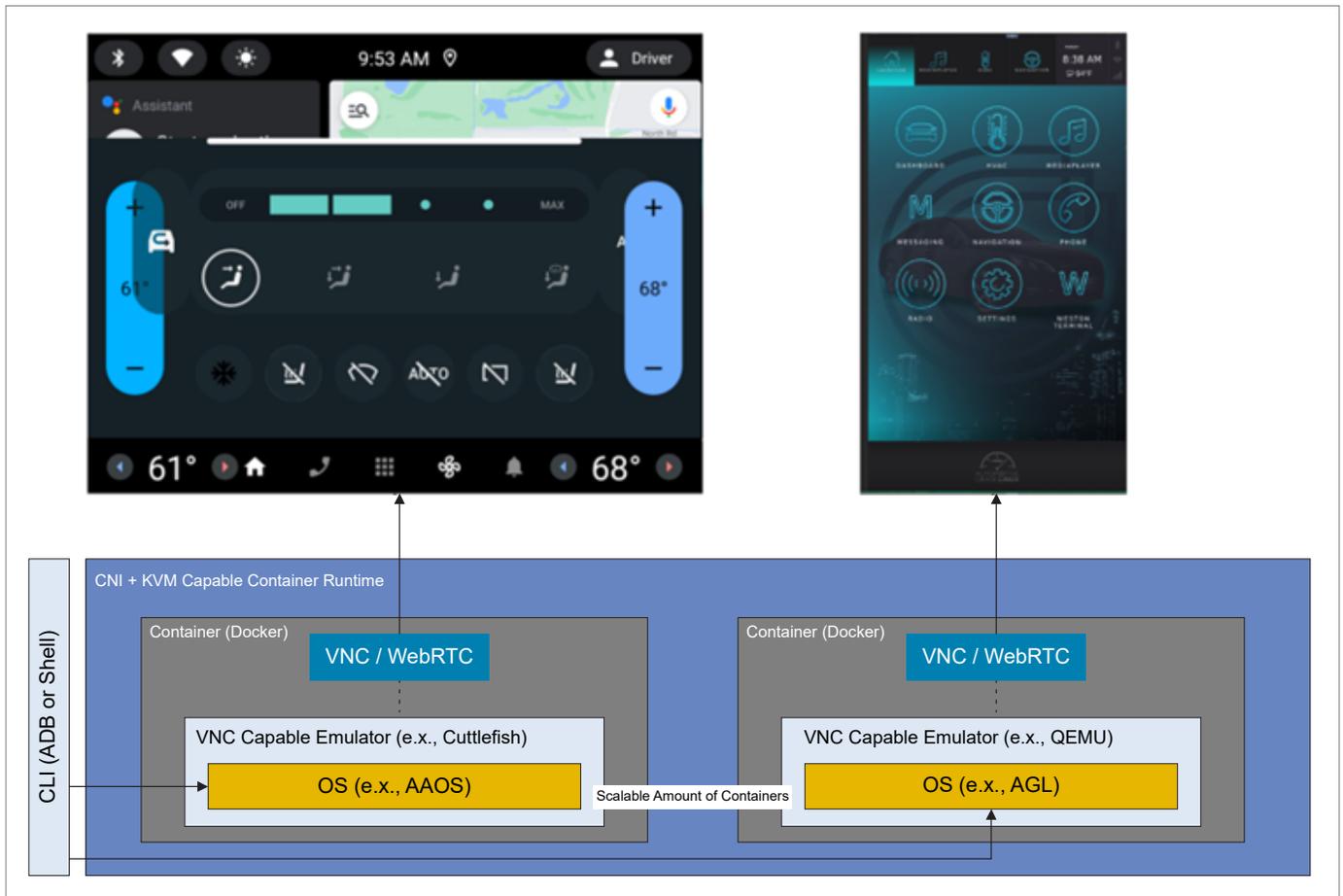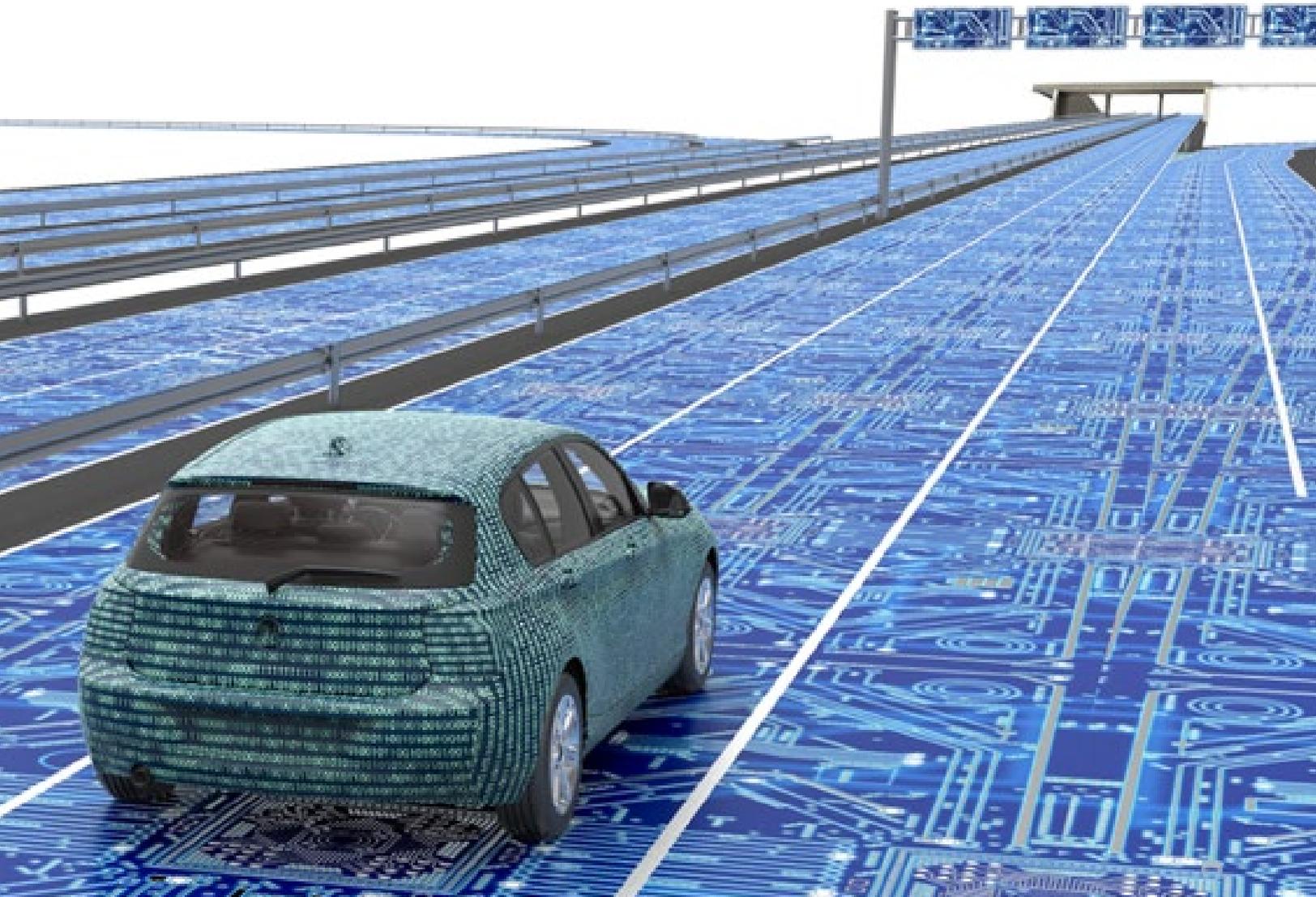

Figure 2

PoC OS Emulator in the Cloud

4. Conclusion

Cloud-based virtual testing will not completely replace the testing hardware, but cloud-based virtualization can bring major improvements in terms of time to market and costs. It not only speeds up the delivery pipeline but supports early feature evaluation prior to hardware sample availability and shows potential to become a platform for integrated virtual feature development.

Citation:

1. Continuous delivery pipeline, SAFe
   https://www.scaledagileframework.com/continuous-delivery-pipeline/

2. Testing is known as to be "the bottleneck" in any DevOps pipelines, Wolfgang Platz, The New Stack
   https://thenewstack.io/why-software-testing-remains-a-bottleneck/

References — Pictures

Figure 1: Continous integration according to SAFe / Scaled Agile Inc | https://scaledagile.com/

Figure 2: PoC OS Emulator in the Cloud

About NTT DATA

NTT DATA – a part of NTT Group – is a trusted global innovator of IT and business services headquartered in Tokyo. We help clients transform through consulting, industry solutions, business process services, IT modernization and managed services. NTT DATA enables clients, as well as society, to move confidently into the digital future. We are committed to our clients' long-term success and combine global reach with local client attention to serve them in over 50 countries.

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