Pioneering Software-Defined Vehicles - AGL SDV-Updates

Dec 8

Jerry Zhao

Chief SDV Architect, Panasonic Automotive Systems Co., Ltd.

AGL Software-Defined Vehicle Expert Group Leader

Self Introduction

Jerry, Jiancong Zhao

Joined Panasonic since graduate in 2017 and now leading the overall standardization and development activities of SDV-related virtualization

AGL SDV-EG Leader (previously Virt-EG) since 2020
➔ **5-year as an AGLer**

SOAFEE APAC Regional Hub Chair since this year
➔ **More inter-community collaboration chances**

Born: Tianjin, China

1993

University: Hong Kong

2012

Work: Yokohama, Japan

2017

Hobby:

Travel

Game

Pet

AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

Agenda

- **Why**: Industry Trends with Software-Defined Vehicles
- **What**: Architectural Changes in the Automotive World
- **How**: Decoupling Software from Hardware with Device Virtualization
- **To where**: Moving to the Next Journey - Be Realistic, Romantic & Fantastic

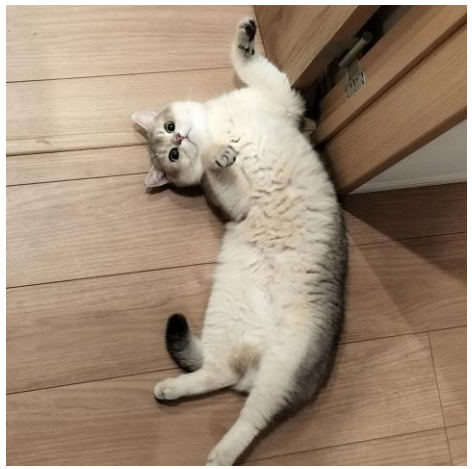
Industry Trends with Software-Defined Vehicles (SDV)

“Software-Defined”?

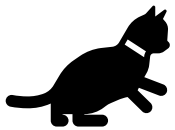
Move to new house

30m² → 80m²

How to clean my house?



How to feed my cat?



Start

HW/Mechanical Defined:
Fixed Functionality, One-time sale

Vacuum Cleaner

Pet Feeder
(Mechanical: Button & Pressure Sensor)

SW Defined:
Always updating, Continuous Subscription

Robot Vacuum

Smart Feeder
(Digital: App Control)

*Note: Vacuum & Pet Feeder Images are all generated by Gen-AI (MS Copilot)

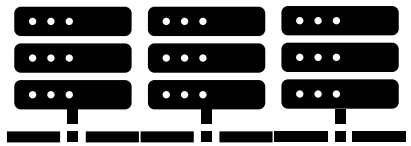
AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

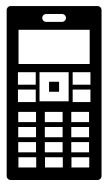
From Hardware-Defined to Software-Defined

Product value defined by hardware/mechanical

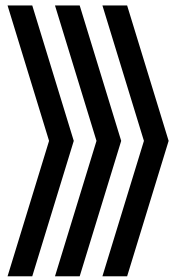
Mainframe: 1964~



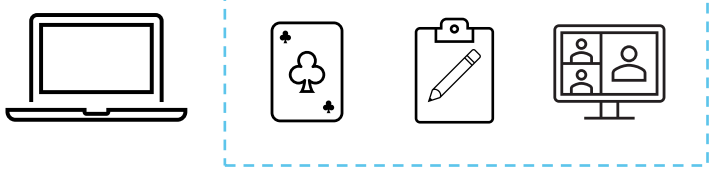
Featurephone：2000~



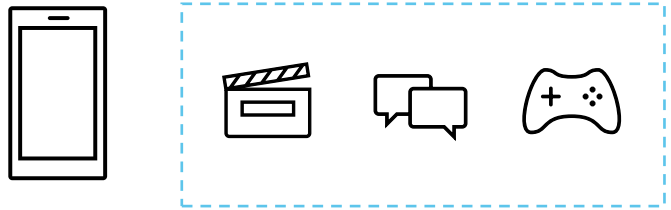
Watch：1930~



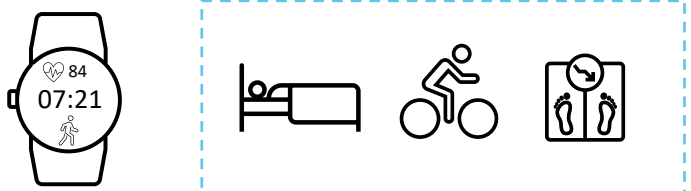
Note PC：2000~



Smartphone：2007~



Smartwatch：2010～



Product value defined by Software

SDx = Software Defined Everything

Starting from PC, various devices has become intelligent thanks to evolution of software

SDV: The Largest SDx Products

Recap of Panasonic Automotive Mizuyama's Keynote

The Future of Automotive Is Driven by Software

Panasonic AUTOMOTIVE

The Speed of Product Discovery Matters

Panasonic AUTOMOTIVE

Product Develop-ment

Measures for software that expands exponentially due to shifting to SDVs

Time To Market, resource limit, explosion of development cost

Product Discovery

Competition to "discover the right products to develop"

How fast can you reach the right product through repeated try-fail-improve?

Competitiveness in product discovery will significantly influence the advantage.

Conventional-type hardware company

Copy machine, car navigation, automotive parts
Development period: 1-3 years
(surveyed by iTiD Consulting)

IT industry

Release in approximately two-week cycles with agile development on the cloud
Amazon: Frequency of once every 11.6 seconds on average

From “Hardware First” to “Software First”

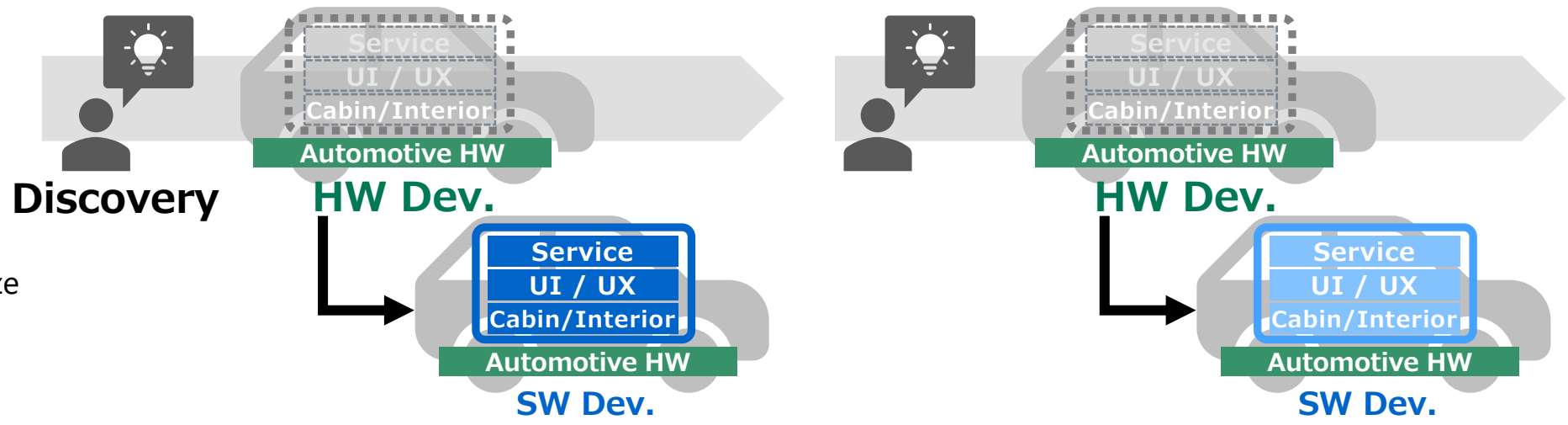
Recap of Panasonic Automotive Mizuyama’s Keynote

Evolve Software Continuously to Increase *Value*, Develop Optimal Hardware to Run it.

Legacy

Hardware First

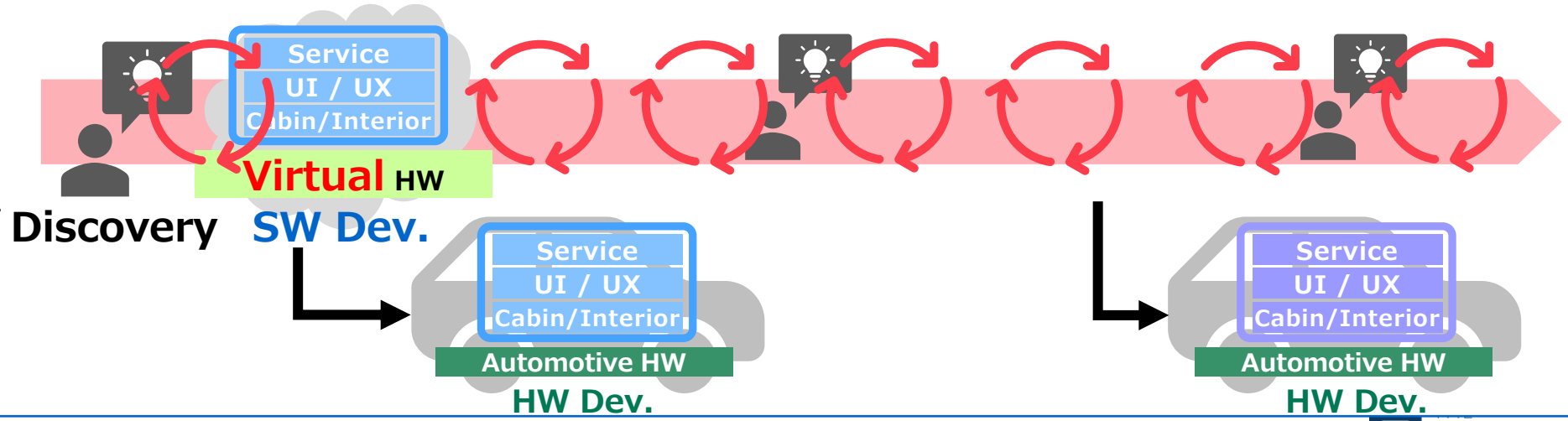
- Realizing limited value within hardware constraints.
- Long lead time to realize new value.



To Be

Software First

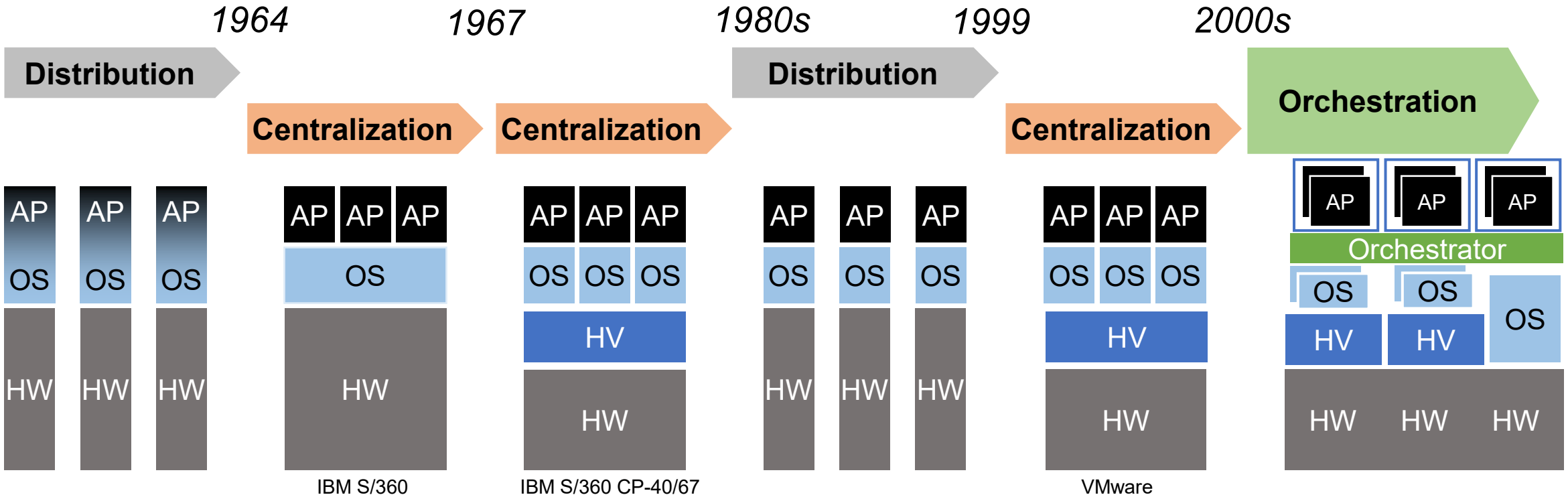
- Selecting the most suitable and latest hardware for realizing value through software.
- Faster value discovery and introduction into market.



Architectural Changes in the Automotive World

Historical Trend of General Computing Architecture (Distribution and Centralization)

The history of general computing architecture is **repeating the cycle between centralization and distribution**, and the automotive industry is following a similar path.



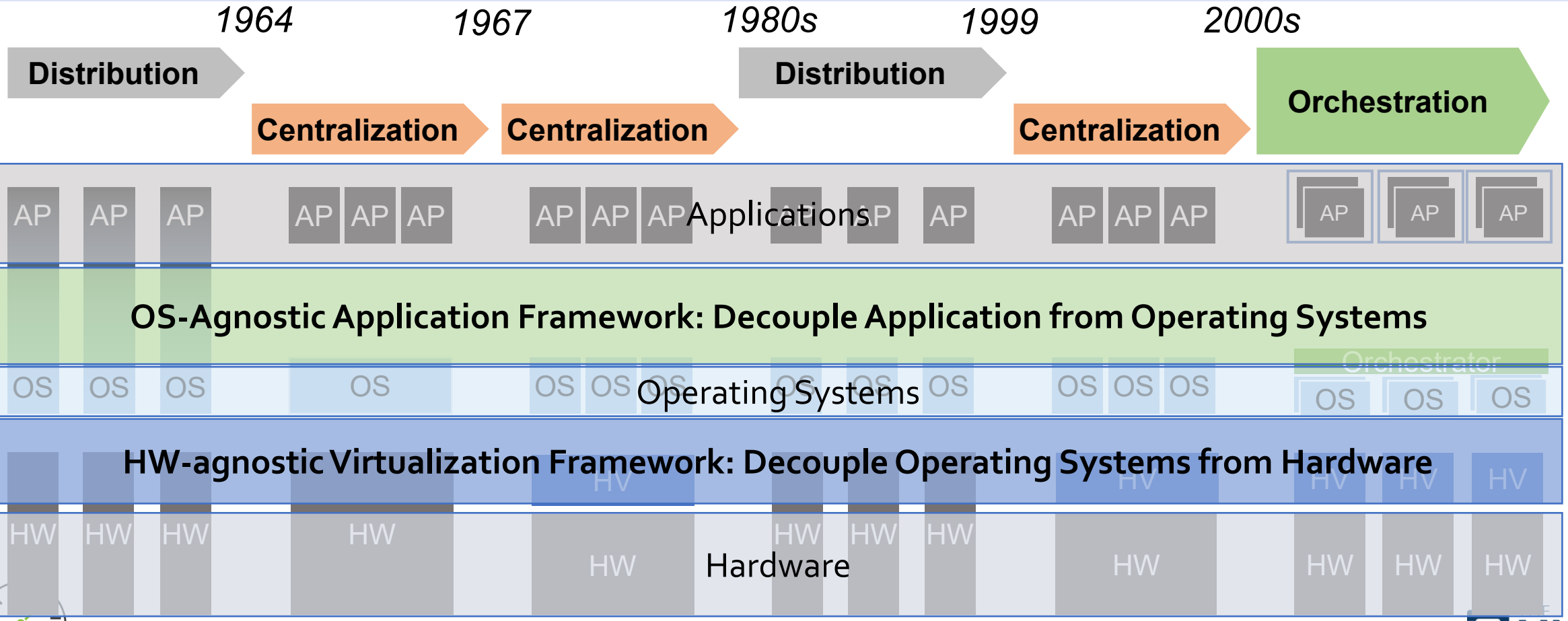
Created by Panasonic Automotive Systems referring to ITmedia IT solution cram school [Graphic explanation] History of virtualization on a single sheet
https://blogs.itmedia.co.jp/itsolutionjuku/2015/06/post_90.html

How to decouple SW and HW is always the key.

Historical Trend of General Computing Architecture (Distribution and Centralization)

No matter how the underlaying computing architecture has changed, a consistent objective is to decouple apps (directly contributed to user values) from underlying computing architecture

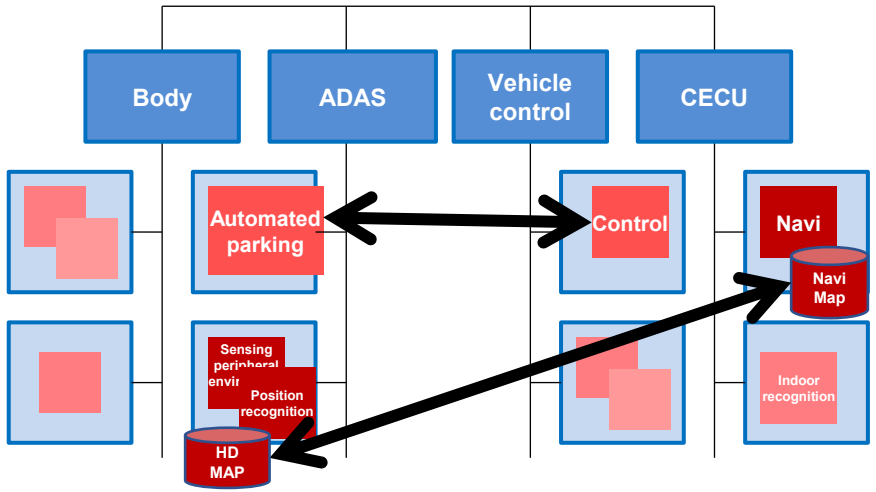
→ Keys are **Operating-System-Agnostic Application Framework** and **Hardware-Agnostic Abstraction Framework**



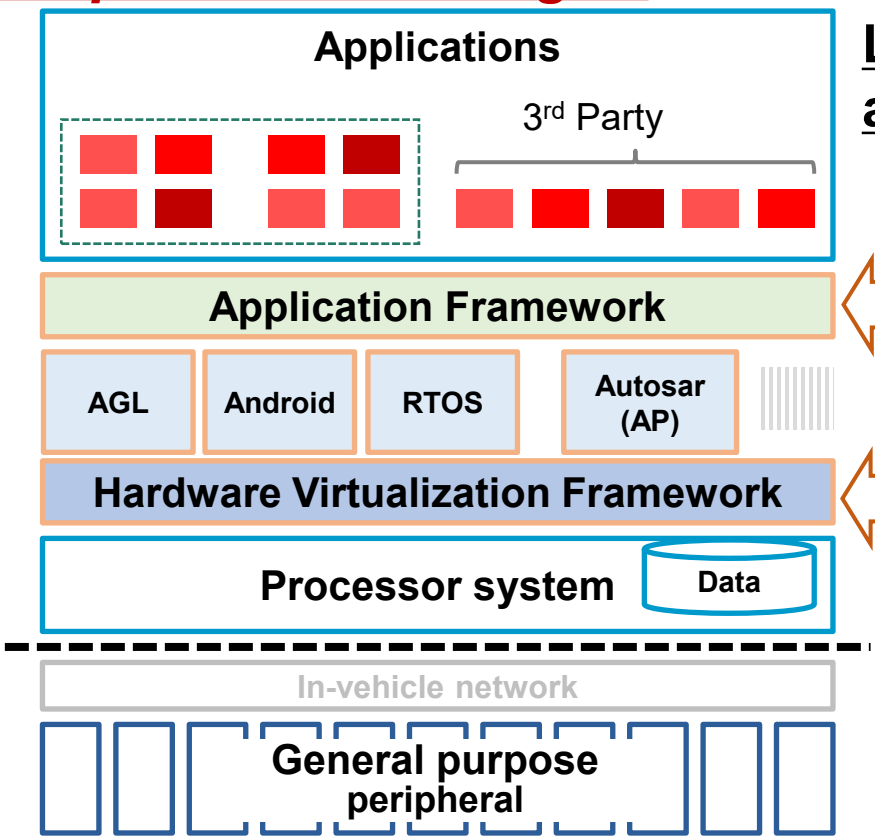
Desirable Direction of Automotive System Architecture

ECU consolidation is not a purpose but means --- **The true purpose is to establish the optimal architecture for evolution of software.**

"Those who can advance their software more rapidly will gain crucial competitive advantage."



Advancement of technology and updates are difficult.
Overlap of computing resources is an issue also.



Logical architecture

Makes Apps code simple by hiding the detail of the underlying platform

Decouples software from underlying hardware

Domain Controllers

ECUs

Applications and Data

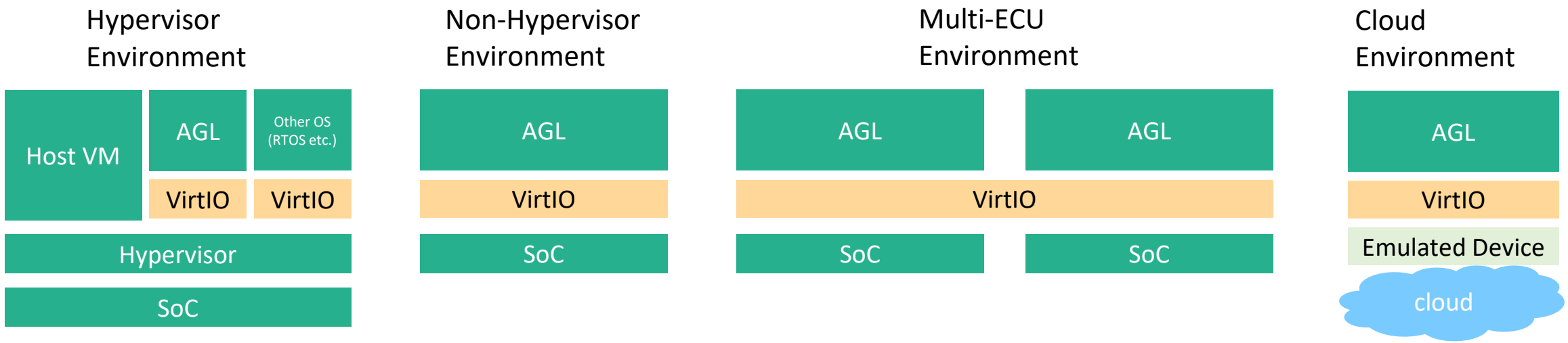
AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

Decoupling Software from Hardware with Device Virtualization

Overview of Device Virtualization in AGL - Concept

Device Virtualization with VirtIO benefits in establishing
a complete and healthy ecosystem for AGL to enhance interchangeability and interoperability in various scenarios.



VirtIO devices (HV-frontend) coverage expands.

AGL has been equipped most of fundamental VirtIO devices for CDC by 2023.

Panasonic Automotive will continue to contribute more ready-to-user VirtIO to evolve AGL implementation.

14 VirtIO Frontends

2020~2021: AGL11~12

- Block Device
- Network
- GPU
- Sound
- Console, Socket, Random Generator

2022~2023: AGL13~15

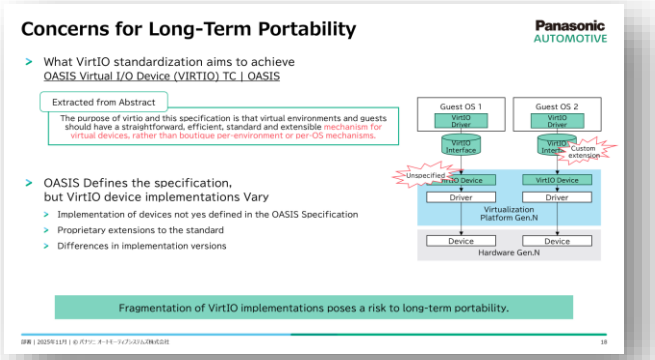
- SCMI (Sensor)
- Video
- Bluetooth
- CAN
- Camera (virtio-video based)

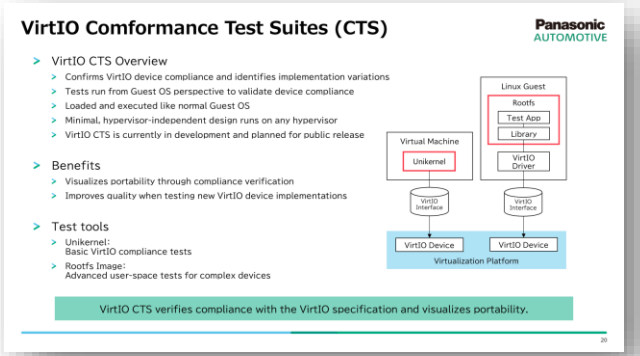
5 New VirtIO Frontends is under planning to Contribute

2026: AGL22~23

- Camera (virtio-camera based)
- GPU (Vulkan)
- Real Time Clock (RTC)
- IOMMU
- Replay Protected Memory Block (RPMB)

(New) A VirtIO CTS approach to guarantee long-term portability is also on the way





VirtIO CTS Breakout Session

For more details, check the following session on Dec 10 11:40~12:20 titled with
“**Towards a Cross-Hypervisor Test Framework for VIrtIO Backend Validation Using VirtIO CTS**”
presented by Kazuki Kuzu from Panasonic Automotive Systems

Towards a Cross-Hypervisor Test Framework for VirtIO Backend Validation Using VirtIO CTS - Kazuki Kuzu, Panasonic Automotive Systems Co., Ltd.

Wednesday December 10, 2025 11:40 - 12:20 JST

Hall B4 (4F)

VirtIO plays a key role in virtualization environments such as QEMU and KVM, enabling efficient device virtualization. However, testing backend implementations for VirtIO devices remains a challenge due to the lack of standardized testing tools. In this session, we introduce our ongoing work on integrating and customizing the VirtIO Conformance Test Suite (VirtIO CTS) to validate VirtIO backend implementations.

Speakers

Kazuki Kuzu

Software Engineer, Panasonic Automotive Systems Co., Ltd.

Kazuki Kuzu has five years of experience at Panasonic Automotive Systems Corporation, focusing on the development and research of virtualization for automotive embedded operating systems. He is committed to contributing to the field of automotive software. Outside of work, He enjoys... Read More →

AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

VirtIO Work for Non-Hypervisor Environment

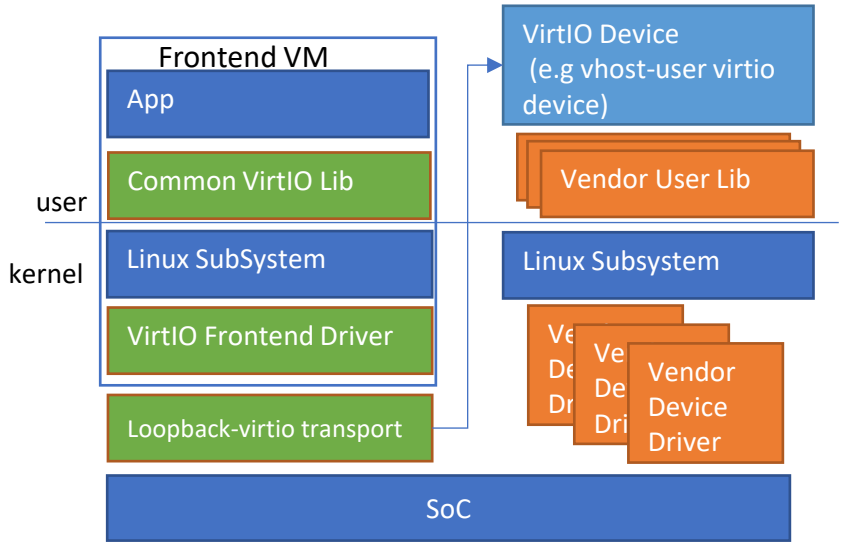
Non-Hypervisor Environment

- Finished Design & Implementation of a common virtio-based HAL layer “virtio-loopback” portable to execute on both native and virtual environments with basic devices support
- Completed conceptual development of multi-container use case

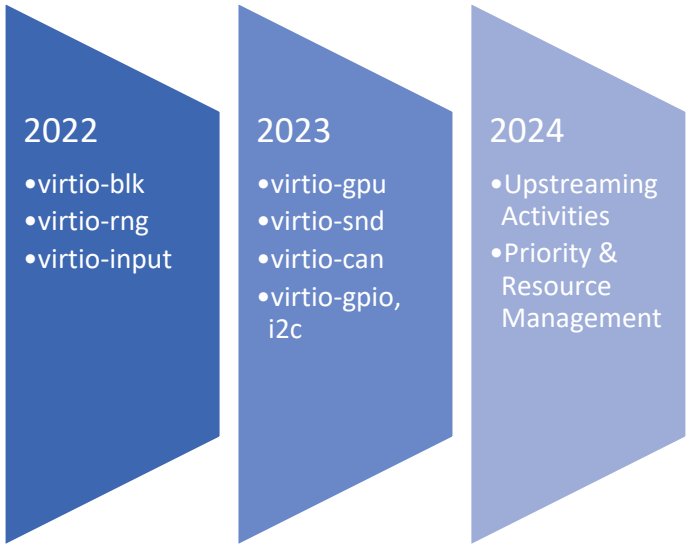
Priority of Device Virtualization Voted by each AGL EG (2021)

Device	Total Score	Priority
Input Device	29	1
Display	27	2
GPU	26	3
CAN bus	20	4
Block Device	19	5
Audio	18	6
Ethernet	11	7
Bluetooth	9	8
SPI	8	9
Serial console	8	9
SCMI	8	9

High Level Architecture Design



Status and Future Plan

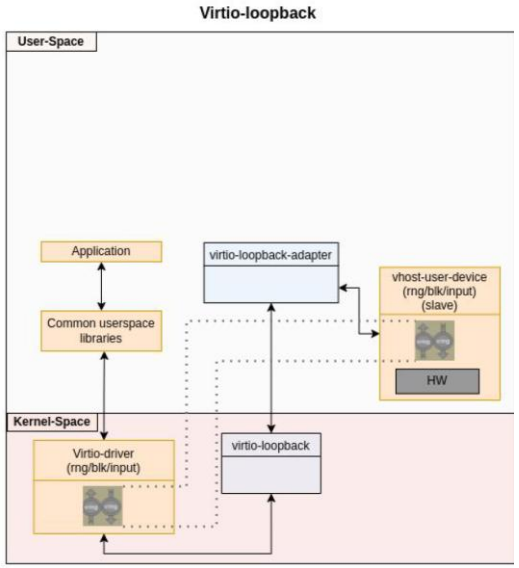


AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

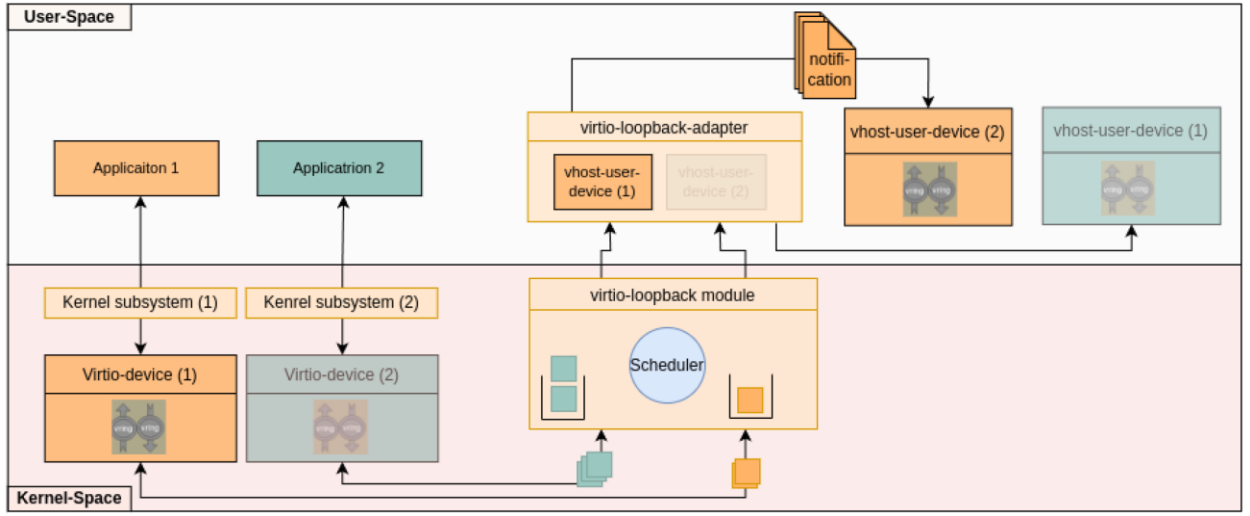
Non-virtual (=w/o HV) VirtIO evolves.

(2022~2023) Design & Implement Non-virt VirtIO for basic devices

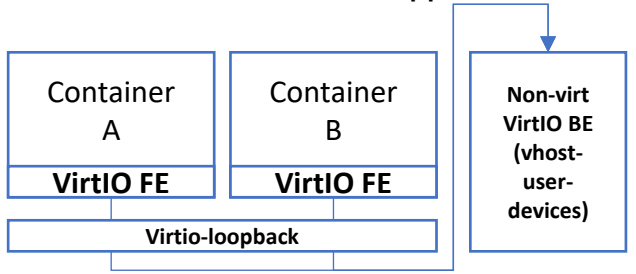


- Implementation First:
  Already applied Non-virt architecture to virtio-blk, net, rng, console, input, snd, gpio, can, **gpu(experimental work now)**
- Upstreaming Continuously:
  - Some device backend (CAN/console) merged to rust-vmm
  - virtio-loopback proposed to kernel upstream and discussion undergoing for merge

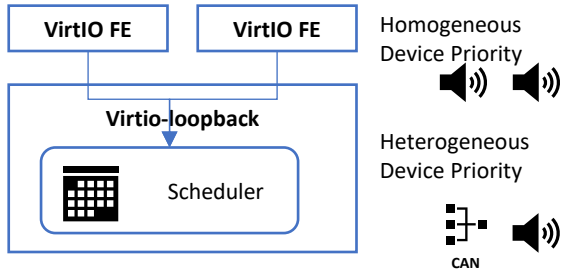
(2024) Design and PoC implementation for Multi-Container Use Cases



Resource Management:
Multi-instance Access from Apps/Containers



Priority Management:
Homogeneous & Heterogeneous Devices



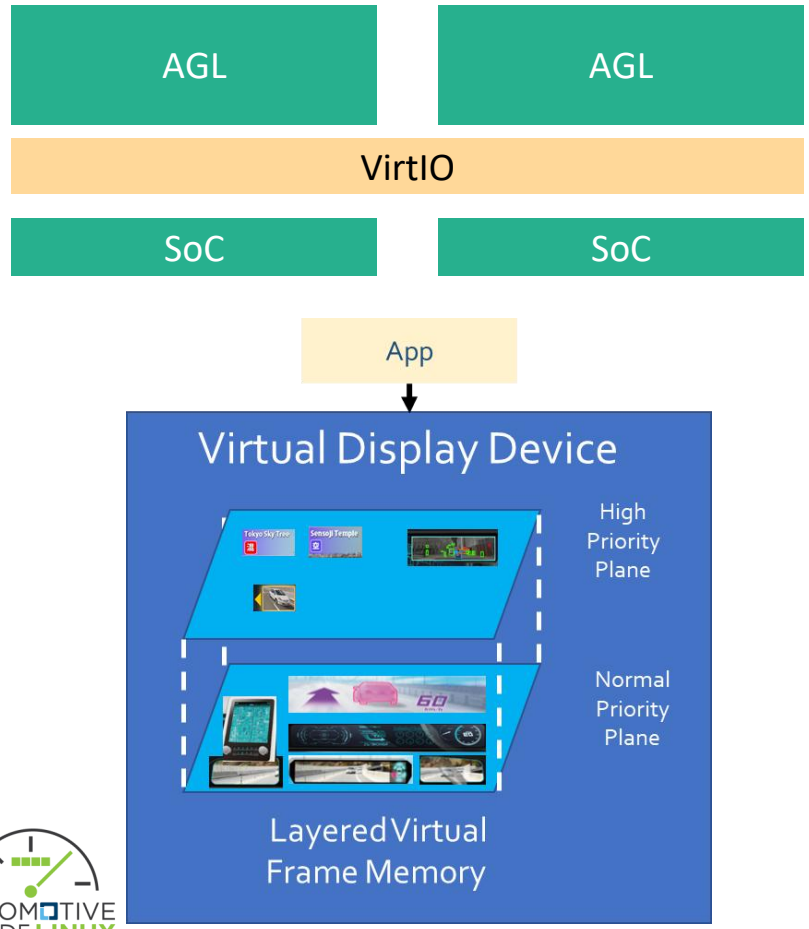
AUTOMOTIVE GRADE LINUX

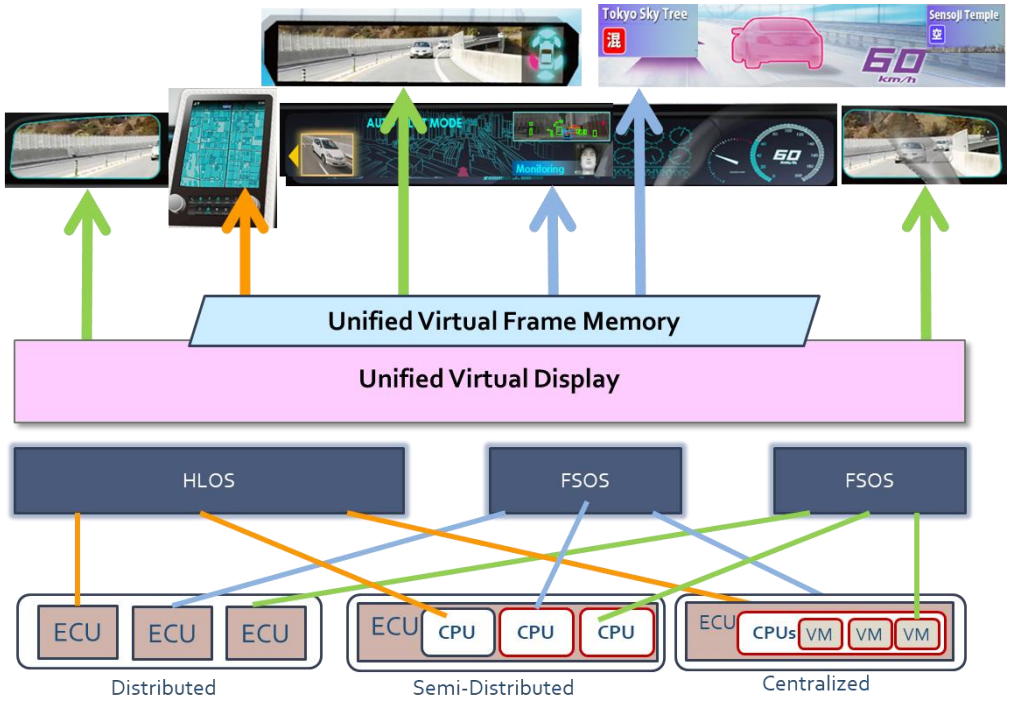
THE LINUX FOUNDATION

VirtIO Work for Multi-ECU

A Unified Virtual Display based on VirtIO-GPU (“Unified HMI” technology) can be established to have Integrated control of multiple display on distributed SoC systems

Multi-ECU Environment





- **Mappig multiple physical displays** of cockpit & cabin into a **single large virtual display**
- **Rendering each application** to its **arbitrary region**

Unified HMI architecture

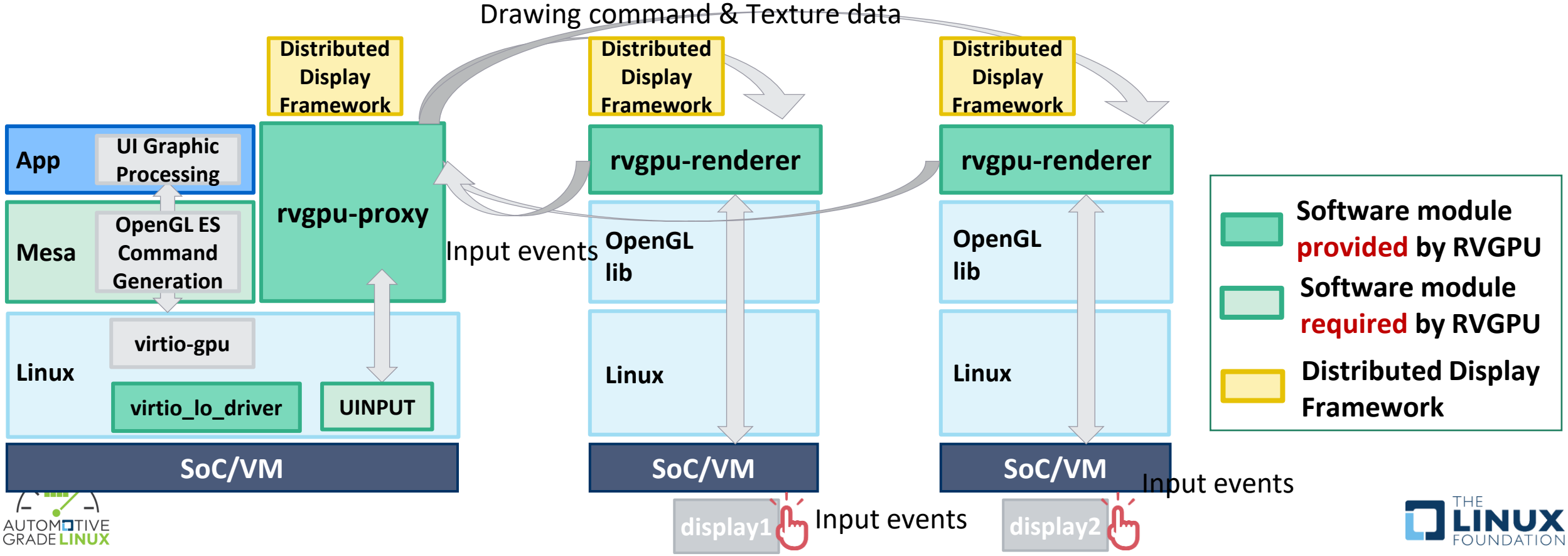
Consists of two main components.

1. **Remote Virtio GPU Device(RVGPU)**：Render apps remotely in different SoCs/VMs.

Already available in AGL UCB since PP (2024.2)

2. **Distributed Display Framework (DDFW)**：Flexible layout control of apps across multiple displays.

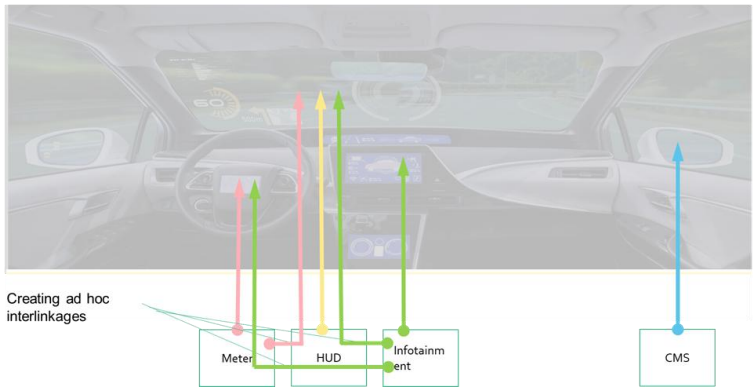
Available in AGL UCB since RR (2024.9)



Use of Unified HMI

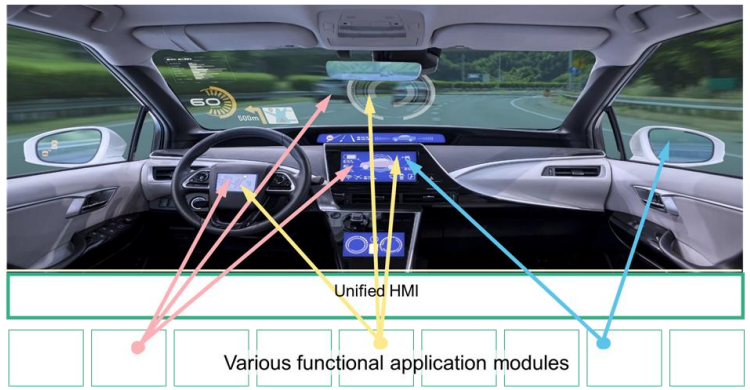
Legacy HMI System

Strict Restriction on ECU & Function-Display Relationship causing harmful Impediment for Cockpit UX



Unified HMI System

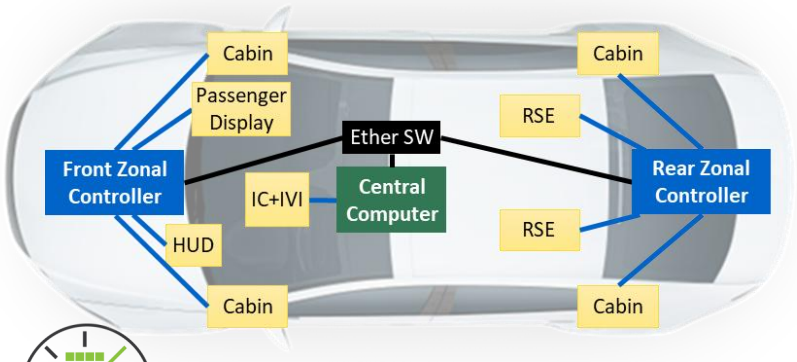
Full Flexibility on ECU & Function-Display Relationship for Cockpit UX Innovation



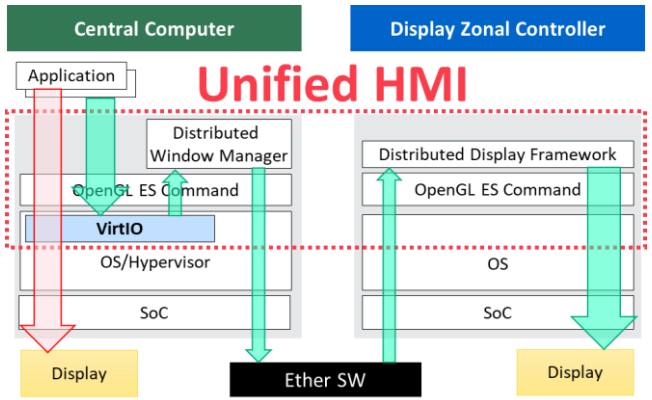
A Big Virtual Display:
From 1-Source-1-Sink
to Many-Sources-Many-Sinks

- Allow applications to flexibly show on different displays (even cross-displays)

Concept of Display Zonal Architecture



Implementation /w UHMI



A Flexible Distribution FW:
From Centralization / Distribution (limited choice)
to Centralization & Distribution (flexible choices)

- Centralize all the applications (cpu computing) and distribute graphic rending (gpu computing) only
- Centralize at first and distribute flexibly when necessary for later generations or different grades.

(PoC in collaboration with Arm)

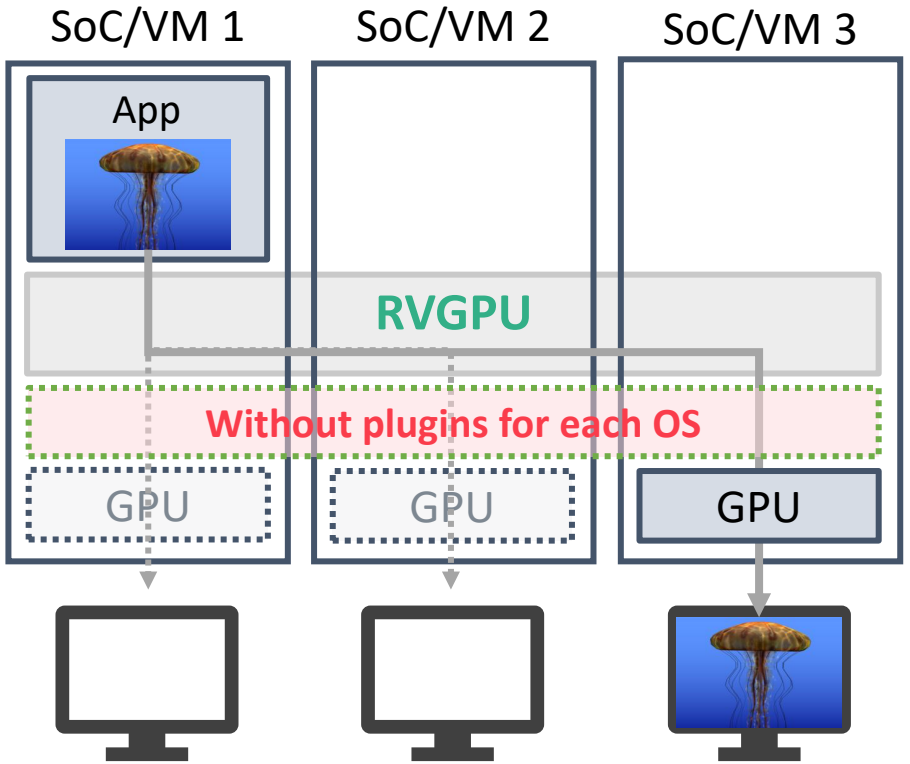
AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

Upgrade to Unified HMI 2.0

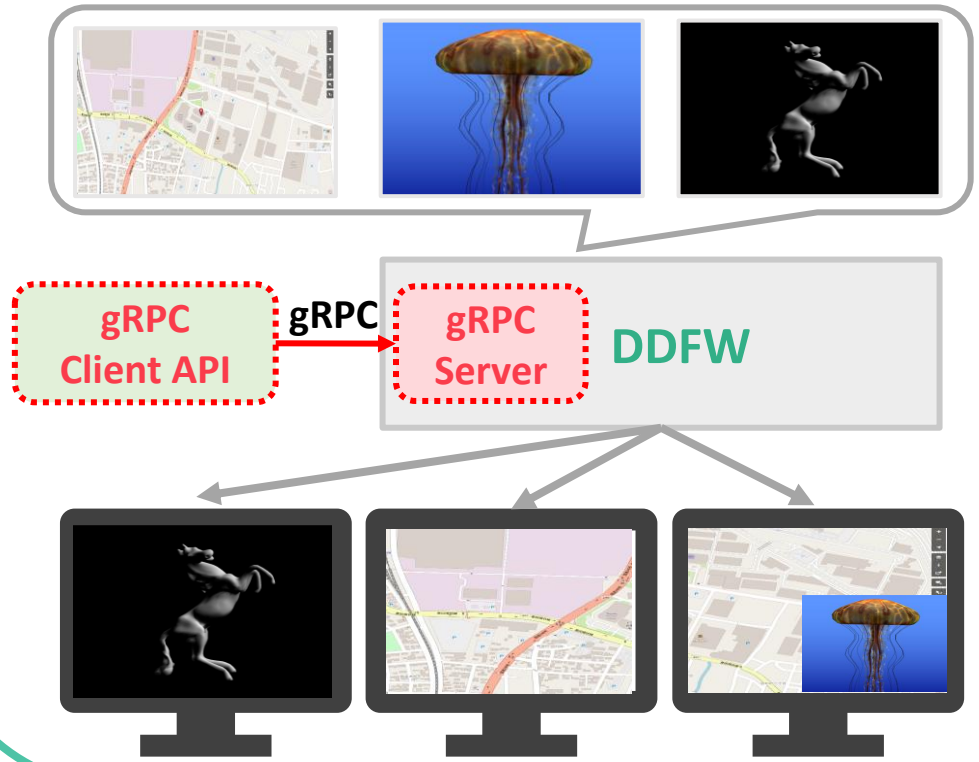
Remote VirtIO GPU Device(RVGPU)

- ✓ Architecture changed to reduce window system dependency.



Distributed Display Framework(DDFW)

- ✓ Extend to multiple programming languages.
- ✓ Adding lifecycle management feature.

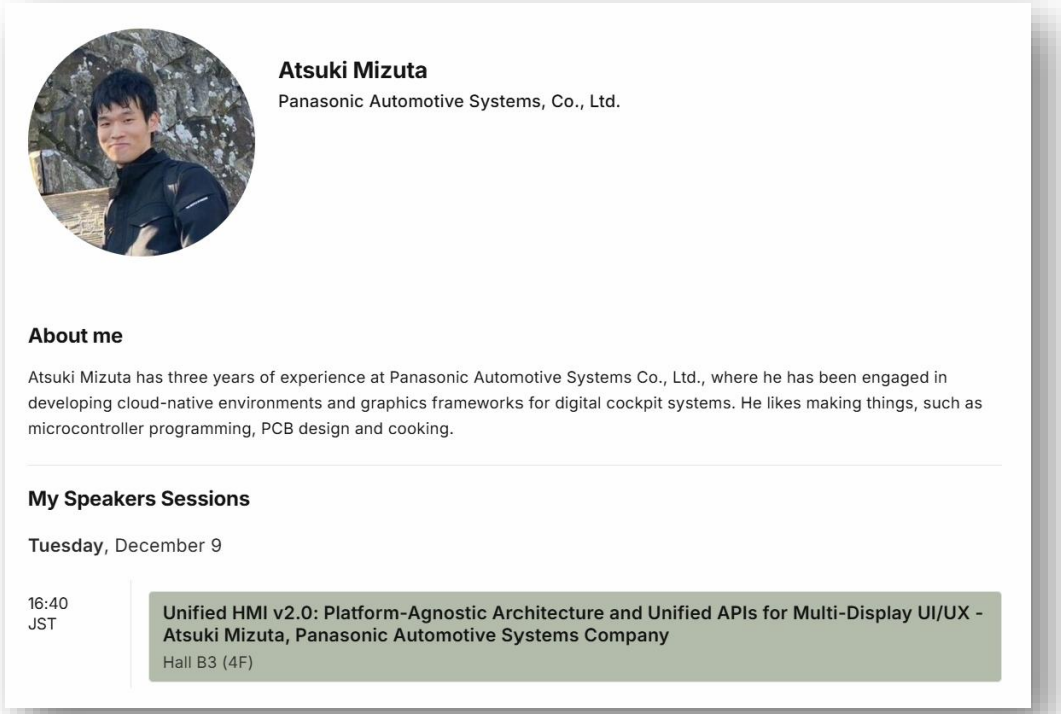


Unified HMI Breakout

Thanks to Murakami-san, who presented about Unified HMI in OSSJ last year, the Unified HMI 2.0 has been alive on both Unified HMI Github and AGL UCB .

Having a parental leave and first time to be a father
→ Send blessing message to him on AGL Discord!

Mizuta-san in his fourth year in Panasonic and 5th month in Unified HMI , will give a deep-in-dive on Unified HMI 2.0 on Dec 9 16:40~17:20.



Atsuki Mizuta
Panasonic Automotive Systems, Co., Ltd.

About me

Atsuki Mizuta has three years of experience at Panasonic Automotive Systems Co., Ltd., where he has been engaged in developing cloud-native environments and graphics frameworks for digital cockpit systems. He likes making things, such as microcontroller programming, PCB design and cooking.

My Speakers Sessions

Tuesday, December 9

16:40 JST

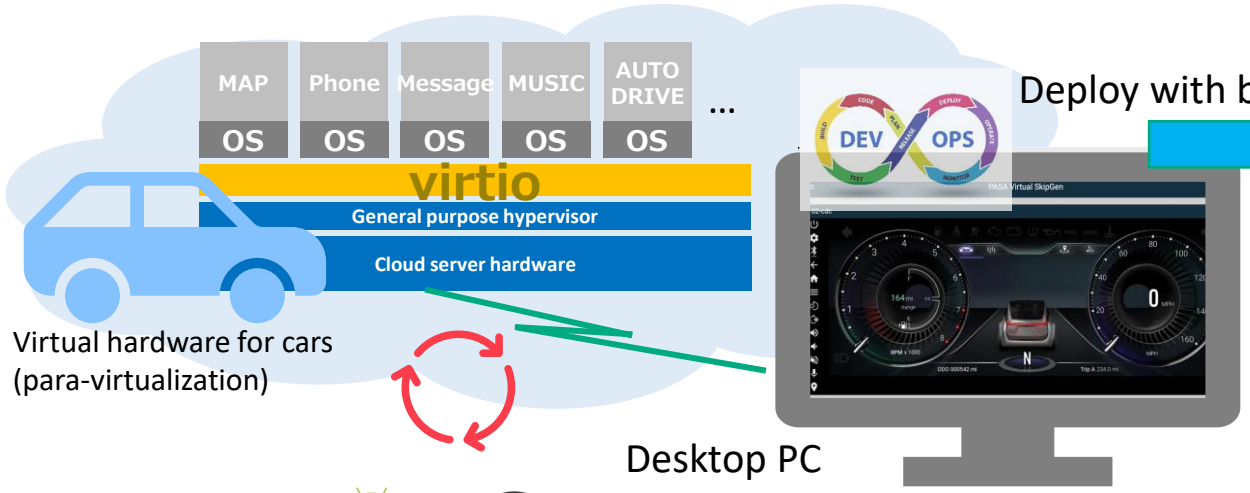
Unified HMI v2.0: Platform-Agnostic Architecture and Unified APIs for Multi-Display UI/UX - Atsuki Mizuta, Panasonic Automotive Systems Company
Hall B3 (4F)

See live Unified HMI demo in Panasonic Booth

VirtIO for Cloud

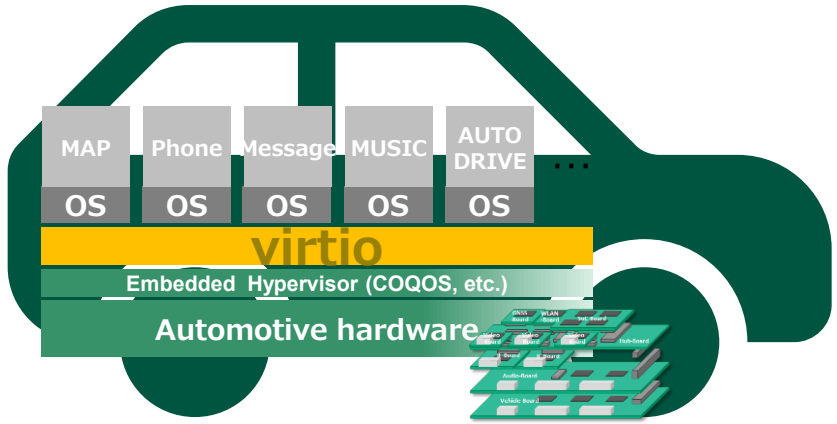
Virtual SkipGen: Achieving binary compatibility in cloud-automotive hardware through VirtIO

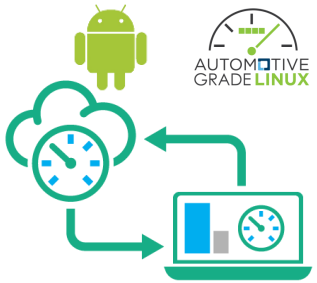
High-efficiency development with Cloud-Native



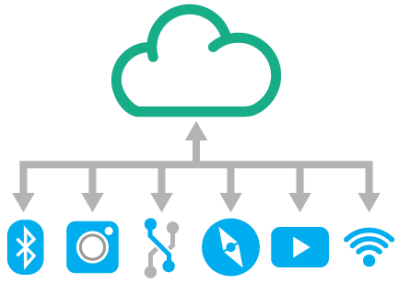
Deploy with binary compatibility

Real World

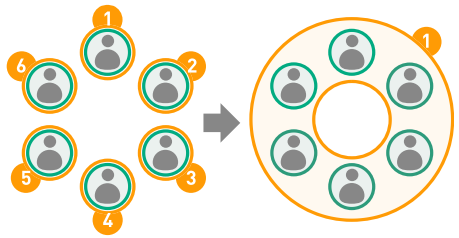




Fully VirtIO Compliant Virtual CDC Reference Platform



Various Virtual Peripheral Devices supported



Multiple vSkipGens on the same cloud server

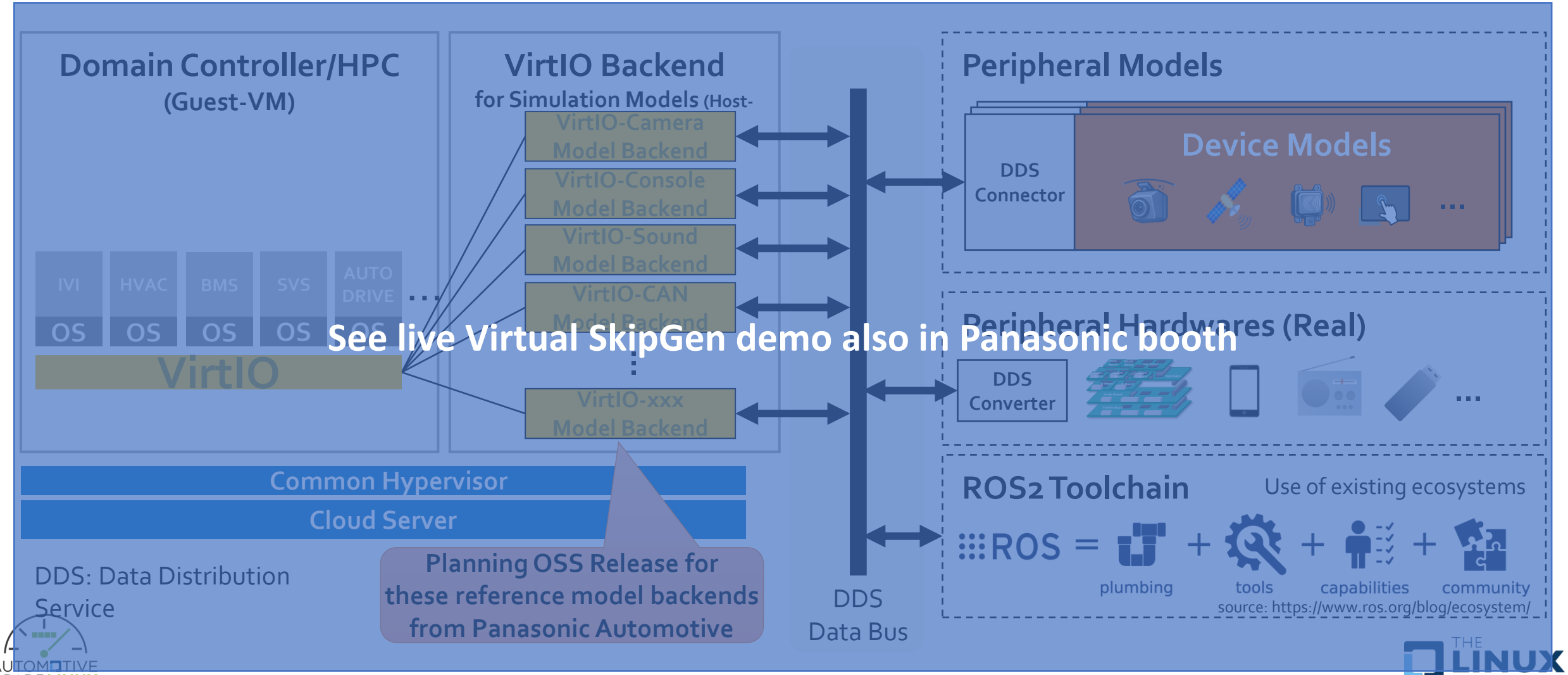
AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

Coupling of Cloud-native with MBD Models or Other Simulated External Systems

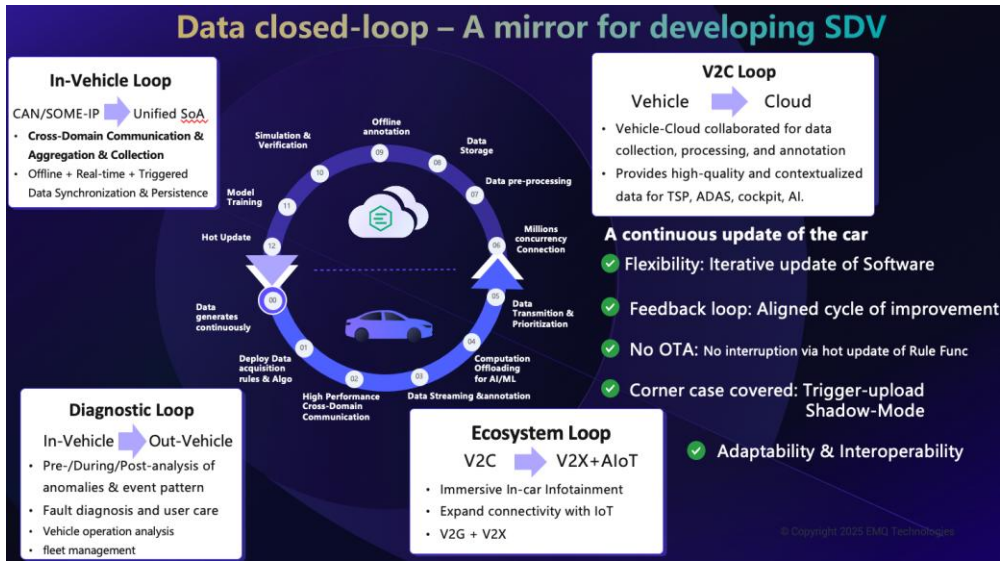
Recap of Panasonic Automotive Mizuyama's Keynote

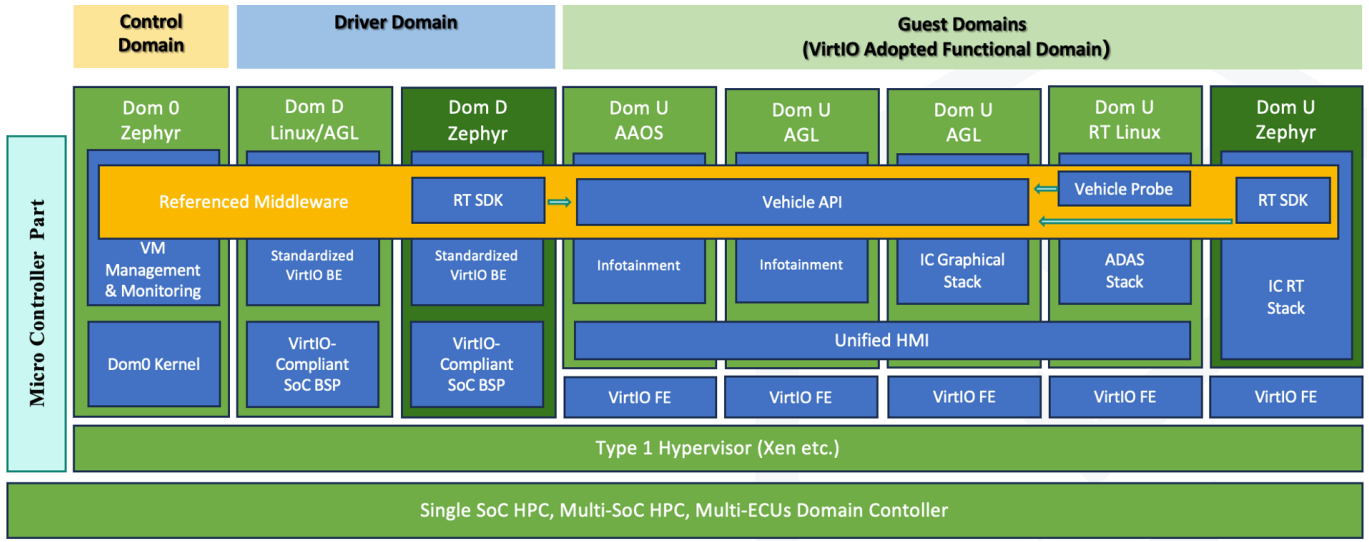
Accelerate model standardization and reuse through a VirtIO-compliant Model interface backend



SDV-EG Beyond Virtualization

- Thanks to Jaylin from EMQ proposal, SDV-EG triggered new activities towards data-closed-loop this year, aiming to create an interoperable layer of VSS/VISS with MQTT





SDV-EG Beyond Virtualization

Check Jaylin's session on their practice in deploying OSS in automotive production on Dec 10 14:00~14:40.

Driving Safety Forward: Lessons Learned From Deploying OSS in Real-world Automotive - Jaylin Yu, EMQ

Wednesday December 10, 2025 14:00 - 14:40 JST

Meeting Room 1 (5F)

While OSS in Automotive is seen as the holy grail to solve SDV complexity challenges with faster time to market and higher performance, it still lacks practical real-world examples and showcases that address OSS usage in compliance with the stringent safety and security demands of Automotive.
In this talk, the author shares his real-world story of bringing OSS into mass production vehicles. This includes the impact of a healthy open-source community and how academic research helped solve security gaps, leading to increased system stability. This also embraces the impact of the software supply chain, providing a proven approach, refined through failures, helping to lower dependency risk for MQTT-based remote vehicle diagnostics.
The session is rounded out by highlighting the link between system utilities and safety functions, covering time synchronization, dependency management, and data integrity within a Linux system, which impact the selection of a file system, and what happens when a customer suddenly requires STR.
The audience will leave the session with a holistic impression of what to consider when creating a secure, safe, OSS-based SDV automotive system.

Speakers

Jaylin Yu
Solution VP, EMQ

Jaylin Yu graduated from CUHK, and previously worked as a Data analyst at UN ESCAP. holds several papers and patents on edge computing & networking. He has devoted himself to IoT, SDV and edge computing for more than ten years as a geek and has rich experience in the collaborative...
Read More →

To Where: Moving to the Next Journey with AGL SDV Reference Platform

AGL SDV Reference Platform – AGL SoDeV

SoDeV is a new AGL SDV-EG initiative offering an open-source SDV reference by integrating the AGL Unified Code Base with various Linux Foundation and Automotive Grade Linux projects.

AGL SoDeV's Key Technical Components

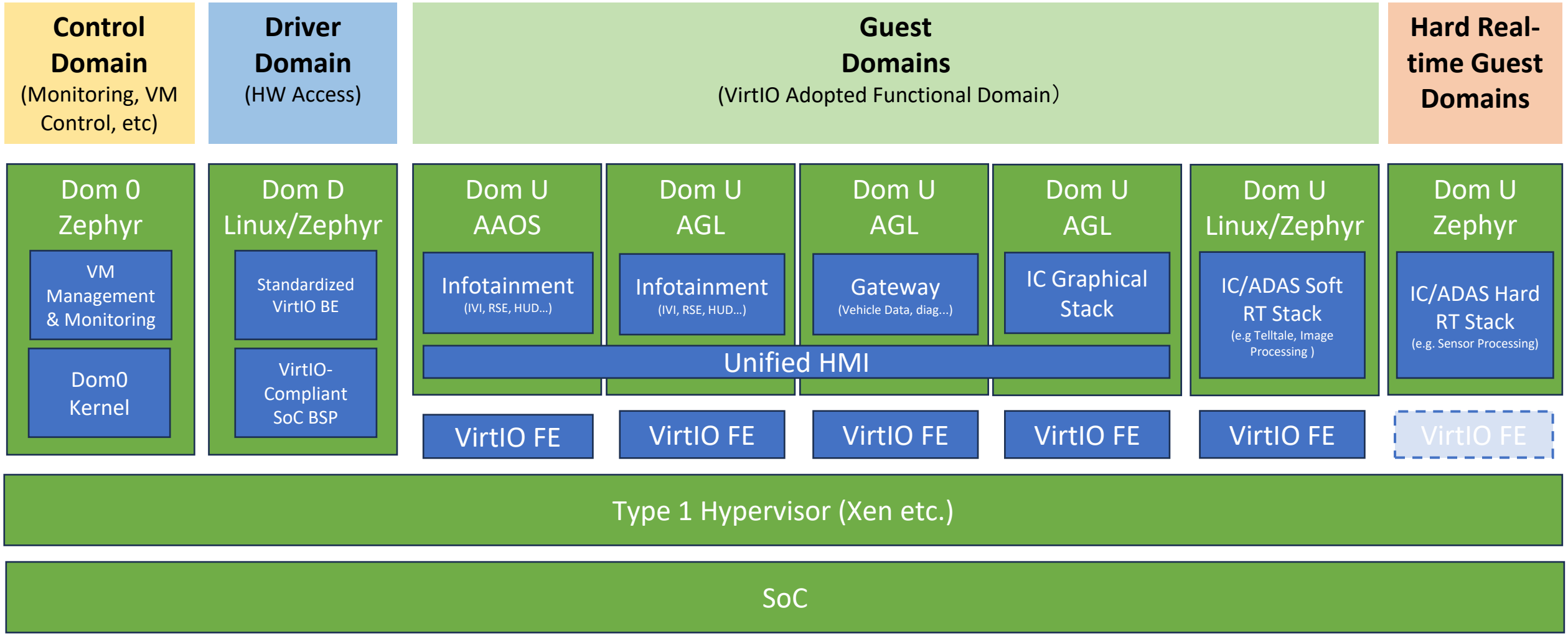
UNIFIED HMI	VirtIO	Xen Project	yocto PROJECT	Zephyr
A flexible multi-display virtualization framework contributed to AGL by Panasonic.	An common interface for device virtualization standardized by OASIS and in the Linux Kernel.	Type 1 hypervisor used widely and hosted at the Linux Foundation.	Enables developers to build custom Linux images for embedded systems.	Provides a secure, modular RTOS for IoT and embedded systems.

and more SDV enablers to be integrated and incubated…

AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

AGL SDV Reference Platform - SoDeV

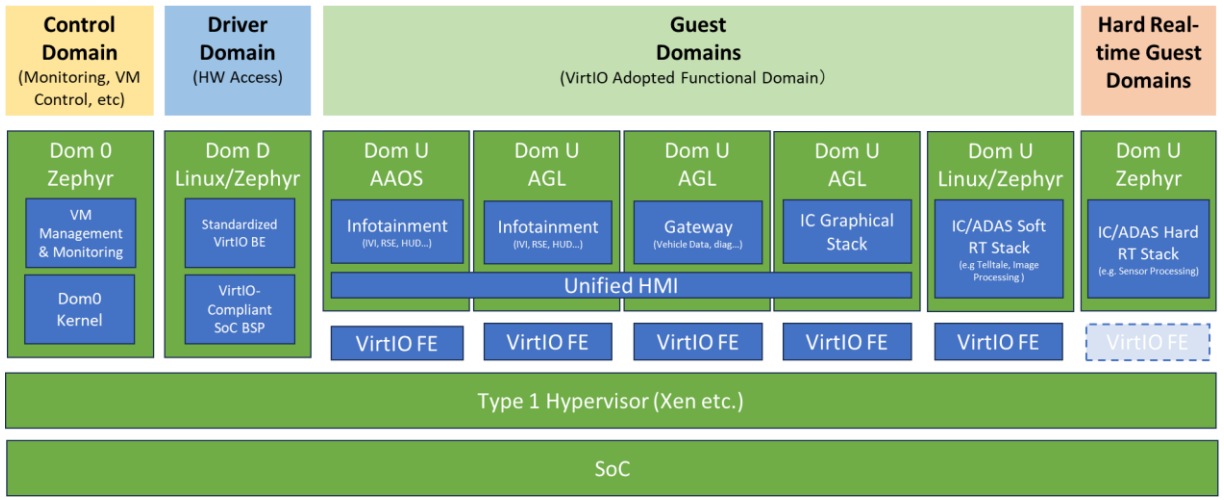


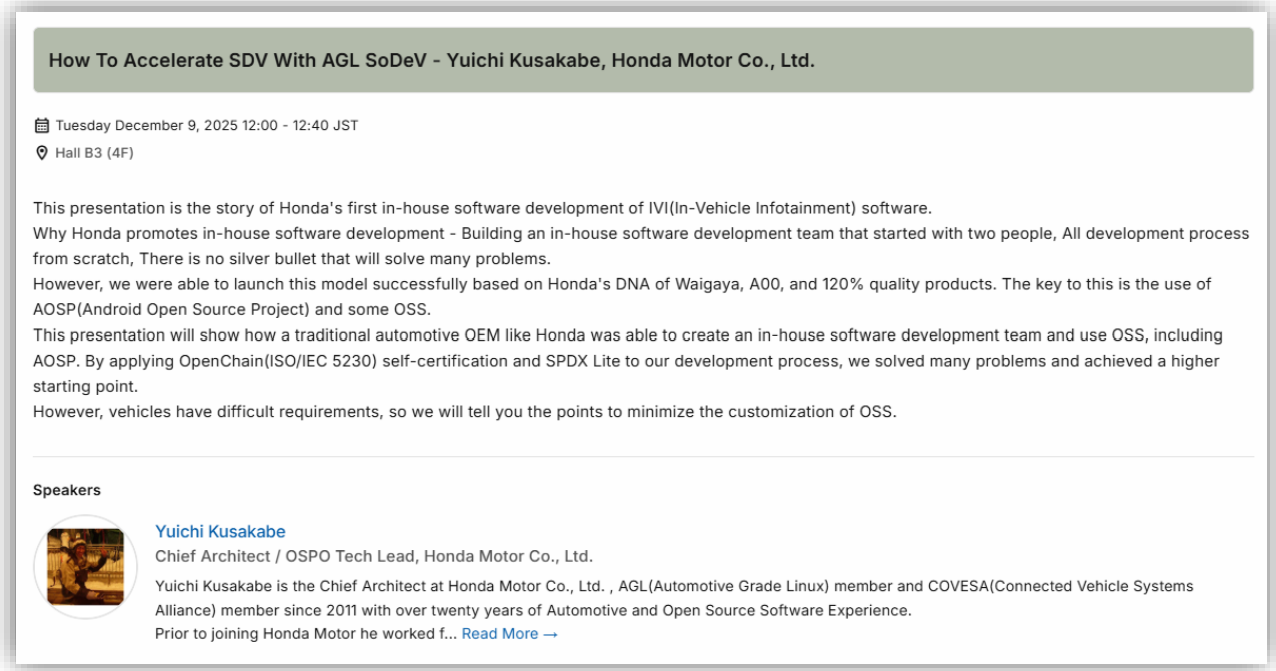
AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

Series of AGL SoDeV Breakout Sessions

Check the overall SoDeV introduction session on Dec 9 12:00~12:40 titled with
“**How to Accelerate SDV with AGL SDV Reference PF**” presented by
Kusakabe-san from Honda, Co-leader for AGL SDV-EG





How To Accelerate SDV With AGL SoDeV - Yuichi Kusakabe, Honda Motor Co., Ltd.

Tuesday December 9, 2025 12:00 - 12:40 JST
Hall B3 (4F)

This presentation is the story of Honda's first in-house software development of IVI(In-Vehicle Infotainment) software.
Why Honda promotes in-house software development - Building an in-house software development team that started with two people, All development process from scratch, There is no silver bullet that will solve many problems.
However, we were able to launch this model successfully based on Honda's DNA of Waigaya, A00, and 120% quality products. The key to this is the use of AOSP(Android Open Source Project) and some OSS.
This presentation will show how a traditional automotive OEM like Honda was able to create an in-house software development team and use OSS, including AOSP. By applying OpenChain(ISO/IEC 5230) self-certification and SPDX Lite to our development process, we solved many problems and achieved a higher starting point.
However, vehicles have difficult requirements, so we will tell you the points to minimize the customization of OSS.

Speakers

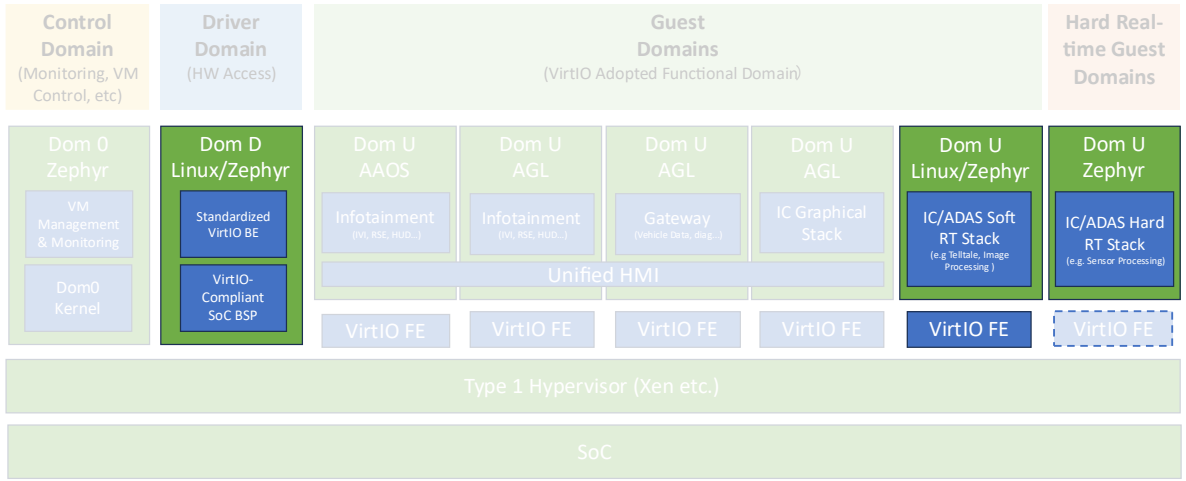
Yuichi Kusakabe
Chief Architect / OSPO Tech Lead, Honda Motor Co., Ltd.
Yuichi Kusakabe is the Chief Architect at Honda Motor Co., Ltd. , AGL(Automotive Grade Linux) member and COVESA(Connected Vehicle Systems Alliance) member since 2011 with over twenty years of Automotive and Open Source Software Experience.
Prior to joining Honda Motor he worked f... Read More →

AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

Series of AGL SoDeV Breakout Sessions

Check the Zephyr Deep-in-Dive session on Dec 9 12:00~12:40 titled with
“**Zephyr-Based VIRTIO Backend on Xen: Toward Open Source Functional Safety”** presented by
Tokita-san from Fujitsu



Zephyr-Based VIRTIO Backend on Xen: Toward Open Source Functional Safety - Hiroshi Tokita

Tuesday December 9, 2025 12:00 - 12:40 JST
Hall B2 (4F)

Xen’s Driver Domain model traditionally embeds a full Linux guest—capable, but anything but lean.
This session introduces the ground-breaking Zephyr-based VIRTIO backend for Xen, crafted by Hiroshi Tokita, which shrinks the trusted computing base to well under 1MB. A Zephyr driver domain boots in mere tens of milliseconds and runs on only a few kilobytes of RAM.

These savings unlock a new design space: multiple, purpose-built driver domains can coexist, each VM hosting just one—or a handful of—device classes. A faulty network stack no longer imperils storage or graphics, delivering micro-kernel-style fault isolation while preserving Xen’s proven architecture.
The tiny footprint also simplifies certification. A minimal RTOS is far easier to audit, bringing open-source functional safety within reach for automotive, robotics, and other high-integrity workloads.

This talk outlines the architecture, current upstream status, and the path to mainline. Attendees will leave with build recipes, integration tips, and concrete first issues—ready to help turn a trimmer Xen into a heavyweight option at the edge.

Speakers

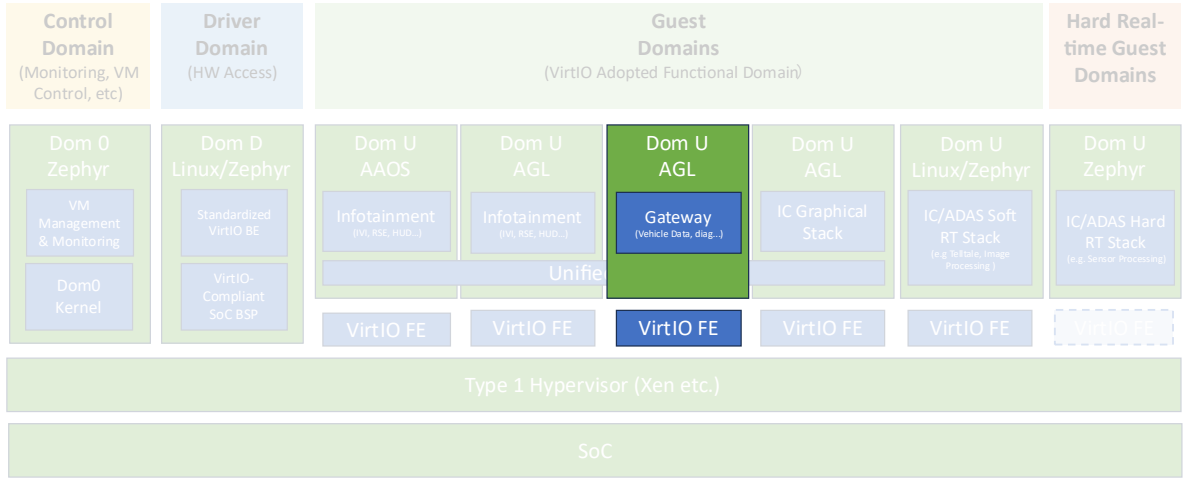
Tokita Hiroshi
Embedded system engineer
TOKITA Hiroshi has been working as an embedded systems developer for 20 years.
He mainly has knowledge of in-vehicle Linux, especially in the infotainment area.
He is also involved in the Japanese translation of KiCad, and is involved in development and writing activities spanning... Read More →

AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

Series of AGL SoDeV Breakout Sessions

Check the SOVD & Virtual Fleets Deep-in-Dive session on Dec 9 11:10~11:50 titled with
“**SDV-Oriented Use Cases Leveraging Next-Generation Vehicle Diagnostics(SOVD) and Virtual Fleets**”
presented by **Itoh-san** from Toyota



SDV-Oriented Use Cases Leveraging Next-Generation Vehicle Diagnostics(SOVD) and Virtual Fleets - Masanori Itoh, Toyota Motor Corporation

Tuesday December 9, 2025 11:10 - 11:50 JST

Hall B3 (4F)

This session introduces SDV use cases enabled by the next-generation vehicle diagnostics standard, SOVD. We explore how vehicle and environmental data can be exchanged between vehicles and edge nodes, enabling advanced services that go beyond the capabilities of individual vehicles.

The use cases are based on a PoC currently under discussion within AECC in collaboration with AutoCore. The PoC environment is built primarily using open-source software in a virtualized setup. Specifically, AGL is used as the in-vehicle OS, with each AGL instance running an SOVD server to acquire and control vehicle data.

Each virtual vehicle is composed of multiple AGL instances, and multiple virtual vehicles are orchestrated as a fleet using the Virtual Vehicle Fleet(VVF) Manager, previously introduced. Connectivity is emulated within the virtual environment, demonstrating the effectiveness of virtual development platforms for SDV scenarios.

One highlighted use case involves V2X communication via cellular networks or Wi-Fi, where environmental data is shared among nearby vehicles. This enables cooperative services that cannot be achieved by a single vehicle alone, showcasing the potential of SDV concept.

Speakers

Masanori Itoh

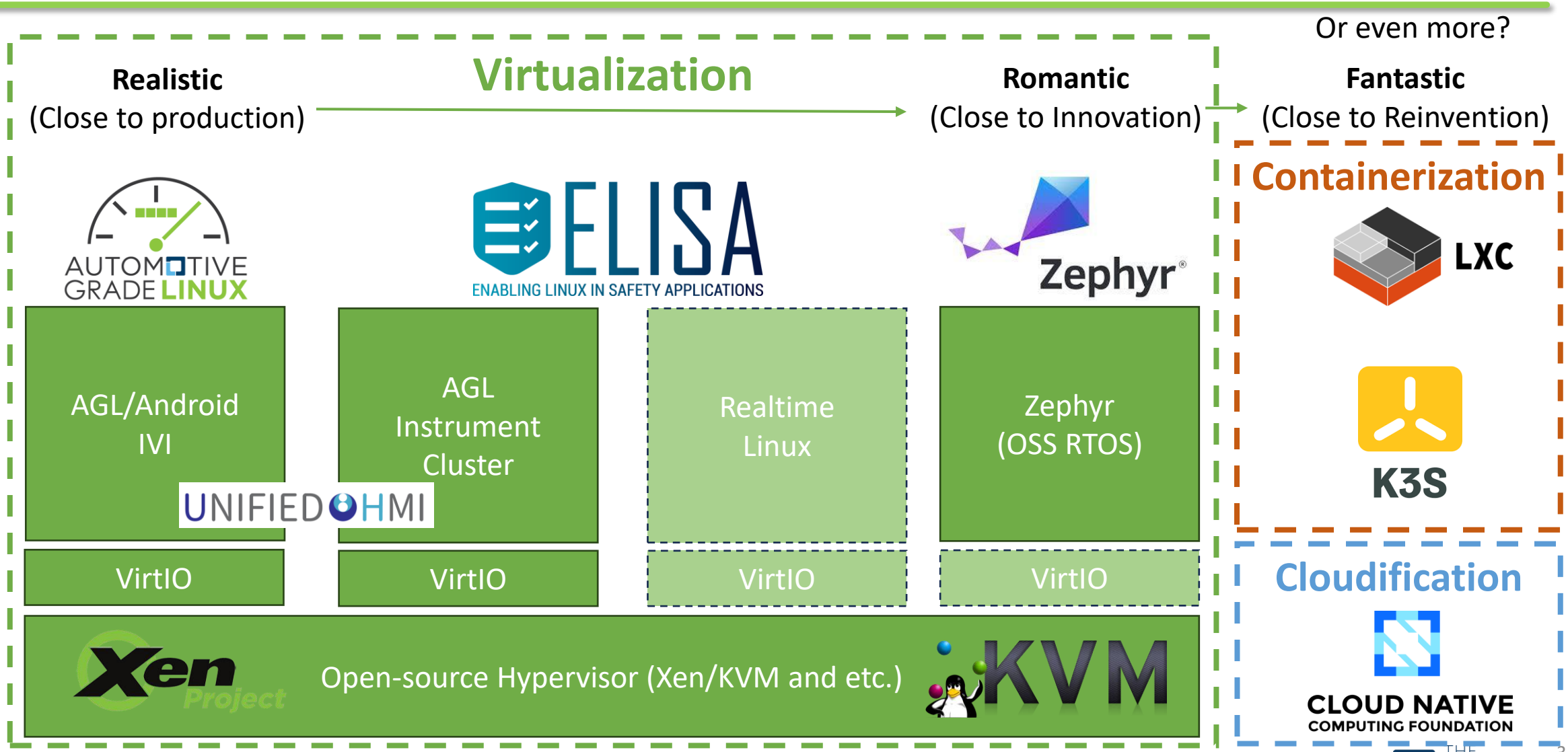
Project General Manager, TOYOTA MOTOR CORPORATION

Masanori has been working in IT industry or IT related areas roughly 30 years.Starting as a software engineer of an operating system of mission critical servers, he worked on high-speed cluster interconnect, Cloud Operating System, etc.
After worked on various IT projects for var... Read More →

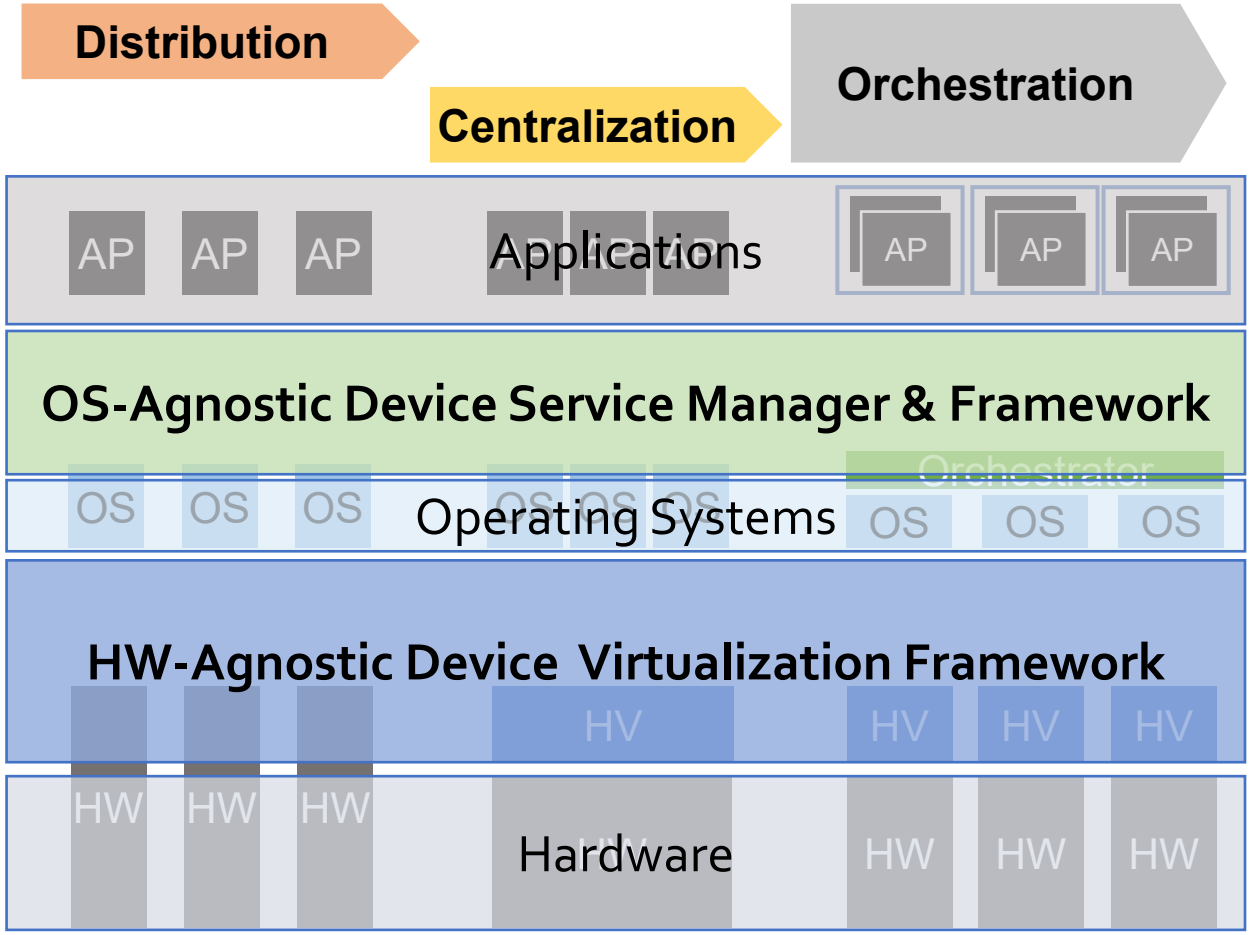
AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

AGL Reference Implementation for SDV - Vision



AGL in the Era of SDV - Realistic, Romantic, Fantastic



Automotive **G**rade **L**inux

AUTOMOTIVE GRADE LINUX

Automotive **G**reat **L**inux

AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

Last but Not Least

Join us to co-develop the critical technologies enabling Software-defined Vehicle to define a bright future for vehicles.

Meeting Notes

- Confluence
  - https://confluence.automotivelinux.org/display/VE/Meeting+Notes+2024

Meeting Time

- Zoom
  - Tuesday 11:00am to 12:00pm UTC in Odd Week

Meeting Members

- Aisin
- AWS
- Honda
- Konsulko
- Open Virtual System
- Panasonic
- Qualcomm
- Renesas
- Red Hat
- Renesas
- etc.

AUTOMOTIVE GRADE LINUX

THE LINUX FOUNDATION

Thank you