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Vehicle Domain Interaction Workshop
Hypervisor for Safety Domain interaction
October 11, 2017

Role of a hypervisor in automotive

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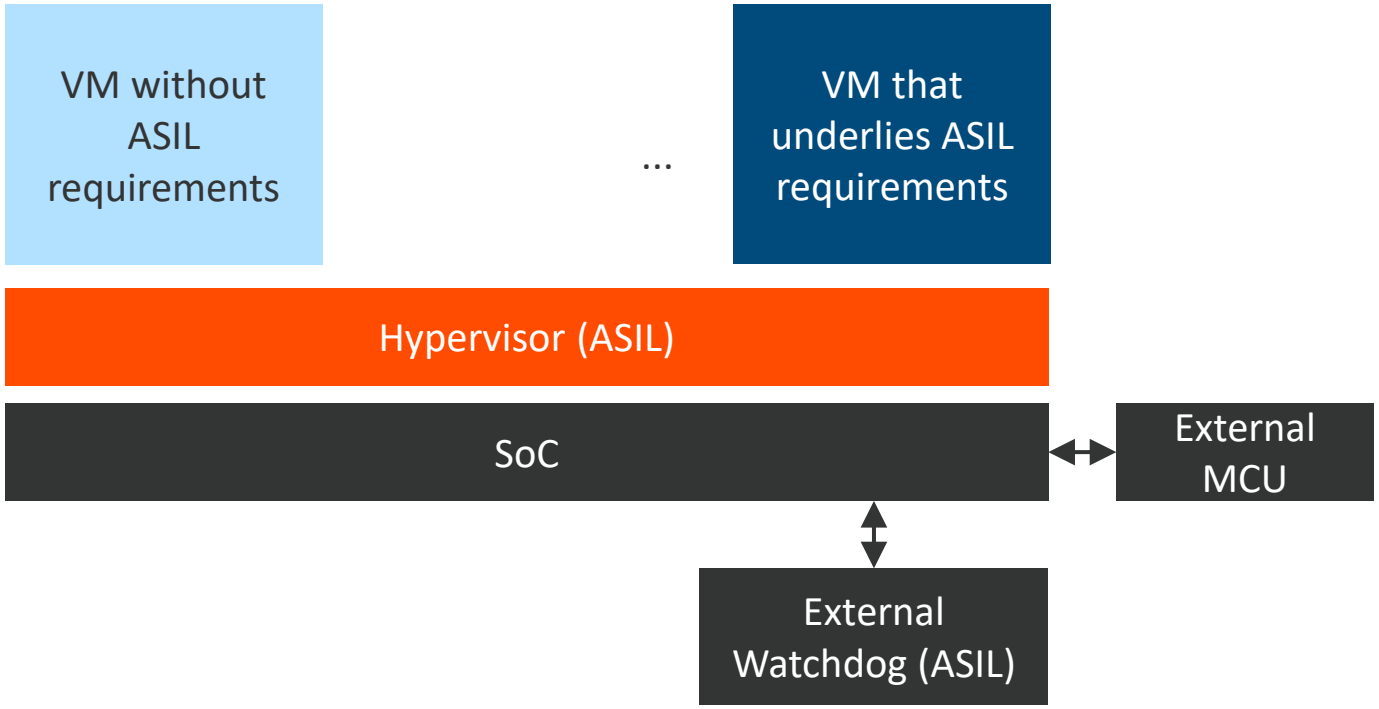
A hypervisor makes it possible to build *mix-criticality systems* and can integrate safely and securely:

- Software that is developed according to different quality standards:
  - **Related to safety** (different ASIL levels)
  - **Related to security** (different levels of trustworthiness, isolating a minimal trusted computing base)
  - **Related to reliability**
- Software that has different **real-time** (e.g. RTOS and generic OS) and **boot-time requirements**

In addition, a hypervisor:

- Enables the use of **optimally suited operating systems** and frameworks (Linux, Android, AUTOSAR, RTOS)
- **Isolates** faults (safety, reliability) and attacks (security) and supports **ASIL decomposition**
- Enables modular development and **modular software updates**
- Supports **software reuse across platforms** and integration of **legacy** software

Design Patterns for Safety



- Design the system to reduce the amount of software that must be developed according to ASIL processes and maximize as much software as is safe to not require development according to ISO26262:
  - use a hierarchical watchdog approach
  - use checking/monitoring strategies wherever possible
  - use E2E protection in the communication wherever possible
- The Hypervisor must provide **freedom from interference** to separate the VMs developed to different safety standards up to the requirements of **ISO 26262 ASIL-B**

Design Patterns for Security

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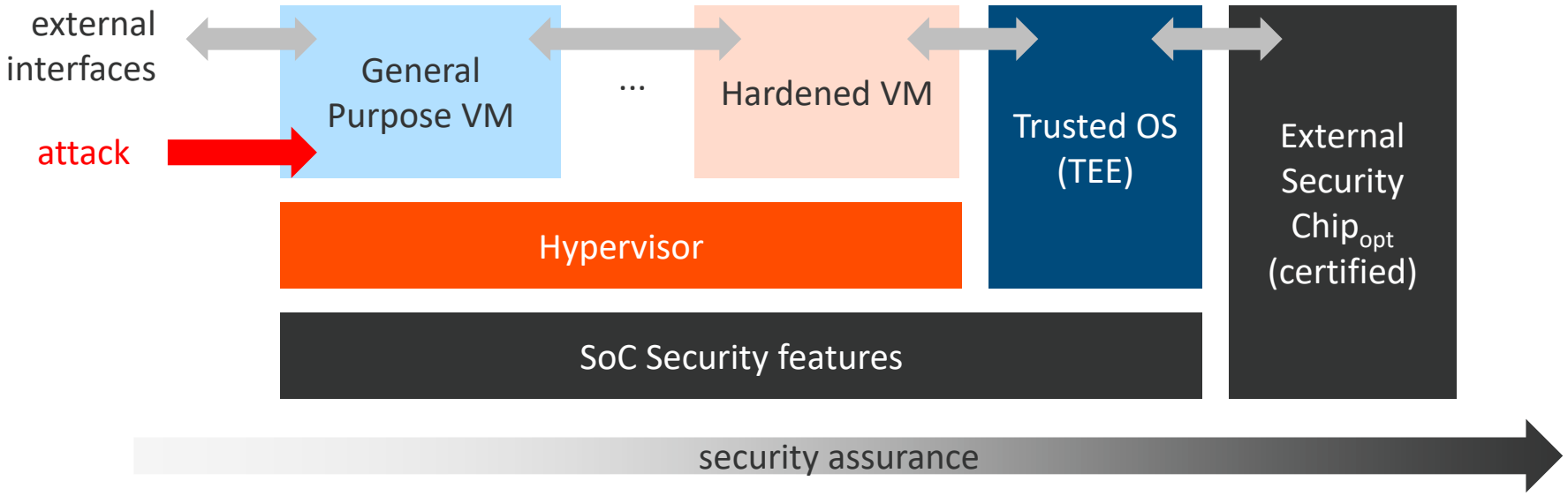

- Enforce the MILS (Multiple Independent Levels of Security) architecture
- Most systems will want to use a layering of security technologies, whereby the upper domain:
  - provides better security assurance than the lower domain
  - manages the communication with the previous domain
- Hypervisor ensures **strong separation** between general purpose VMs (with external interfaces) and hardened VMs and provide secured access to trusted OS
- Hypervisor supports the **SoC-specific hardware security** features (such as Secure Boot, TrustZone,...)
- Hypervisor supports secure and modular **software update** to patch vulnerabilities in the field

Separation

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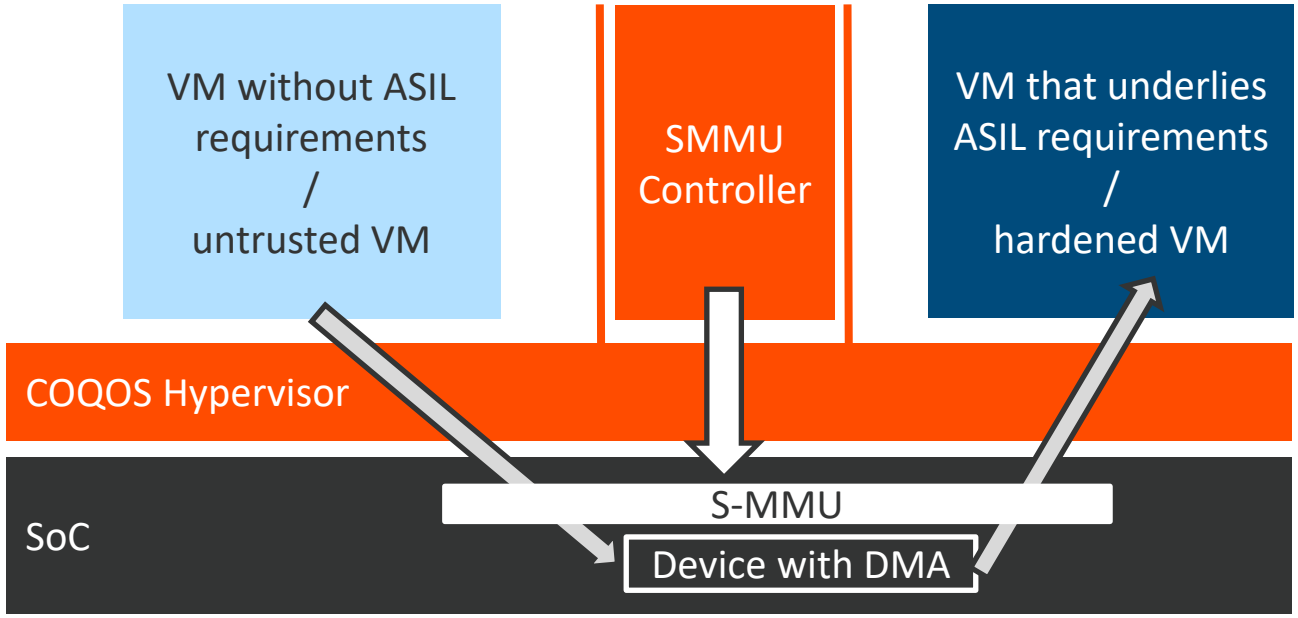
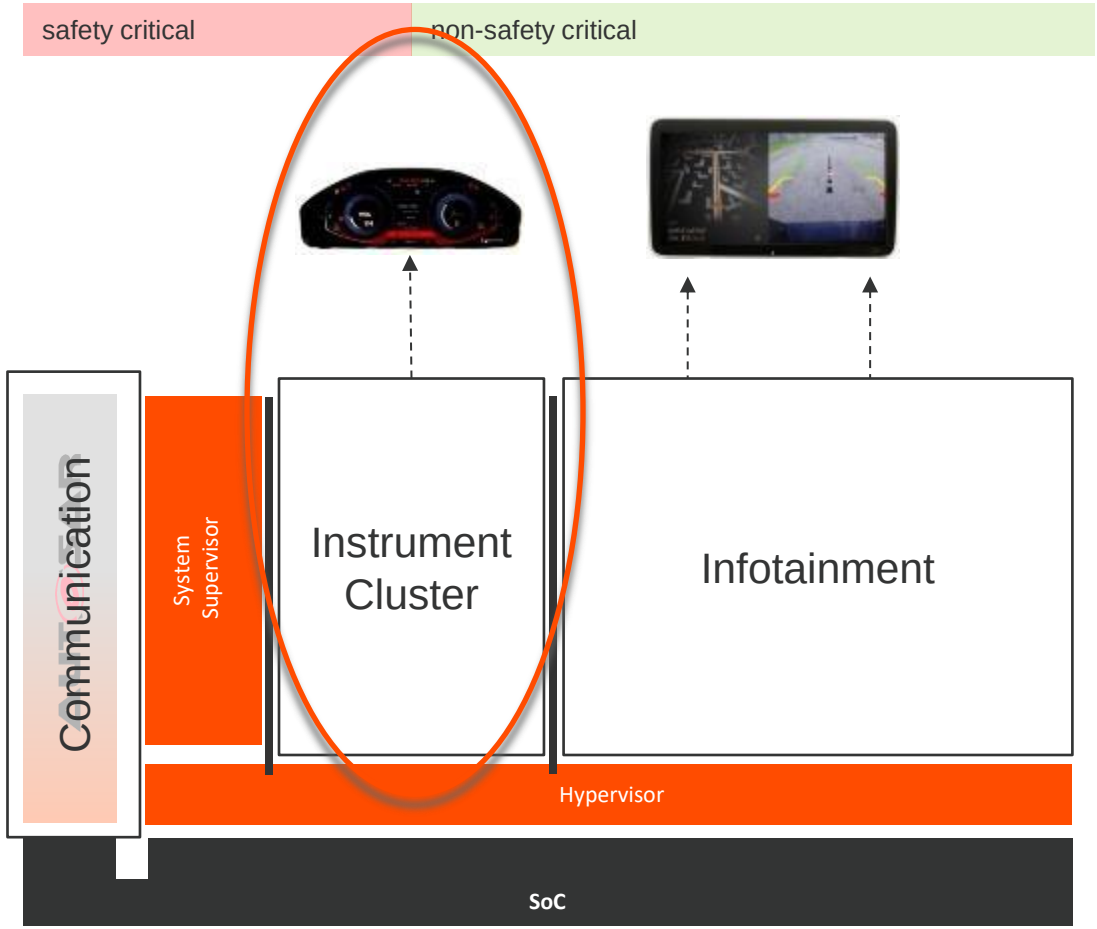


SMMU = System MMU, or IO-MMU
DMA = Direct Memory Access

- On most SoC's several devices have DMA capabilities.
- To use such devices
  - safely (to ensure freedom from interference between the VMs)
  - securely (so that an attacker cannot abuse a DMA-capable device to break separation)
- the SoC needs the right hardware mechanisms (such as the presence of an SMMU or IO-MMU).
- In COQOS, the SMMU Controller is located in a VM (and can be integrated with the System Supervisor)

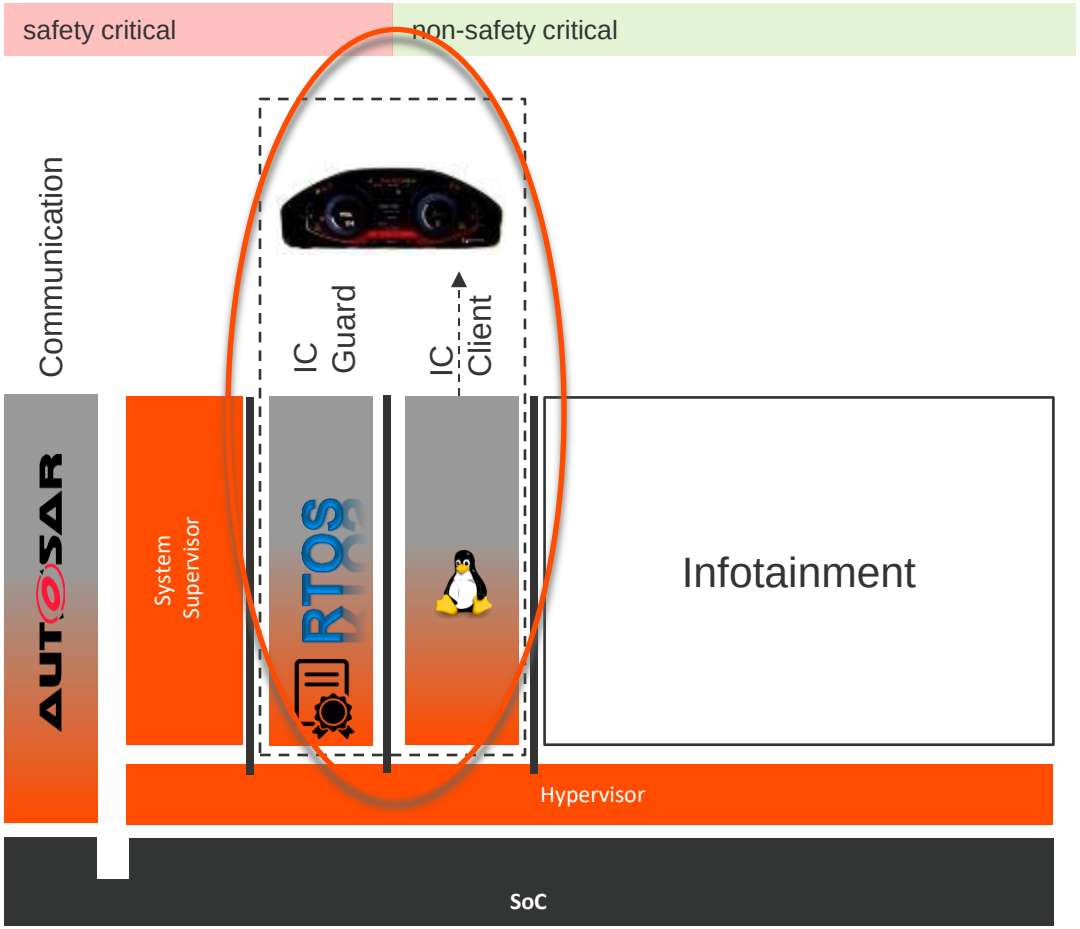
- **The availability of an SMMU Controller is SoC-specific**

Overall Cockpit Controller Architecture



- **Integrate Instrument Cluster and In-vehicle Infotainment functionality on a single device to save cost and provide an integrated driver experience**
- **Hypervisor separates functions with different requirements on real-time behavior and functional safety**
- **The displays must share information from different functions**
  - infotainment
  - real-time driver information
  - safety-critical information
- **The system must interact with an AUTOSAR-based vehicle network**

Mixed Safety Instrument Cluster Reference Architecture



- **an IC Client component is rendering *all* graphical elements – including safety-critical graphical elements.**
- **an independent IC Guard component**
  - verifies the rendering of the safety critical graphical elements in time and in contents and
  - hosts all safety relevant functions
- **an independent System Supervisor component supervises the computational fitness of the IC (hierarchical watchdog).**

Mechanisms for device sharing

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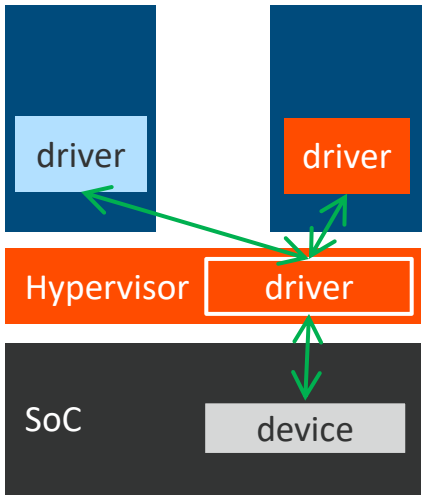
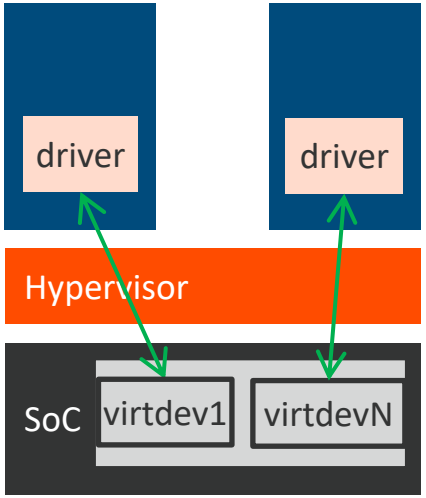
in Hypervisor



- Only used for UART (optionally)
- not recommended for other devices as the Hypervisor is minimalistic.

Example: UART

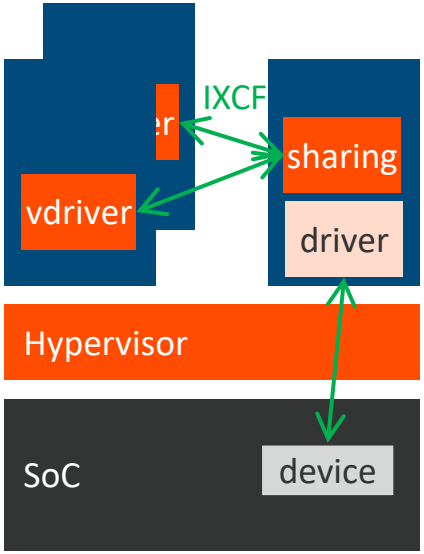
device with virtualization support



- COQOS supports this when the SoC hardware supports virtualized devices
- Recommended wherever the hardware supports it, as it tends to give the best performance and separation

Example: GPU on RCAR-H3

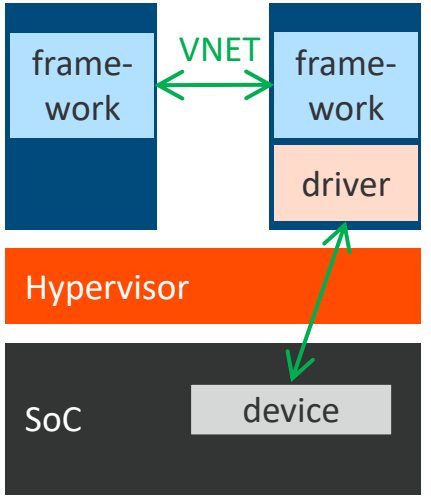
low-level client-server



- Single driver in VM that acts as "server"
- Driver-specific sharing logic is needed.
- Other VMs use "virtual driver".
- Compromise between performance and flexibility

Example: shared block device

distributed frameworks over VNET



- Allows reuse of existing frameworks for distributed applications in a virtualized environment over VNET.
- Supports complex sharing semantics at the cost of more overhead

Example: NFS, PULSE AUDIO

Introduction

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- **Virtualized IO devices are available for desktop and cloud applications because everyone uses standardized interfaces (virtio, xen, vmware)**
  - Disk
  - Network
- **Embedded devices lack the ecosystem that cloud providers build upon**
- **Challenges for virtualized IO devices in automotive**
  - High effort of SoC specific device virtualization
  - Multimedia device virtualization
  - Low amount of reusable virtual devices

Device Virtualization Technologies

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Technology	Description	Reusability	Platform independence
Standard library (or layer) virtualization (OpenGL, DRM, Android HAL …)	Implement hypervisor specific standard libraries	As long as the same hypervisor is used	As good as vendor interface
Virtio	Implement virtio based devices that follow either existing standards or specify new ones	Virtio support is available in Linux, Android and many other operating systems	Builds upon the kernel-userspace interface of Linux and allows large flexibility because the devices themselves make no assumption about the hardware
HV vendor custom	Develop virtual devices optimized to be used with a particular hypervisor	As long as the same hypervisor is used	Implementation specific

Trade-off between development effort, reusability, platform independence, availability and maturity

Virtio

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- **Virtio “De-Facto Standard For Virtual I/O Devices” (Russel 2008)**
- **Standardized since March 2016 (OASIS VIRTIO-v1.0)**
- **Virtio provides interfaces for many devices**
  - Block Storage
  - Network
  - Console
  - GPU
  - Input (hid)
  - Crypto device
  - vSock
  - File Server (9pfs)
  - Many more in development (vIOMMU, etc.)
- **Still missing pieces**
  - Audio
  - Sensors
  - Media Acceleration Offload (VPU)

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