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IOMMU Evaluation in Automotive use-cases

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WHO AM I ?

- Name：Khiem Trong. Nguyen (KHIEM Nguyen)

- Company：Renesas Design Vietnam

- Career：10 years experiences in embedded software development
  - Development and verification for Mobile and In-vehicle software platform
  - Development for test automation solutions of In-vehicle software platform

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ABOUT RENESAS AND RENESAS DESIGN VIETNAM

Sales Companies

Renesas Electronics America
Renesas Electronics Canada
Renesas Electronics Brasil-Servicos
Renesas Electronics Europe (UK)
Renesas Electronics Europe (Germany)
Renesas Electronics (China)
Renesas Electronics (Shanghai)
Renesas Electronics Hong Kong
Renesas Electronics Taiwan
Renesas Electronics Singapore
Renesas Electronics Malaysia
Renesas Electronics India
Renesas Electronics Korea

Manufacturing and Engineering Service Companies

Renesas Semiconductor Manufacturing
Renesas Semiconductor Package & Test Solutions
Renesas Semiconductor (Beijing)
Renesas Semiconductor (Suzhou)
Renesas Semiconductor (Malaysia)
Renesas Semiconductor (Kedah)
Renesas Semiconductor Technology (Malaysia)
Renesas Semiconductor KL

Design and Application Technologies Companies

Renesas System Design
Renesas Engineering Services
Renesas Design Vietnam
Renesas Semiconductor Design (Beijing)
Renesas Semiconductor Design (Malaysia)

Business Corporation

Intersil Corporation

- Renesas Design Vietnam Co., Ltd. (RVC) was founded in October 2004, as one of the main design centers in Renesas group.

- Business line: Design of semiconductor for both hardware and software.

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IOMMU EVALUATION IN AUTOMOTIVE USE-CASES

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08/30/2018, VANCOUVER
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RENESAS ELECTRONICS CORPORATION

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AGENDA

- Motivation

- IOMMU Overview

- IOMMU support for Automotive use-cases

  - Buffer Sharing

  - Resource Isolation

- Conclusion

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MOTIVATION

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MOTIVATION (1/3)

- Nowadays, multiple applications or services running in parallel in a vehicle.

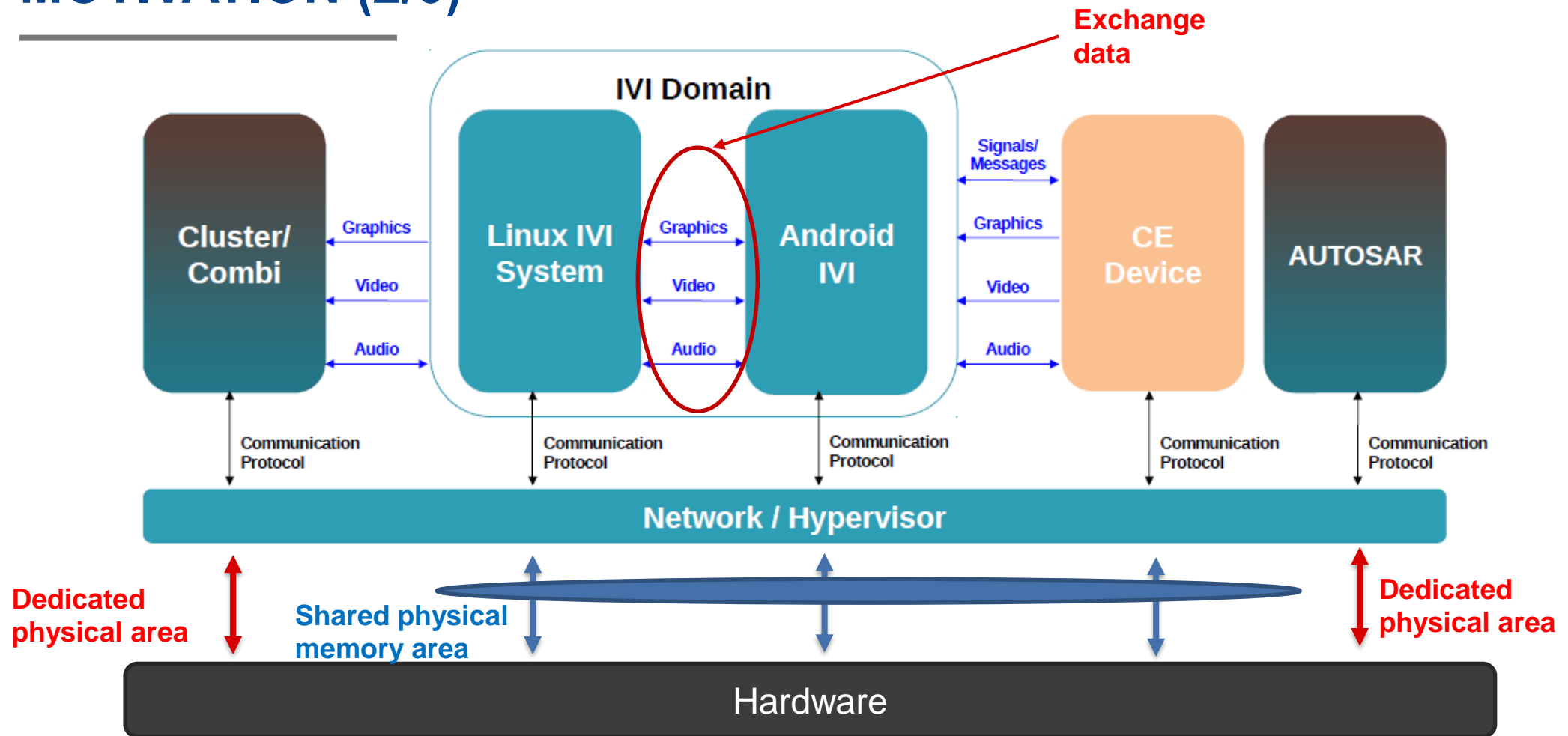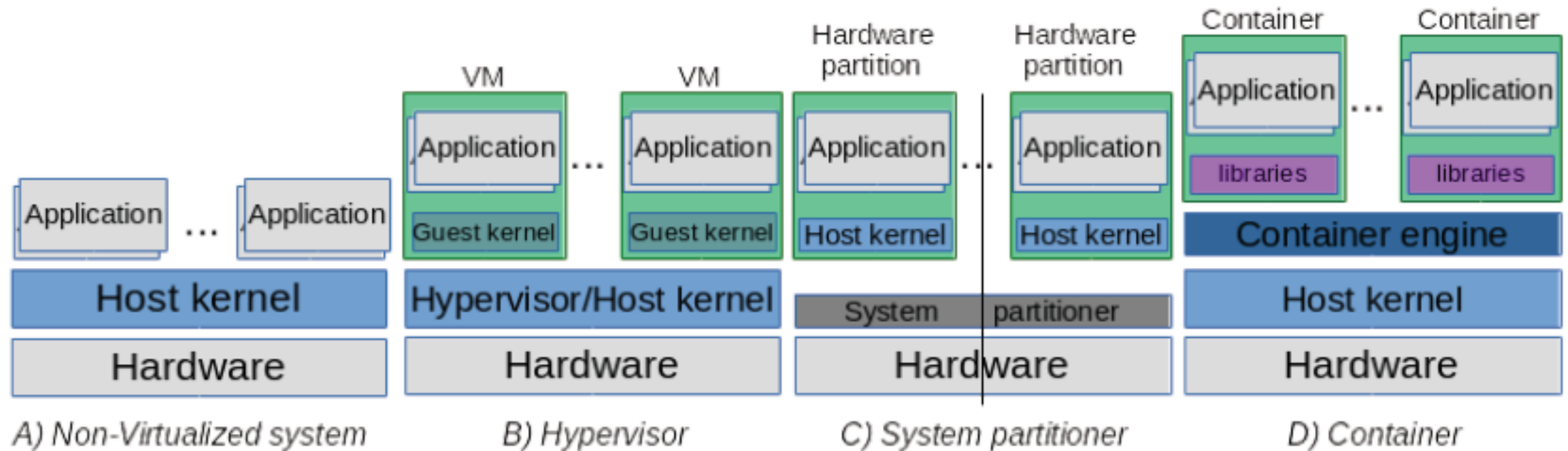- The services can be implemented in multiple silicon or share the power of a single silicon.

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MOTIVATION (2/3)

Image from *GENIVI* Graphics Sharing and Distributed HMI Compositing presentation in Dec 2017

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MOTIVATION (3/3)

Image taken from The AGL Software Defined Connected Car Architecture white paper

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IOMMU OVERVIEW

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IOMMU OVERVIEW – IOMMU HARDWARE

- Have similar capability like MMU for CPU cores.

- Have been supported in recent ARM architecture, i.e. ARMv7 and ARMv8.x

  - In ARMv7, it's an optional extension called LPAE (Large Physical Address Extension), be available in ARM Cortex-A15 and newer ARMv7 cores.

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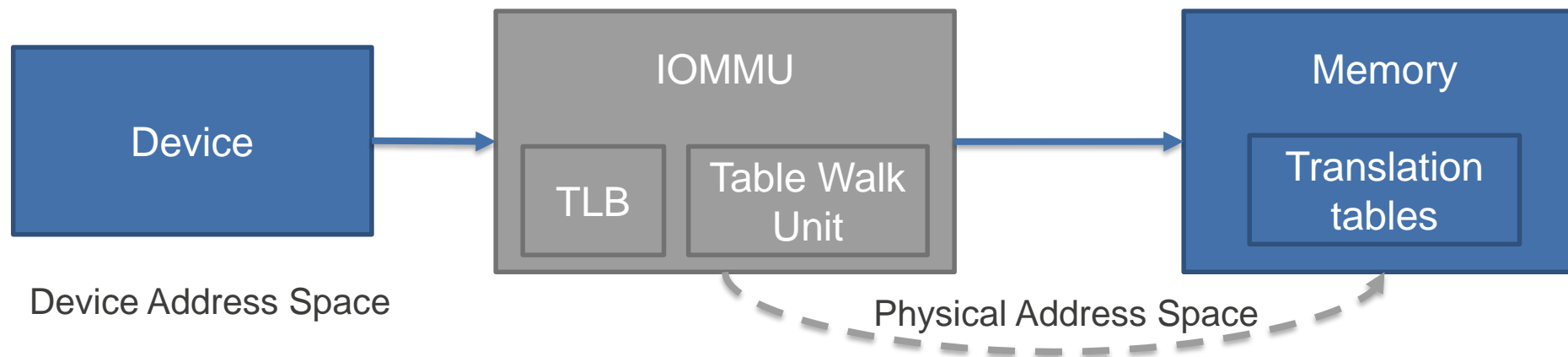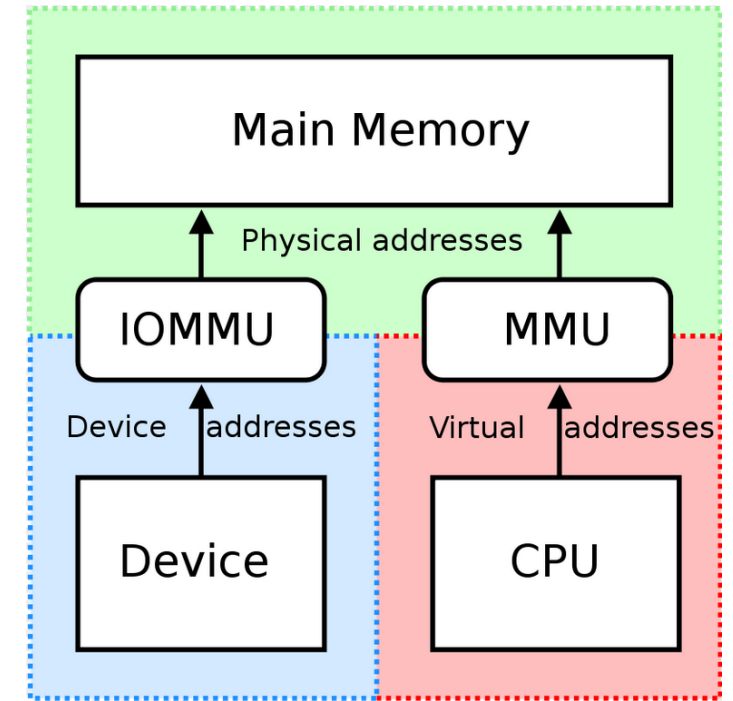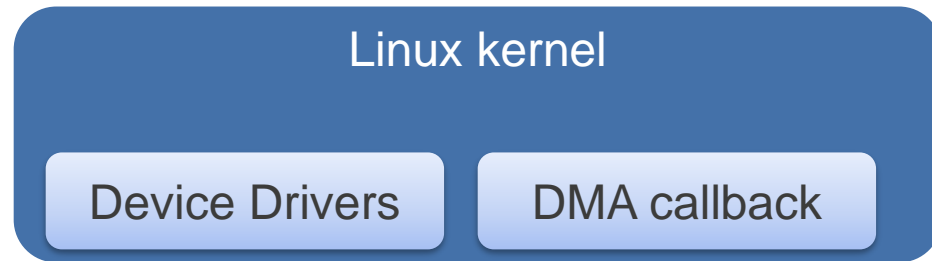
IOMMU OVERVIEW – IOMMU HARDWARE

- Support 03 translation granule type.

  - 4KB, 16KB and 64KB

- Support 1-stage address translation and 2-stage address translation.

  - 1 stage (Physical Address <-> Virtual Address)

  - 2 stage (Physical Address <-> Immediate Physical Address <->Virtual Address)
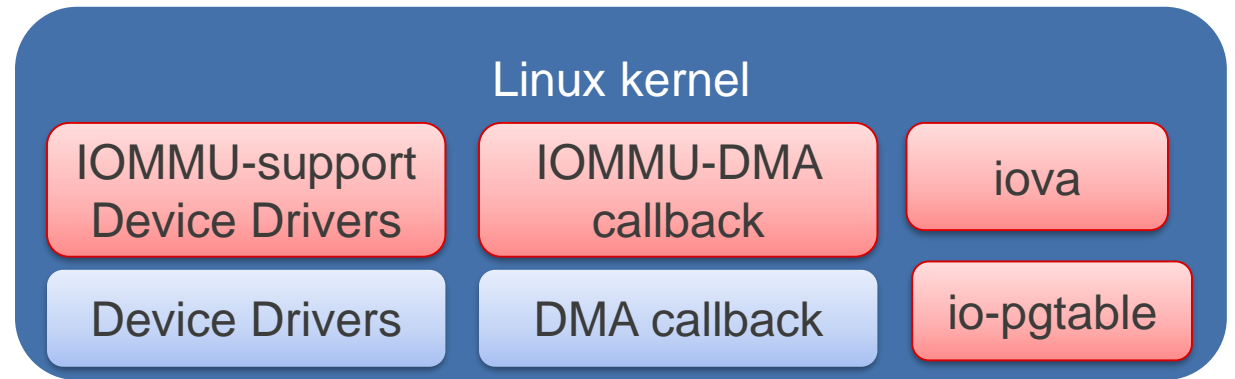
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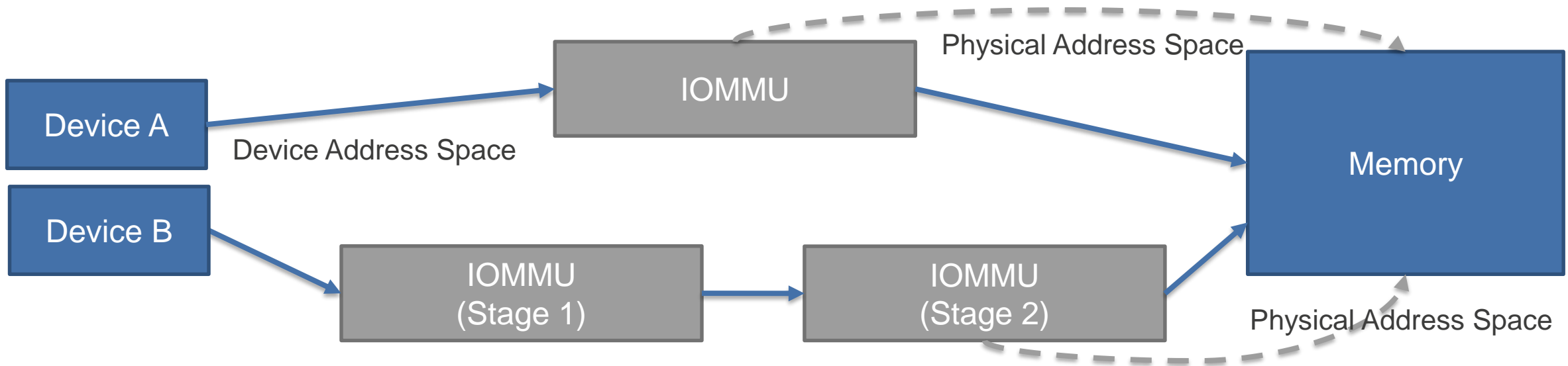
IOMMU OVERVIEW – IOMMU FRAMEWORK

- Be a part of Linux kernel for a long time (dated back to 2007).

- Support 4KB (default configuration) page size, 16KB and 64KB.

- Support managing address translation for Linux device drivers.

  - Initialize the translation contexts (MMU pagetables)

  - Initialize the memory mapping, physical to virtual, and register DMA callback handlers for each device attached to the contexts.

  - Re-mapping the buffers when sharing buffers are triggered across the contexts.

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IOMMU OVERVIEW – IOMMU FRAMEWORK

Linux kernel

- Device Drivers
- DMA callback

Without IOMMU support

Linux kernel

- IOMMU-support Device Drivers
- IOMMU-DMA callback
- iova
- Device Drivers
- DMA callback
- io-pgtable

With IOMMU support

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IOMMU SUPPORT FOR AUTOMOTIVE USE-CASES

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IOMMU SUPPORT FOR AUTOMOTIVE USE-CASES
## HOW IOMMU SUPPORT AUTOMOTIVE USE-CASES ?

- Guarantee the correct and efficient dataflow among the devices.

- **Buffer sharing**

  - Among devices in same contexts

  - Among devices in different contexts

  - Between non-IOMMU-supported devices and IOMMU-supported devices

- **Resource isolation**

  - Create different memory mapping to grant access or block the access to specific memory areas.

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BUFFER SHARING
VIDEO CAPTURE: PROCESSING FLOW AND ISSUES

1 Demand for BIG buffer allocation

2 Sharing data between IOMMU contexts

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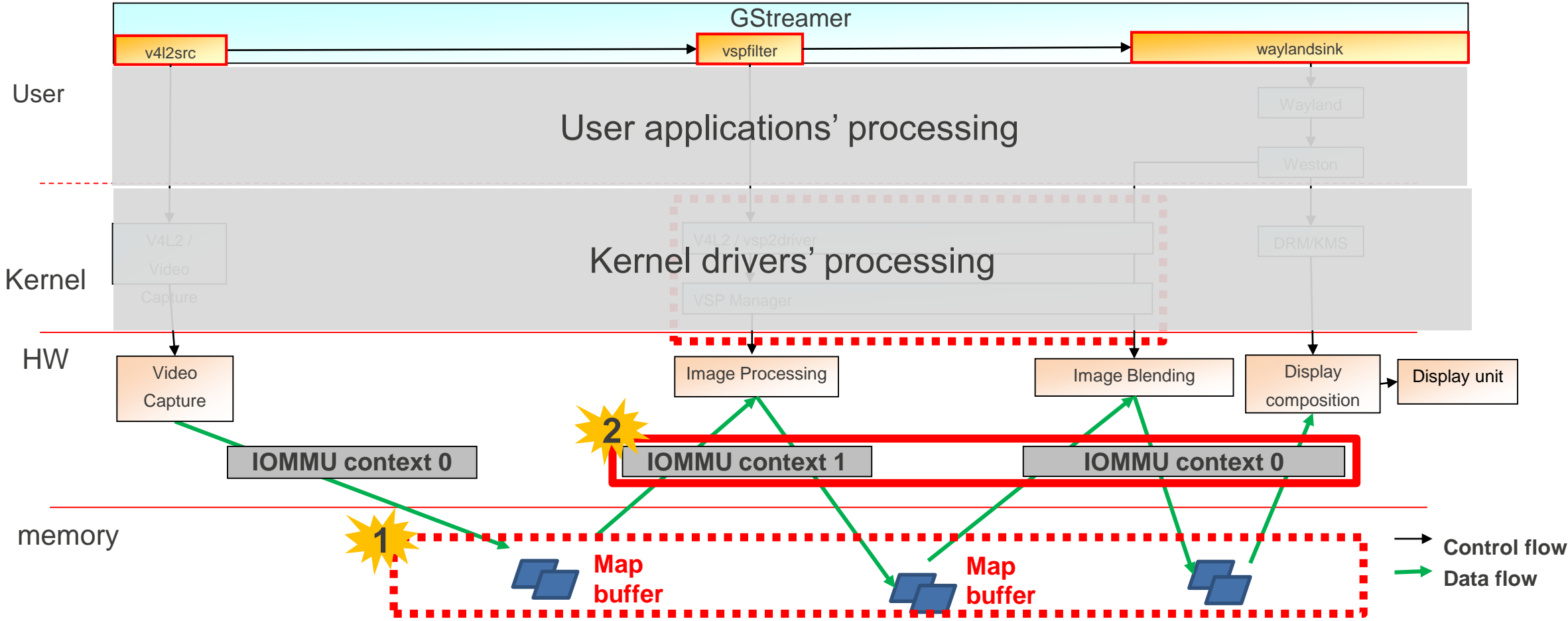
BUFFER SHARING
BIG BUFFER ALLOCATION - USE CONTIGUOUS DMA BUFFER – 1/3

- **Why ?**

  - The multimedia use-cases require a lot of CMA buffers.

    - With the default kernel allocation (4KB per allocation), it takes time to map/re-map big CMA buffers (e.g 2MB, 4MB, etc).

  - Should use CMA contiguous allocation for big buffer allocation.

    - Improve the performance

    - Buffer sharing among two or more devices with different memory requirements.


  Use DMA_ATTR_FORCE_CONTIGUOUS

  - The IOMMU support for ARM64 architecture has been available since Linux kernel v4.12.

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BUFFER SHARING
BIG BUFFER ALLOCATION - USE CONTIGUOUS DMA BUFFER – 2/3

1 ▪ CMA buffer allocation (in one function call)

2 ▪ Map the buffer to corresponding IOMMU pagetable (in one function call)

3 ▪ Buffer is shared via DMA Buffer sharing Framework

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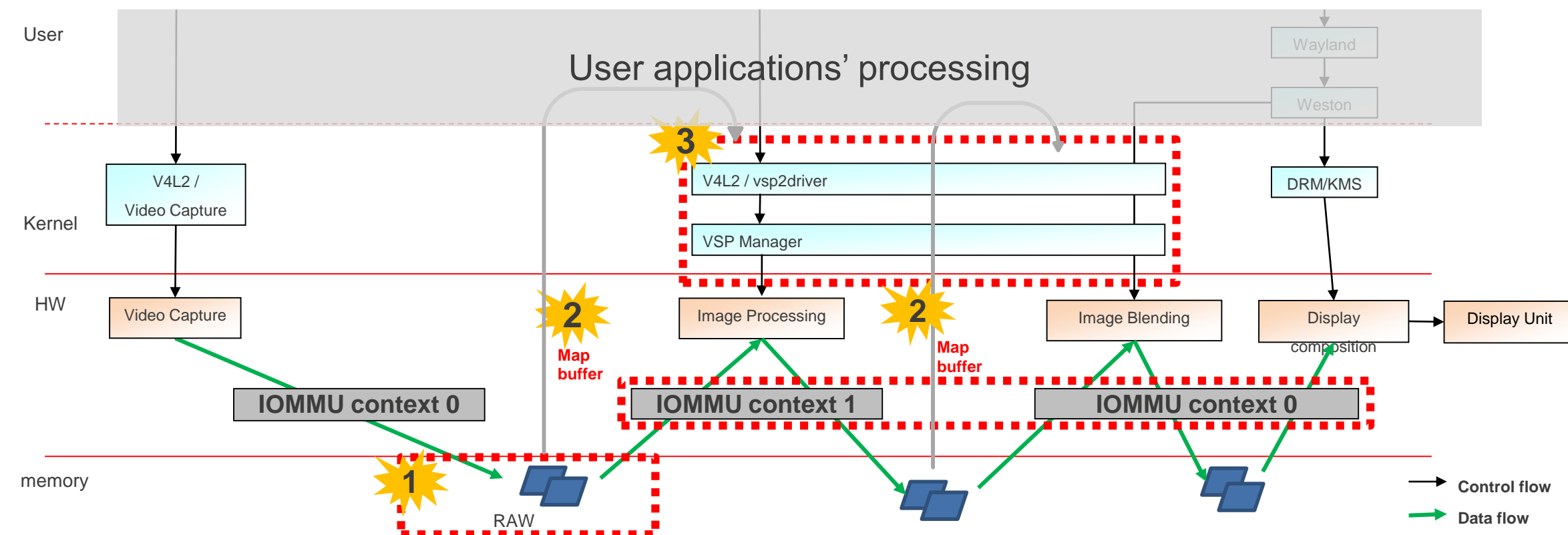
BUFFER SHARING
BIG BUFFER ALLOCATION - PHYSICALLY CONTIGUOUS DMA BUFFER – 3/3

- Below shows the performance between non-IOMMU and IOMMU environment

No.	Video capture	non-IOMMU	IOMMU enabled + use contiguous CMA Buffers
1	Video capture (1080p)	60 fps	60 fps
2	Video capture with scaling (input/output: 1080p/720p)	60 fps	60 fps

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CONCLUSION

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CONCLUSION

- IOMMU can support buffer sharing and resource isolation, which are important criteria of implementing complex Automotive use-cases.

- To guarantee the system performance when IOMMU is enabled,

  - Use contiguous CMA buffer allocation for sharing big buffers.

  - Handle the address translation and dataflow across devices with different view of system memory.

- Future work

  - Check the dataflow and consider the solution to ensure the system performance in other automotive use-cases.

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