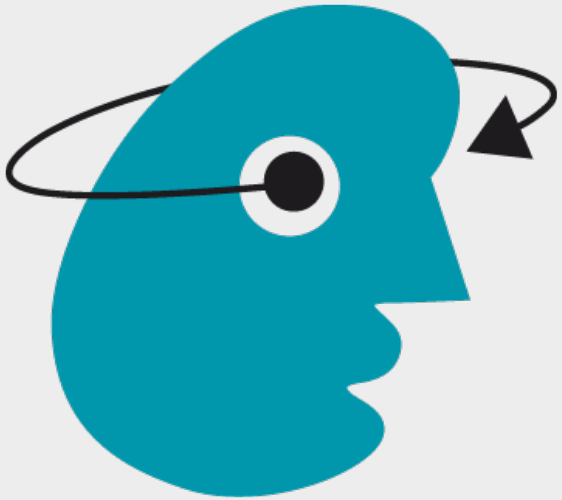

DAVe
Embedded Systems

Real-Timeness and System Integrity on a Asymmetric Multi Processing configuration

D&E Event – **November 2nd**
Relator: Manuele Papais
Sales & Marketing Manager

DAVE Embedded Systems

DAVE Embedded Systems' HEADQUARTER
Via Talponedo, 29/A
33080 Porcia, Italy

DAVE Embedded Systems' BRANCH OFFICE
Maximilianstrasse, 13
80539 München, Germany

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- UK – Swindon
- France – Paris
- Israel – Tel Aviv
- Belgium / The Netherlands
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- Now opening: Japan

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Concept and Design
of Embedded Systems

DAVE
Embedded Systems

DAVE Embedded Systems

Concept and Design
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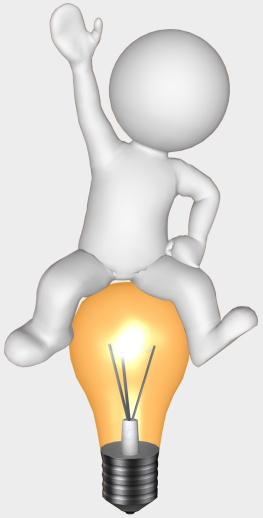
Solutions Provider



Supporting and Promoting
Customer Ideas and
Concepts
from Scratch to Business

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Embedded Systems

Products Portfolio

DAVE Embedded Systems

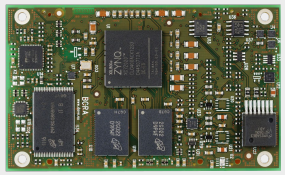
Products Portfolio

System On Modules

Texas Instruments
SITARA, DA VINCI

NXP i.MX6...

XILINX Zynq



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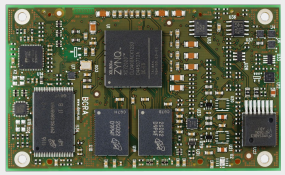
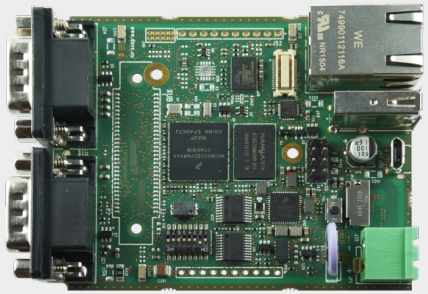


Single Board Computers

Wall mount

DIN Bar mount



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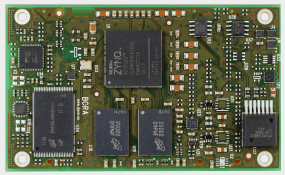

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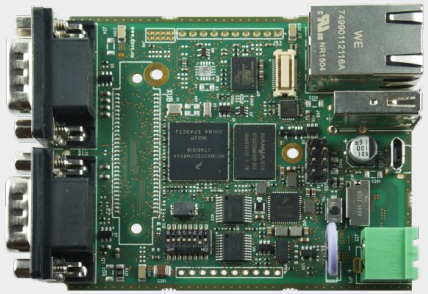

Customized Solutions

Based on customer requirements

Based on existing proven solutions

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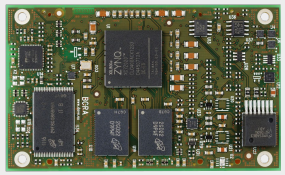

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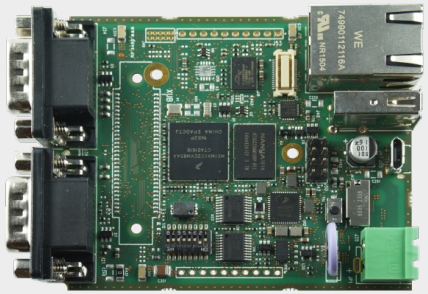

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DAVe Embedded Systems

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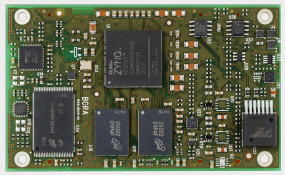

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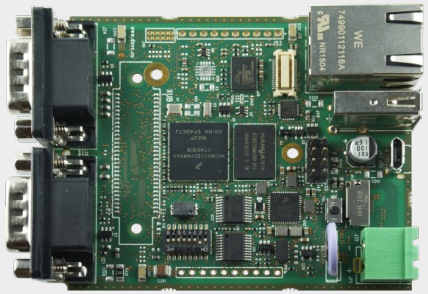

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DAVE Embedded Systems

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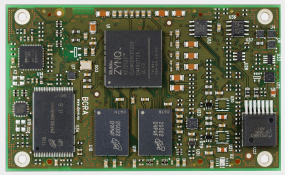

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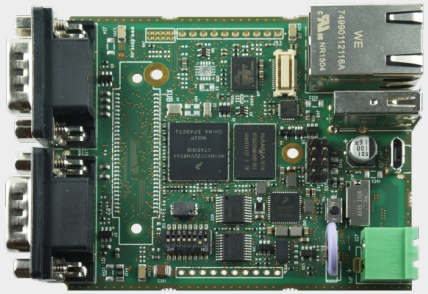

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DAVE Embedded Systems

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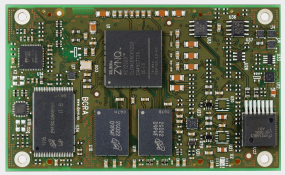

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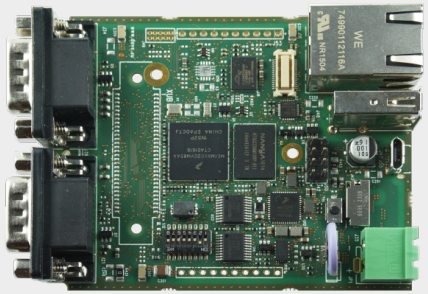

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Products Portfolio

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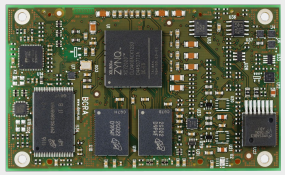
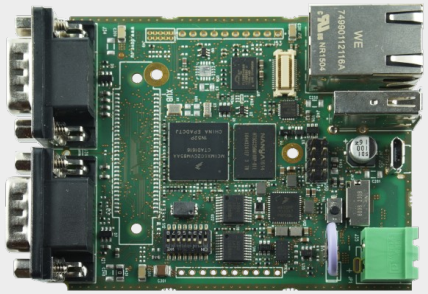
XILINX Zynq		





Available with advanced SW elements

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RTOS Integration/examples

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AMP Asymmetric Multi Processing

BIG - LITTLE

- NXP Vybrid
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- ...

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SIMMETRIC

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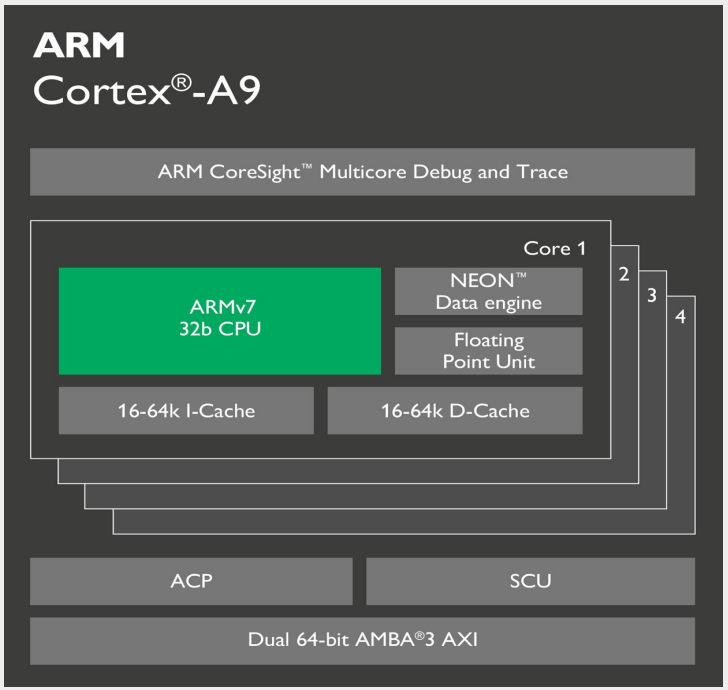
Cortex-A9 architecture



- Multicore platform approach
- Low power architecture
- Industrial grade proof

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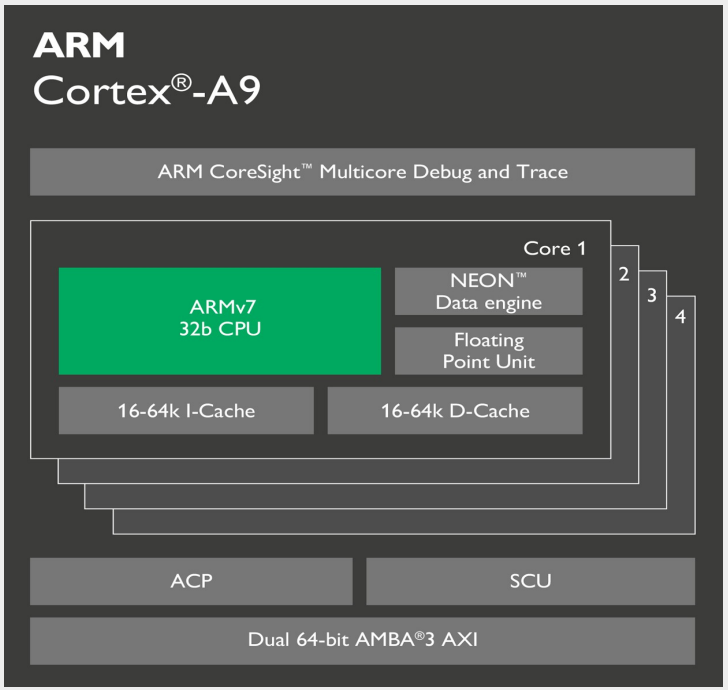
Cortex-A9 architecture



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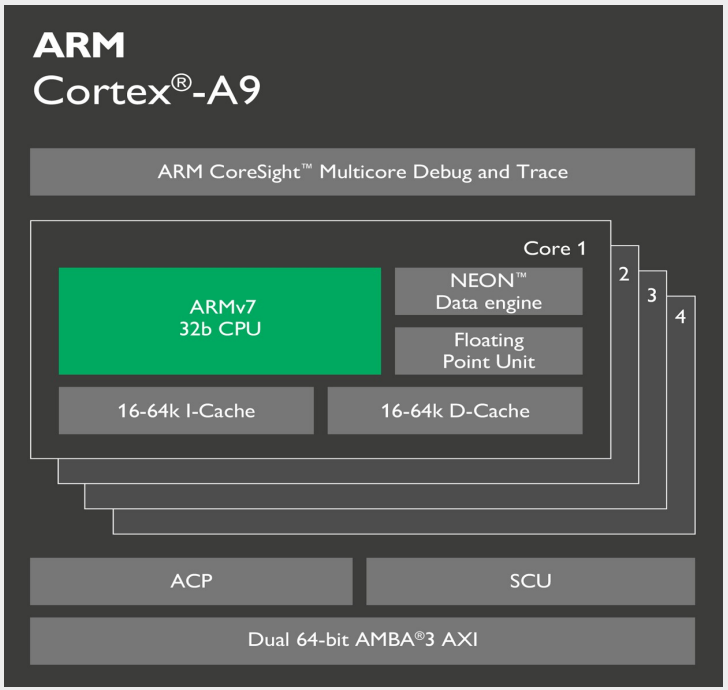

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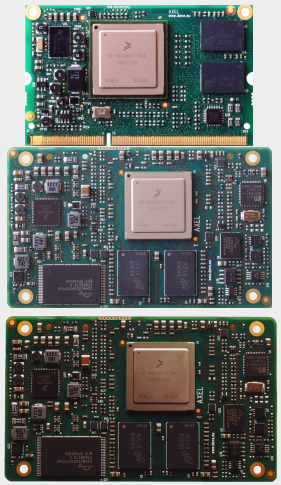
NXP i.MX6



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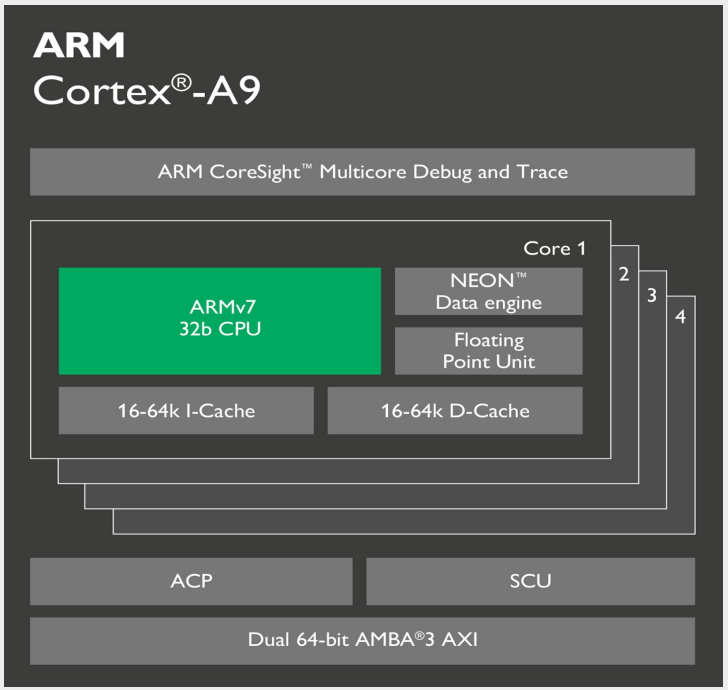
Cortex-A9 architecture



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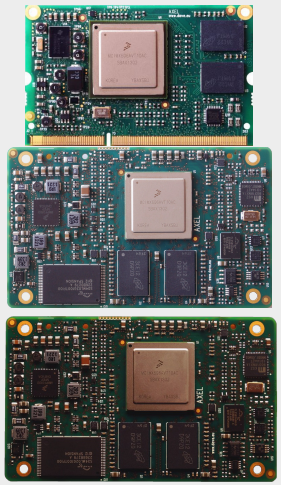
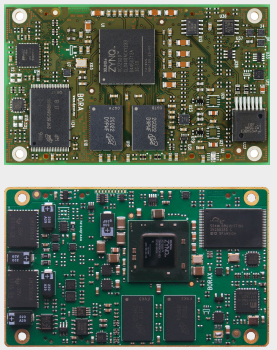


Xilinx Zynq



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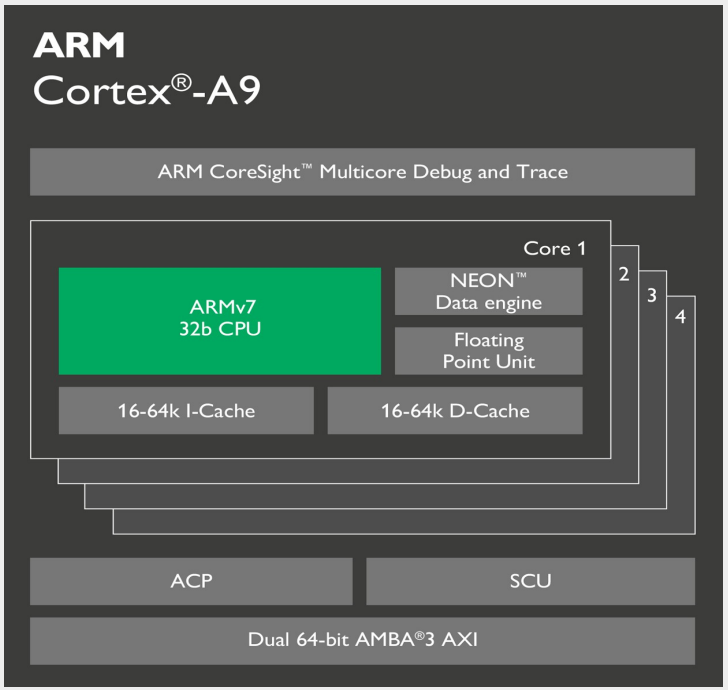

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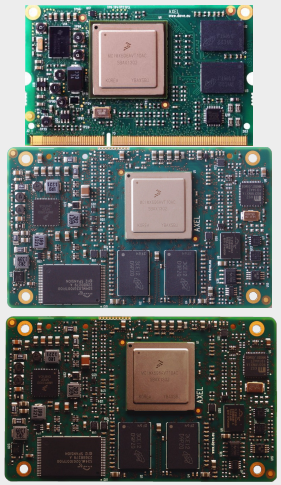

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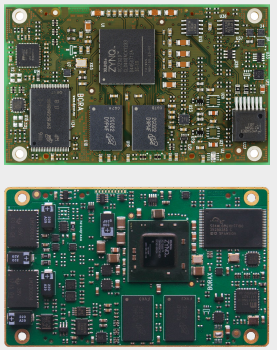

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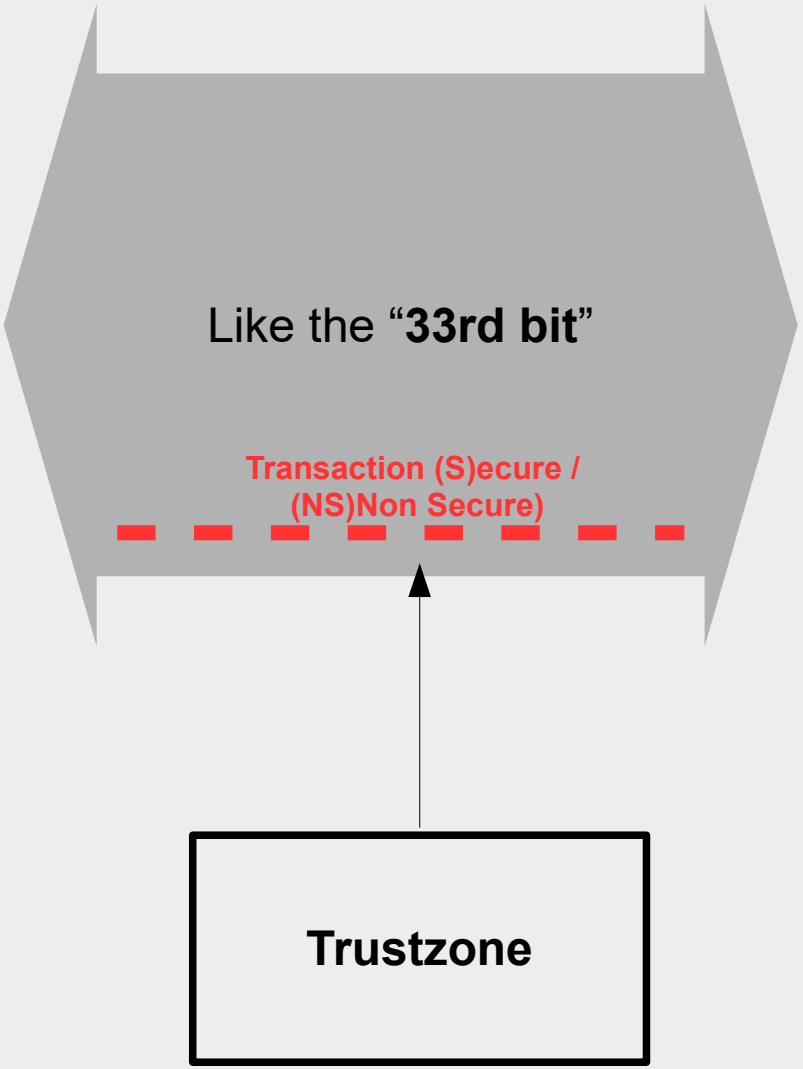
The TrustZone IP



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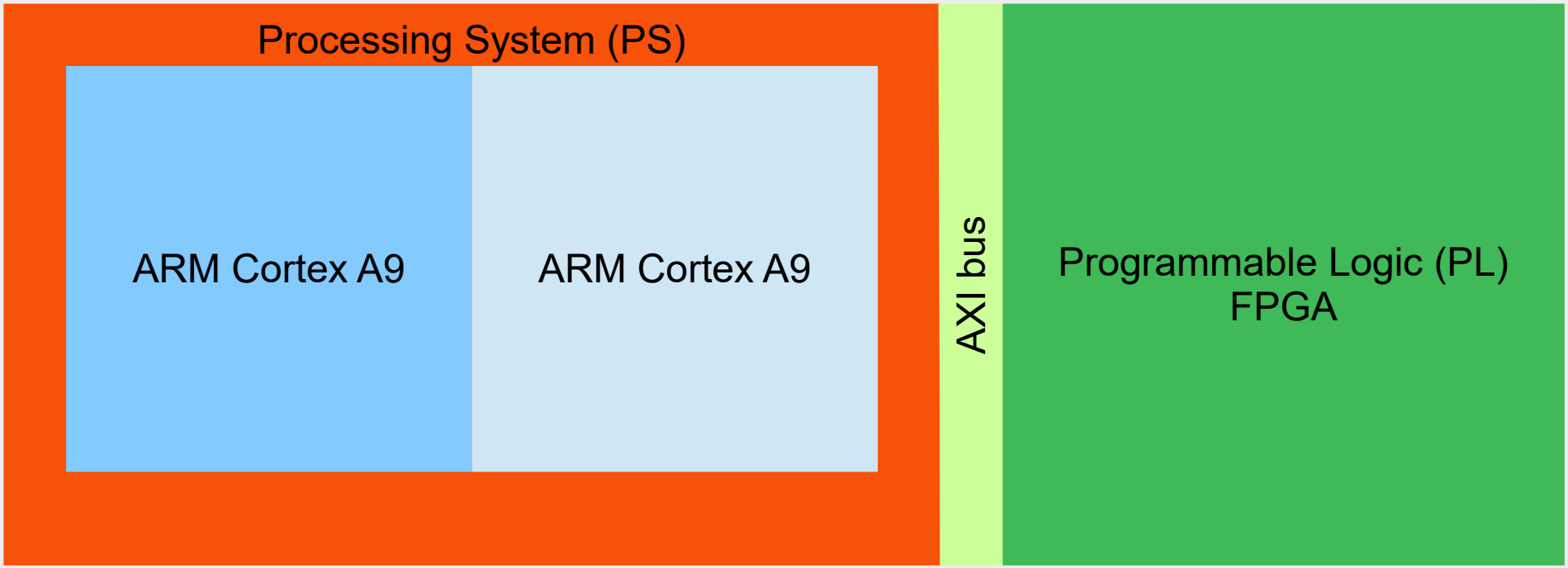
The Asymmetric Multi Processing on Zynq Architecture



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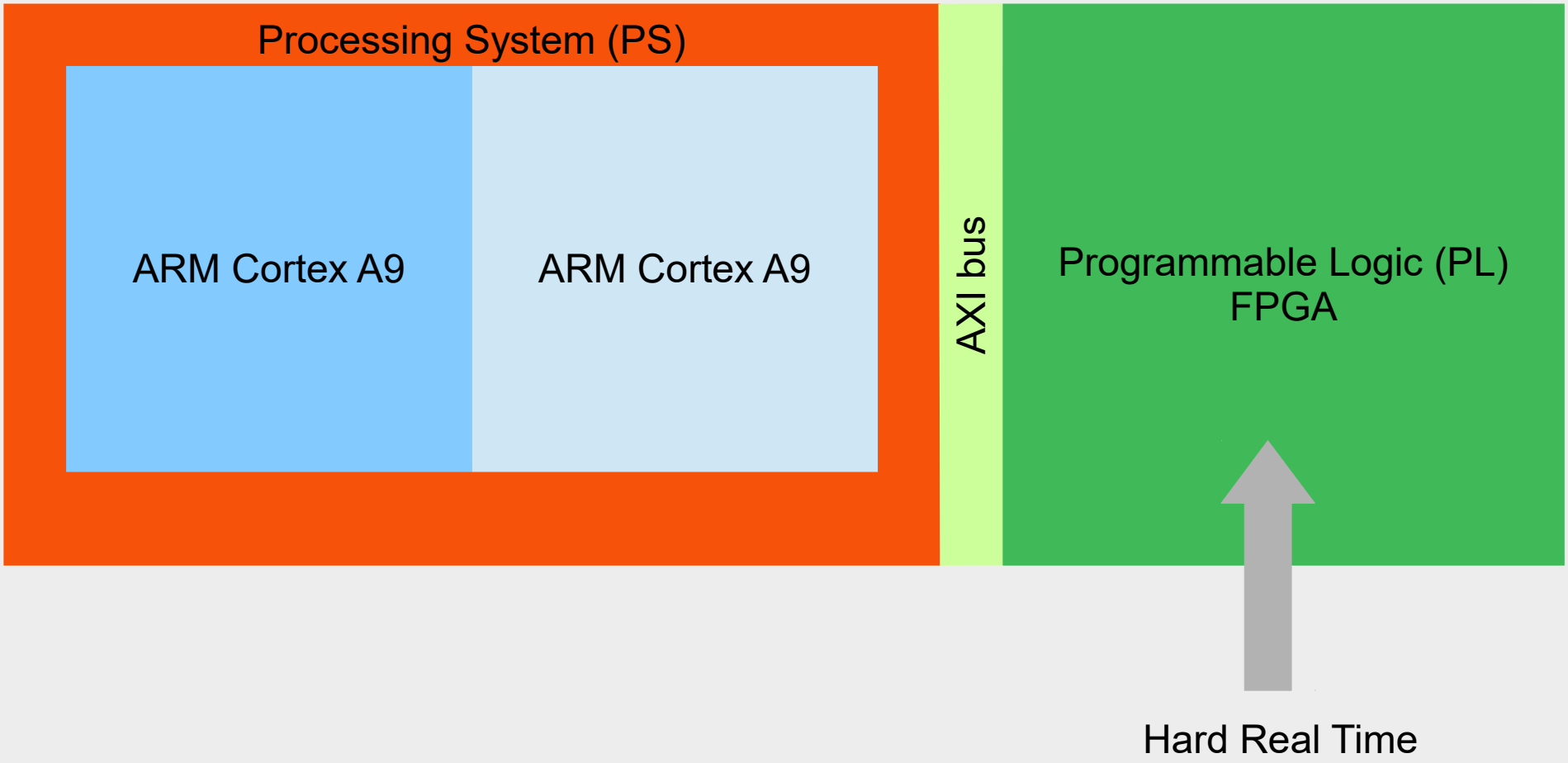

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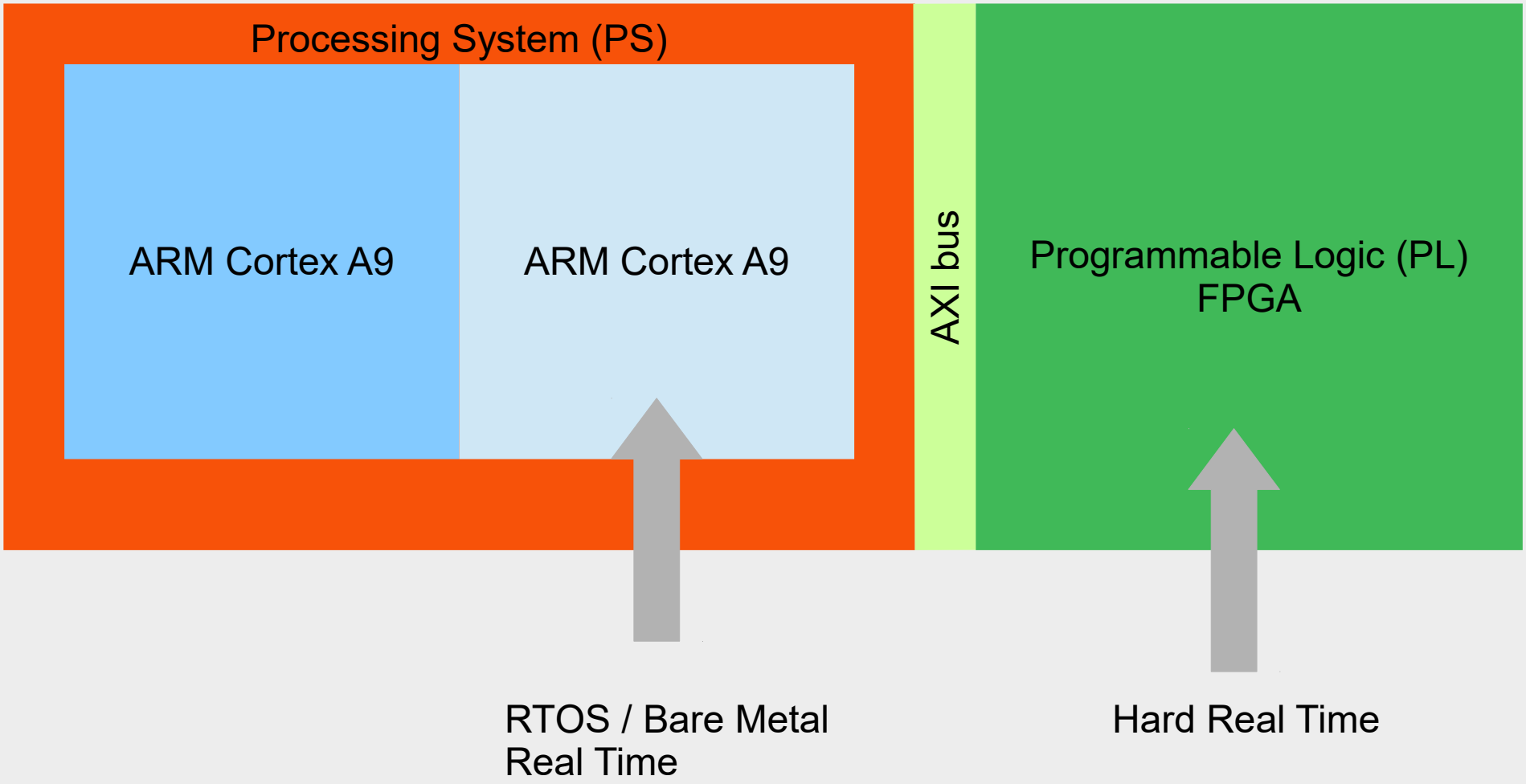

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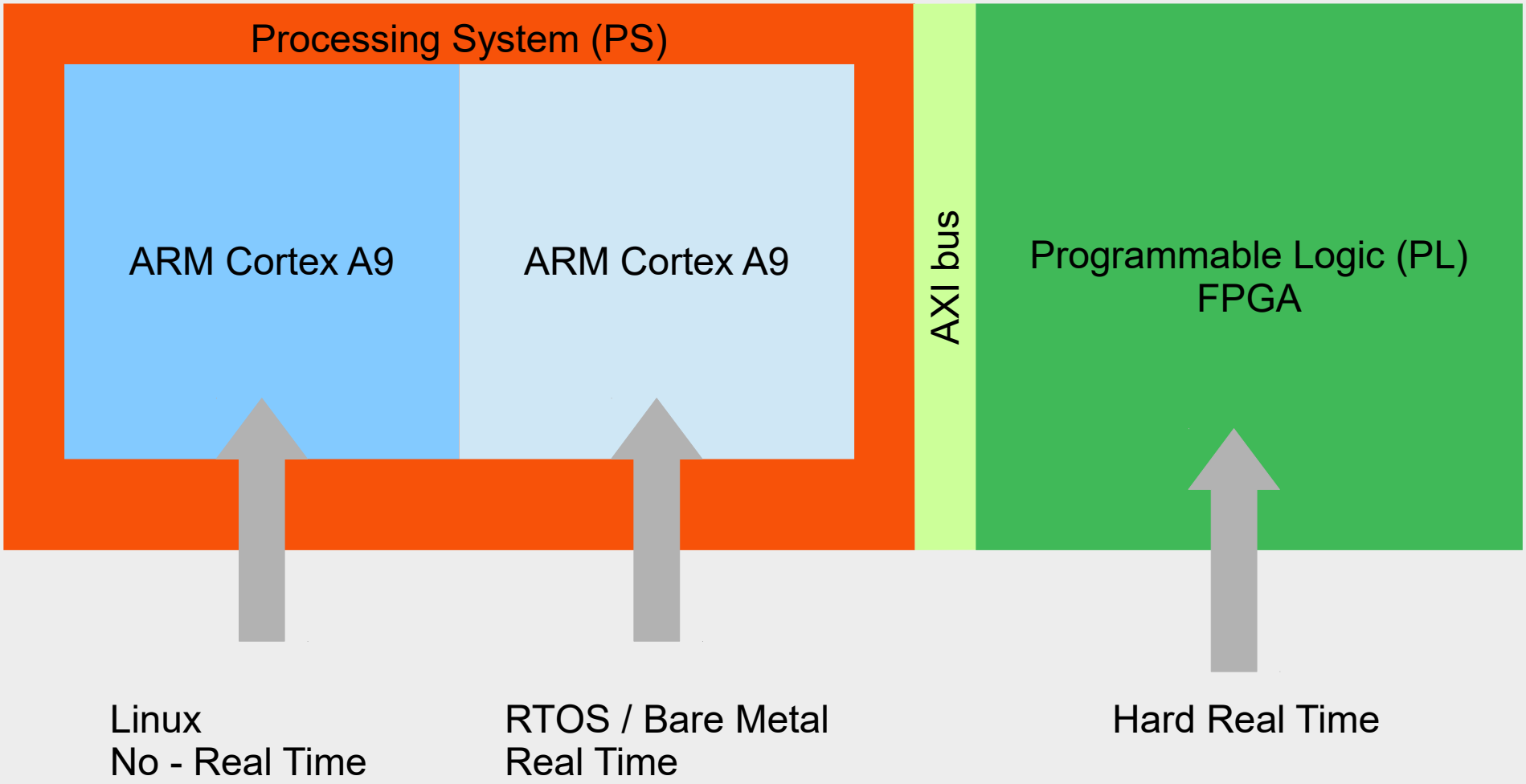

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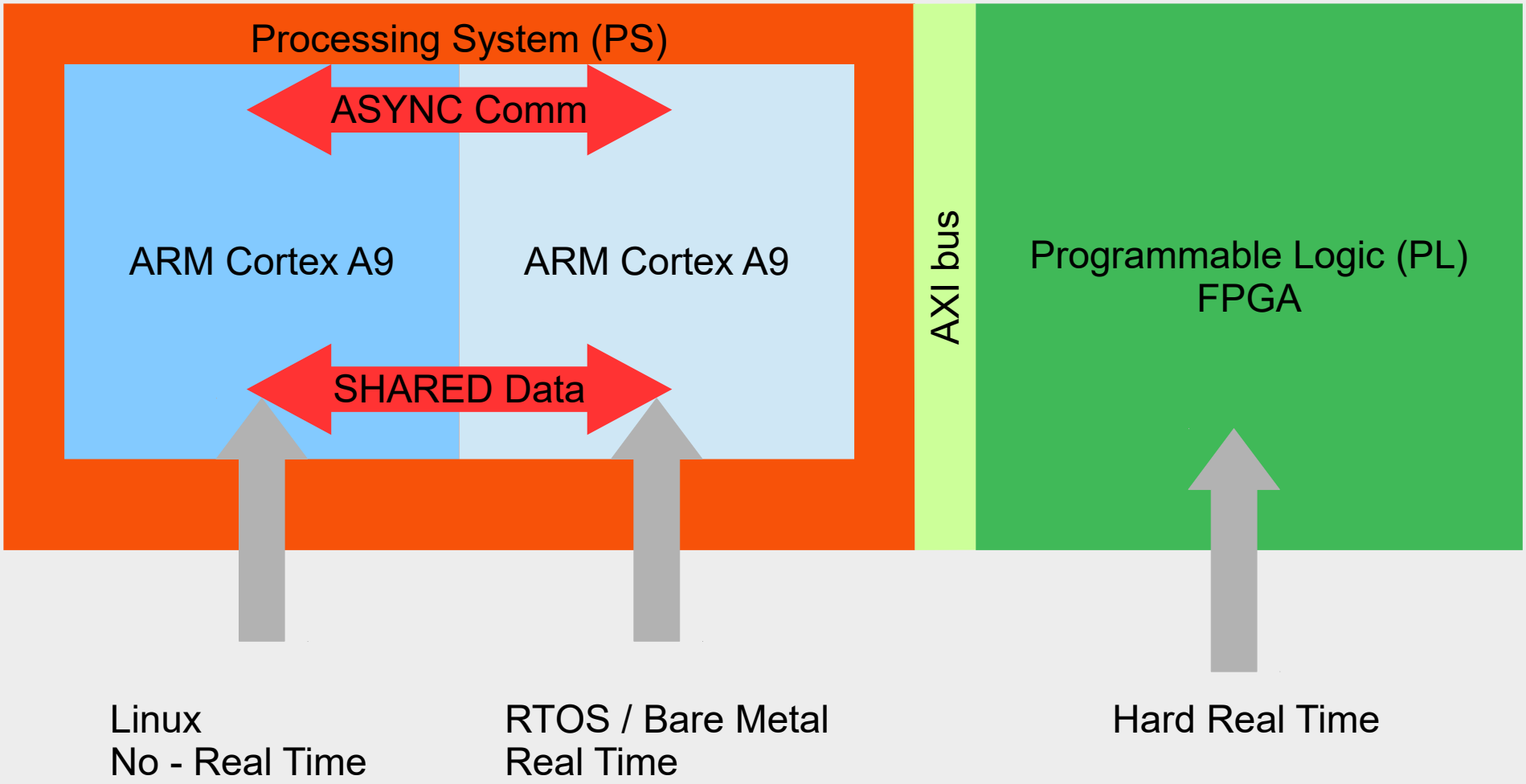

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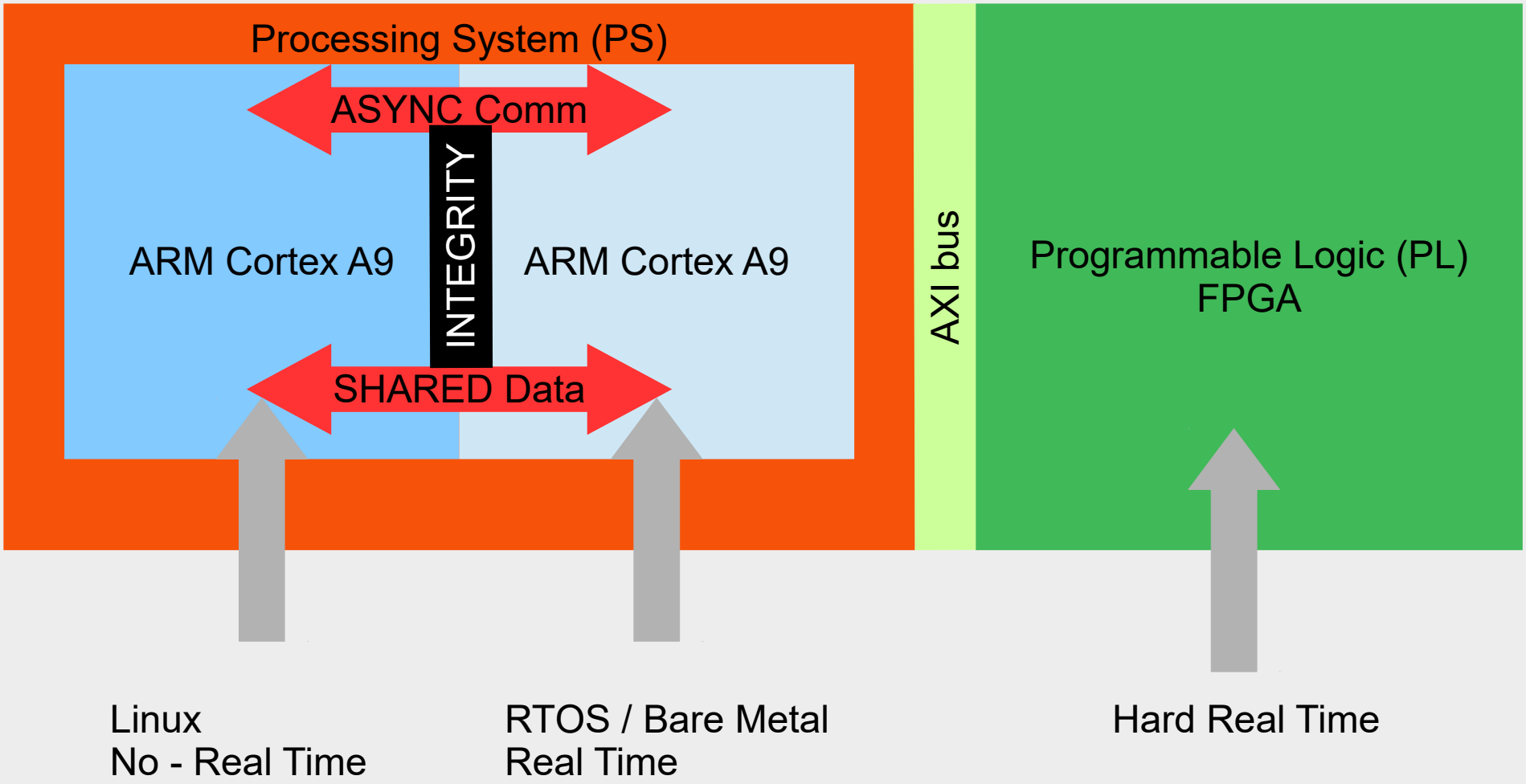

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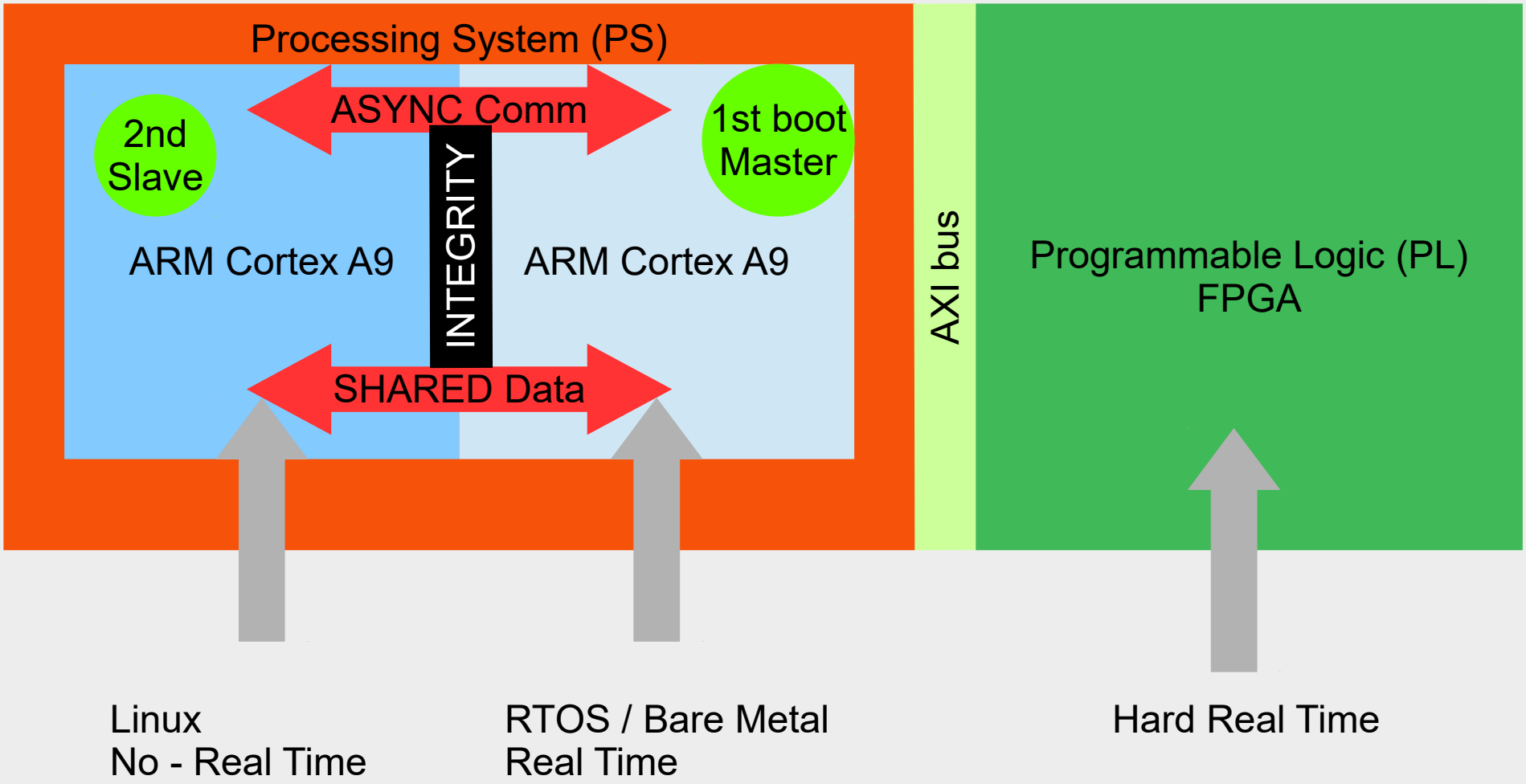

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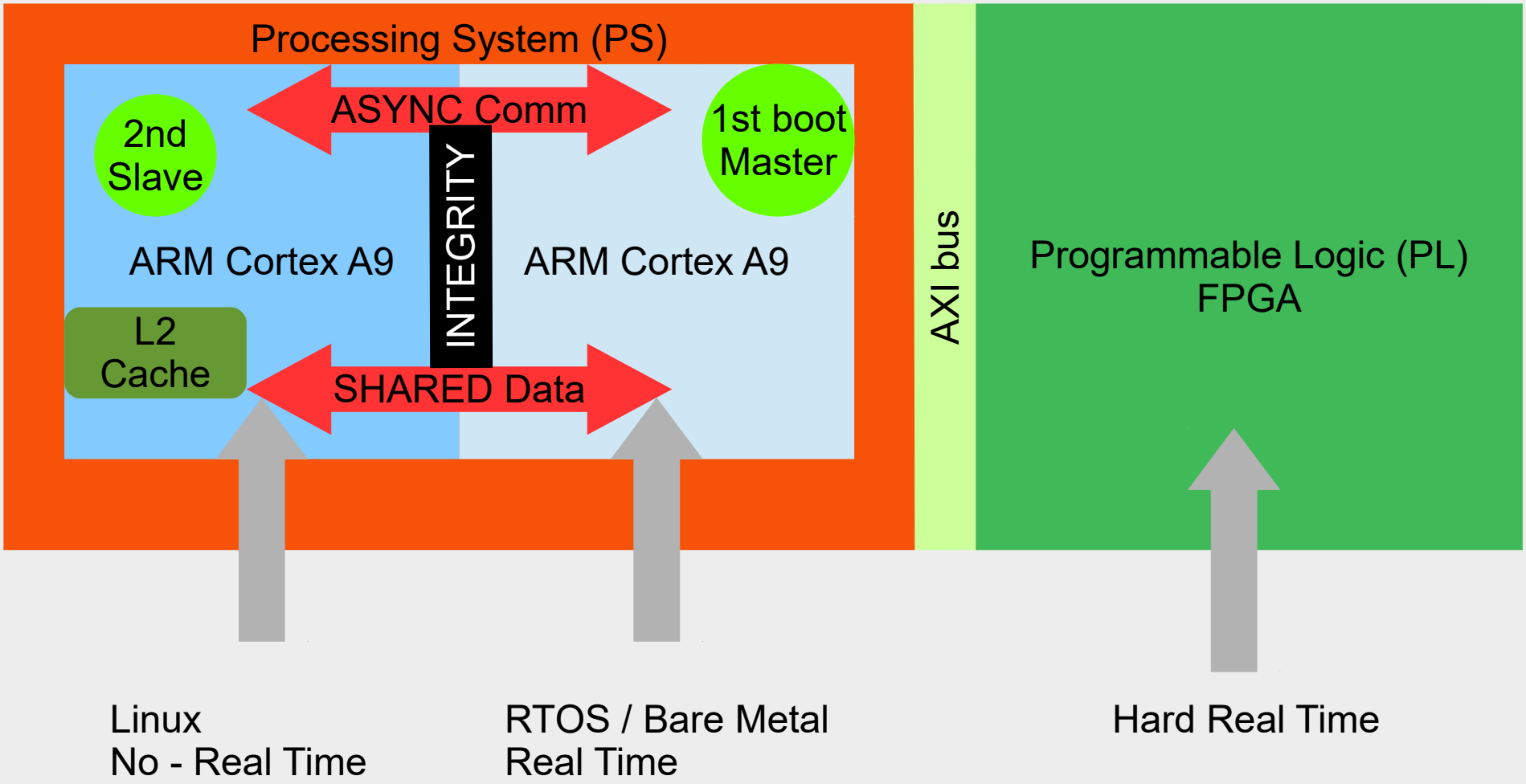

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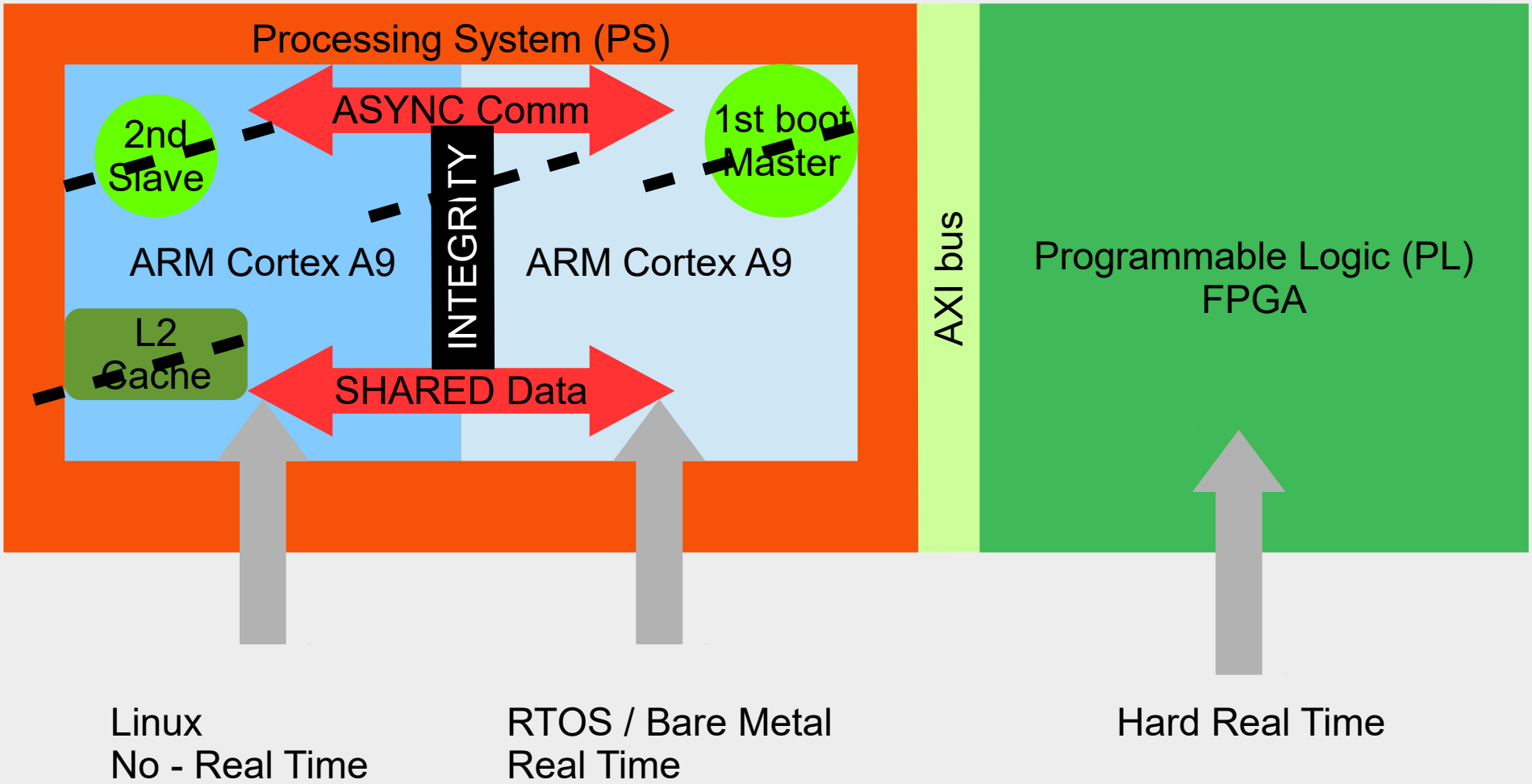

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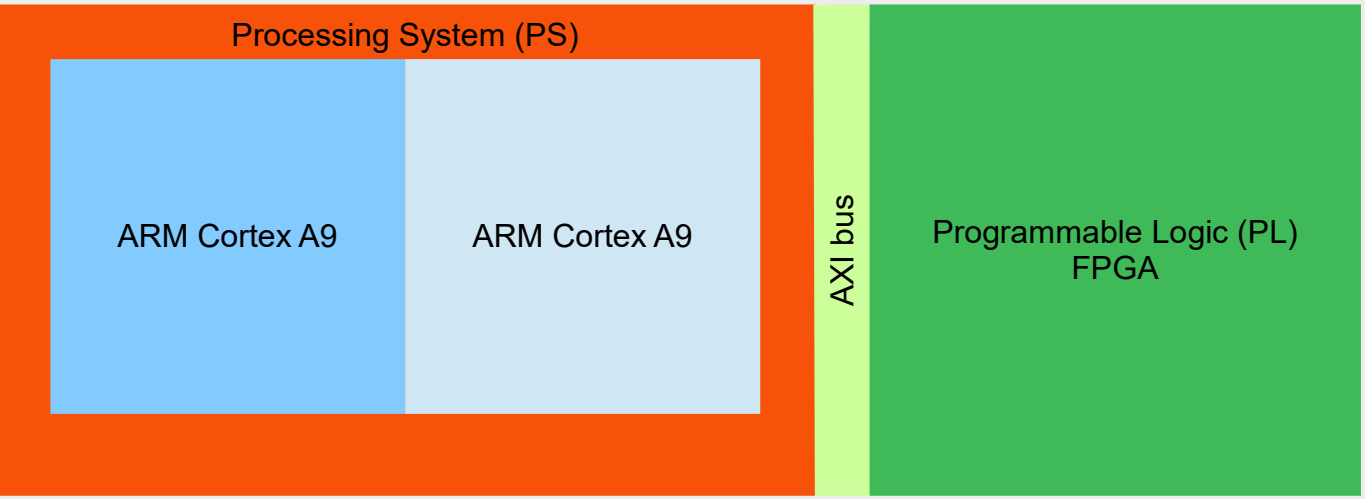
Traditional AMP has not ALL these feature so, integrate all new feature listed?

The TrustZone-based Approach



- It is required a Software Monitor

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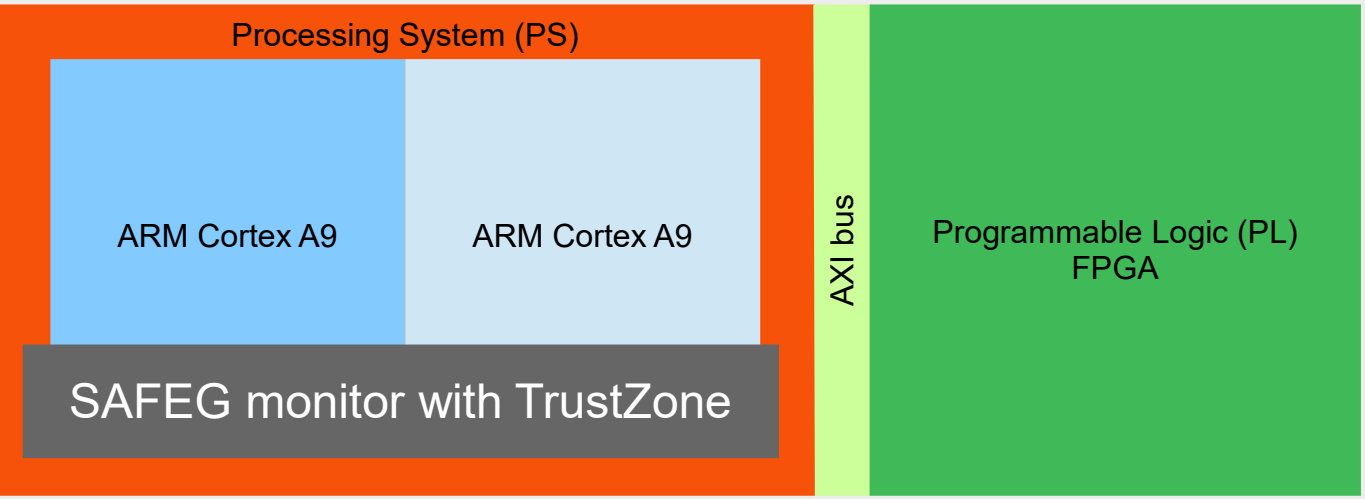
The TrustZone-based Approach



- It is required a Software Monitor
- Customized version of SAFEG

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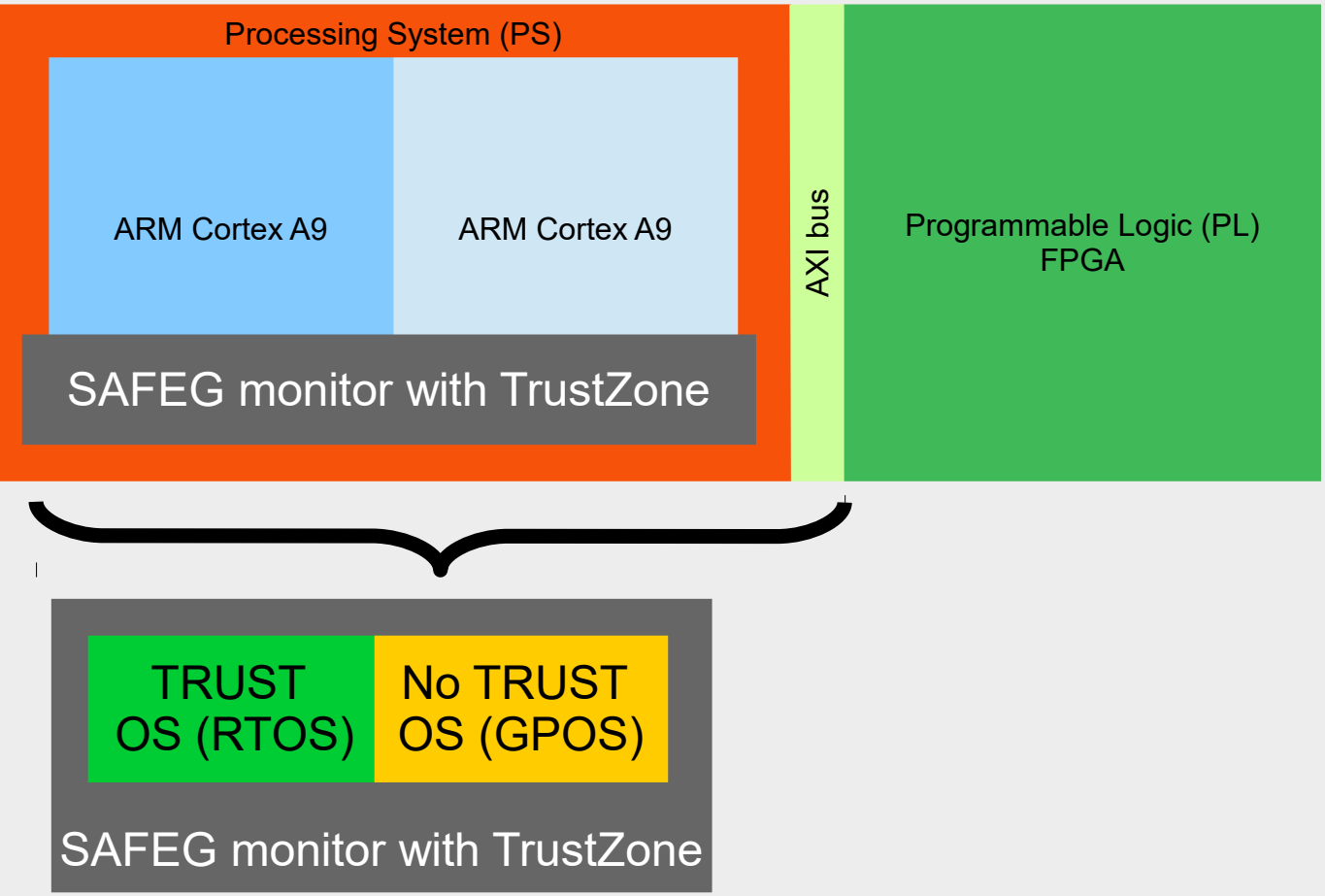
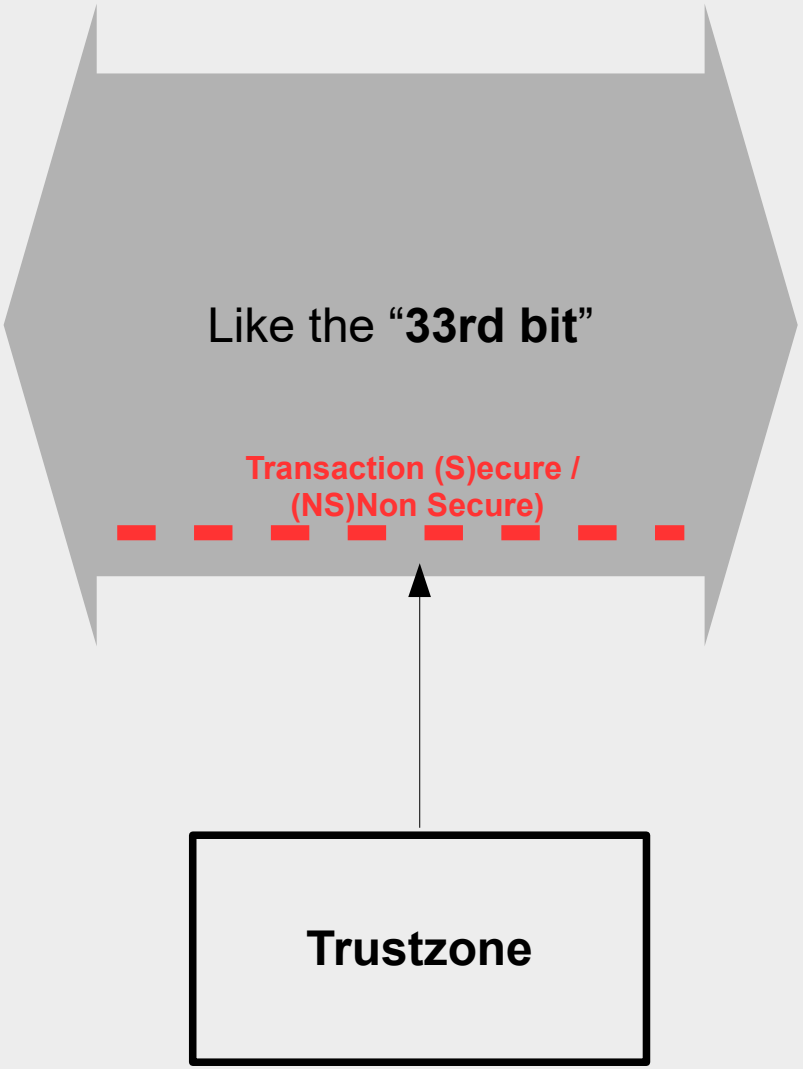


- It is required a Software Monitor
- Customized version of SAFEG
- The monitor is responsible for:
  - Enable TrustZone IP
  - Initialize Trusted /Non Trusted areas

DAVE Embedded Systems

The TrustZone - based Approach



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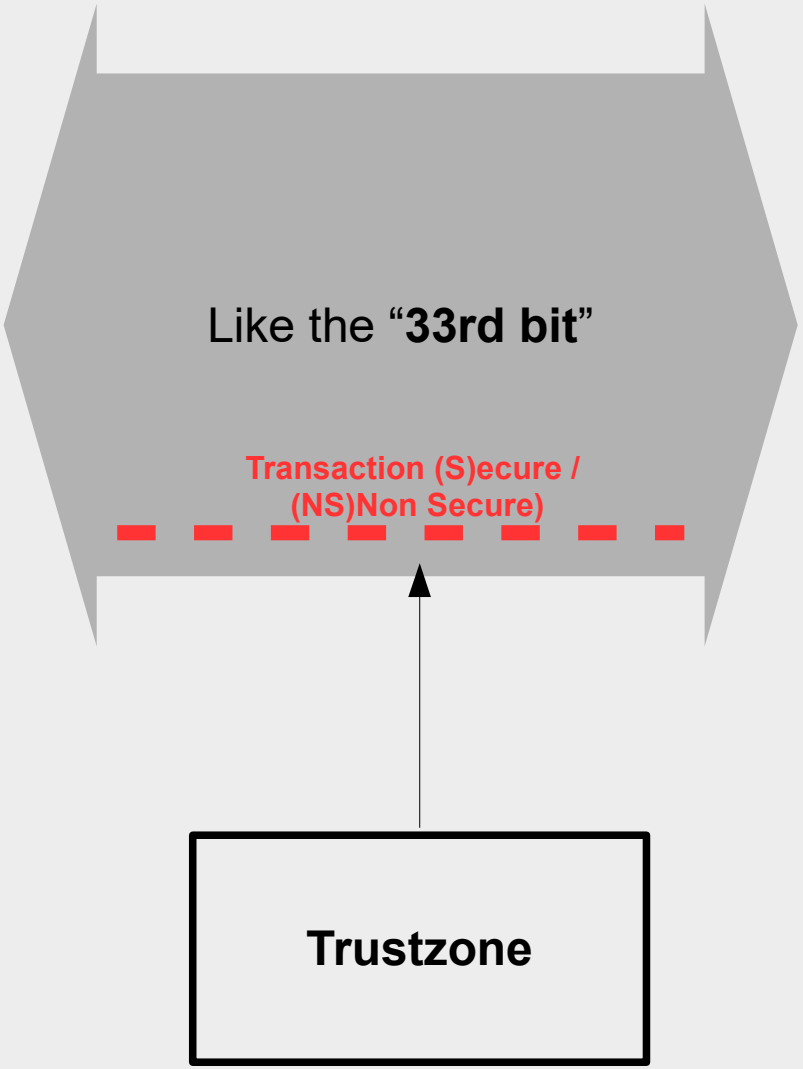

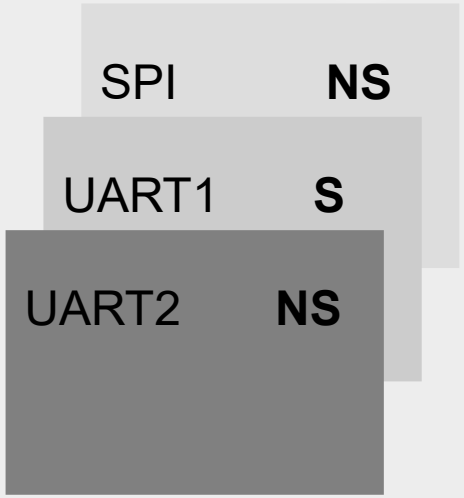

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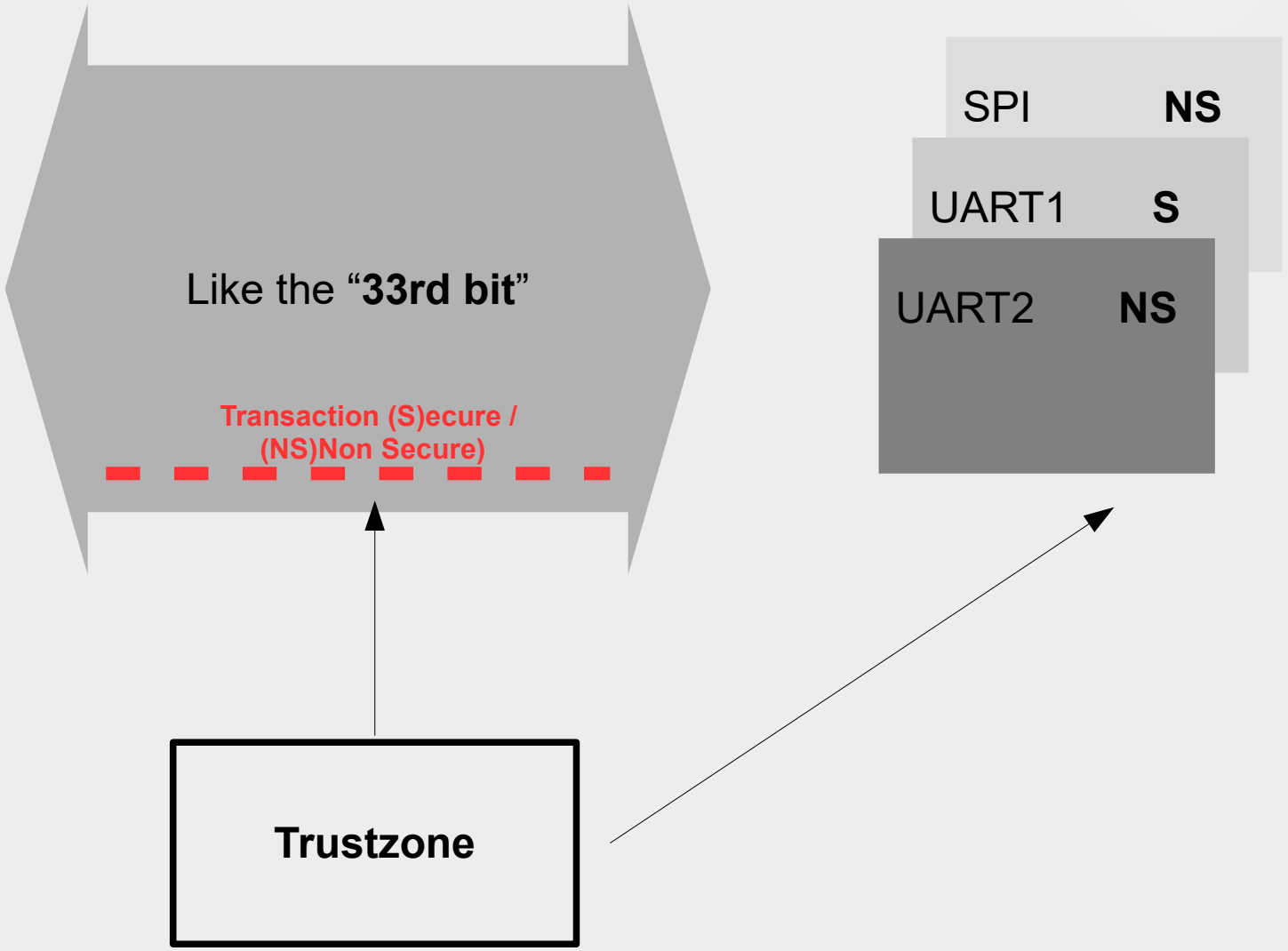
The TrustZone - based Approach



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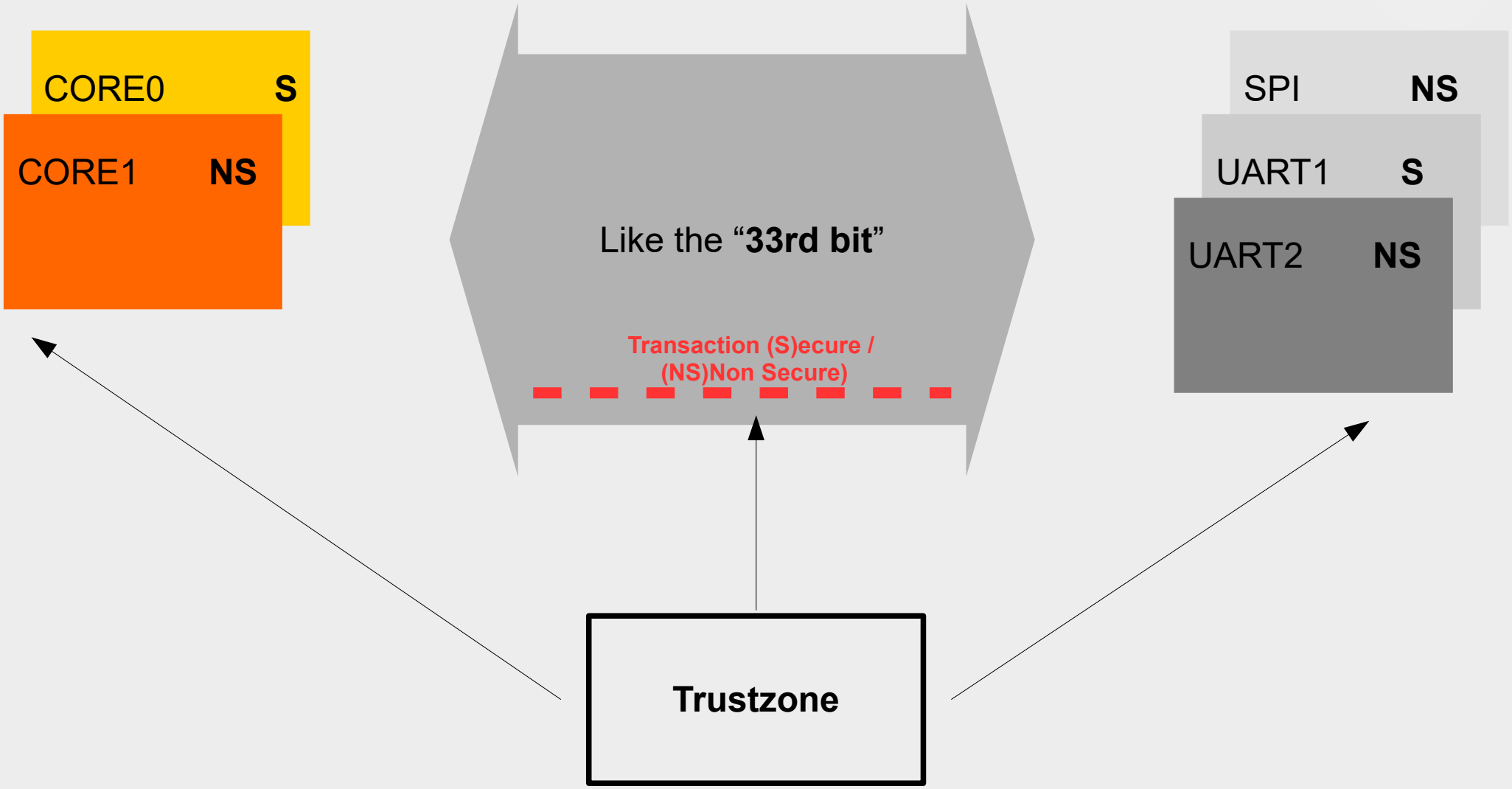

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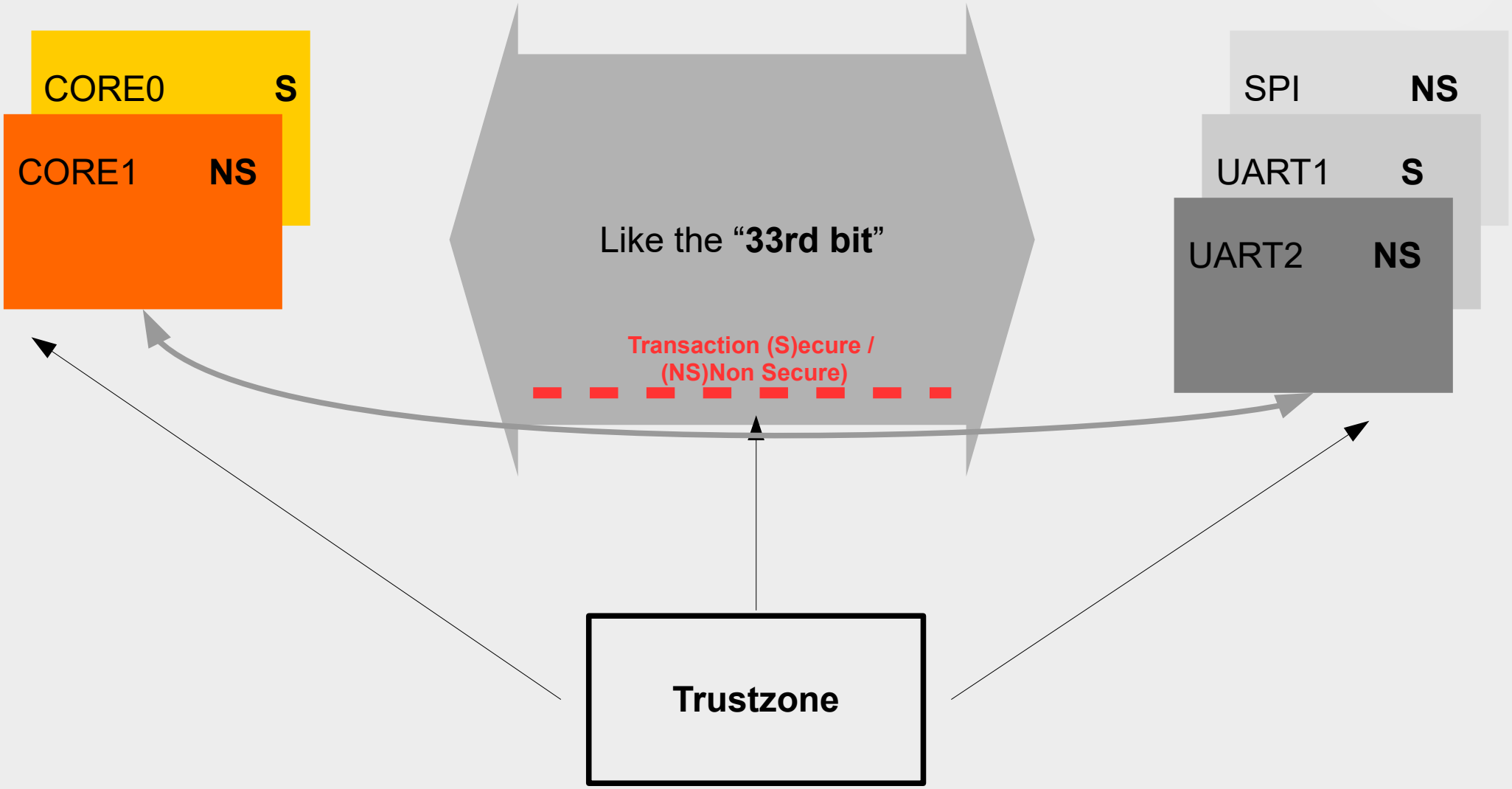
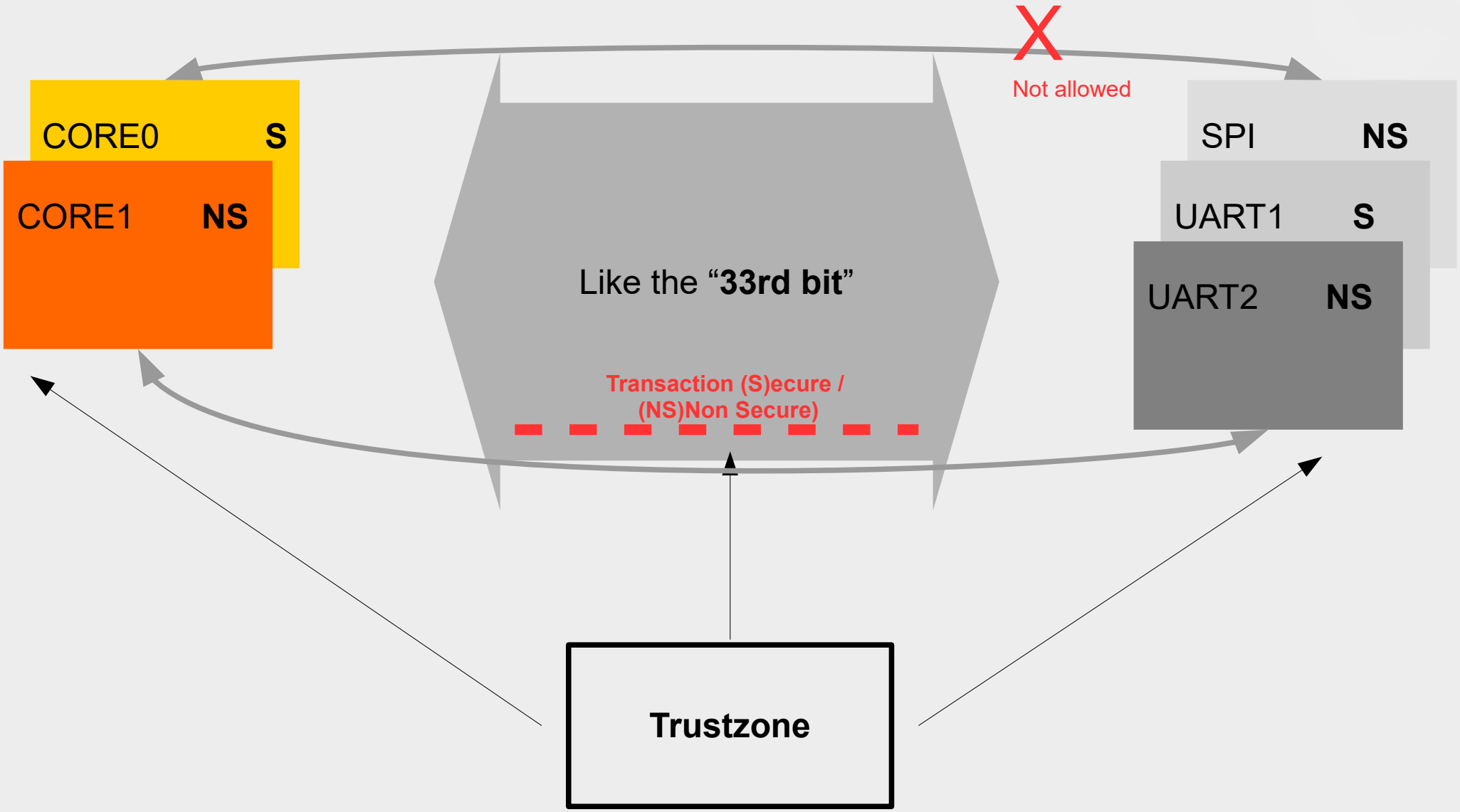


DAVE Embedded Systems

The TrustZone - based Approach



DAVE Embedded Systems

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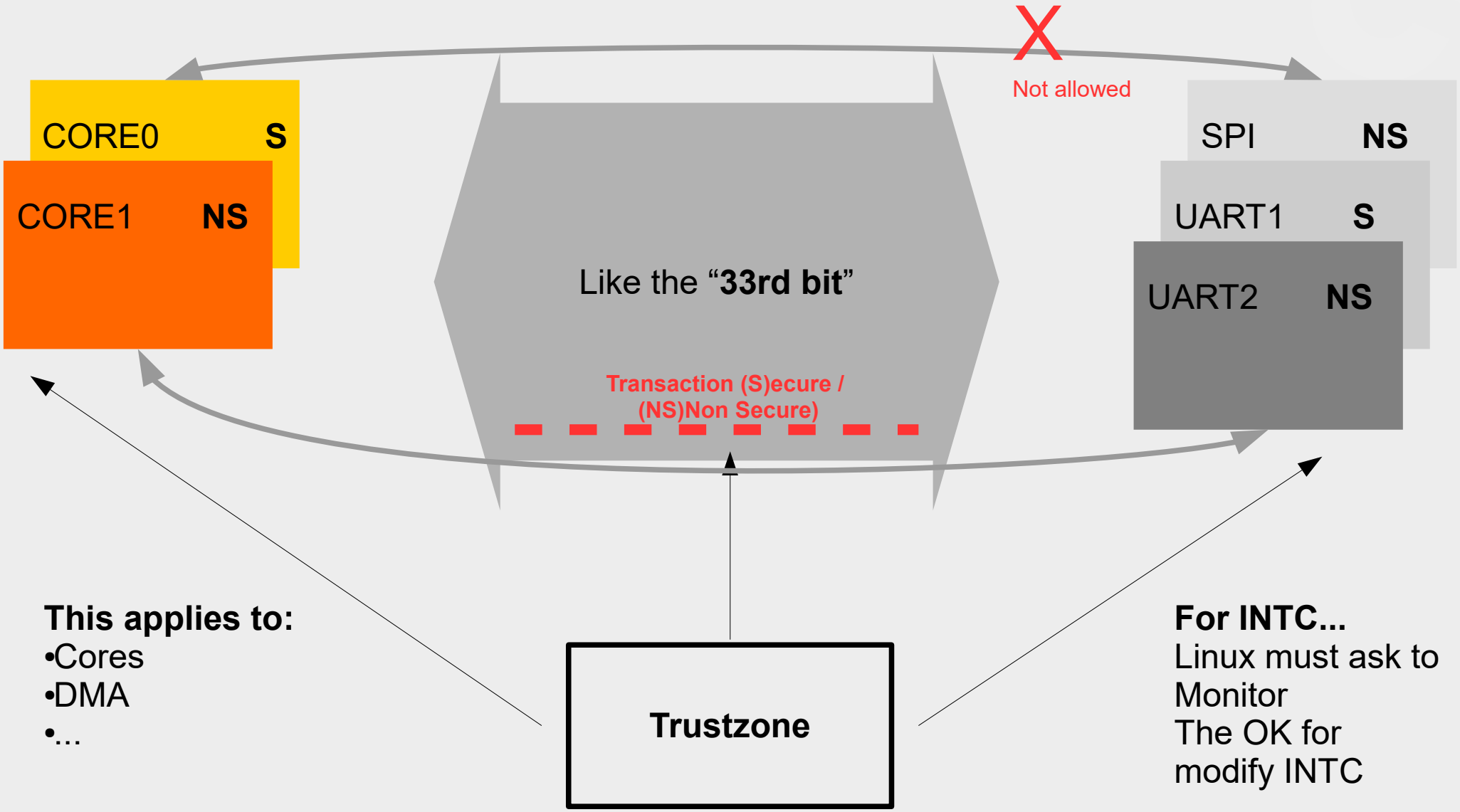
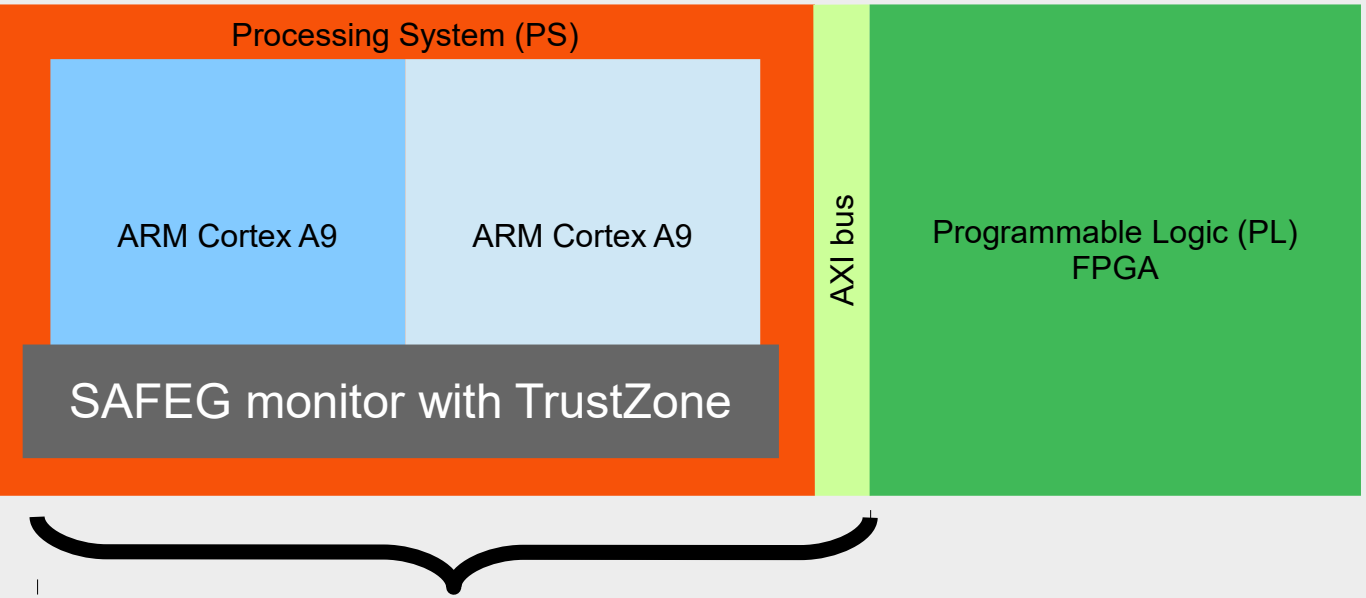


This applies to:
- Cores
- DMA
- ...

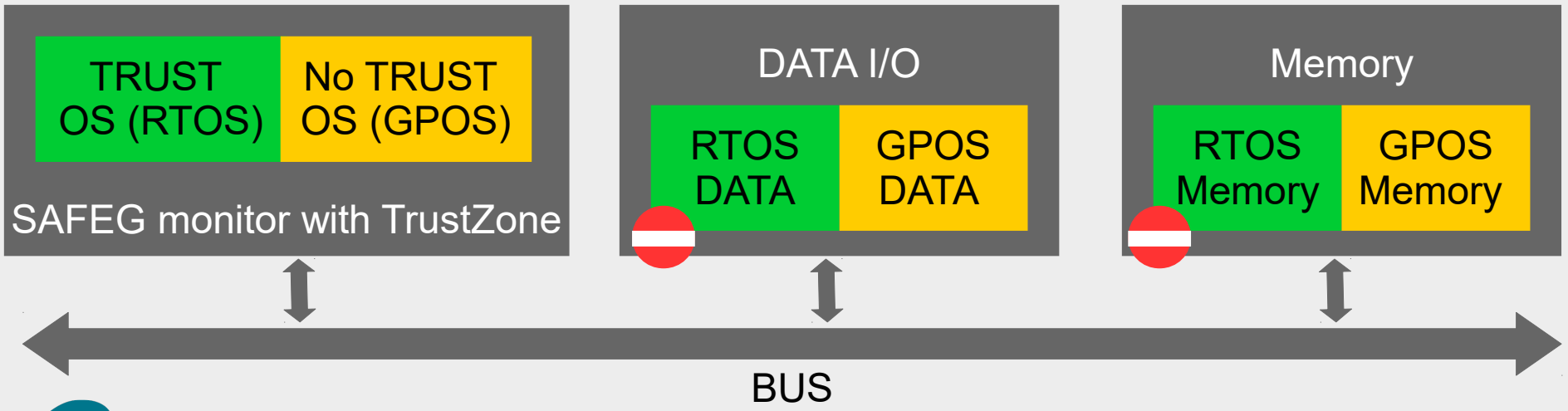
For INTC...
Linux must ask to Monitor
The OK for modify INTC

DAVE Embedded Systems

The TrustZone-based Approach



- It is required a Software Monitor
- Customized version of SAFEG
- The monitor is responsible for:
  - Enable TrustZone IP
  - Initialize Trusted /Non Trusted areas
  - Setup data struct and except handlers



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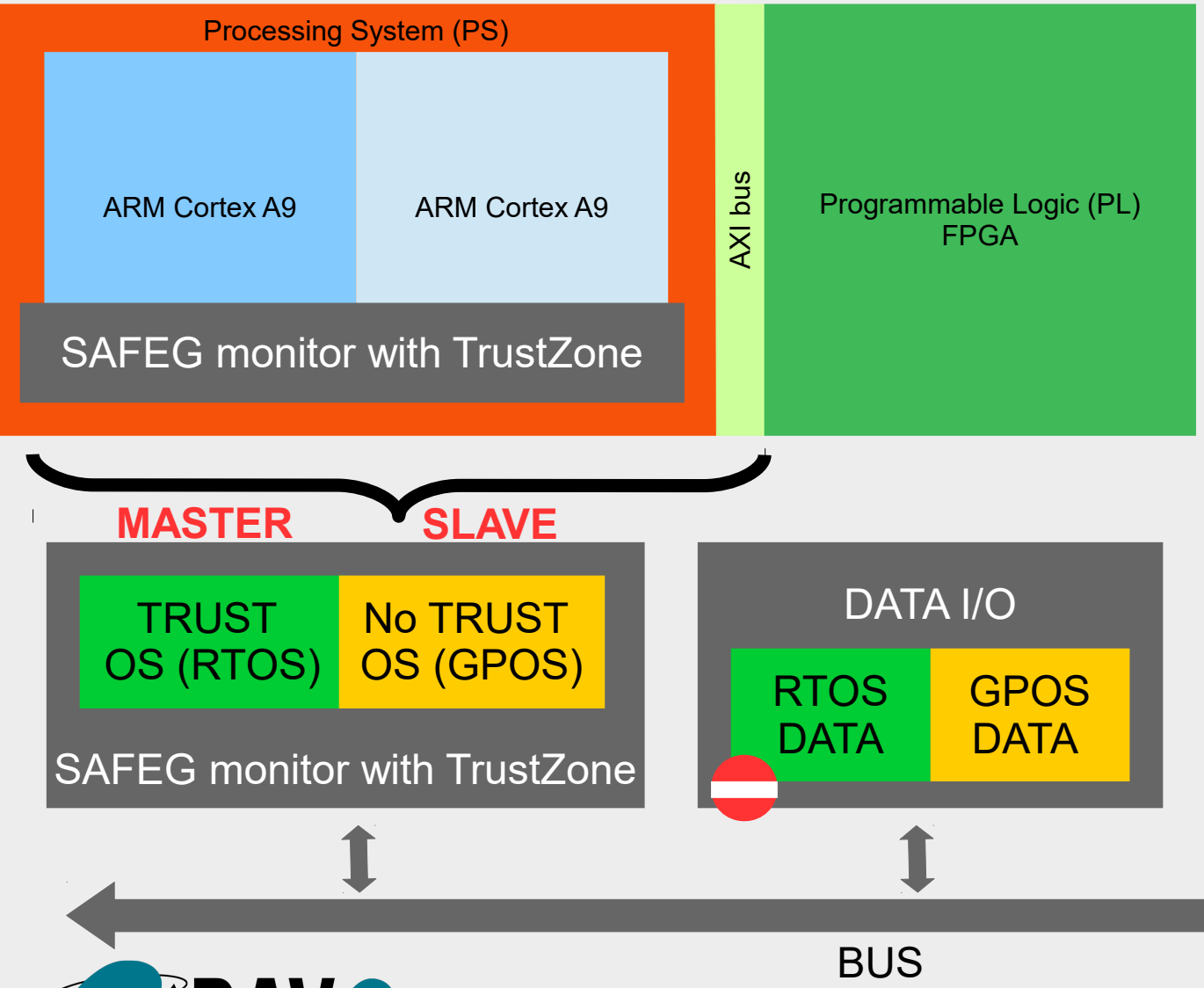
The TrustZone-based Approach



- It is required a Software Monitor
- Customized version of SAFEG
- The monitor is responsible for:
  - Enable TrustZone IP
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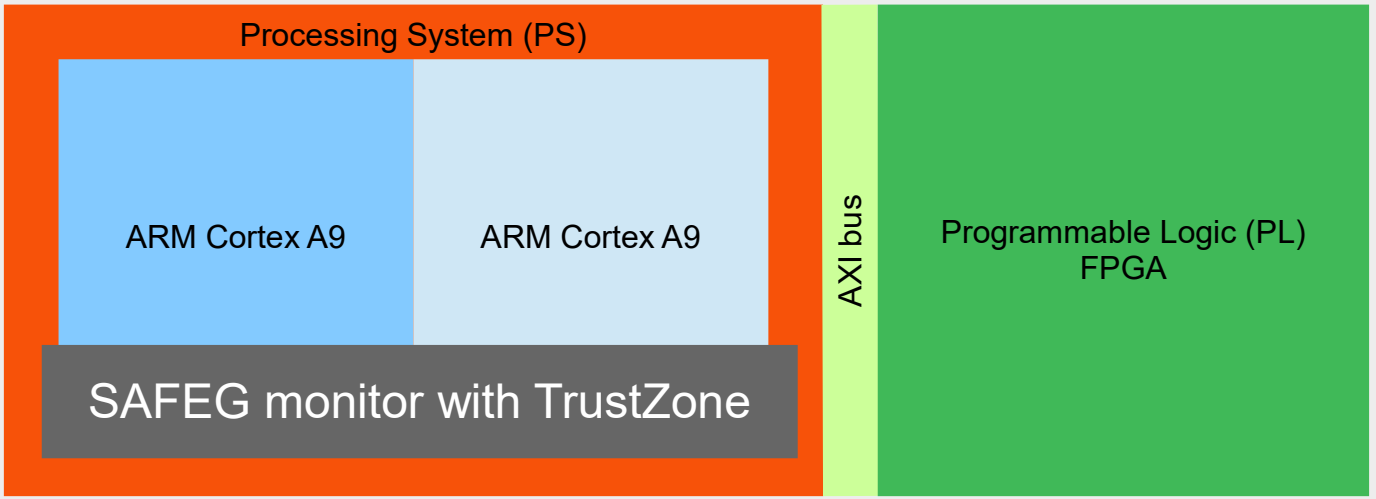
  - Start Trusted OS

DAVE Embedded Systems

DAVE Embedded Systems' example



DAVE Embedded Systems

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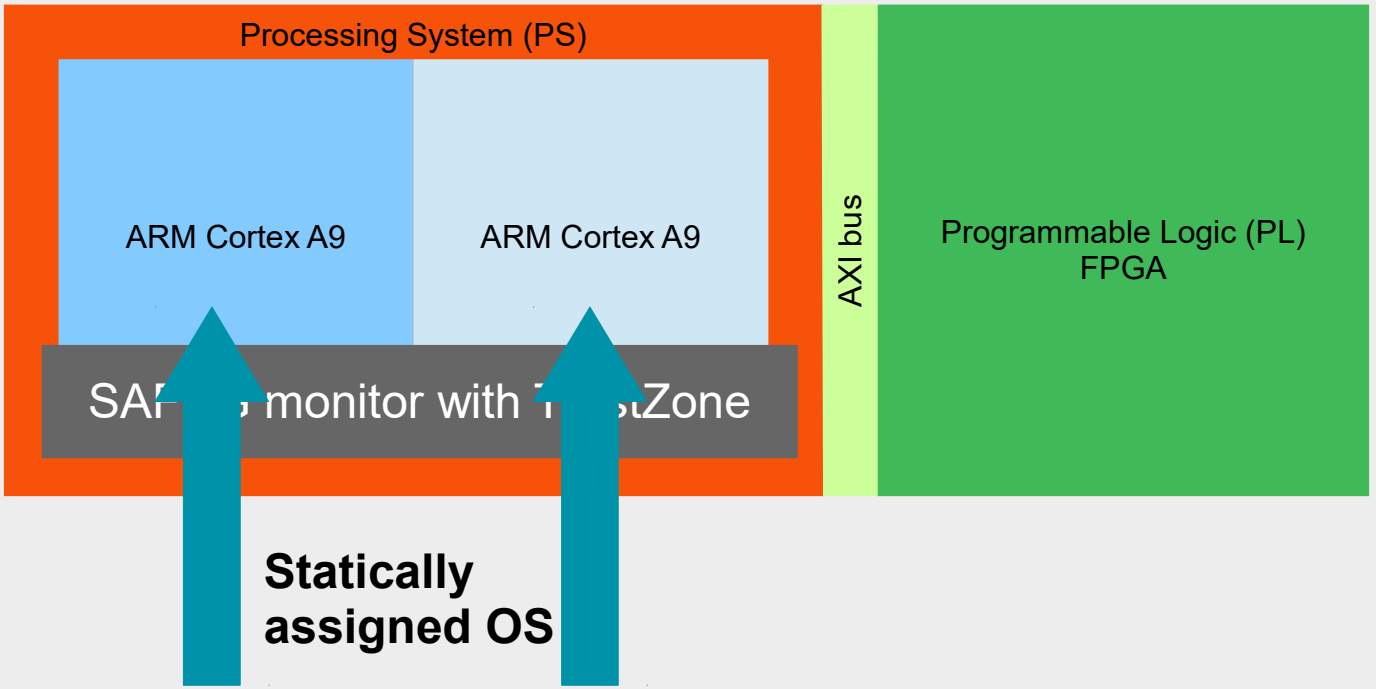

DAVE Embedded Systems

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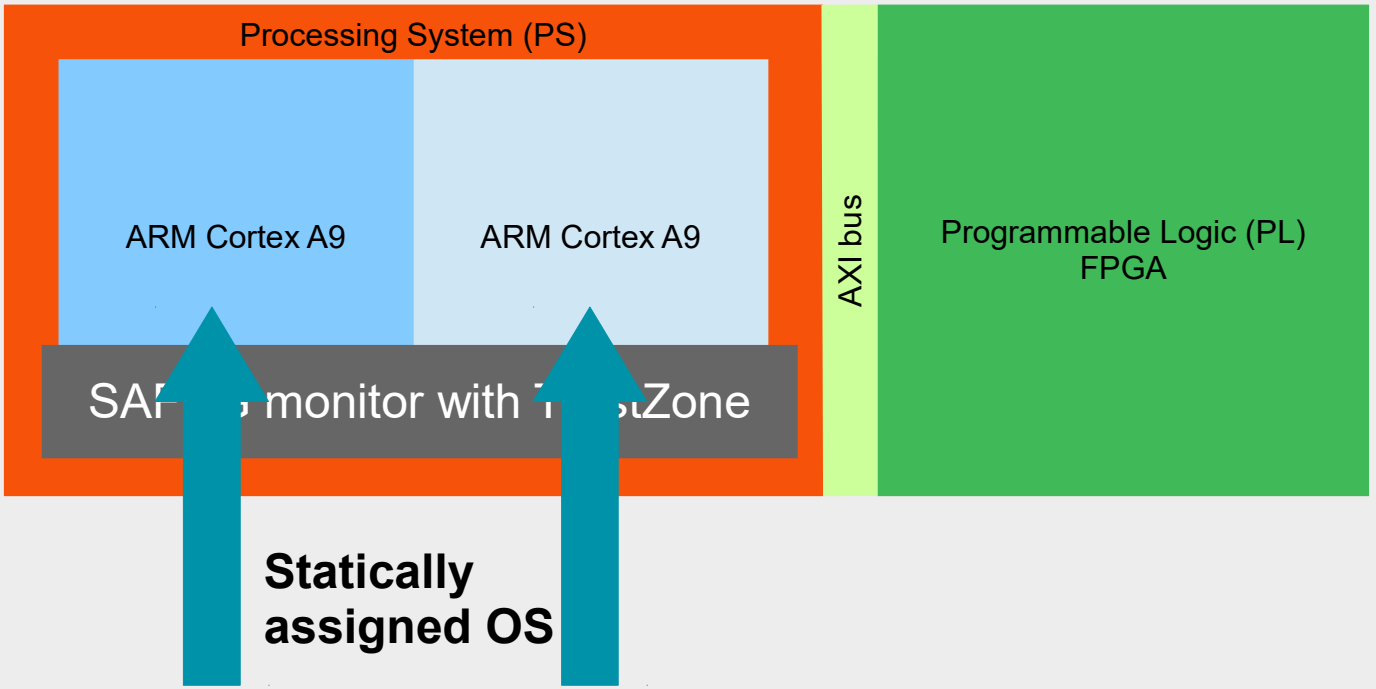
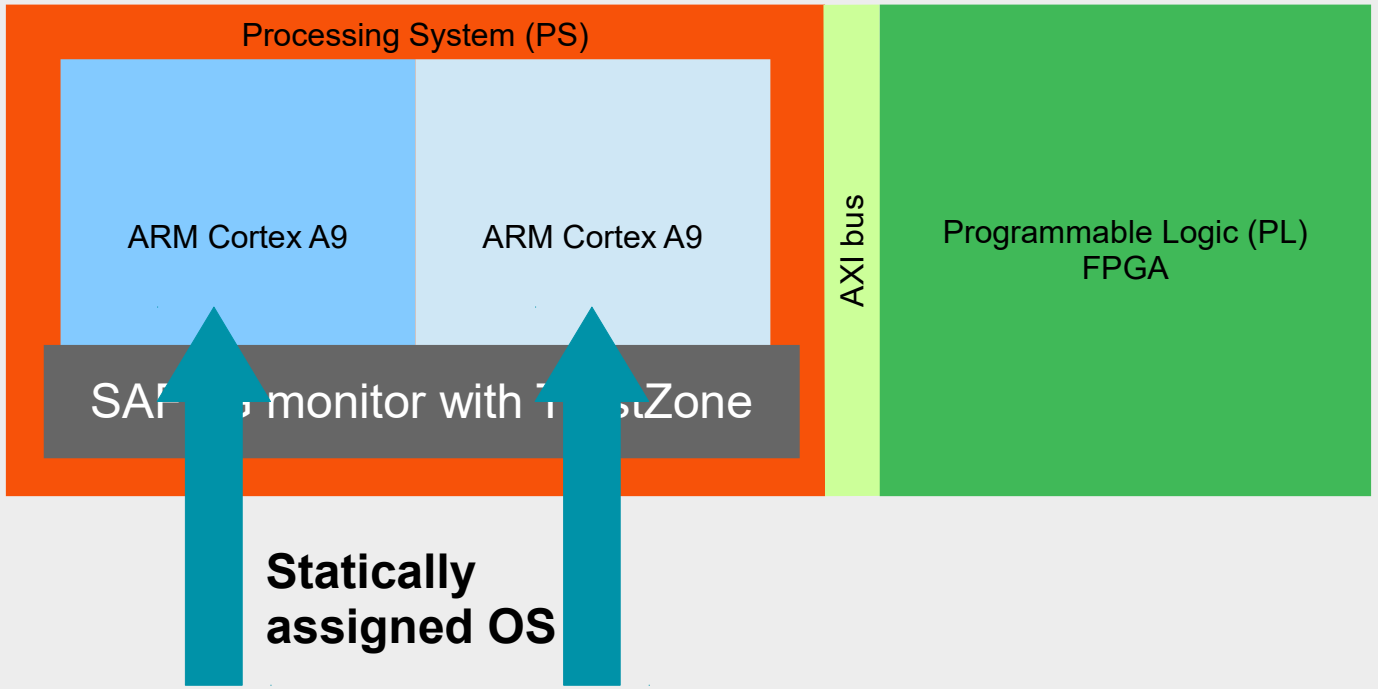


100% No Trusted
Linux

DAVE
Embedded Systems

DAVE Embedded Systems' example



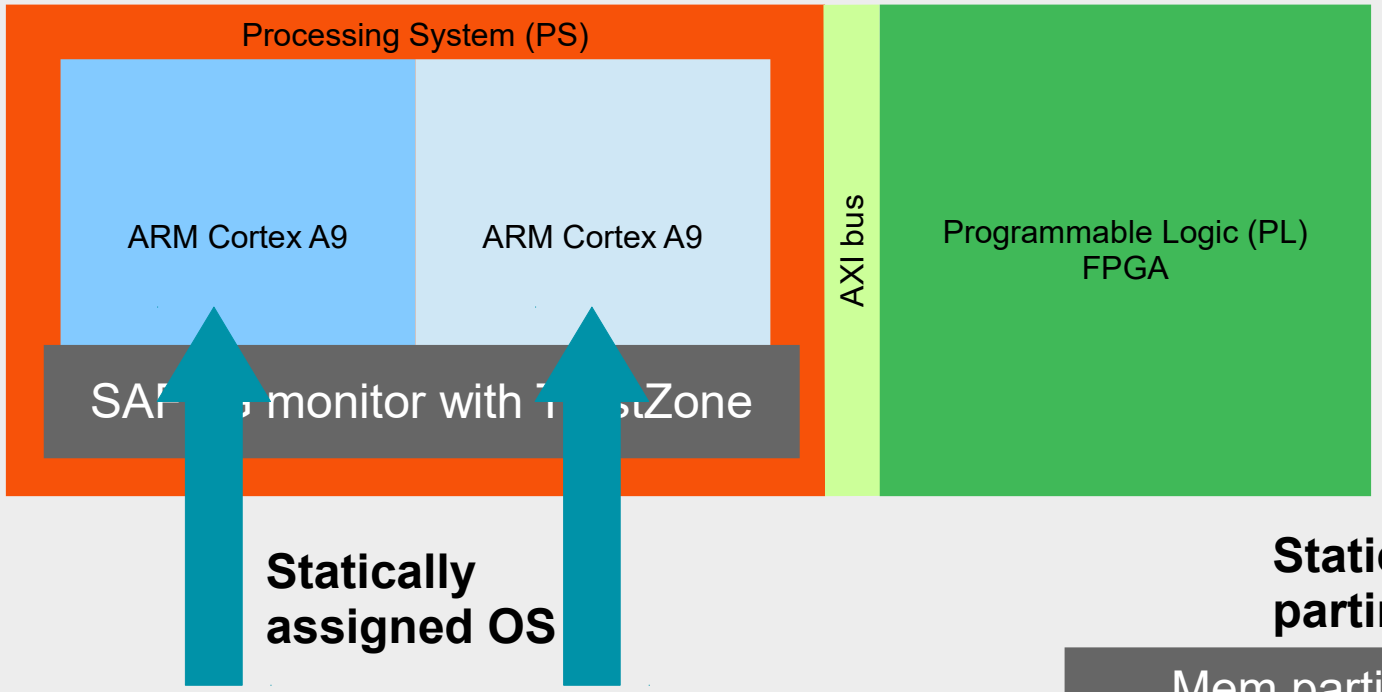
100% No Trusted
Linux

100% Trusted
FreeRTOS

No context switch
Reduced latency

DAVE
Embedded Systems

DAVE Embedded Systems' example



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**Statically
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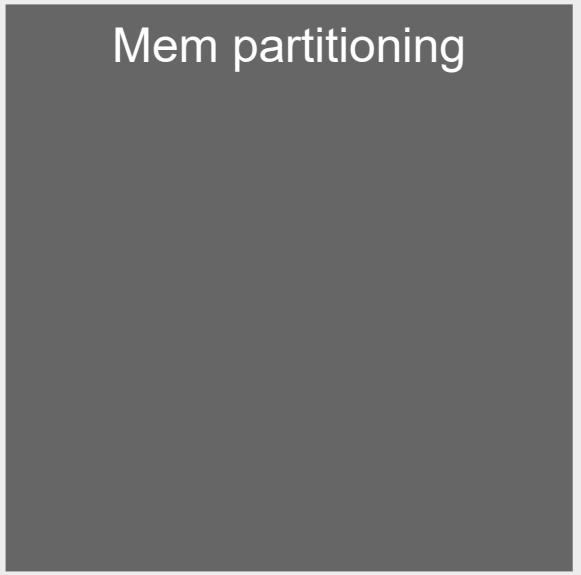

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Embedded Systems

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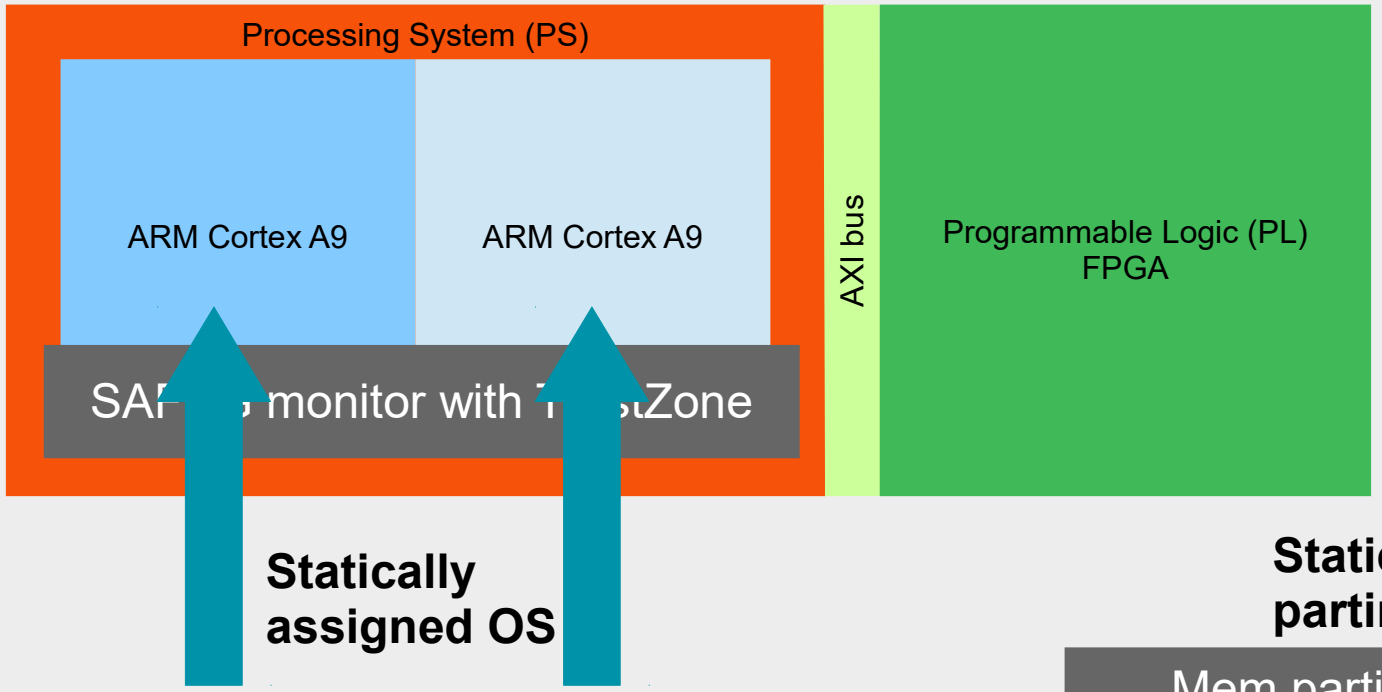

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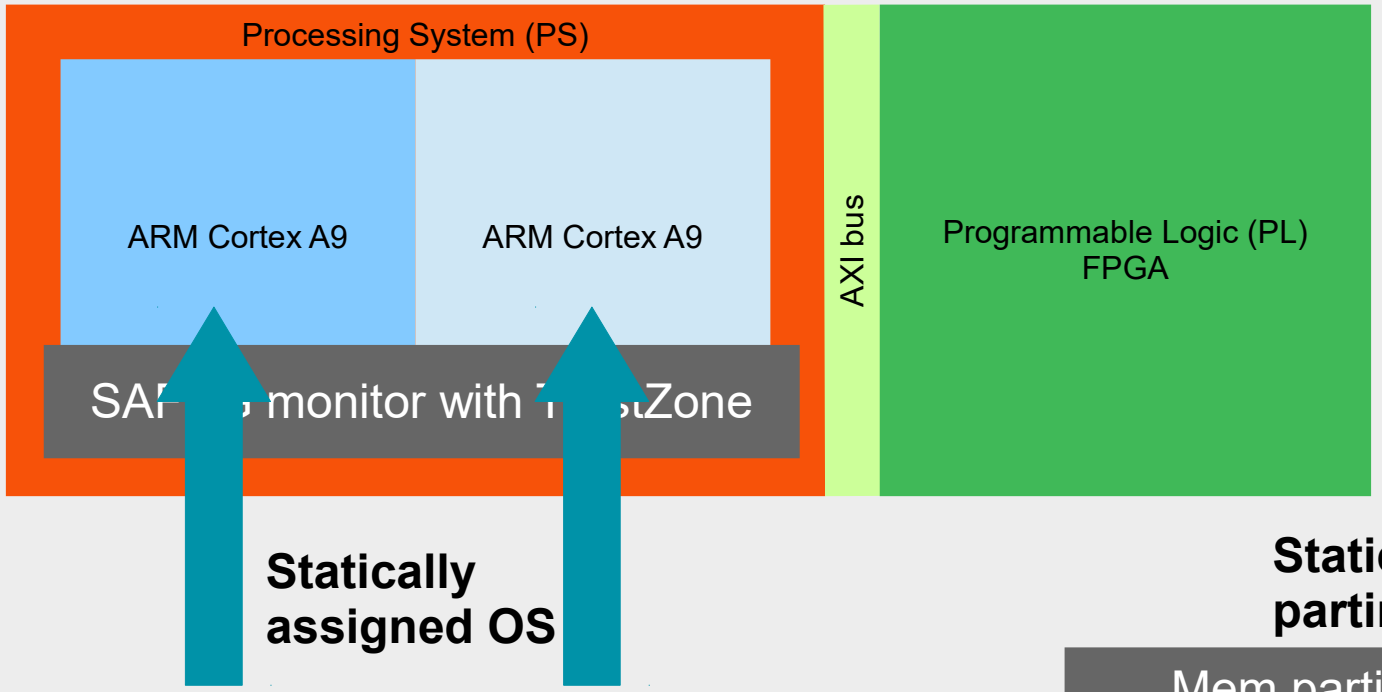
Statically partinioned

Mem partitioning

No trusted private
Area (MMU level)

DAVE
Embedded Systems

DAVE Embedded Systems' example



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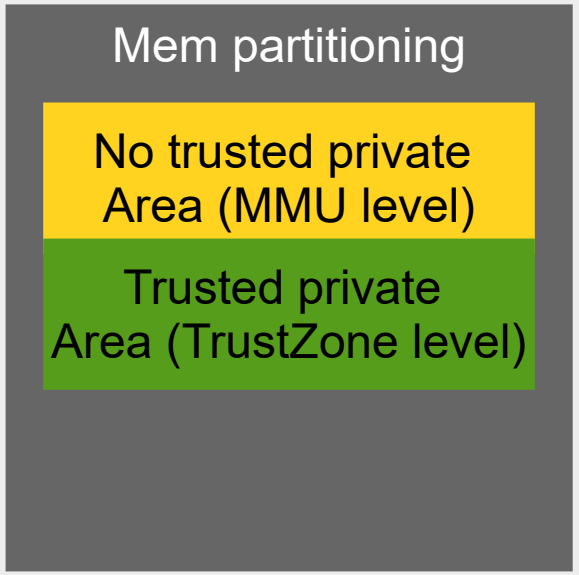

DAVE
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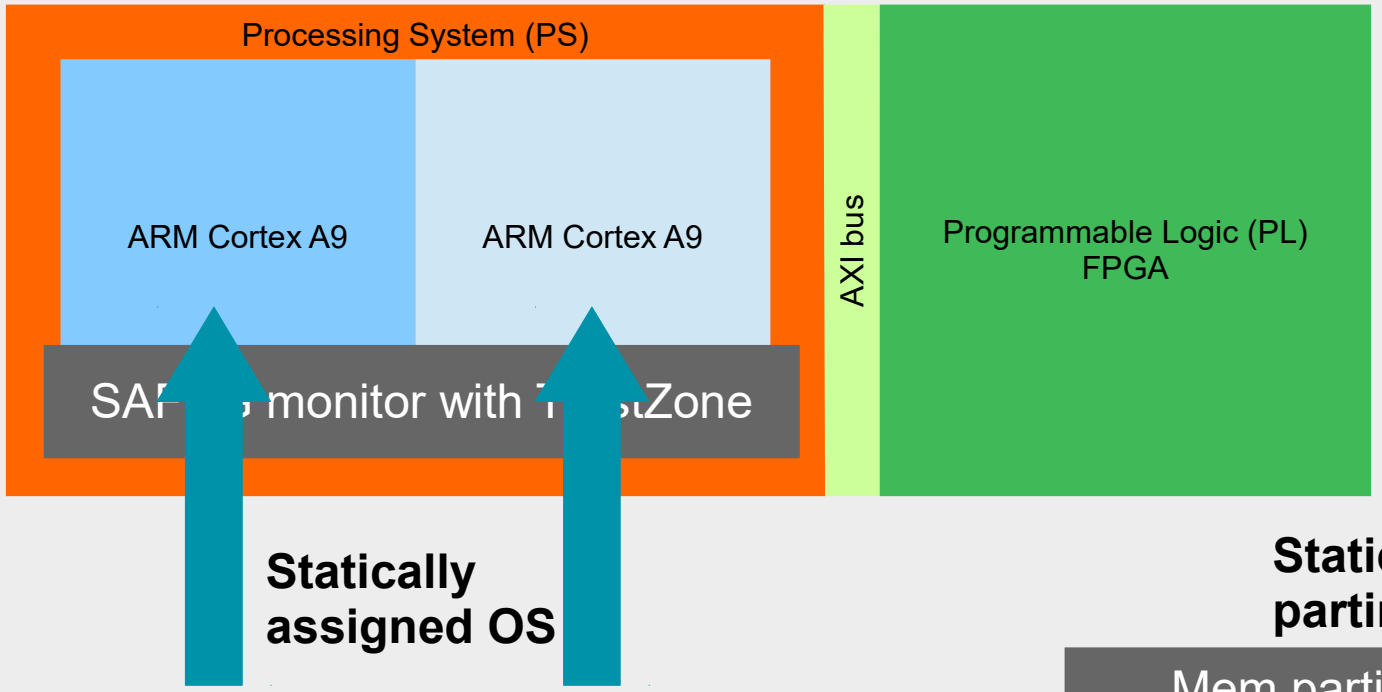

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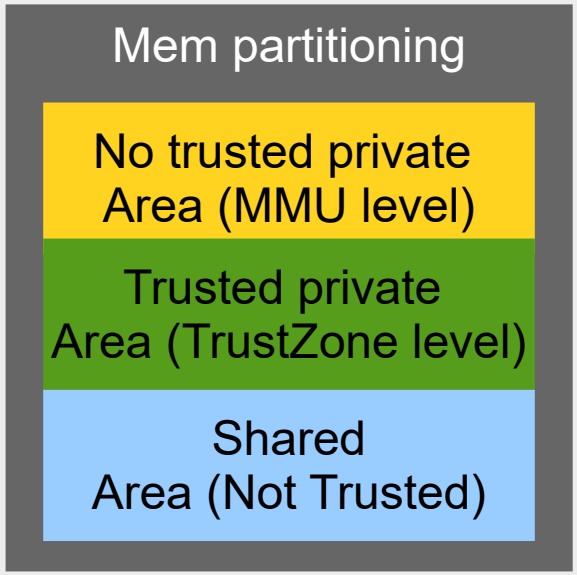

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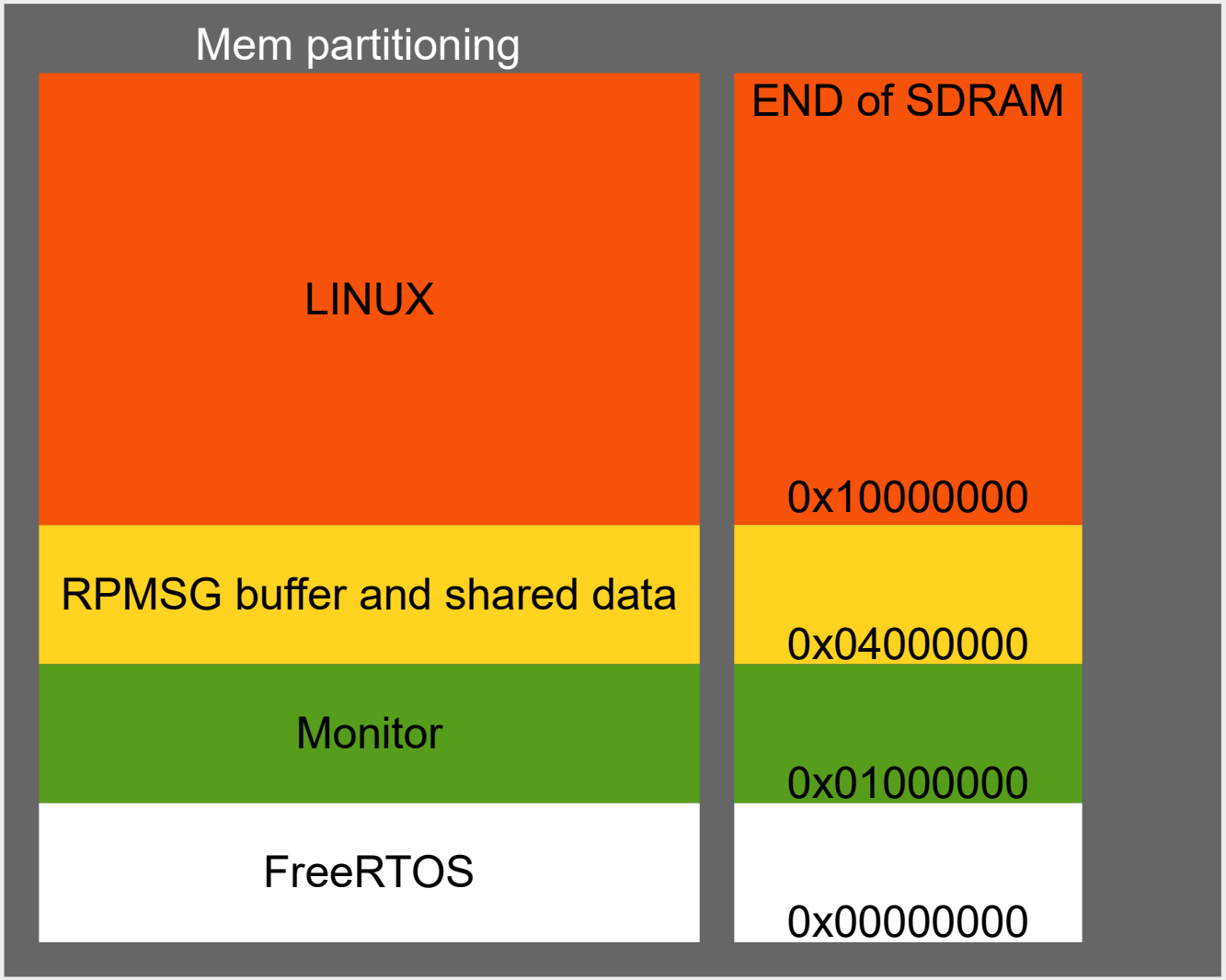
Embedded Systems

Details: The MEM partinioning



DAVE Embedded Systems

Details: The BOOT process

0 – **RESET**

DAVE Embedded Systems

Details: The BOOT process

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1 – **BootROM**: FSBL taken from NV-memory and loaded on On Chip Memory

DAVE Embedded Systems

Details: The BOOT process

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2 – **FSBL**: SDRAM init and Uboot image load in memory

DAVE Embedded Systems

Details: The BOOT process

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DAVE Embedded Systems

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DAVE Embedded Systems

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- Init TrustZone
- Enable data structures and Handlers for both cores
- Gives to Trust code the control of machine FREERTOS **MASTER**

DAVE Embedded Systems

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- Enable data structures and Handlers for both cores
- Gives to Trust code the control of machine FREERTOS **MASTER**

6 – **RTOS** FreeRTOS:
- Under his control decides to start No Trusted OS (LINUX) **SLAVE**

DAVE Embedded Systems

Details: Inter-World comm

Several methods available

OP - TEE

dualoscom

Based on TOPPERS
Very specific
Too SW layers

RPMsg

Based on TI DSP accepted on mainline
Used by Xilinx in AN
Very well structured on buffers and cache handlings

OpenAMP

Similar to RPMsg
Used on MPSoCs

DAVE Embedded Systems

Details: Inter-World comm

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OP - TEE

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Selection Criterias

DAVE Embedded Systems

Details: The BOOT process

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Acceptance into
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Acceptance into
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Control over the
isolation level between
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DAVE Embedded Systems

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Acceptance into Mainline Linux Kernel

Maintenance – future developments

Control over the isolation level between the two worlds

DAVE Embedded Systems

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↓

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↓

The level of isolation is application dependent

DAVE Embedded Systems

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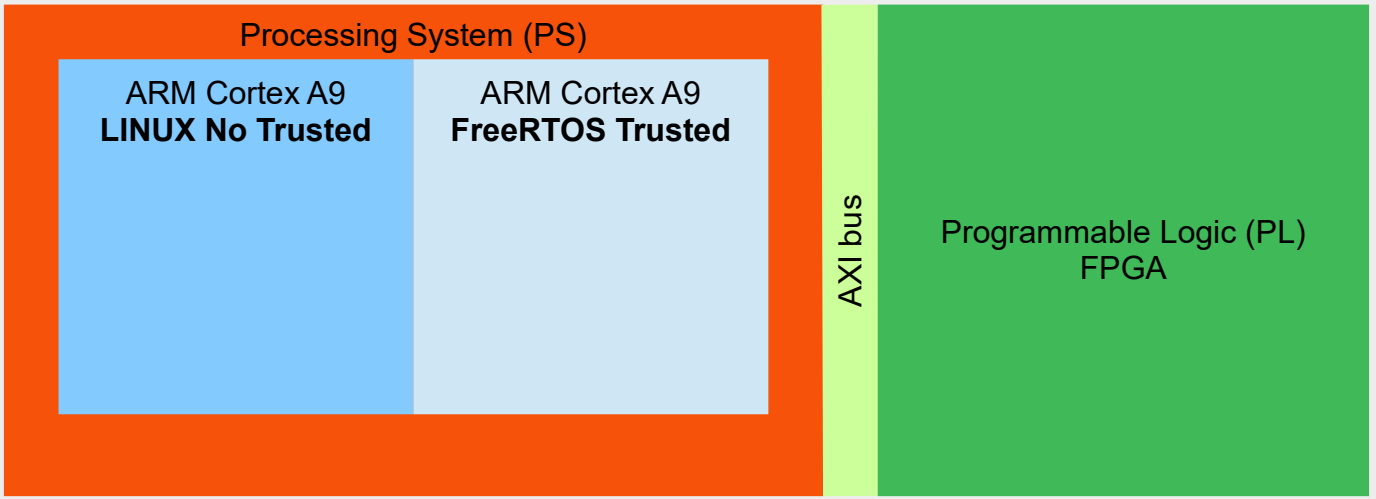
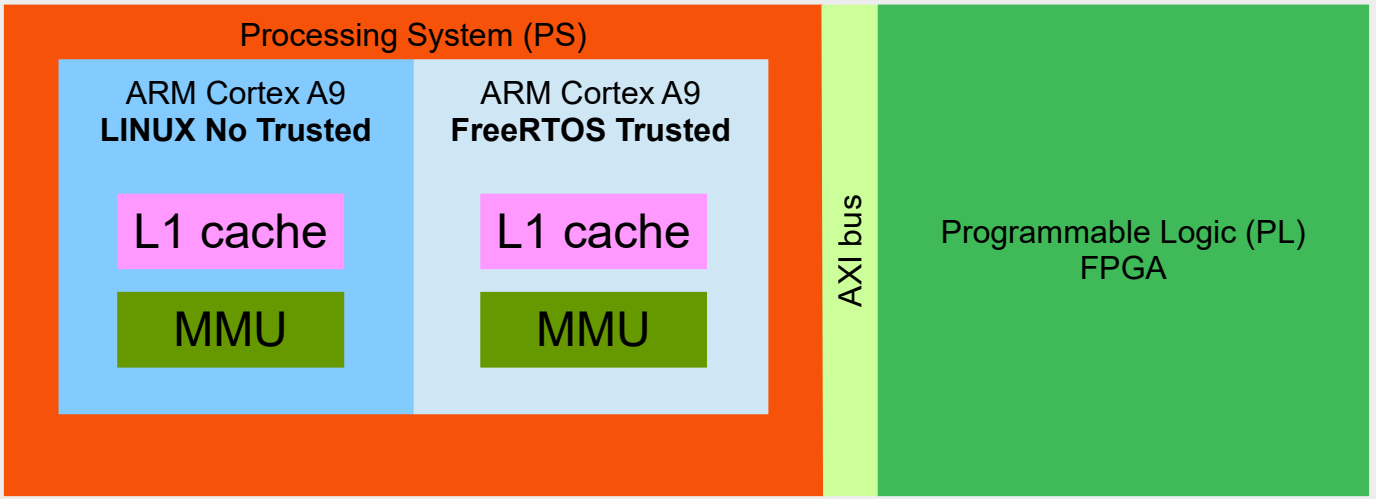
DAVE Embedded Systems

Details: L2 cache management



DAVE Embedded Systems

Details: L2 cache management



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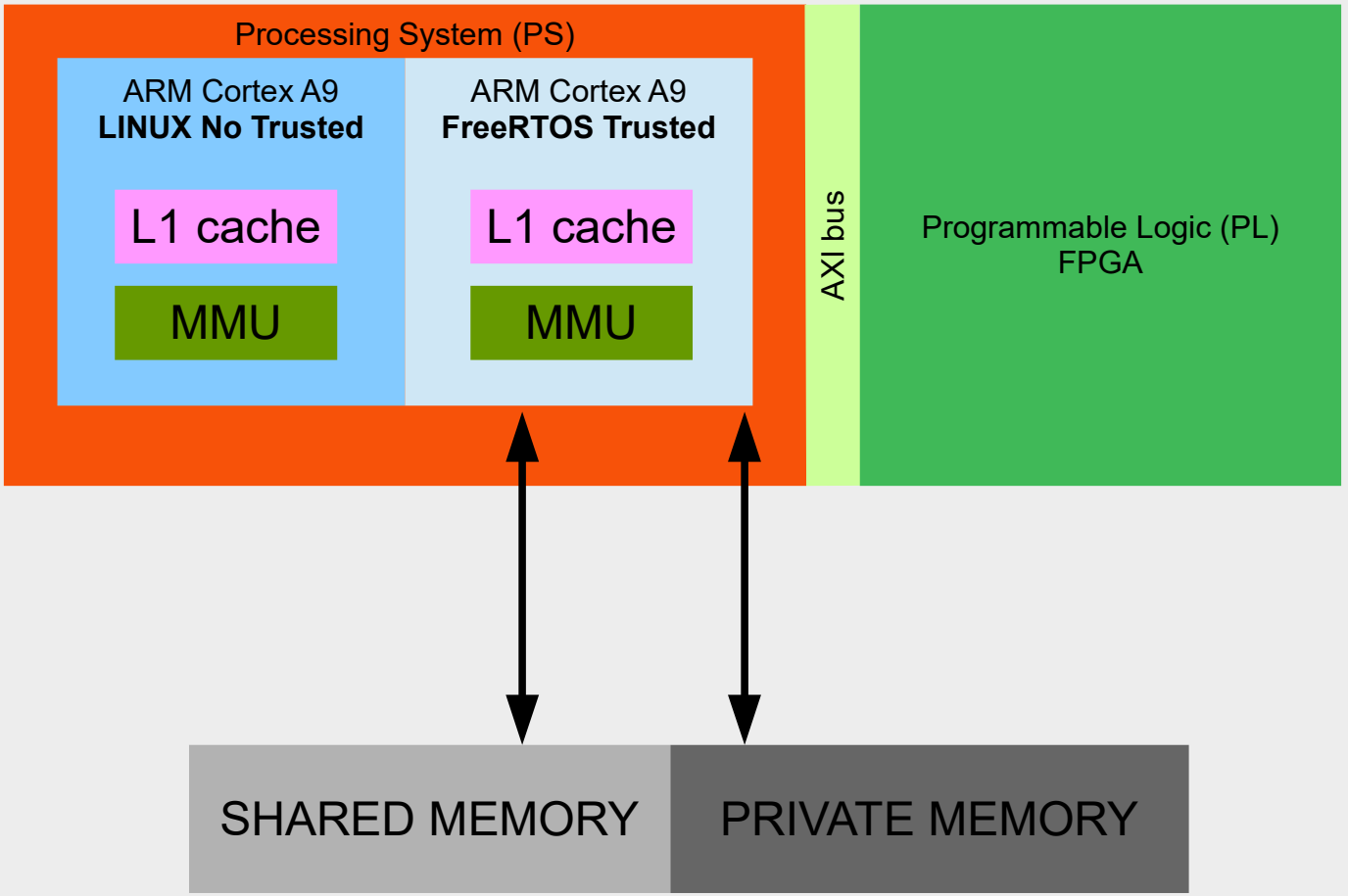

DAVE Embedded Systems

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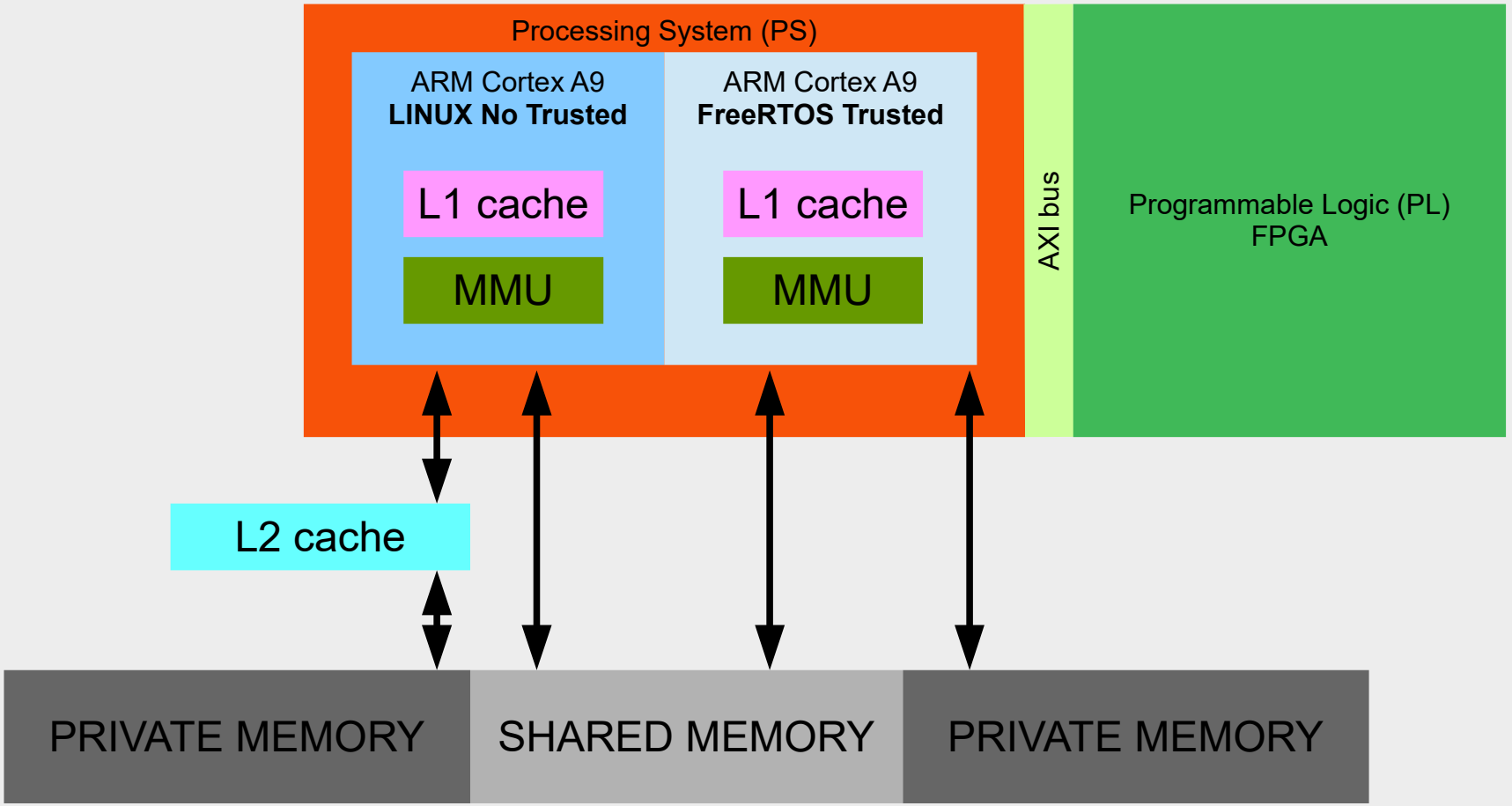

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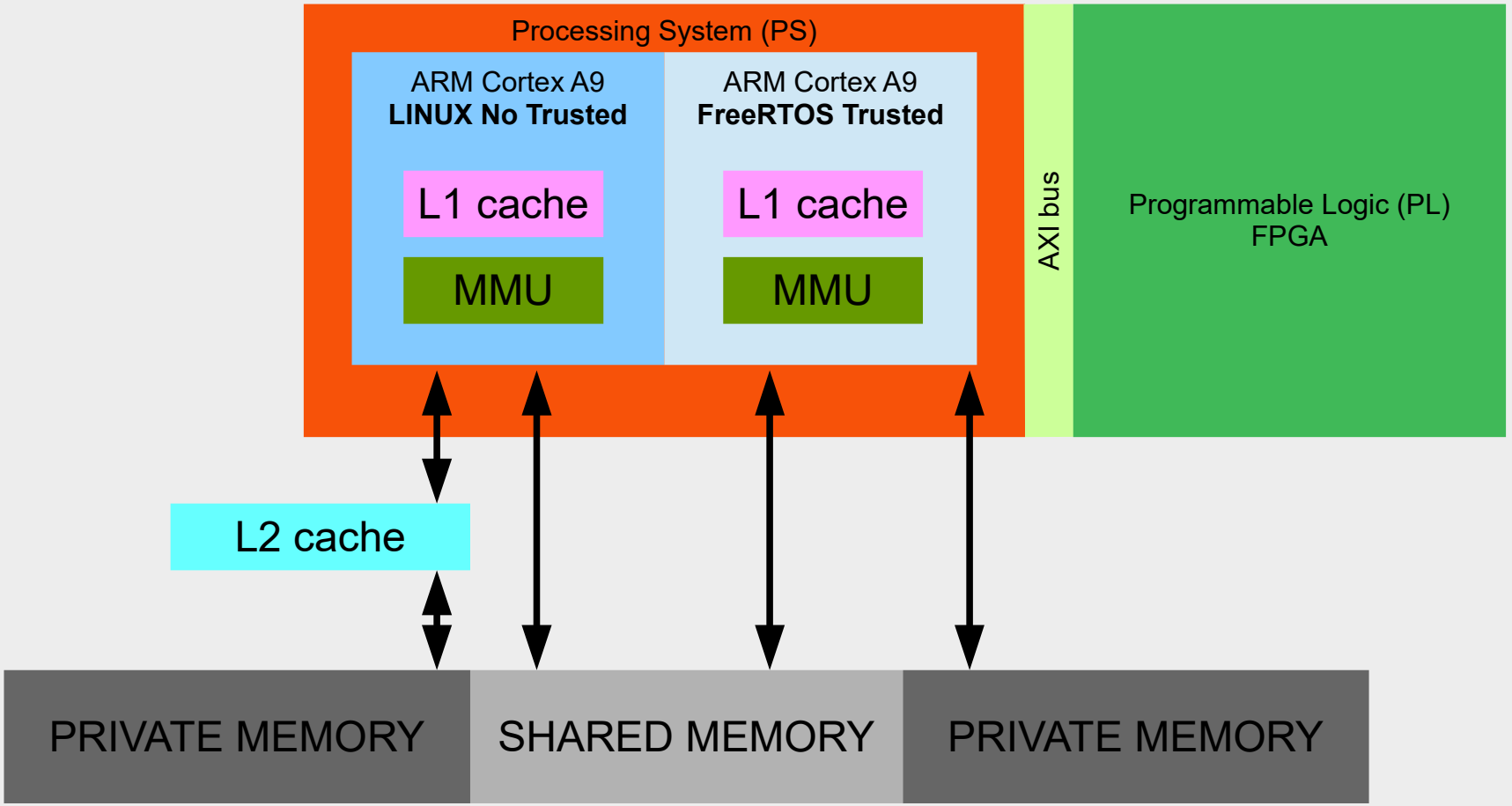

- Linux performances are not affected by dual OS solutions
- FreeRTOS determinism is granted
- Shared mem is not cached

DAVE Embedded Systems

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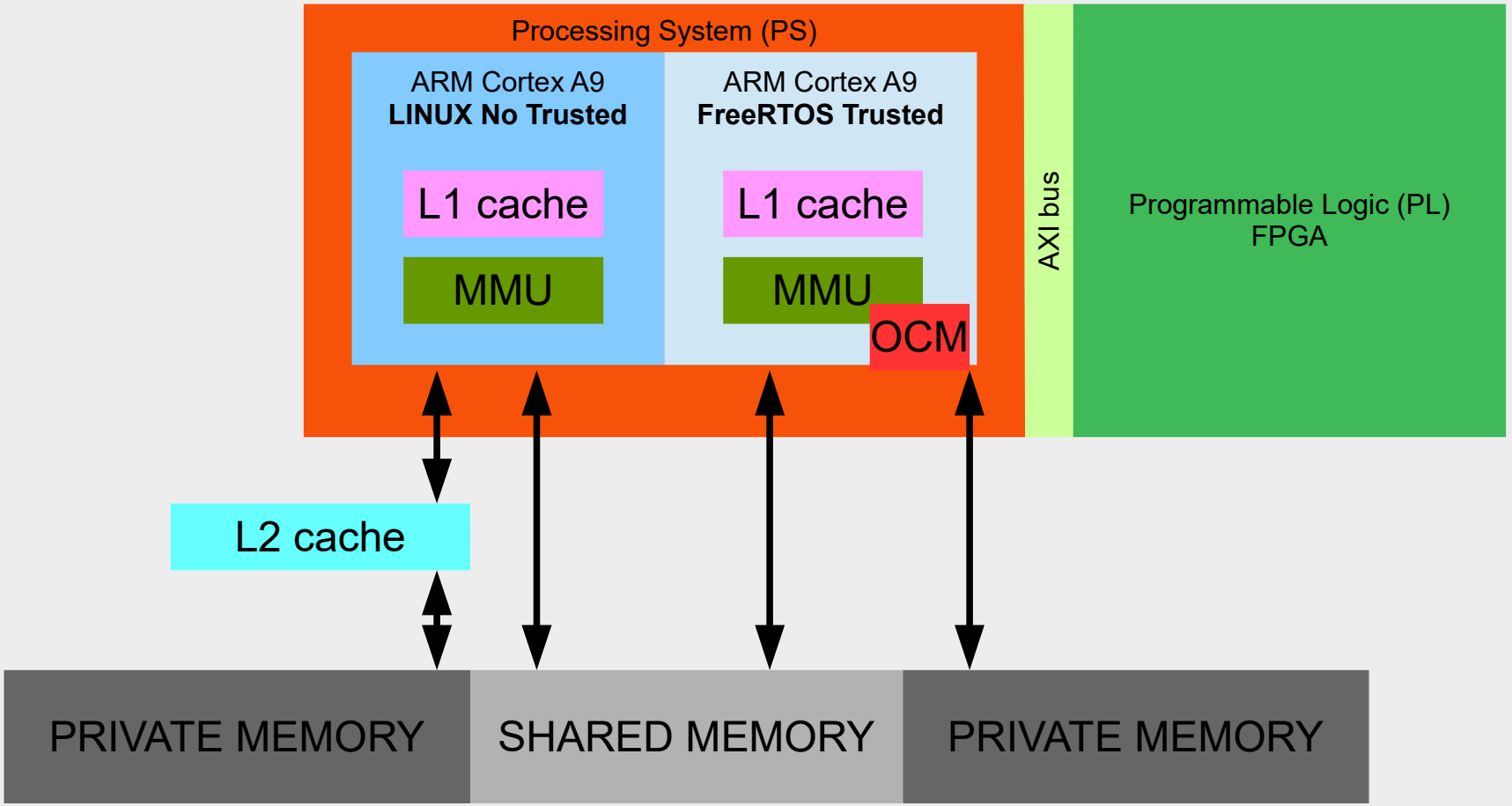
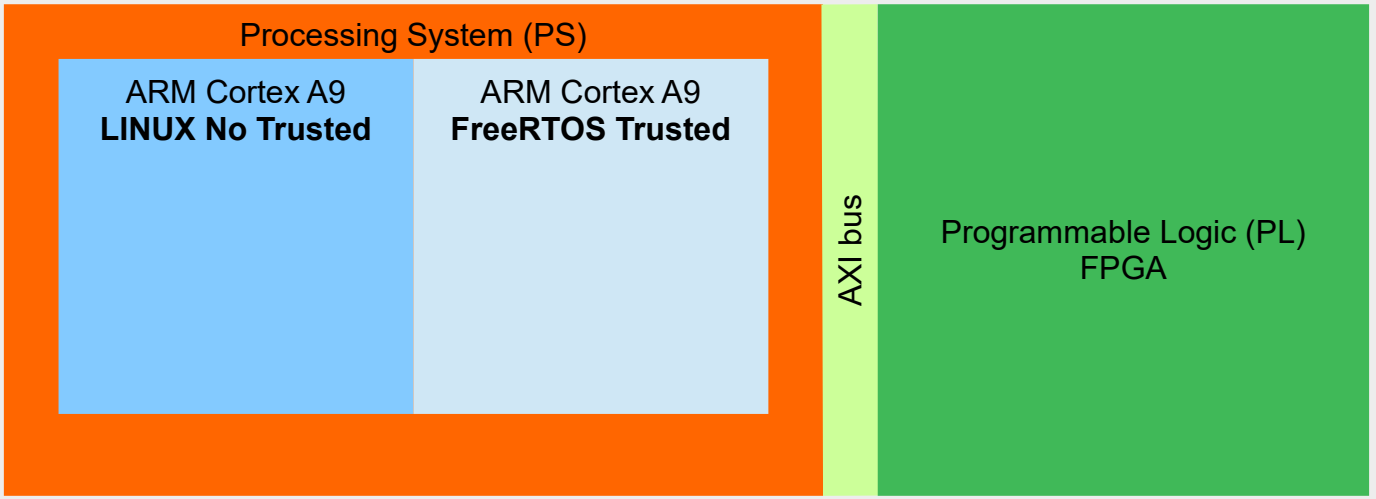


- Linux performances are not affected by dual OS solutions
- FreeRTOS determinism is granted
- Shared mem is not cached
- Internal OCM can be granted only to Trust OS

DAVe Embedded Systems

Details: Performances achieved

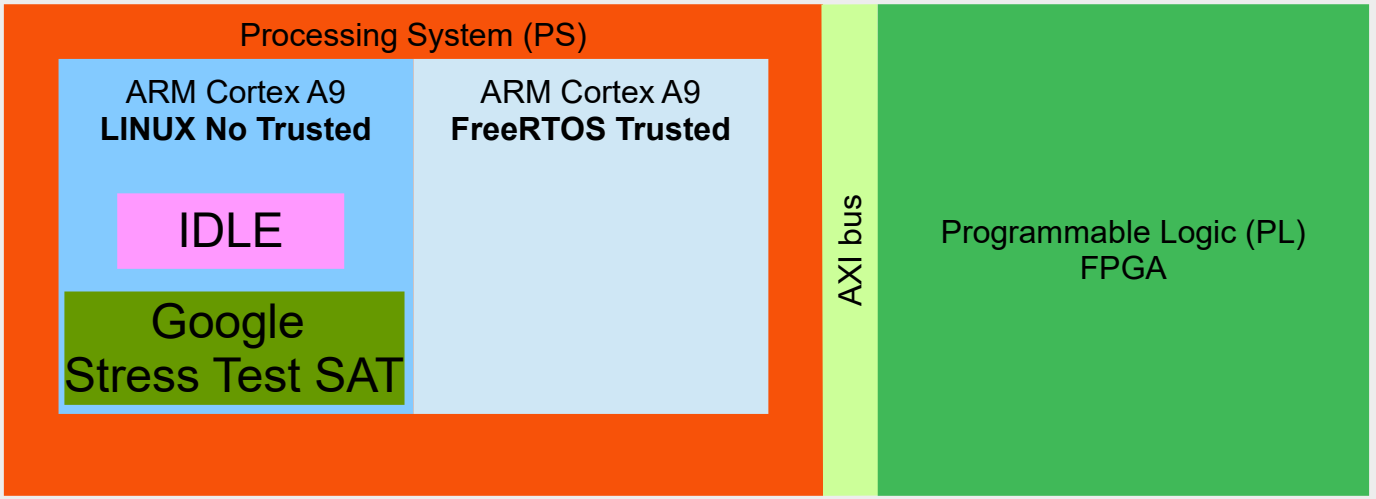


TEST BENCH: used the internal timer to measure the latency between:

- INT handling
- INT service

DAVE Embedded Systems

Details: Performances achieved



DAVE
Embedded Systems

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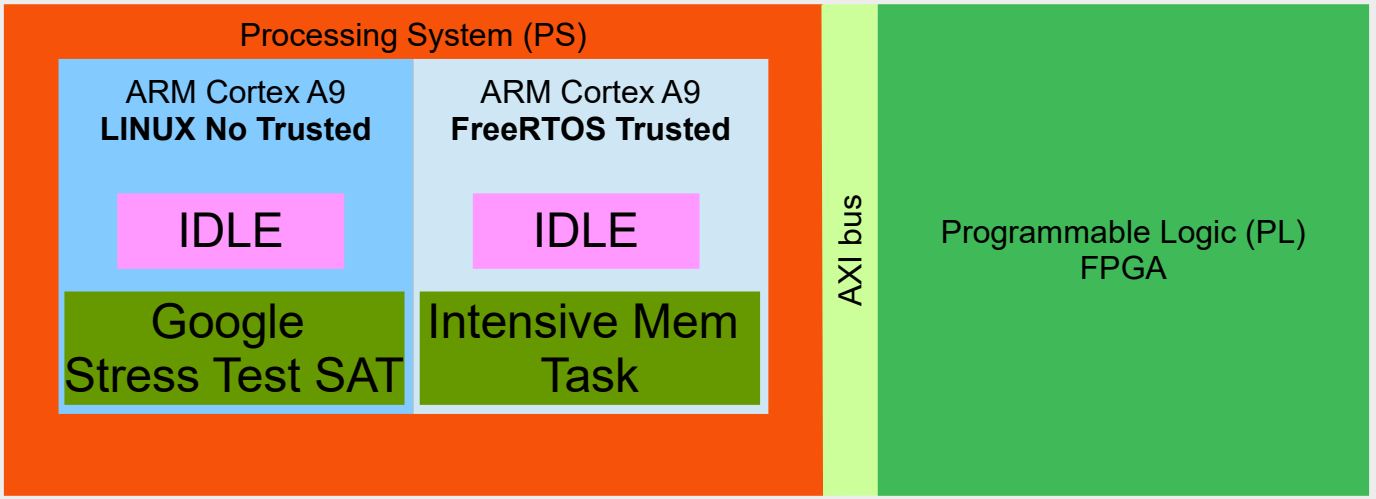

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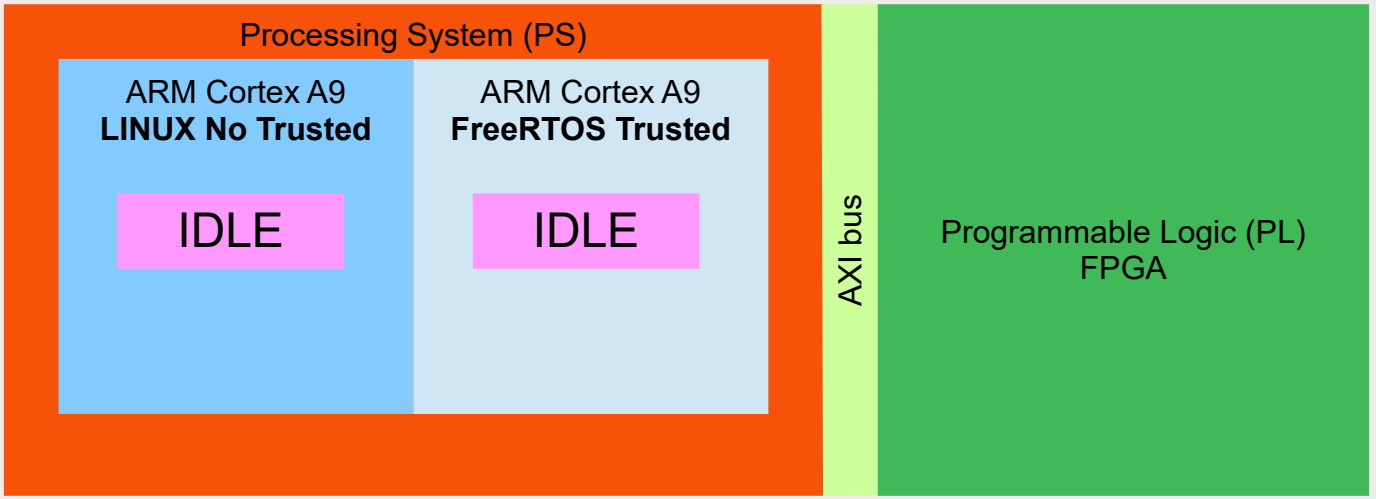
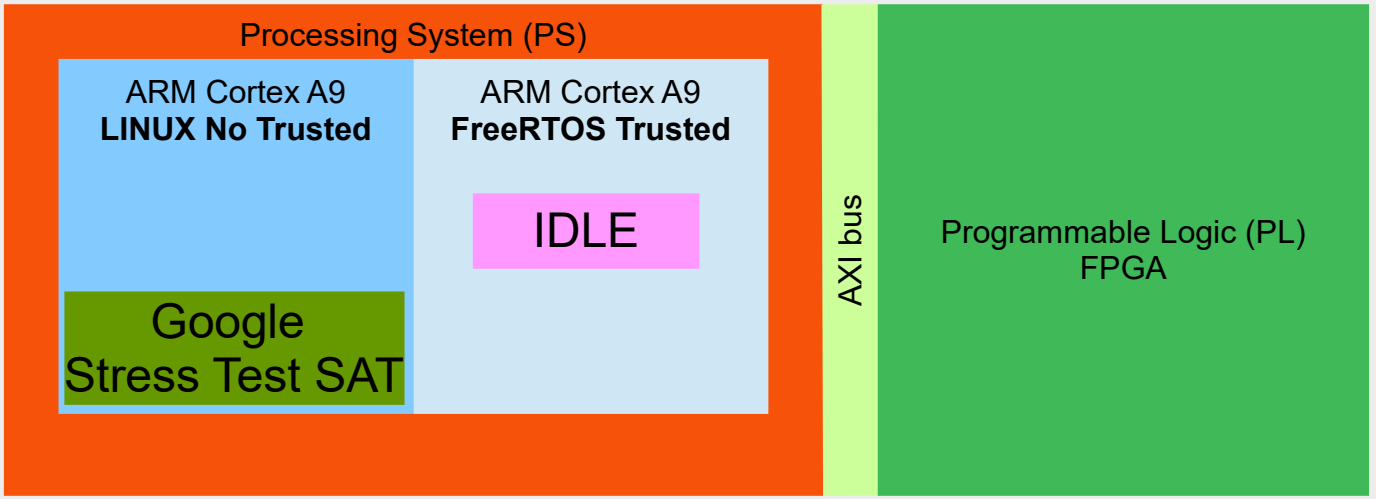


Latency	Linux IDLE RTOS IDLE	
min	287ns	
avg	287ns	
max	548ns	

DAVE Embedded Systems

Details: Performances achieved



Latency	Linux IDLE RTOS IDLE	LINUX SAT RTOS IDLE
min	287ns	287ns
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DAVE Embedded Systems

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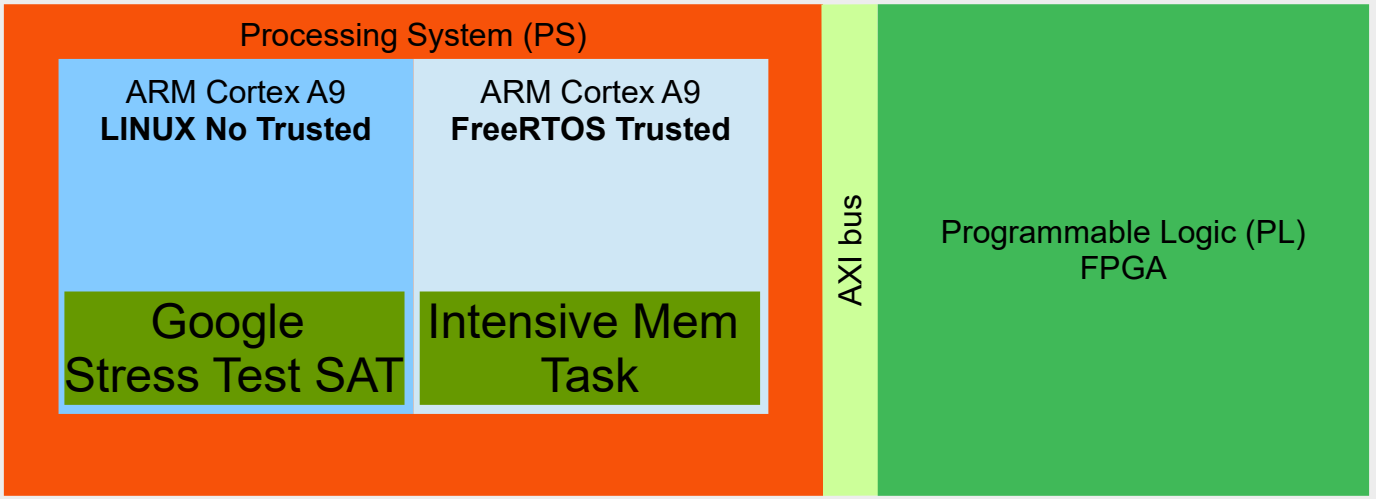

Latency	Linux IDLE RTOS IDLE	LINUX SAT RTOS IDLE	LINUX SAT RTOS 16k task load
min	287ns	287ns	287ns
avg	287ns	296ns	205ns
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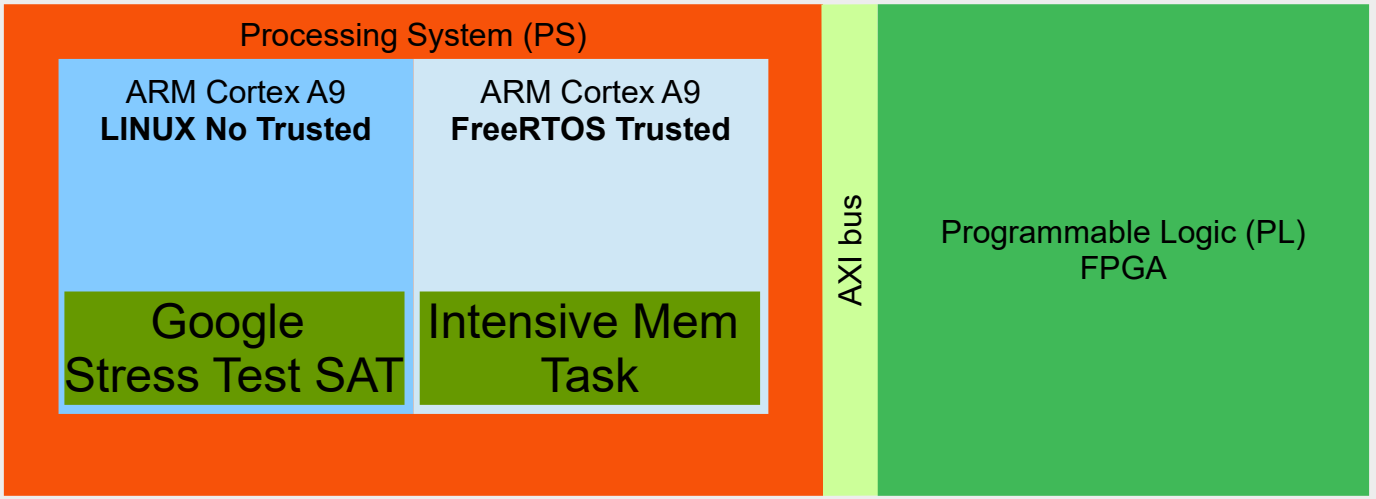
- Linux performances not affect RTOS in any condition
- FreeRTOS latency is granted with not heavy load tasks

DAVE Embedded Systems

Details: Performances achieved



Latency	Linux IDLE RTOS IDLE	LINUX SAT RTOS IDLE	LINUX SAT RTOS 16k task load	LINUX SAT RTOS 128k task load
min	287ns	287ns	287ns	1268ns
avg	287ns	296ns	205ns	2024ns
max	548ns	539ns	575ns	3050ns

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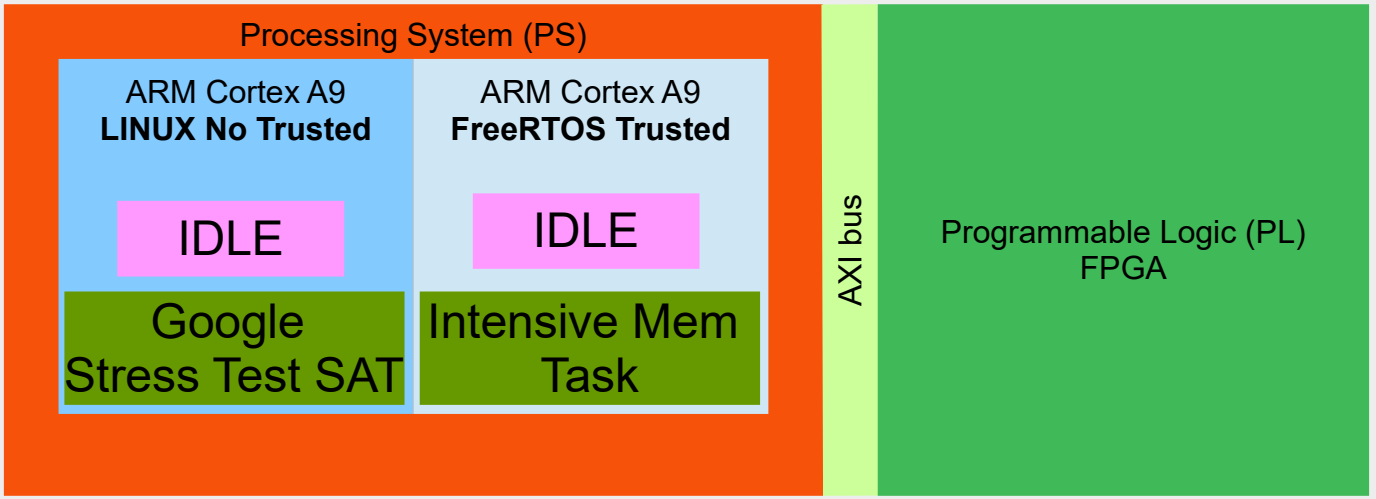
- FreeRTos is affected by high mem loads due to it is not cached

DAVE Embedded Systems

Details: Performances achieved



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  The L2 cache can be also used only on Trust OS – there are pro and cons (typically a determinism reduction is noted)

DAVe Embedded Systems

Future works and references

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Embedded Systems

Future works and references

- Complete Reboot of Slave core from Master Core

DAVE Embedded Systems

Future works and references

- Complete Reboot of Slave core from Master Core
- Deep understanding and optimization of INTerrupt handling and communication data interchange between two worlds related to determinism and latency aspects

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Embedded Systems

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- Refers to:

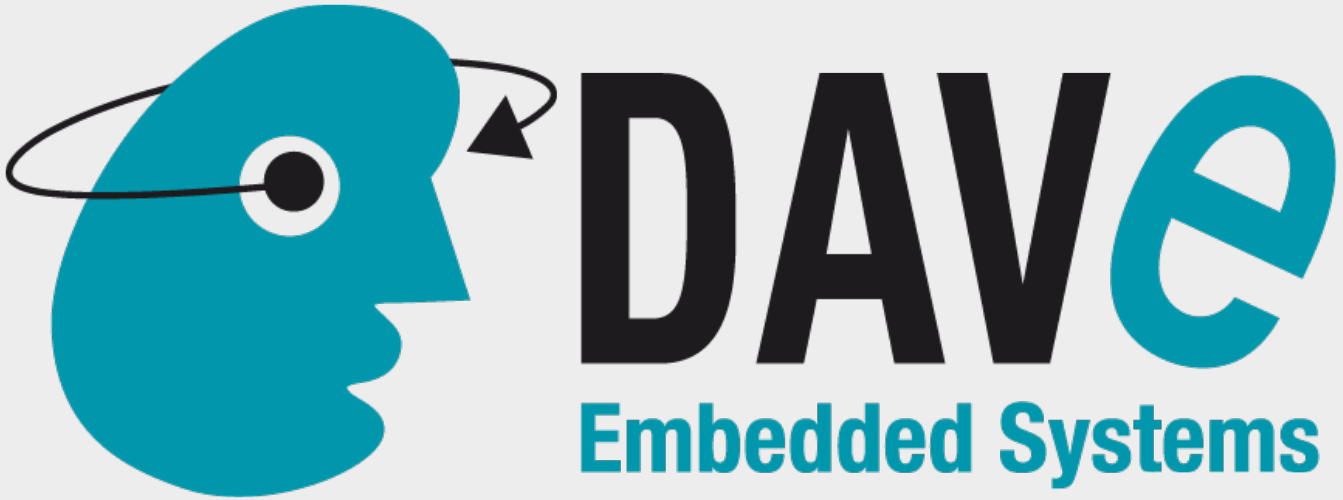
http://www.dave.eu/sites/default/files/BRX-WP001.pdf
Yashu Gosain and Prushothaman Palanichamy, Xilinx WP429 - TrustZone Technology Support in Zynq-7000 All Programmable SoCs (v1.0), May 20, 2014
DAVE Embedded Systems, AN-BELK-001: Asymmetric Multiprocessing (AMP) on Bora – Linux FreeRTOS, -
TOPPERS SafeG home page (English), -,
https://www.toppers.jp/en/safeg.html

and many others

DAVE Embedded Systems

Question and answers

DAVE Embedded Systems



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