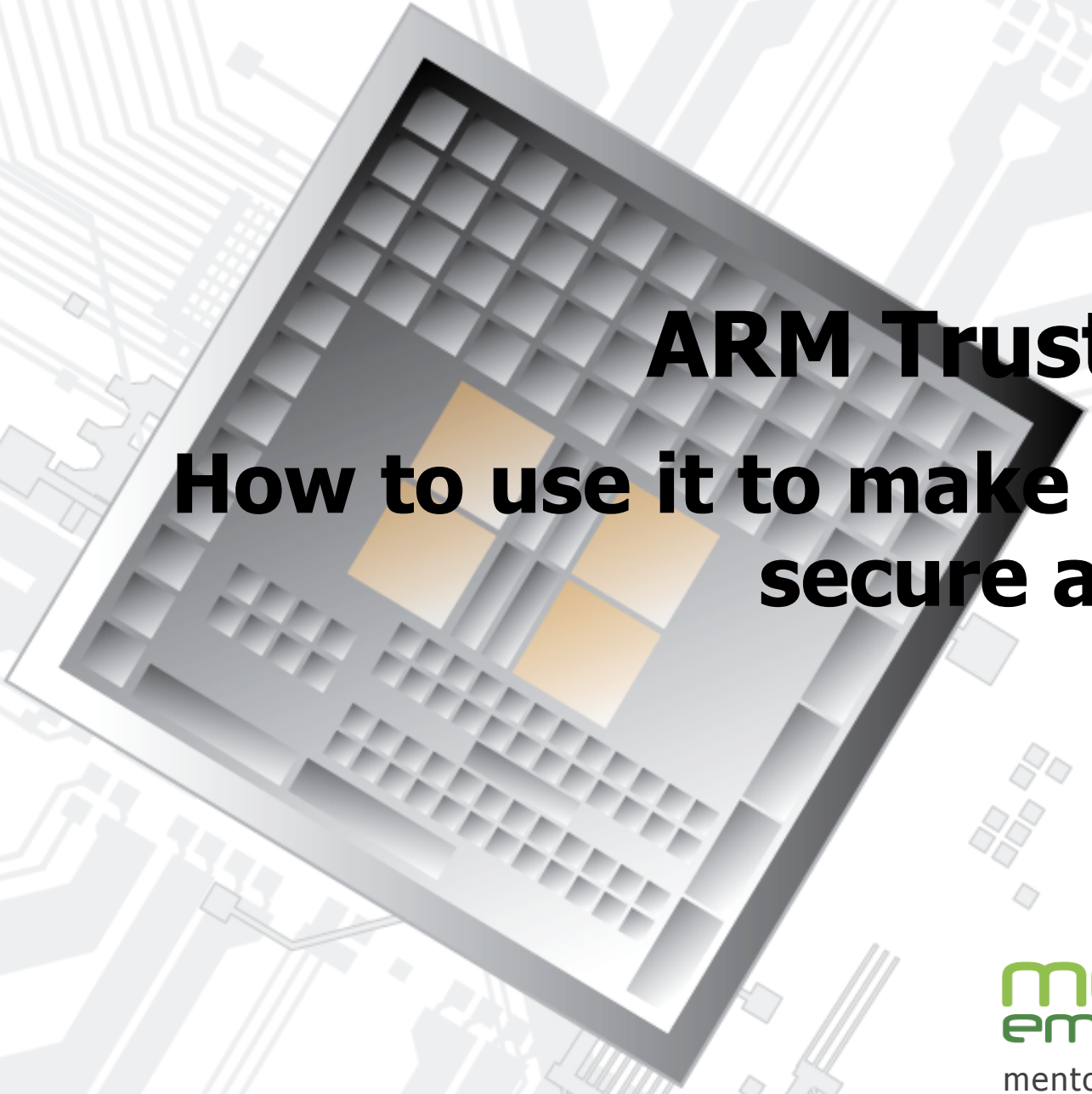


ARM TrustZone®

How to use it to make devices secure and safe

Felix Baum

mentor embedded

mentor.com/embedded

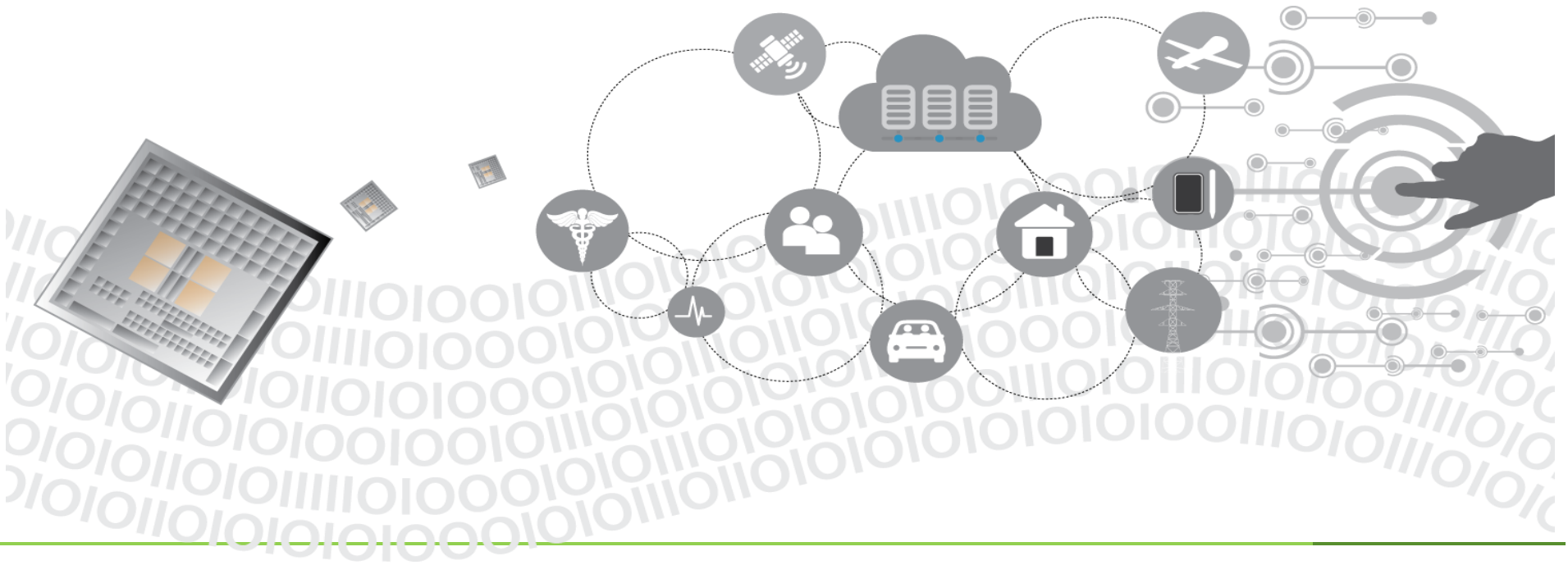
Agenda

Objectives

- Describe the need for hardware enforced security
- Outline the use cases for the ARM TrustZone deployments
- Highlight the pros and cons of various options

Results

- Provide a better understanding of how to secure embedded devices by utilizing the ARM Cortex-A hardware and software capabilities Mentor Embedded products



Recent Security Incidents in the News

- Blast Furnace – via plant's business network
  - Caused "massive" damage to blast furnaces
- Jeep Grand Cherokee – via vehicle connectivity
  - Malicious code allowed access to vehicle's CAN bus
- Medical Devices – via medical network
  - Devices accessed to steal patient medical data
- Power plant in Ukraine – via spearphishing e-mail attack
  - Power outage to 80,000 people
- More to come…

Growing threat of attacks

Embedded devices

15x

more vulnerable to attack than enterprise endpoints
- Columbia University Research Study

IoT & Industrial IoT

70%

of IoT devices are vulnerable to attack
- HP Labs research study

Defense & Aerospace

148

companies were victims of cyber attacks from Chinese cyber warefare groups.
- Mandiant security report

Medical Devices

300+

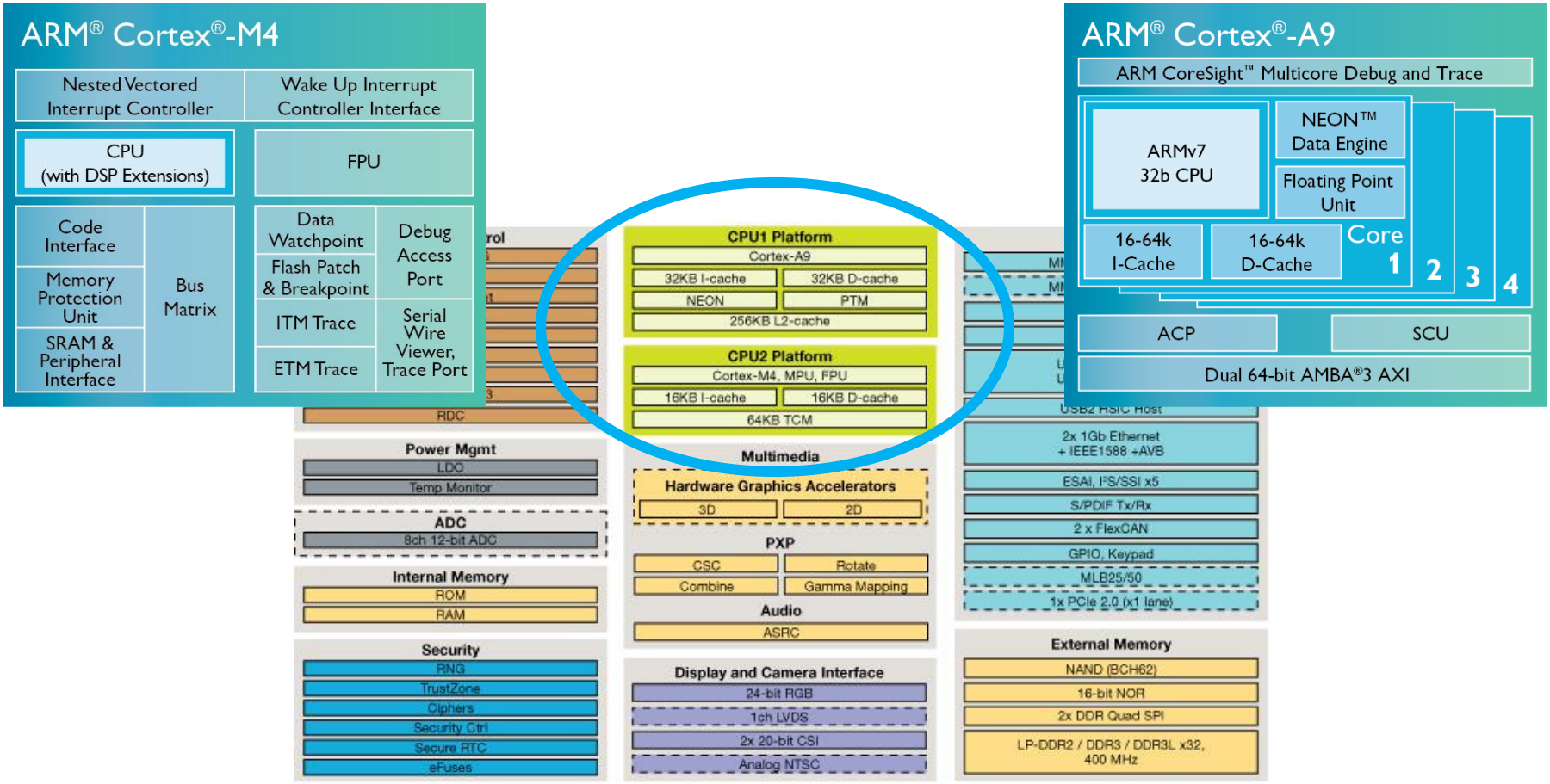
medical devices with hardcoded passwords
- ICS-CERT vulnerability report

Industrial & Critical Infrastructure

52%

Increase in cyber security attacks
- 2012 US Department of Homeland Security

Consolidation on the SoC level



Security and Safety via Separation

Safety: Protecting the world from the device

Security: Protecting the device from the world

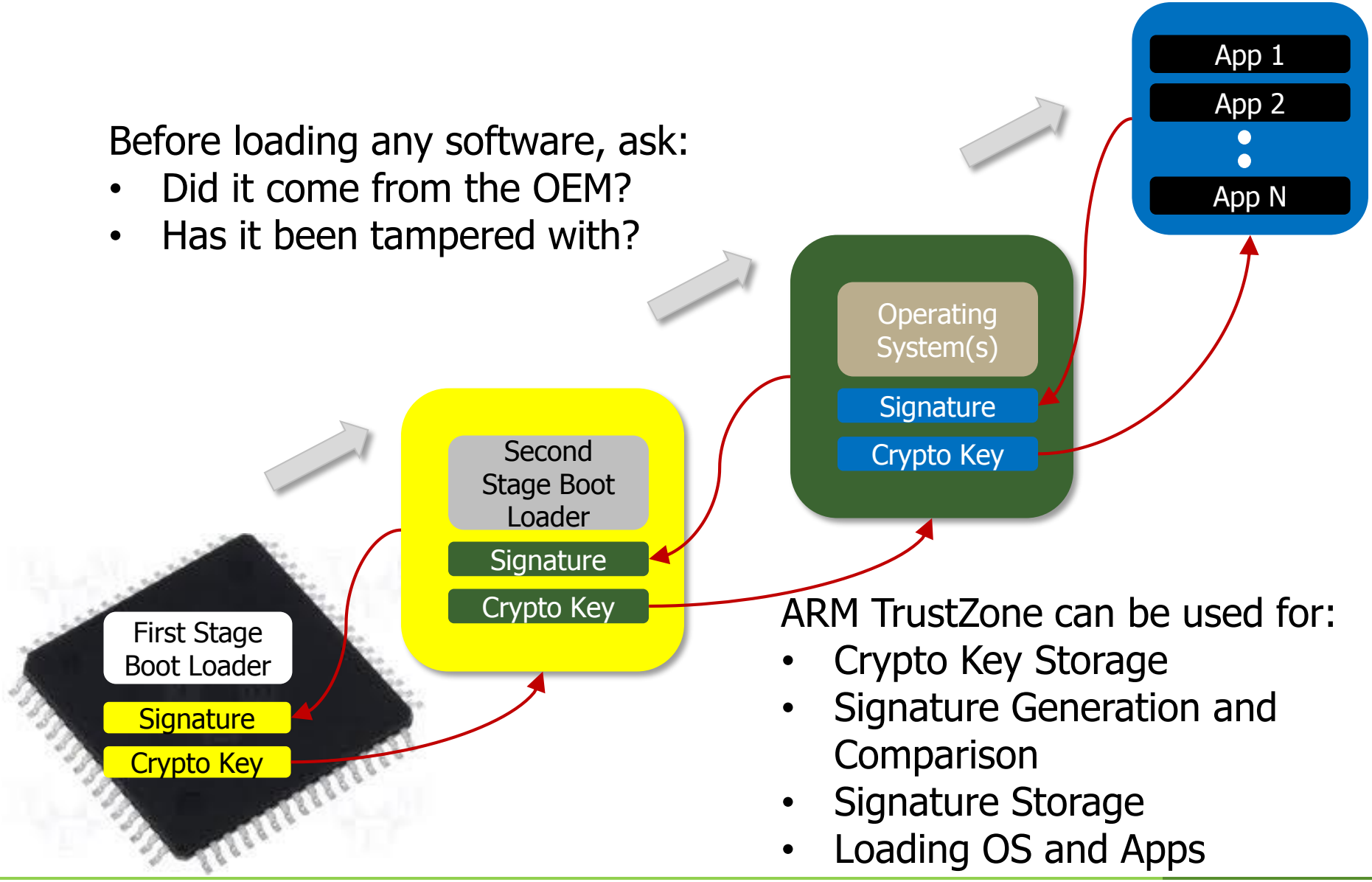
Mixed criticality: Protecting of security or safety critical parts of the device from other parts of the device

ISO26262-6 requires "freedom from interference". If two systems can interfere with each other, they must be certified to the highest ASIL level of the two. Secure separation aims to eliminate such interference.

Starting point: Chain of Trust

Before loading any software, ask:

- Did it come from the OEM?
- Has it been tampered with?



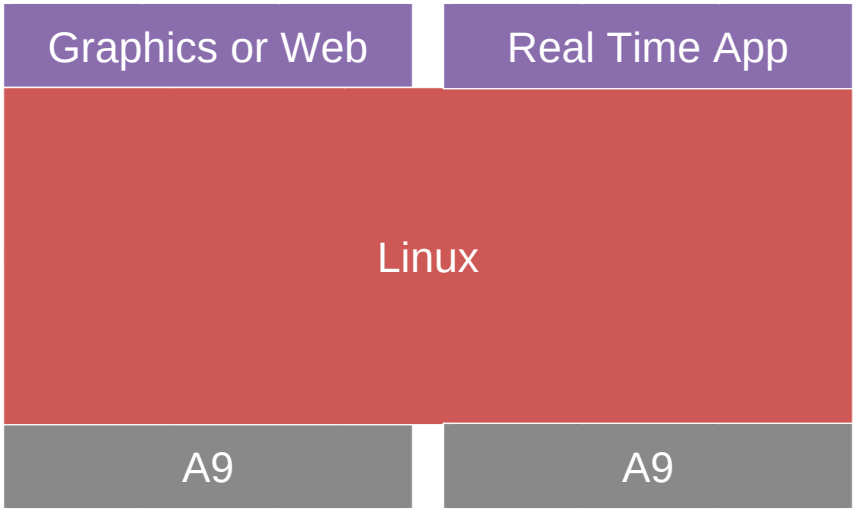
ARM TrustZone can be used for:

- Crypto Key Storage
- Signature Generation and Comparison
- Signature Storage
- Loading OS and Apps

Use Case 1:

Physical Separation aka AMP

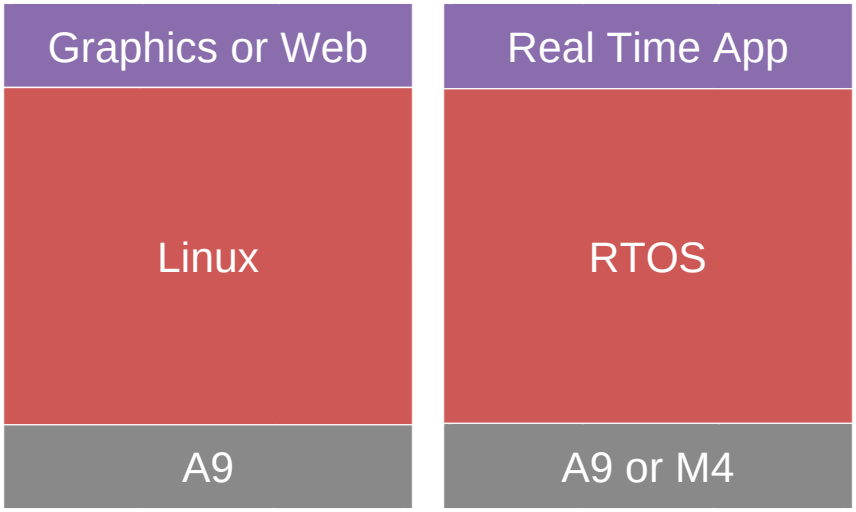
Physical Separation aka AMP



Multicore Device running one Operating System

- Migrating to multicore device for the next generation or project
- Need to consolidate applications that require real time and determinism with applications requiring Linux networking or graphics services
- Addressing performance constrains of existing design

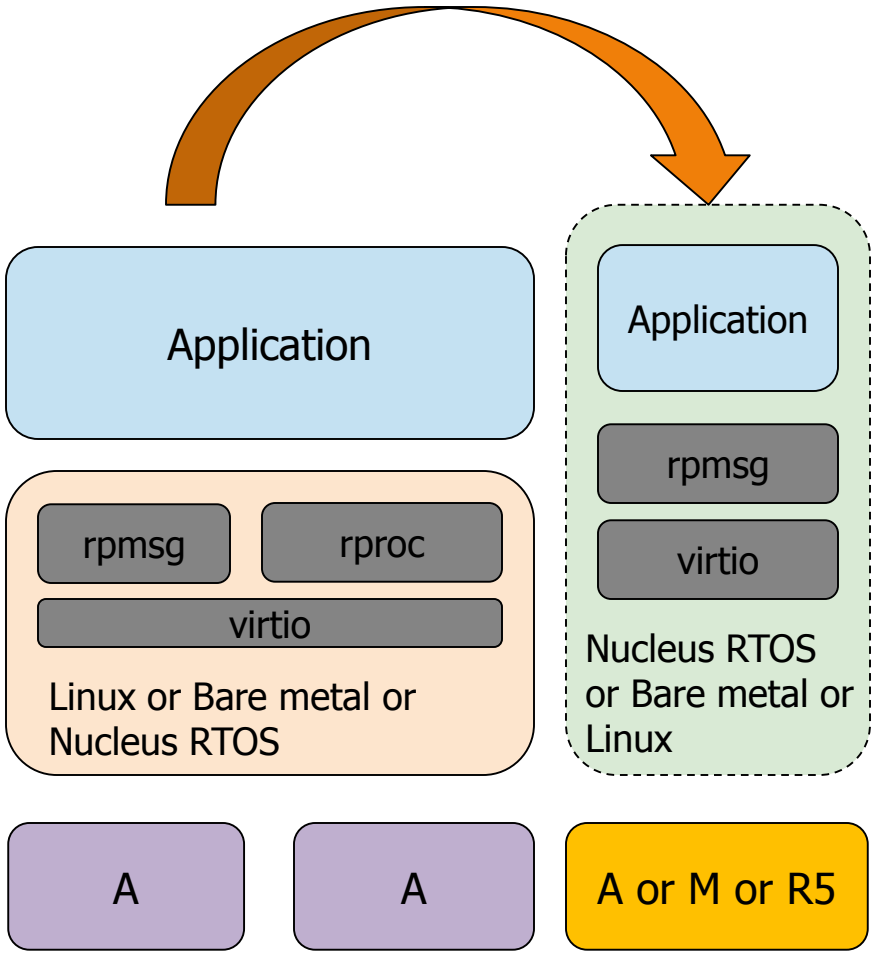
Physical Separation aka AMP



Multicore Device running multiple Operating Systems

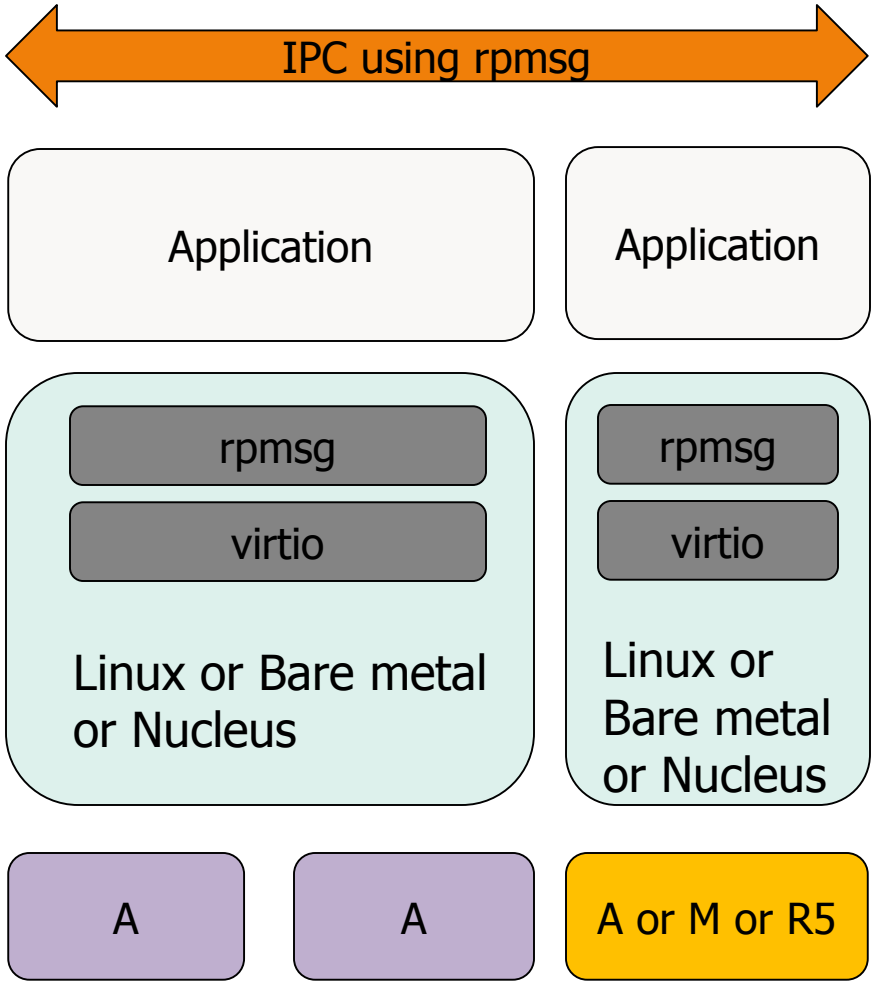
- Single user interface for Configure, Edit, Debug, Optimize work
- Framework to configure, boot, execute and communicate across cores and Operating Systems
- Take full advantage of the underlying 'silicony goodness' ☺

Remote CPU Lifecycle Management



- Used by master OS to boot remote OSs on remote CPUs
- remoteproc user API for processor lifecycle management
- Conformance to upstream Linux remoteproc implementation
- Stand alone OS agnostic clean-room implementation of remoteproc API

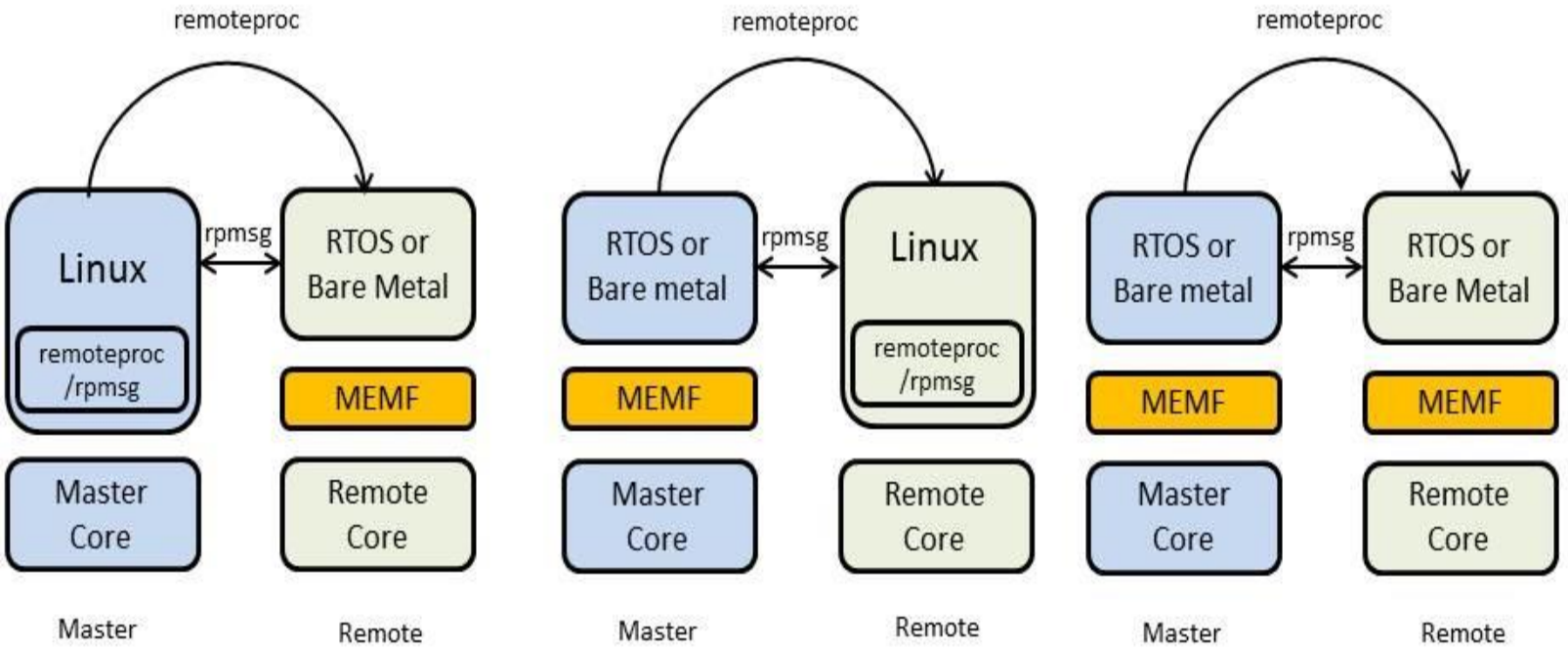
Inter Processor Communications



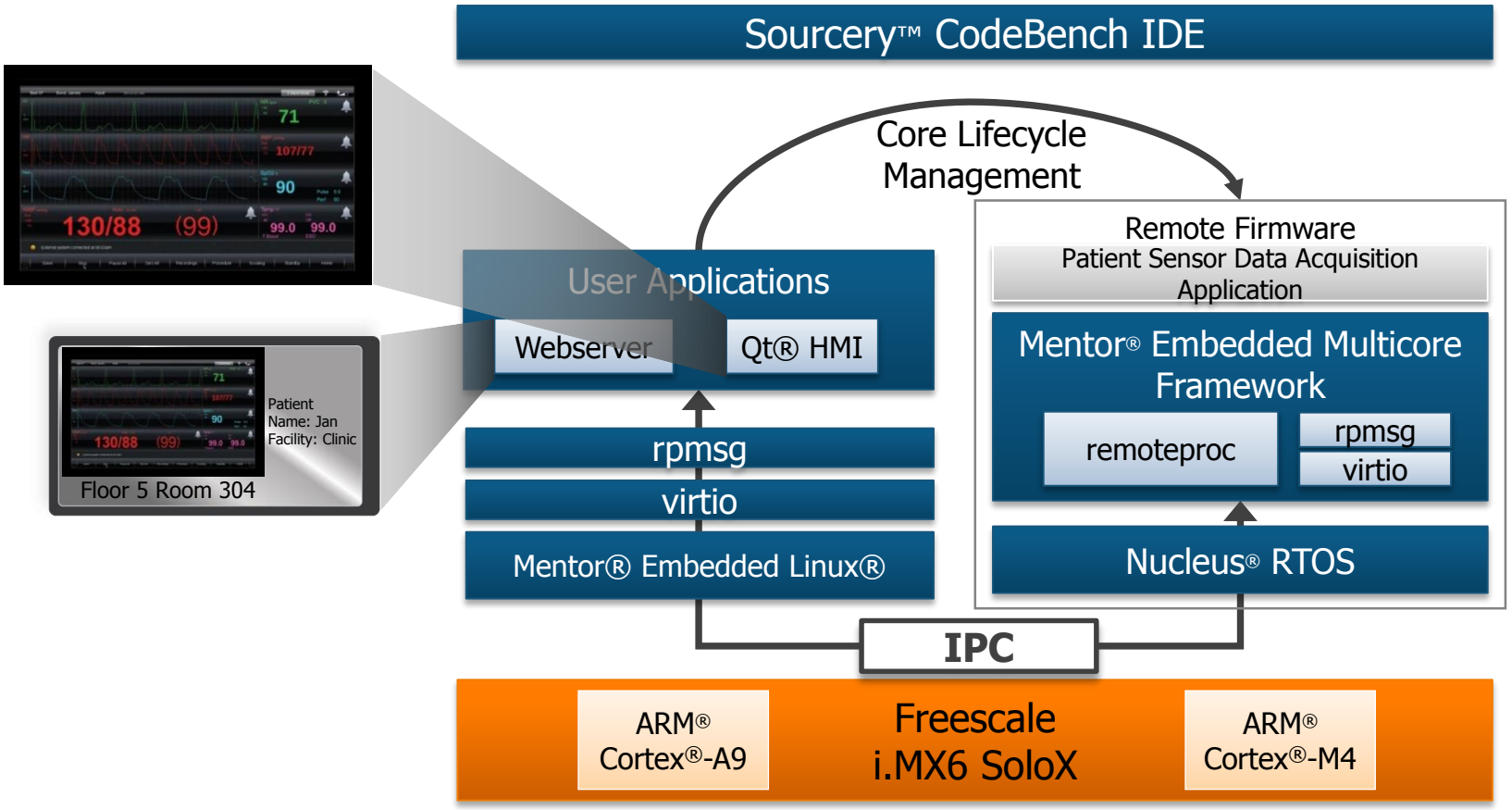
- For inter-processor communications between OS/software contexts
- rpmsg user API for Inter Processor Communication
- Conformance to upstream Linux rpmsg implementation
- Stand alone OS agnostic clean-room implementation of virtio and rpmsg
- Usable from RTOS and BME contexts

OpenAMP Use Cases

- Separation of Resource constrained for example power management
- Offload work for Computationally intensive operations such as processing, encryption of secure, sensitive data



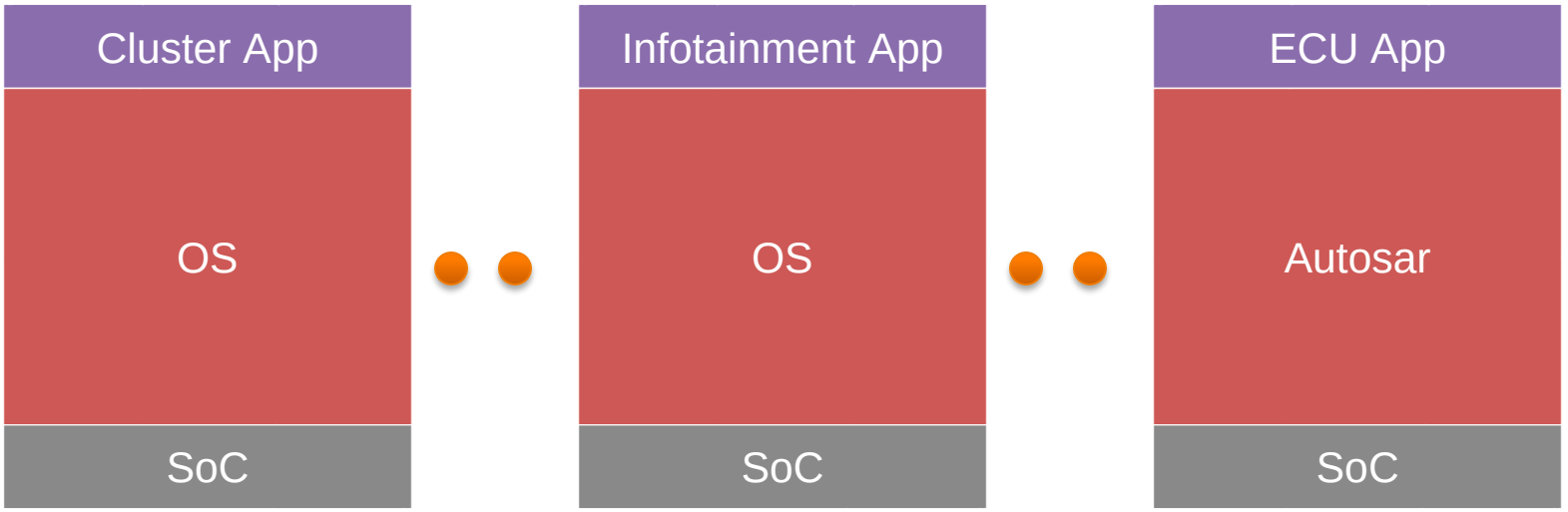
How this could be accomplished



Use Case 2:

Virtualization Enforced Separation

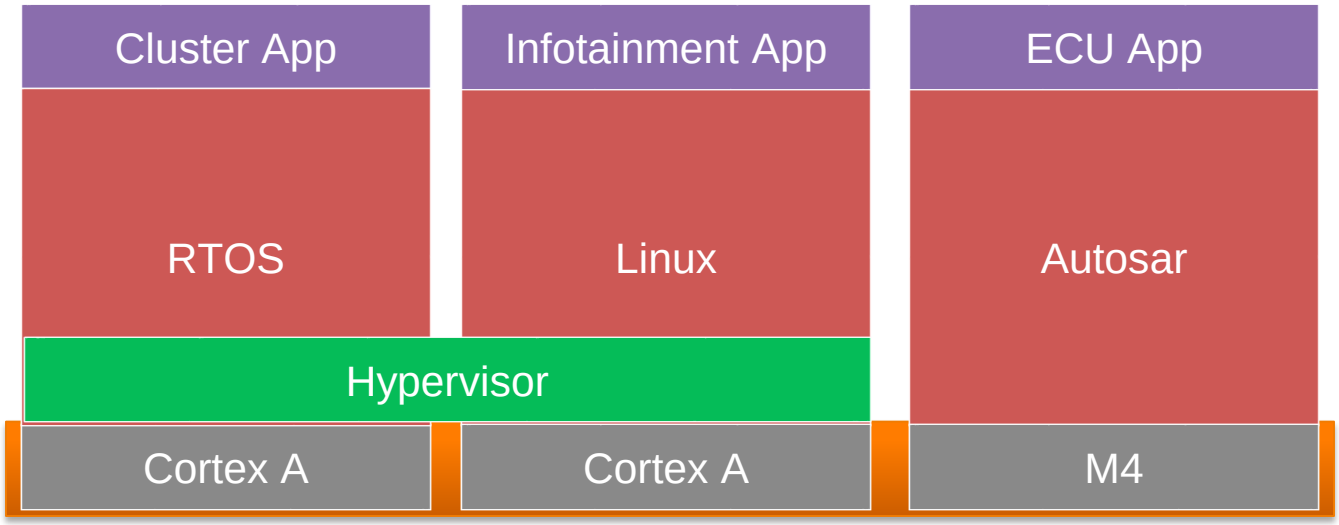
Separation via Virtualization



Multiple boards running various Operating Systems and dedicated applications

- Migrating to multicore device for the next generation or project
- Need to consolidate applications that require real time with Linux
- Must share displays and other resources

Separation via Virtualization

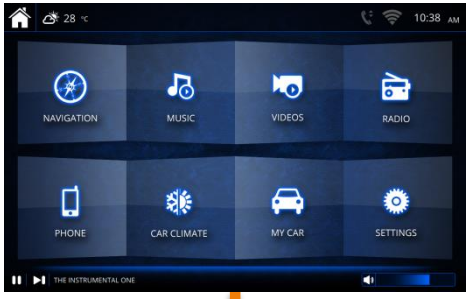


Consolidation to a single Heterogeneous Multicore SoC running multiple Operating Systems and Applications

- Virtualizing GPU to either control multiple displays per application or layer multiple applications on a single display (1:1, 1:N, N:1)
- Framework to configure, boot, execute and communicate across domains in safe and reliable matter

Separation via Virtualization

Infotainment Display



FPD-Link Touch Display
10″ (1280x800)

Cluster Display

FPD-Link Display
12″ (1280x480)

BusMaster CAN Vehicle Simulator

USB 2CAN

CAN BUS

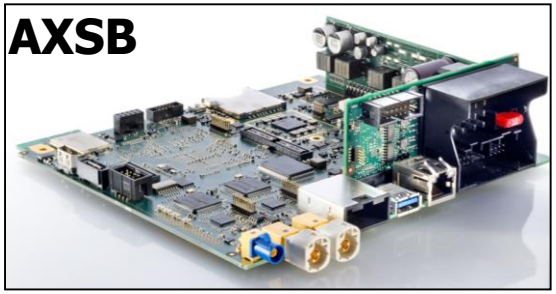
AUTOSAR & CAN stack on M4

IVI Linux

Nucleus

Hypervisor (2x CortexA) + GPU sharing

AXSB

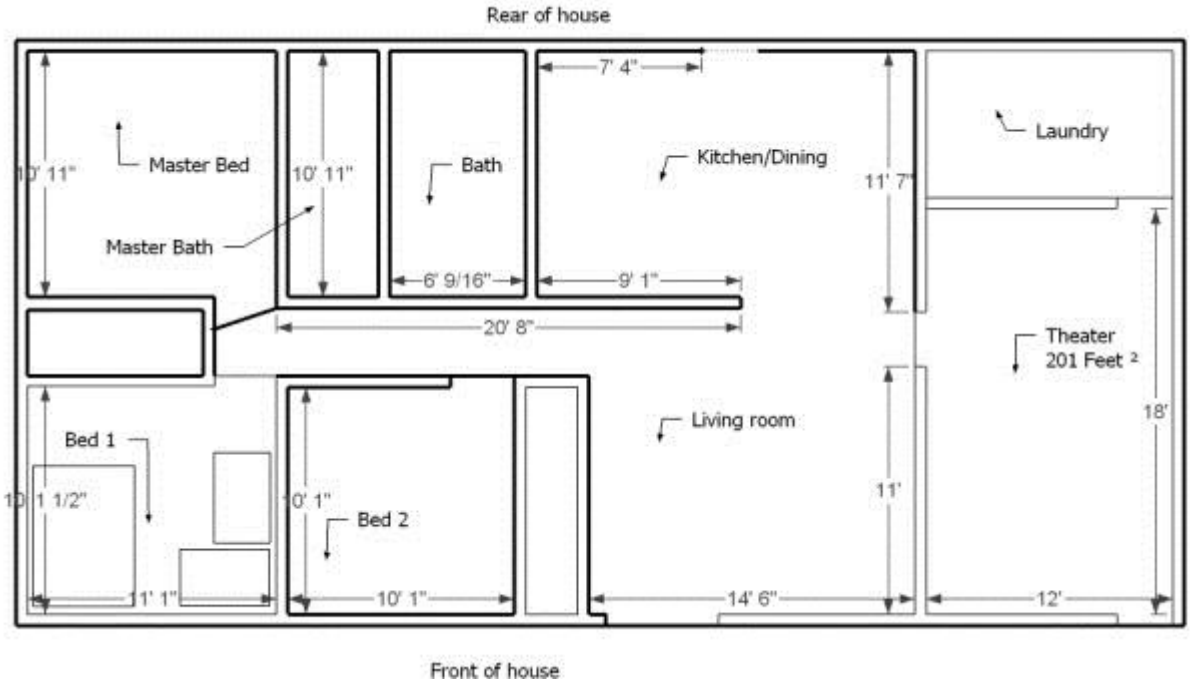


Use Case 3:

Hardware Enforced Separation

Separation via ARM TrustZone

- ARM TrustZone® can be thought of as a hardware-based solution that can be used to define a subset of the SoC for access by software.
- Software that is designated as Secure World software has access to ALL of the SoC, while software that is designated as Normal World can access only those HW elements that are defined as "Non-Secure".



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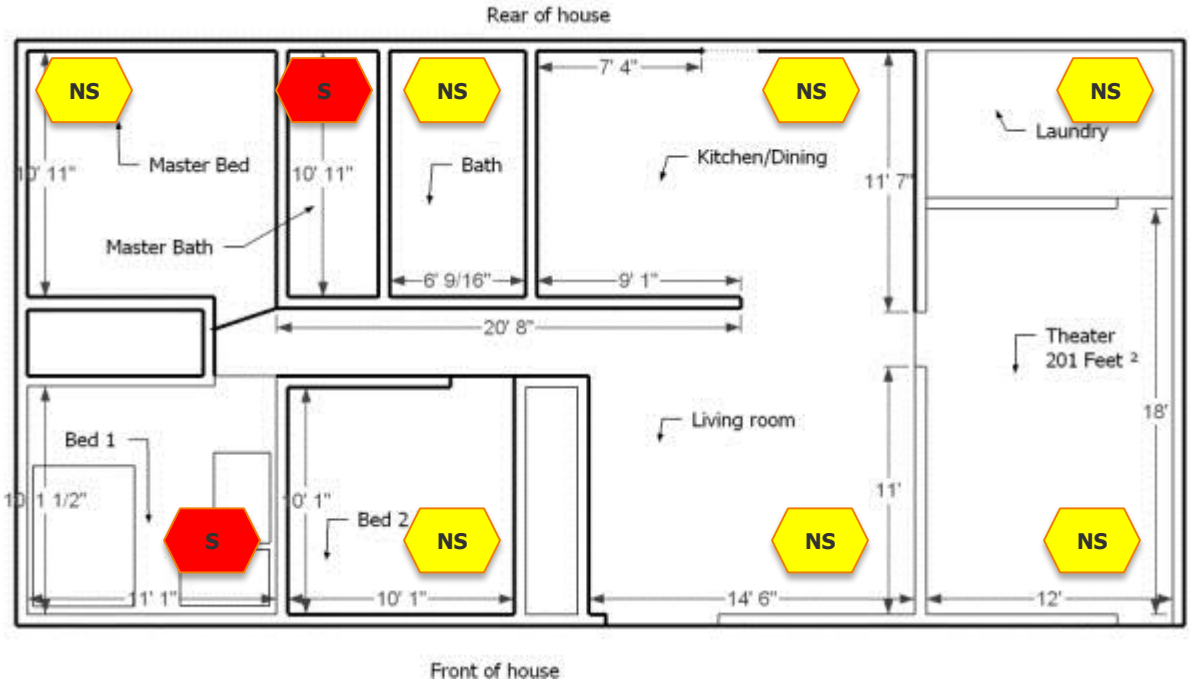

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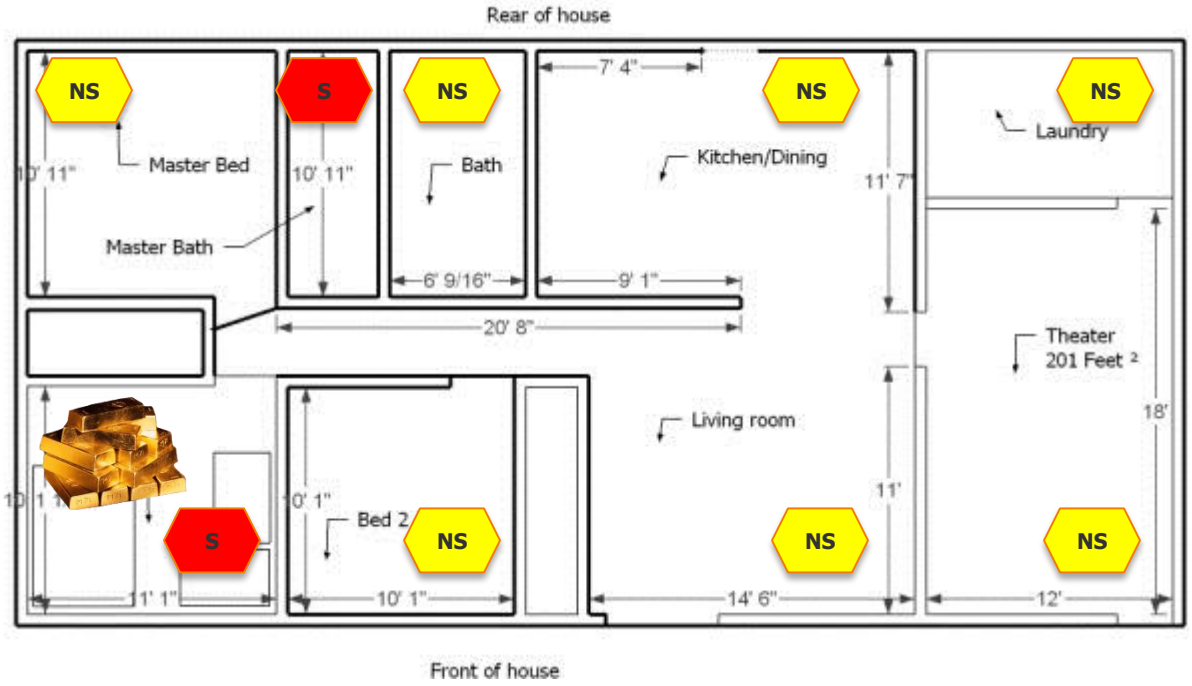

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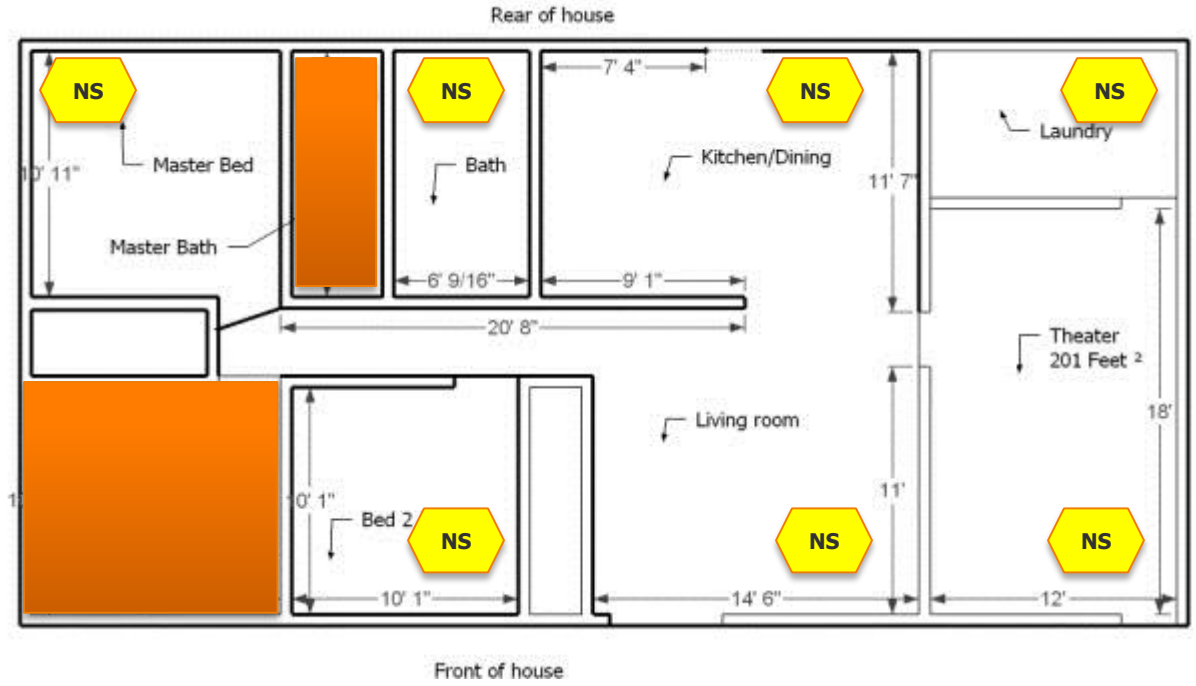


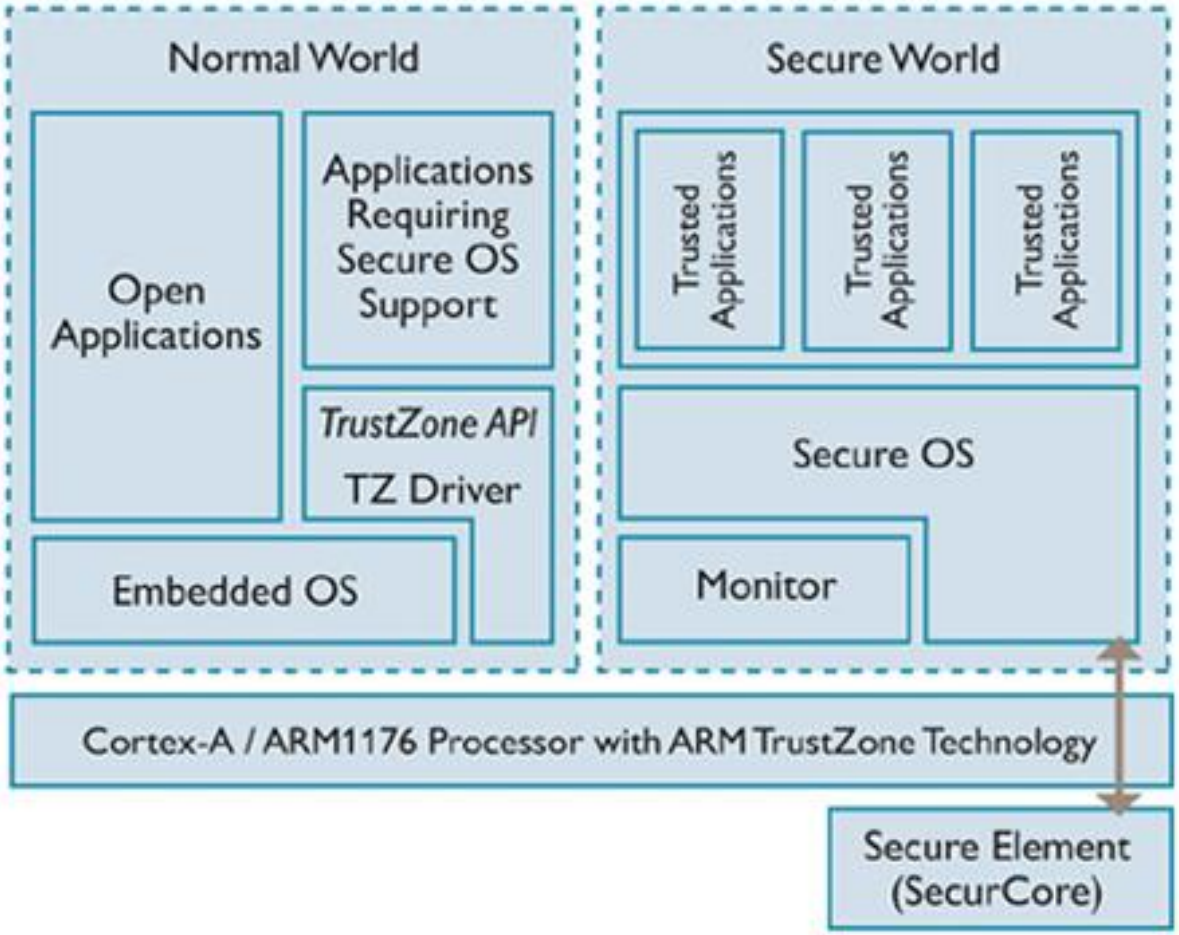
GlobalPlatform and TEE

- GlobalPlatform identifies and develops technical specifications which facilitate the secure and interoperable deployment and management of multiple embedded applications on secure chip technology. Its proven technology is regarded as the international industry standard for building a trusted end-to-end solution which serves multiple actors and supports several business models. .
- The Trusted Execution Environment (TEE) offers the best route to meeting security objectives. TEE is a separate execution environment that runs alongside the OS and provides security services to that environment. The TEE offers an execution space that provides a higher level of security than an OS; though not as secure as a Secure Element (SE) , the security offered by the TEE is sufficient for most applications.

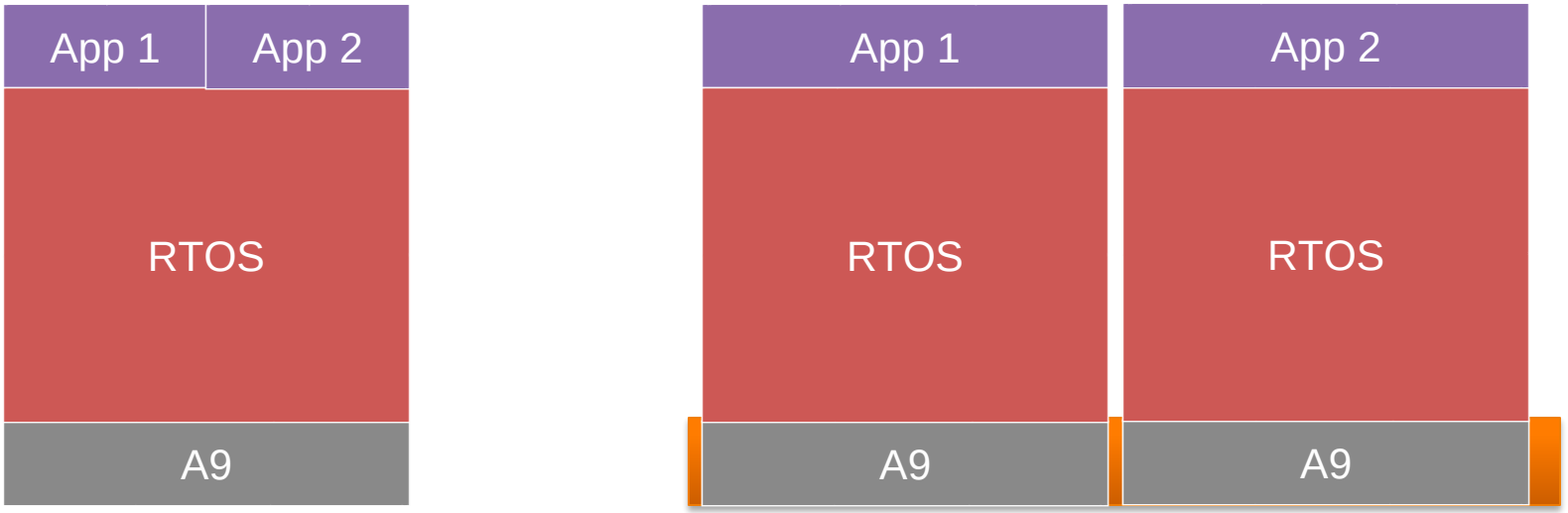
GLOBALPLATFORM™

GlobalPlatform and TEE

- GlobalPlatform identifies and develops technical specifications which facilitate ...nagement of multi ...ogy. Its proven ...y standard for build ...ultiple actors and sup...
- The Tru... route to meeting ...nvironment that run ... to that environ... ...ides a higher l... as a Secure Element ... for most applicat...



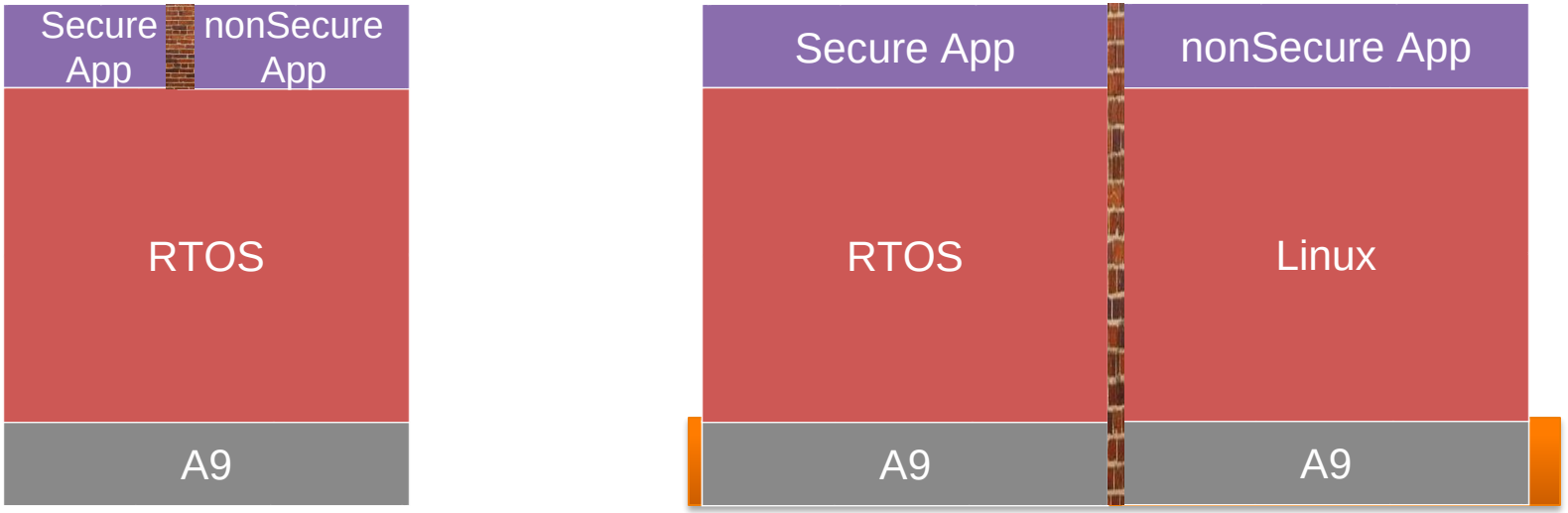
Separation via hardware enforcement



One or more cores running applications of various security or robustness levels

- Migrating to multicore or more powerful device for the next project
- Need to consolidate applications that require secure and non secure apps

Separation via hardware enforcement



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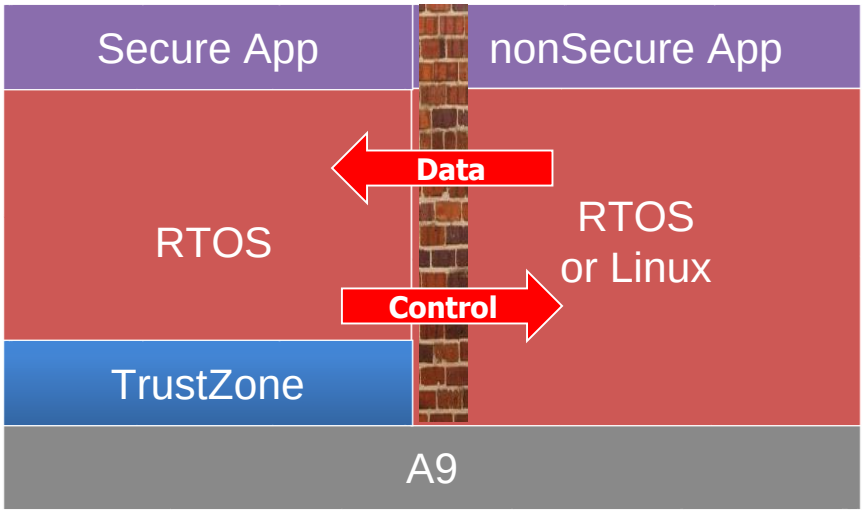

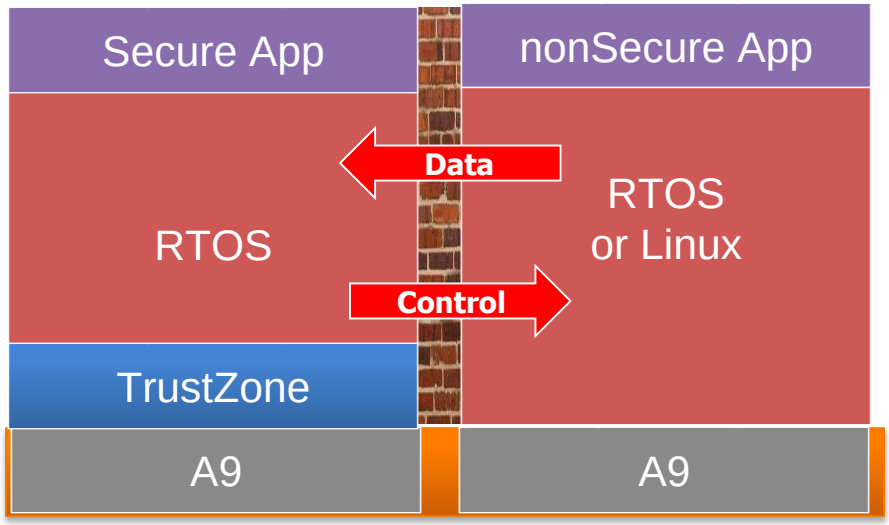

Using the ARM TrustZone capabilities of the SoC separating secure or robust applications from the rest of the system

- Control only flows from Secure World to Normal World
- Data could flow either way

ARM TrustZone & MultiCore

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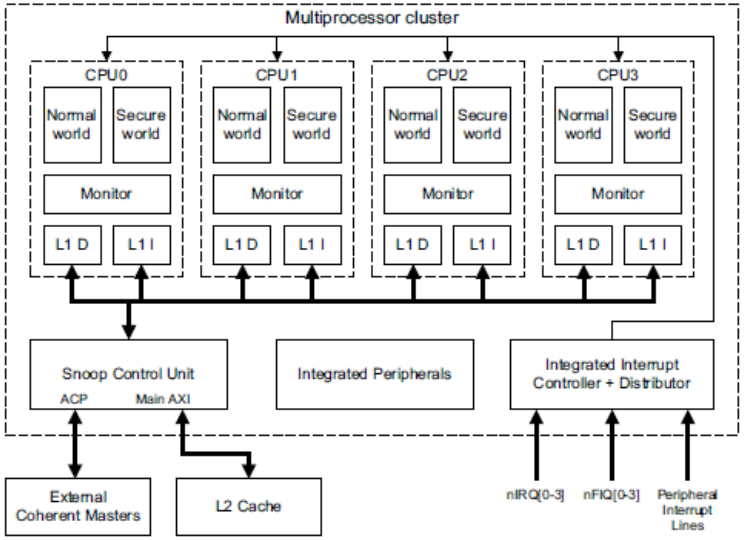
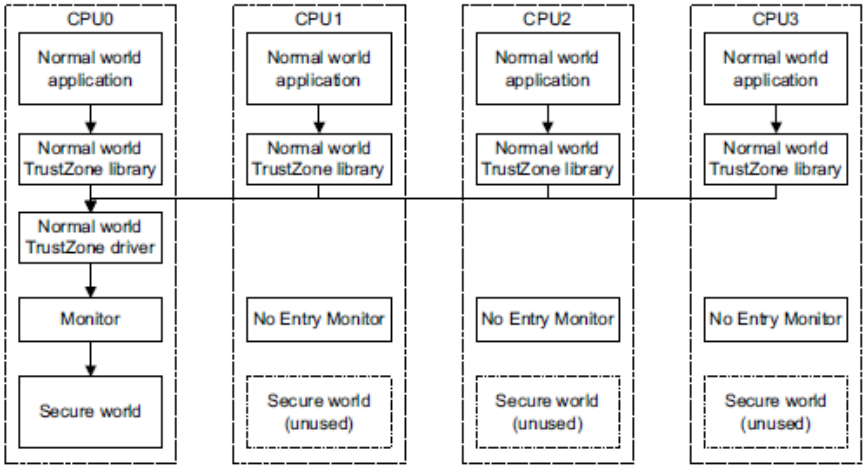
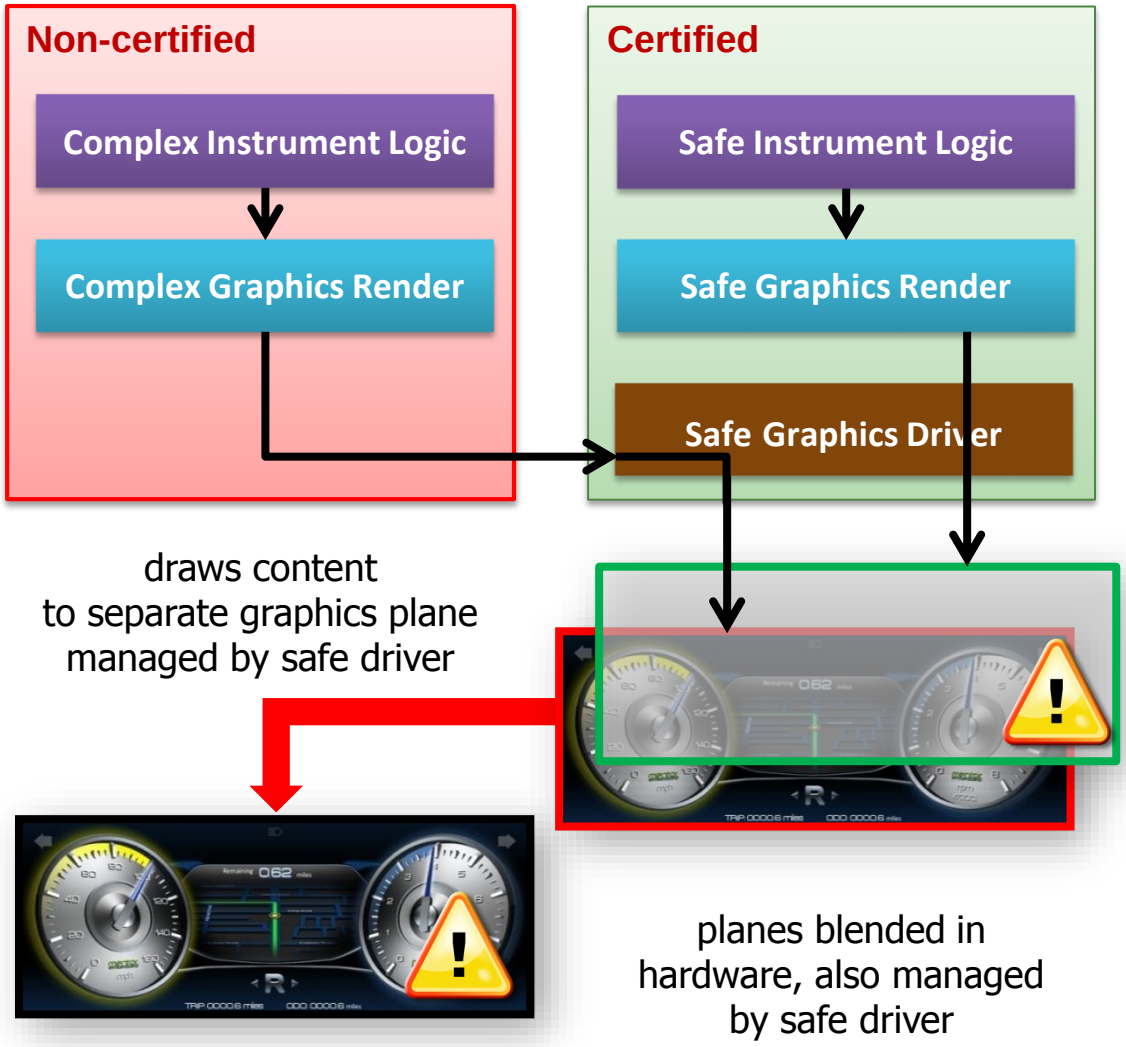


Secure World Apps run on each core

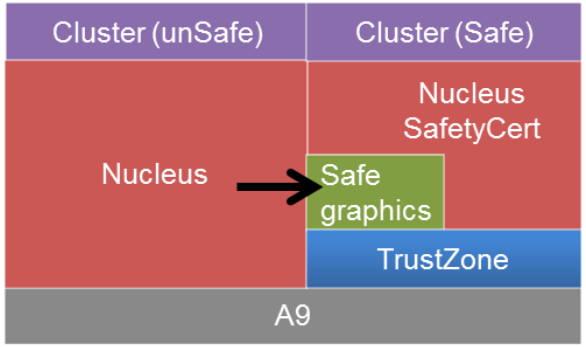


Secure World Apps run on dedicated core

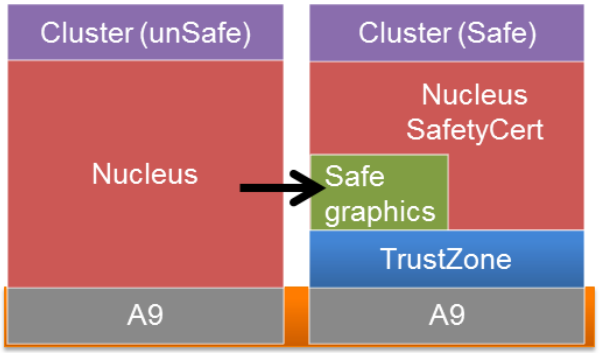
Separation via hardware enforcement



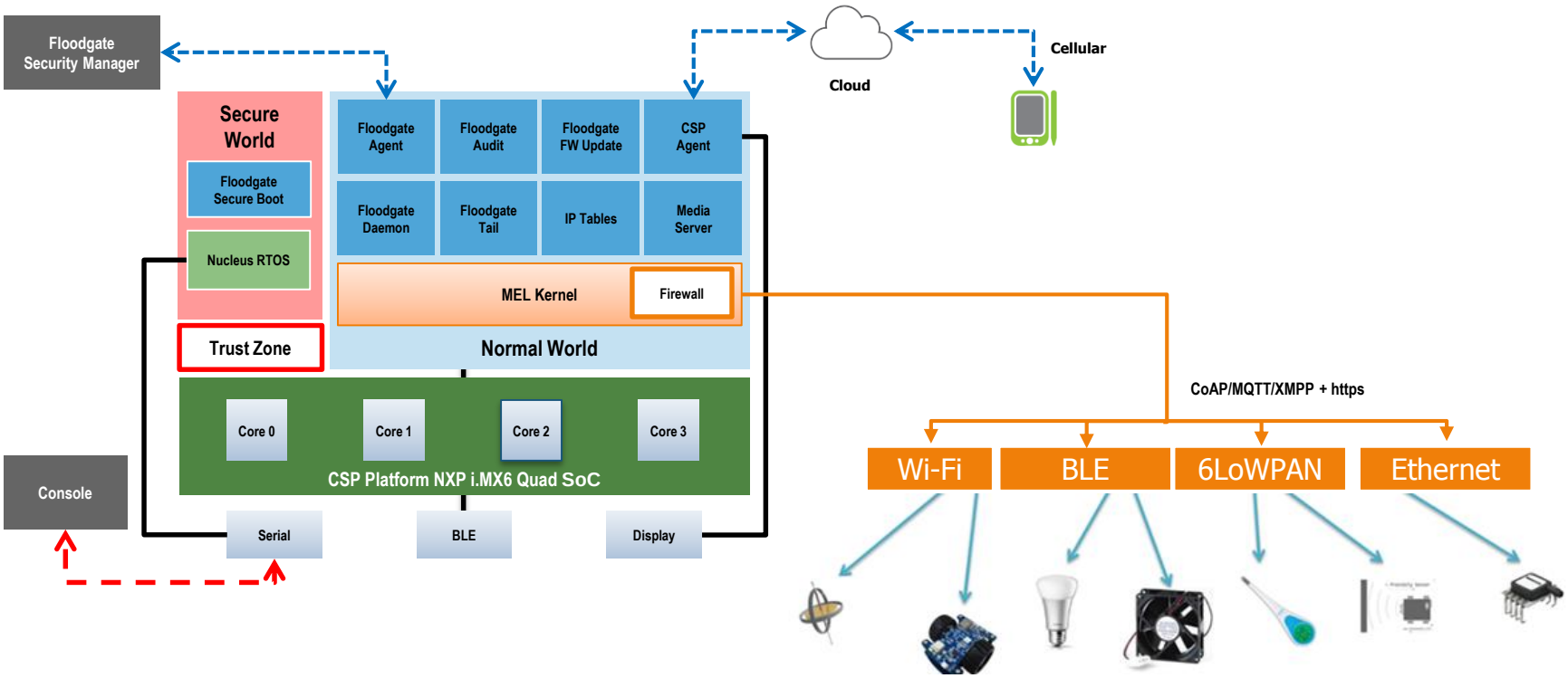
Single Core



Dual Core



Separation via hardware enforcement

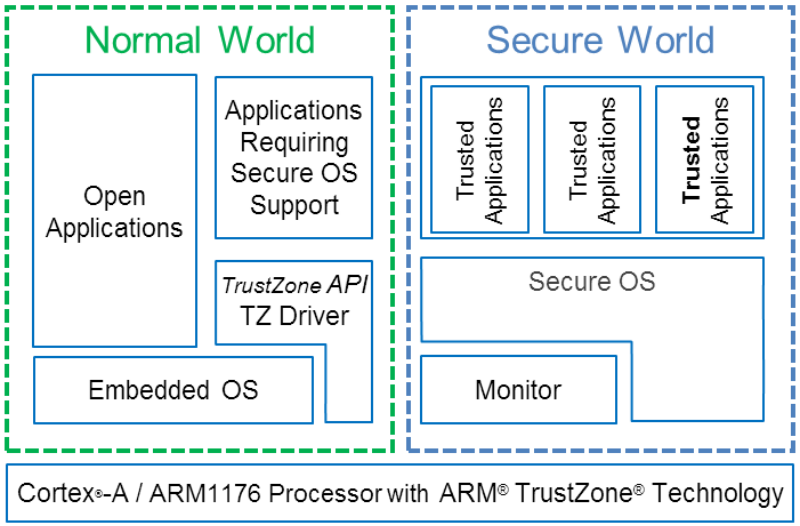


1. TZ Enforced Secure Boot and Chain of Trust
2. Integration with IT tools including McAfee and Symantec
3. Device Integrity Monitoring, Audit and Reporting
4. Network Intrusion detection, prevention and reporting via firewall
5. Secure Update

ARM TrustZone limitations

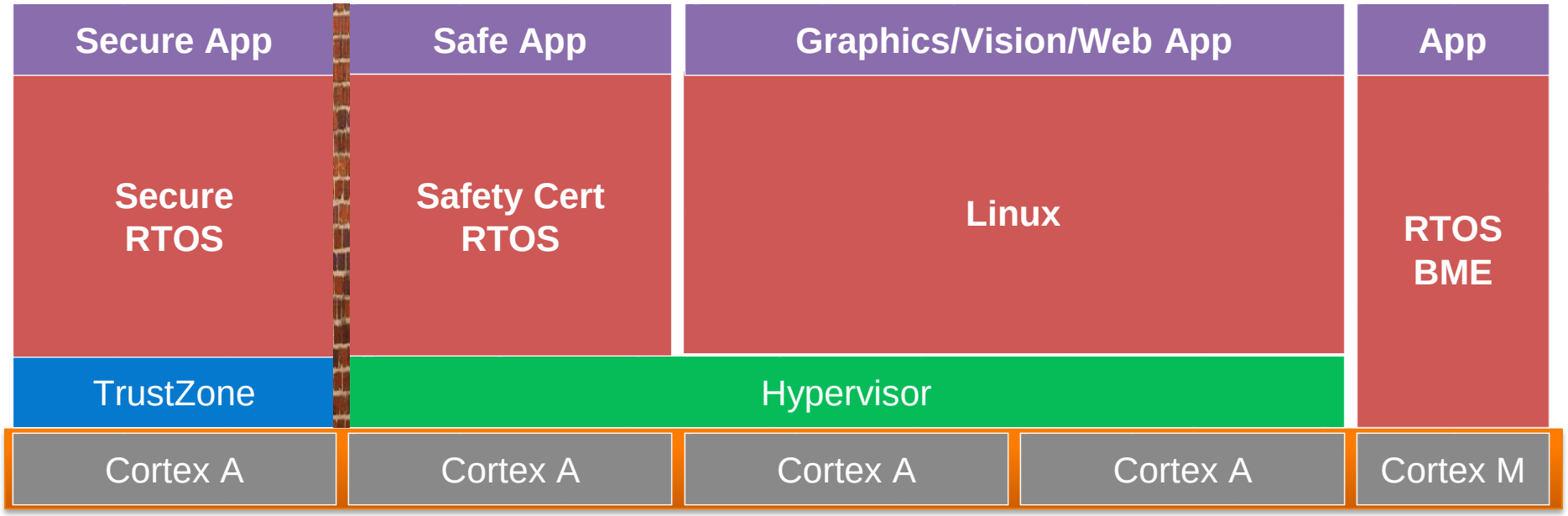
TrustZone includes features that may be helpful to Multi-Core and Multi-OS support, but it alone fails to provide some fundamental capabilities typically required by an embedded system:

- No separation of Normal World resources from Secure World
- It only allows for 2 payloads on one processing core:
  - Normal world content
  - Secure world content
- No Separation of multiple, non Secure Domains



A full safe and secure solution needs a combination of hardware and software elements using virtualization!

Bring it all together



The World of Embedded Devices

The is no silver bullet or one single button to push to adequately protect an embedded device!

Consider using ARM TrustZone and Mentor Graphics products to meet security and regulatory requirements!

Q & A