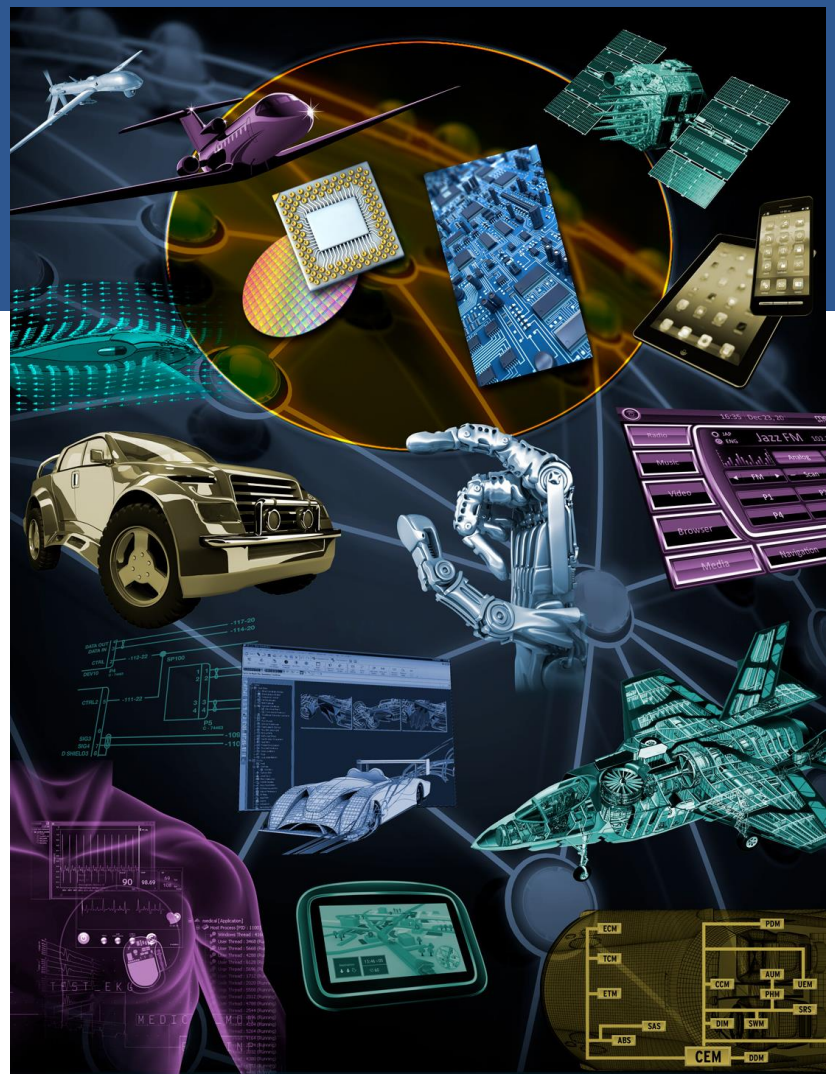

Enabling the Full Power of a Multiprocessor SoC

Jeff Hancock

Senior Product Manager

Embedded Platform Solutions

December 10, 2019

Mentor®
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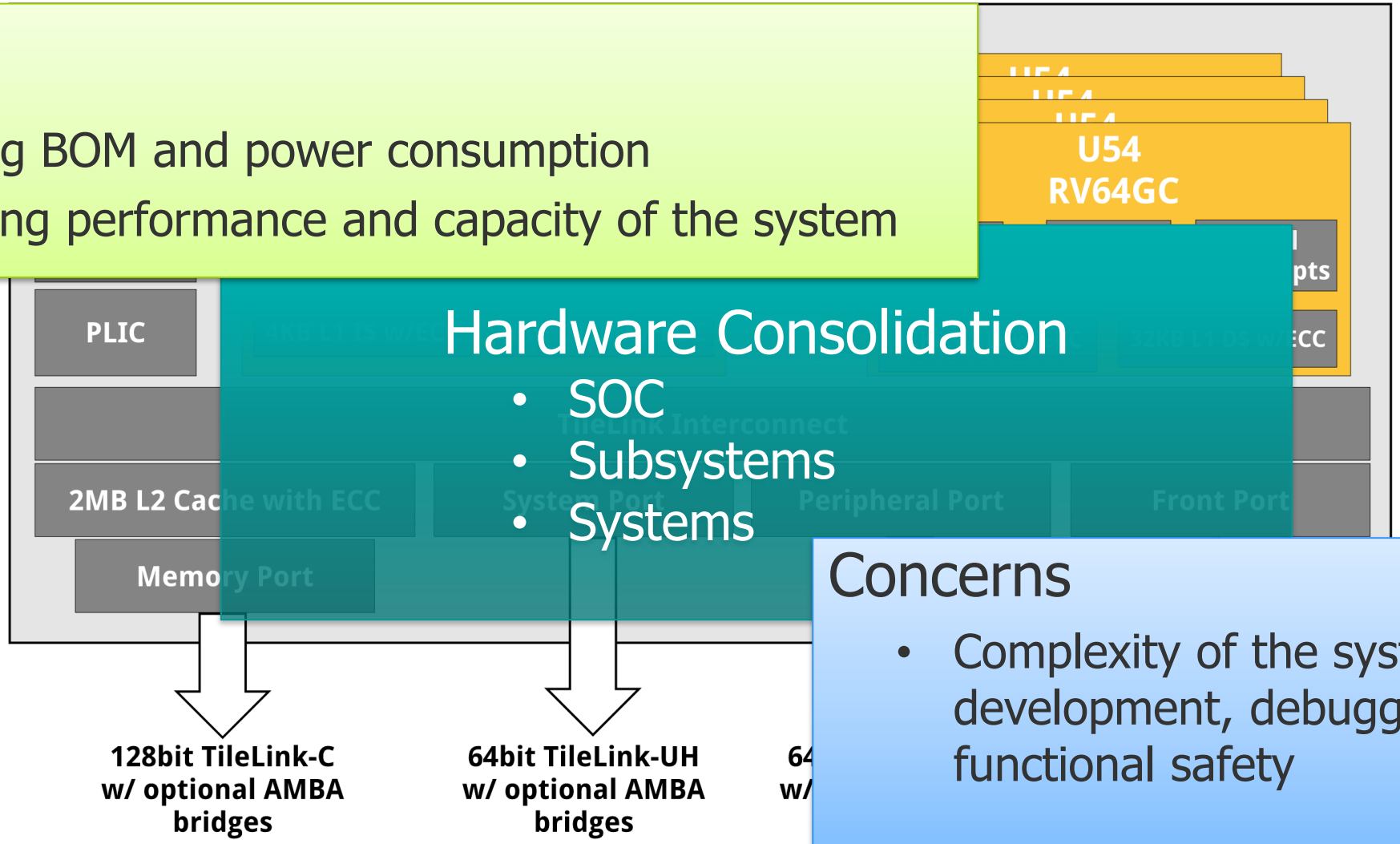
Embedded Industry: Consolidation

Benefits

- Reducing BOM and power consumption
- Increasing performance and capacity of the system



A block diagram of SiFive's U54-MC Coreplex. (Image sourse: SiFive)

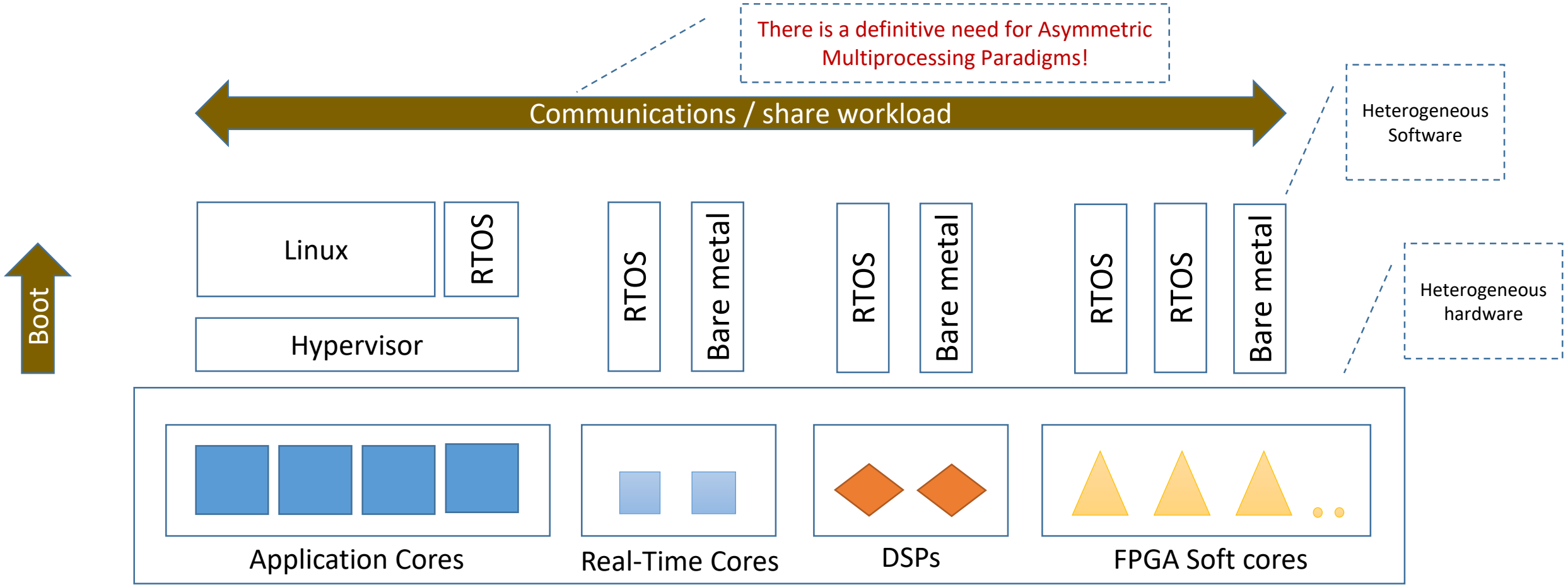
Hardware Consolidation

- SOC
- Subsystems
- Systems

Concerns

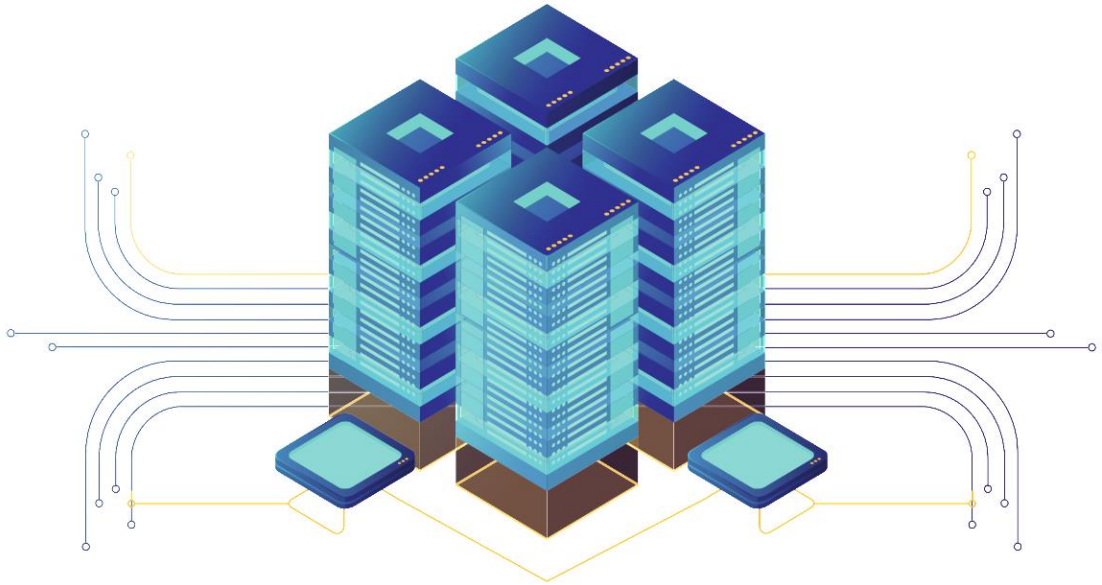
- Complexity of the system design, development, debugging, isolation, functional safety

Trend toward Heterogeneous Multiprocessing in embedded System On Chips (SoCs) ..

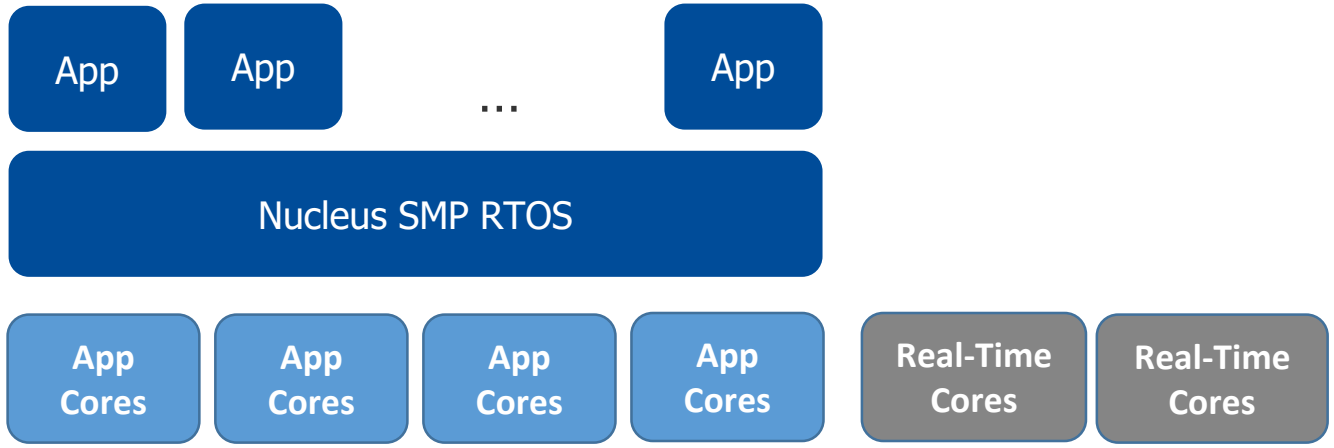


Multicore Hardware Types

- 3 broad possibilities:
  - Homogeneous multicore: all cores identical
  - Heterogeneous multicore: all cores different
  - Hybrid: multiple identical cores, bit some different
    - May be high- and low-power options
    - Possibly regular CPUs and specialized cores

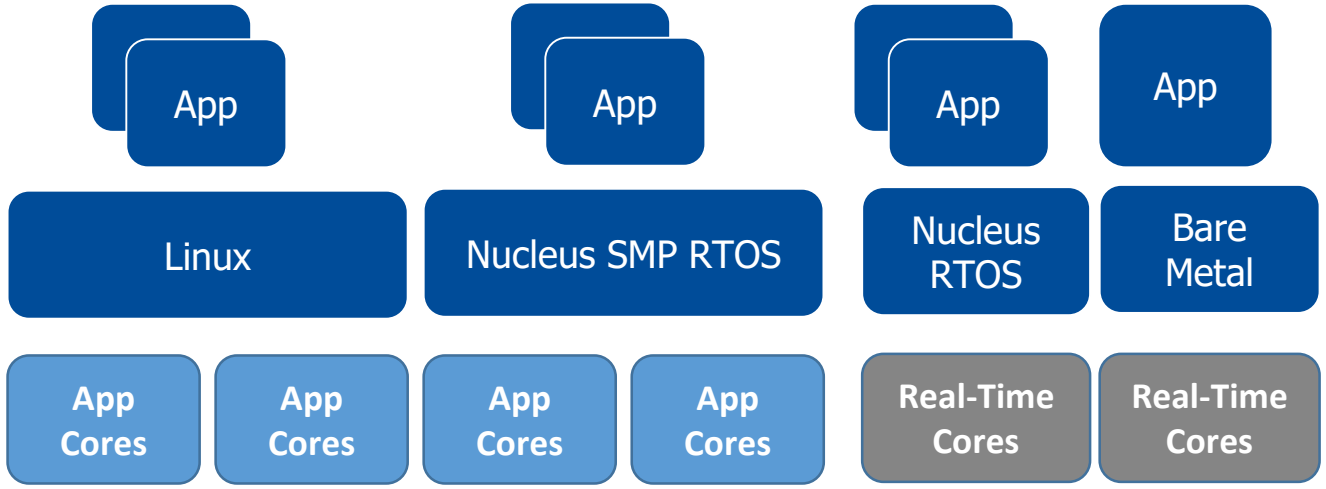


Symmetric Multi Processing (SMP)



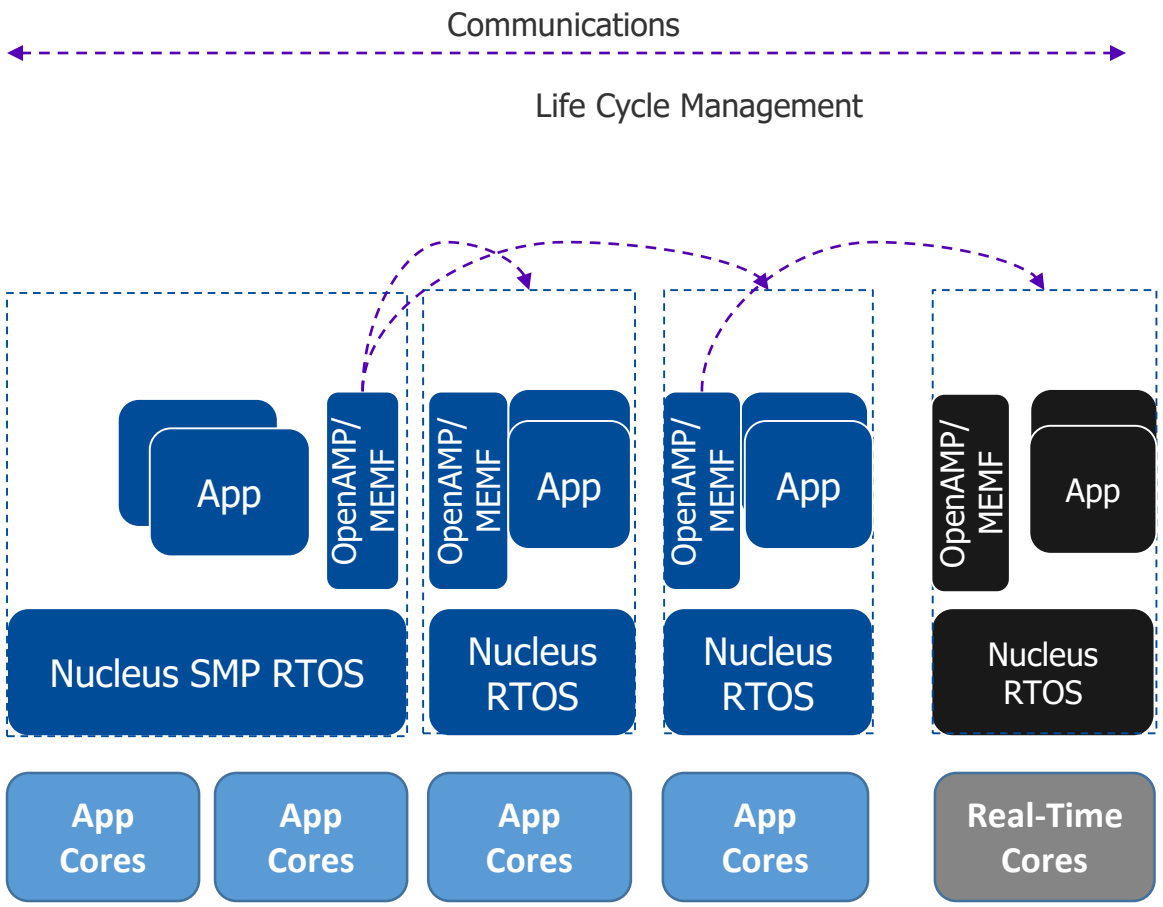
- Provides overall higher compute bandwidth
- Maximum parallelization possible governed by Amdahl's law
- OS scheduler balances workload across available cores in a homogeneous, cache-coherent core cluster
- Facilities provided to affine tasks to specific cores/core-groups
- A number of embedded RTOS products and Linux offer SMP capability
- SMP OSs can be deployed on metal (native) or in supervised environments (on a Hypervisor)

Asymmetric Multi Processing (AMP)



- Multi-OS Model
- System designer choses the right OS environment and processing core for the application workload
- May contain SMP compute domains
- Well suited for consolidation of system functions
  - Real-time/Non Real-Time (HMI)
  - Trusted /Un Trusted
  - Safety certified/ Non certified
- Design considerations
  - Separation requirements
  - System Resource sharing requirements
  - Lifecycle management of cores and associated software contexts
  - Communications between OS contexts
- Further categorized into
  - Unsupervised systems with no separation requirements
  - AMP systems with separation requirements
  - Supervised, systems with separation and/or virtualization requirements

Asymmetric Multi Processing (AMP) using OpenAMP/Multicore Framework



- Multi-OS model
  - Independent OS instances on independent cores
  - Cores and OS instances can be heterogeneous
- Each OS runs natively on the assigned core
  - No separation
  - Co-operative coexistence
- On demand bring-up of compute and software
  - Low power
  - Compute offload/acceleration
- OpenAMP Open Source project
  - remoteproc - Life cycle management
  - rpmsg - Inter-Processor (Inter-OS) Communications
- OpenAMP is a standalone library that enables RTOS and Bare-metal environments
- OpenAMP is compatible with upstream Linux remoteproc and rpmsg components
- Mentor Embedded Multicore Framework
  - Commercial implementation of OpenAMP

Multicore Issues

- Inter-CPU communications
- Inter-CPU safety
- Boot order
- System integrity

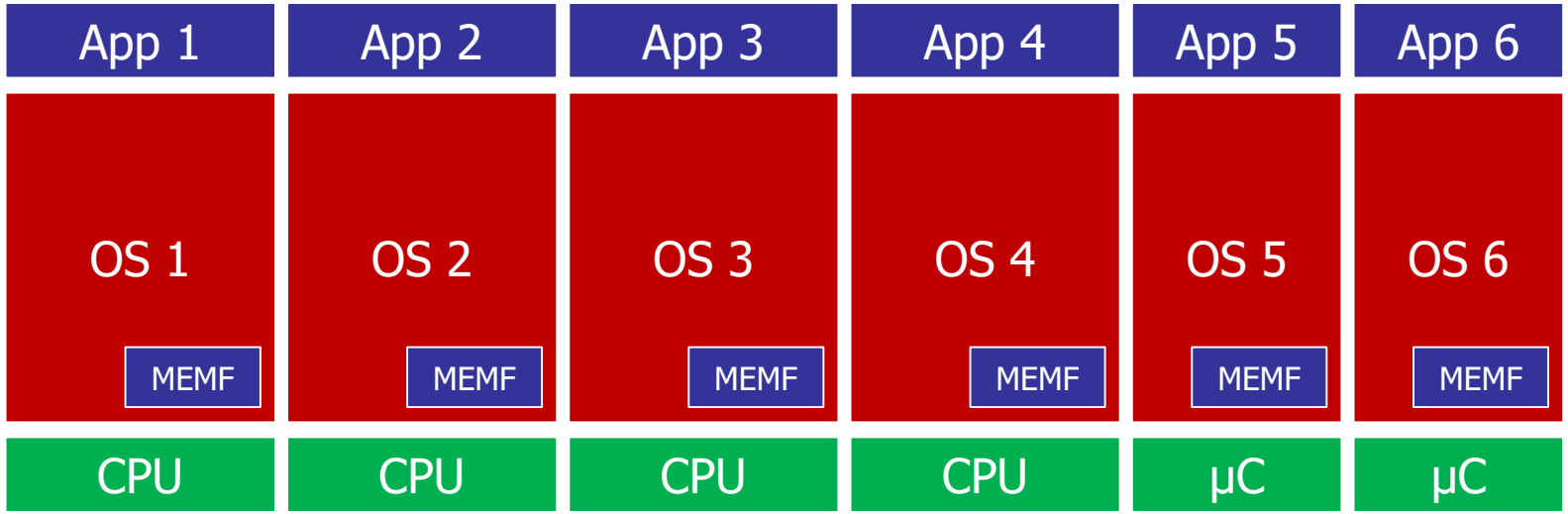
Multicore Management

- Unsupervised
  - Framework
    - OpenAMP / Multicore Framework
- Supervised
  - Hypervisor
- Hybrid

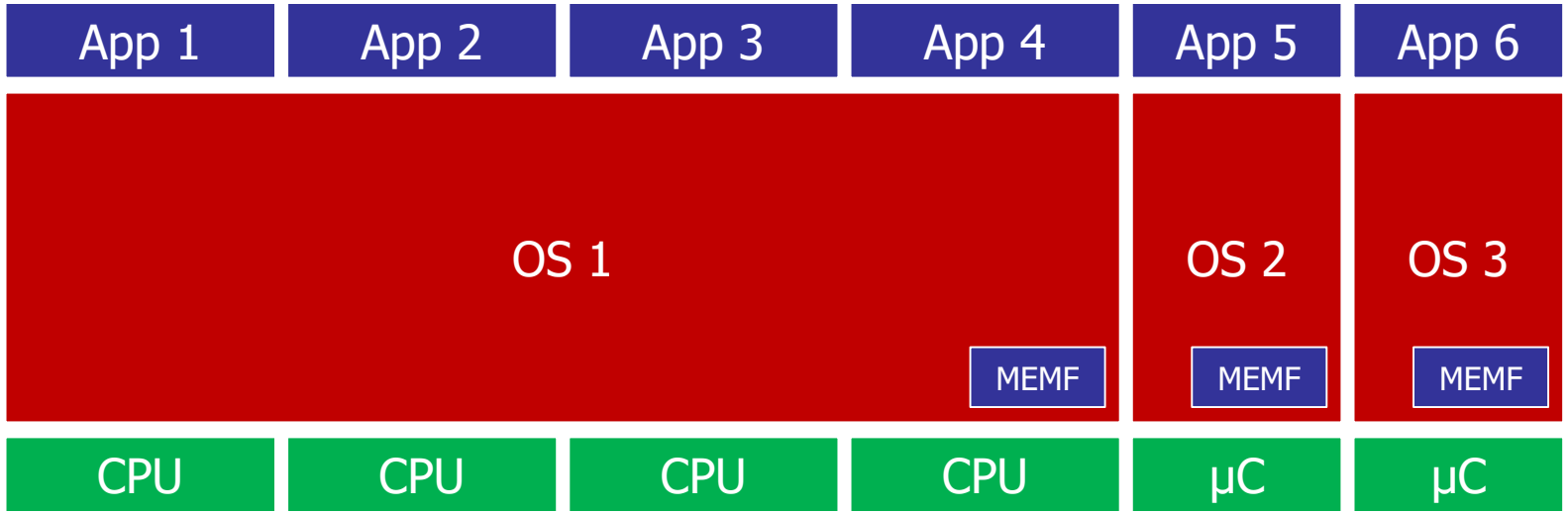
Multicore Management

- **Unsupervised**
  - Framework
    - OpenAMP / Multicore Framework
- Supervised
  - Hypervisor
- Hybrid

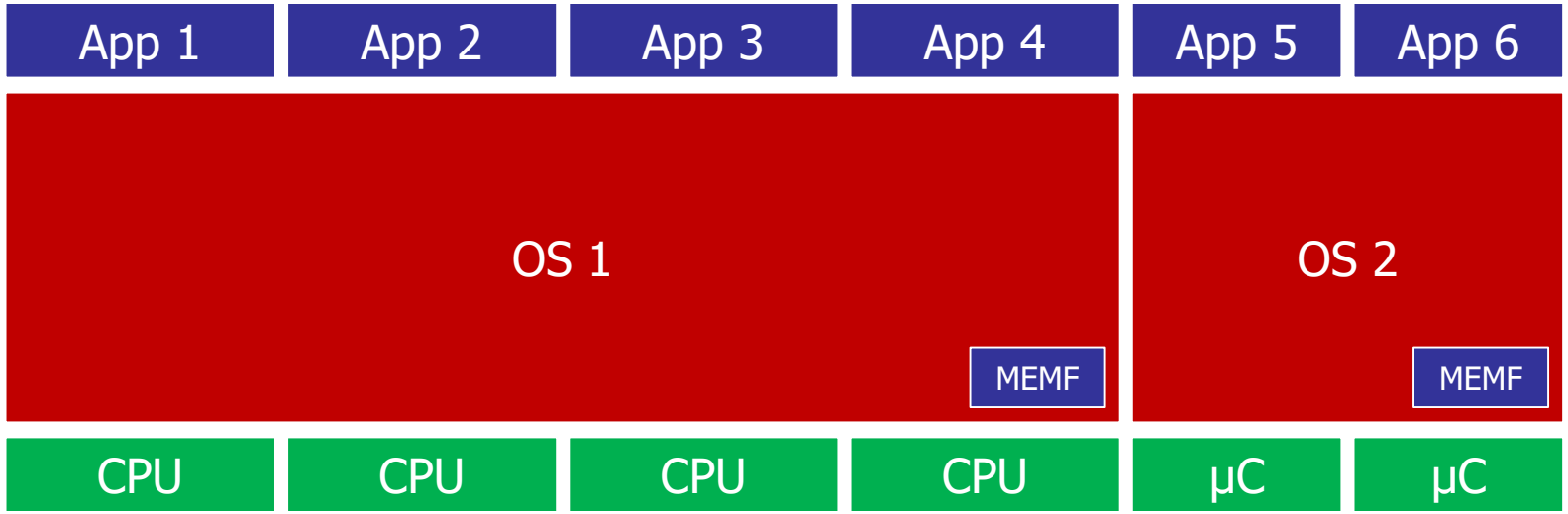
Unsupervised



Unsupervised



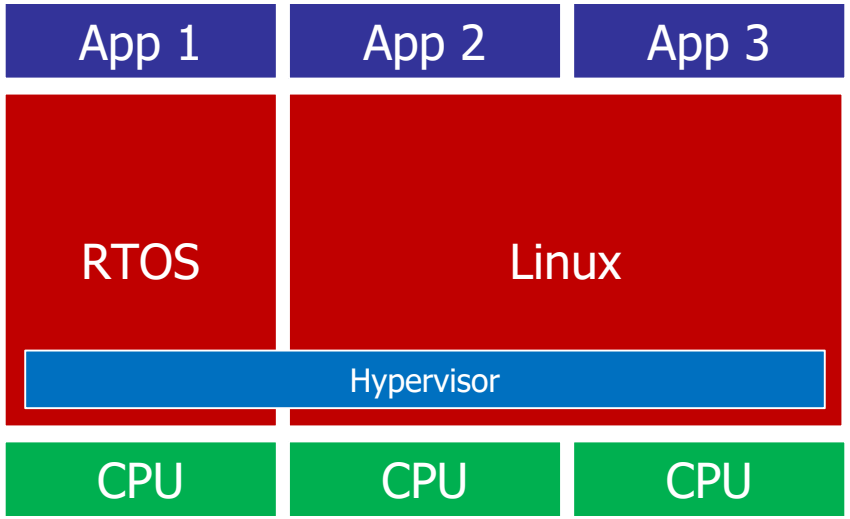
Unsupervised



Multicore Management

- Unsupervised
  - Framework
    - OpenAMP/Multicore Framework
- **Supervised**
  - Hypervisor
- Hybrid

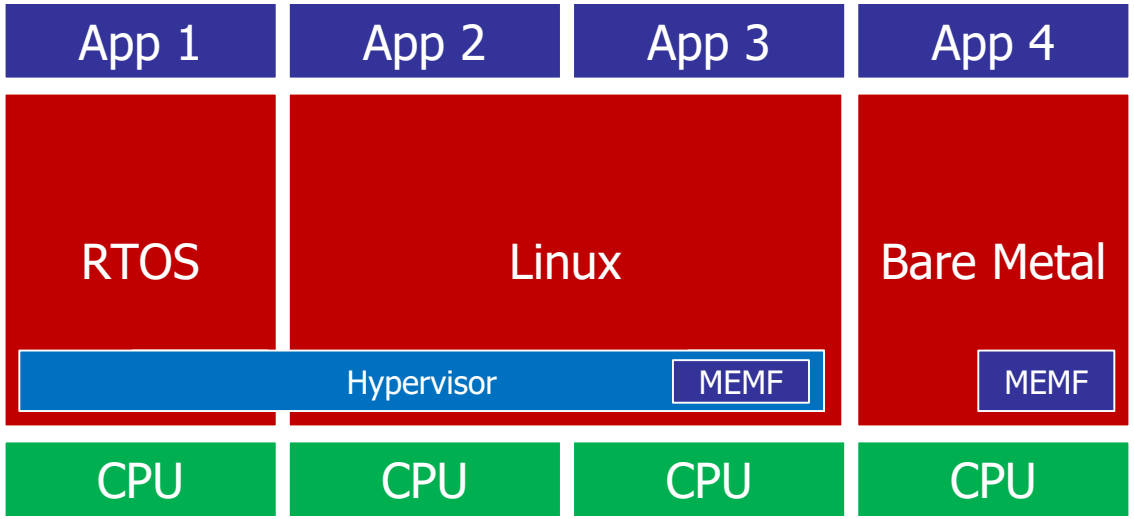
Supervised - Hypervisor



Multicore Management

- Unsupervised
  - Framework
    - OpenAMP/Multicore Framework
- Supervised
  - Hypervisor
- **Hybrid**

Hybrid



System Implementation

Mixed time domain

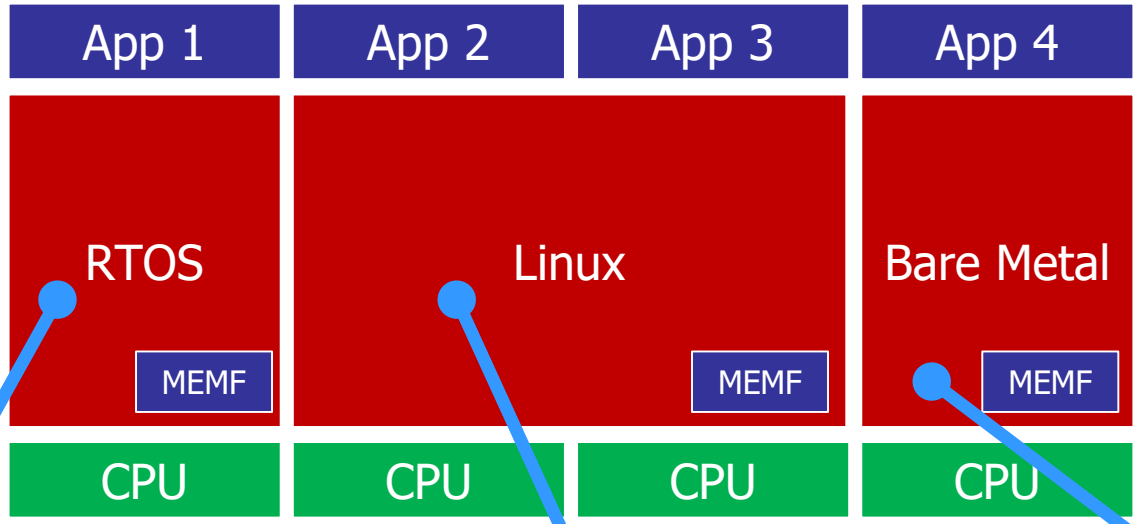
Mixed criticality

System Implementation

Mixed time domain

Mixed criticality

Mixed time domain



- Hard real-time
- Deterministic – predictable
- Responsive
- Compact code
- Fast execution
- Fast start-up

- Non-real-time
- User interface
- Number crunching
- Data processing
- External storage etc.

- Probably real-time
- Optimum CPU performance
- No overheads

Each CPU/OS doing what it is good at

System Implementation

Mixed time domain

Mixed criticality

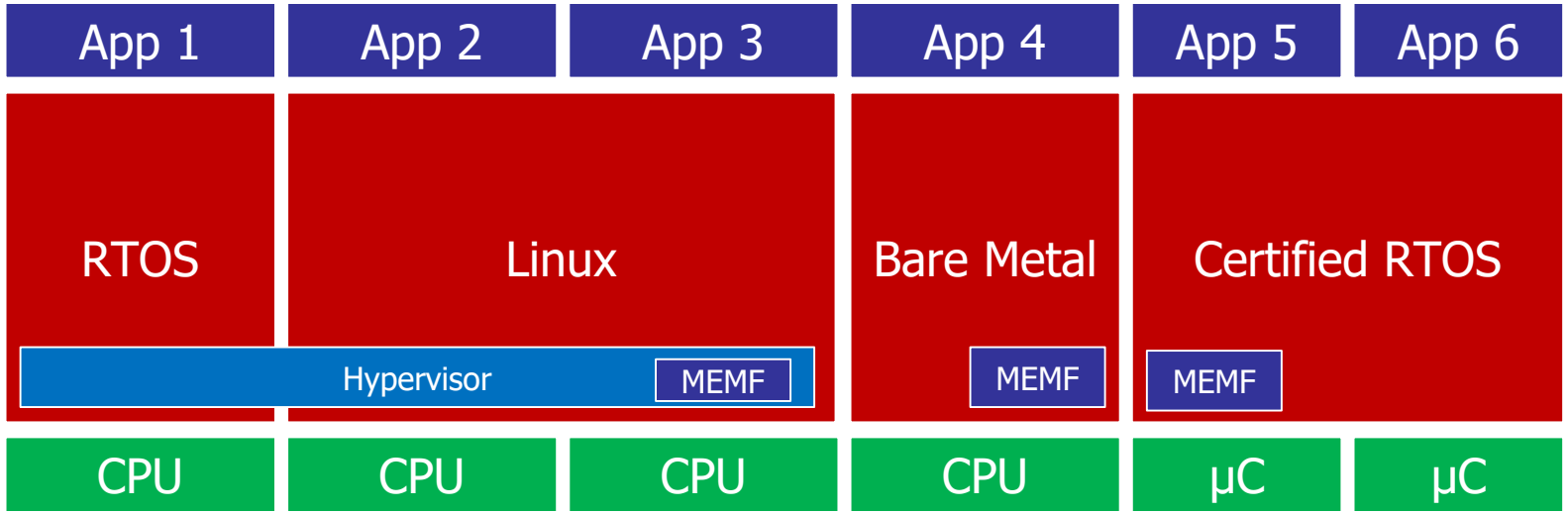
Critical systems

- Secure systems
  - Banking infrastructure
  - POS terminals
  - ATMs
  - Medical
- Safety critical systems
  - Automotive
  - Mil/aero
  - Medical
- Certification

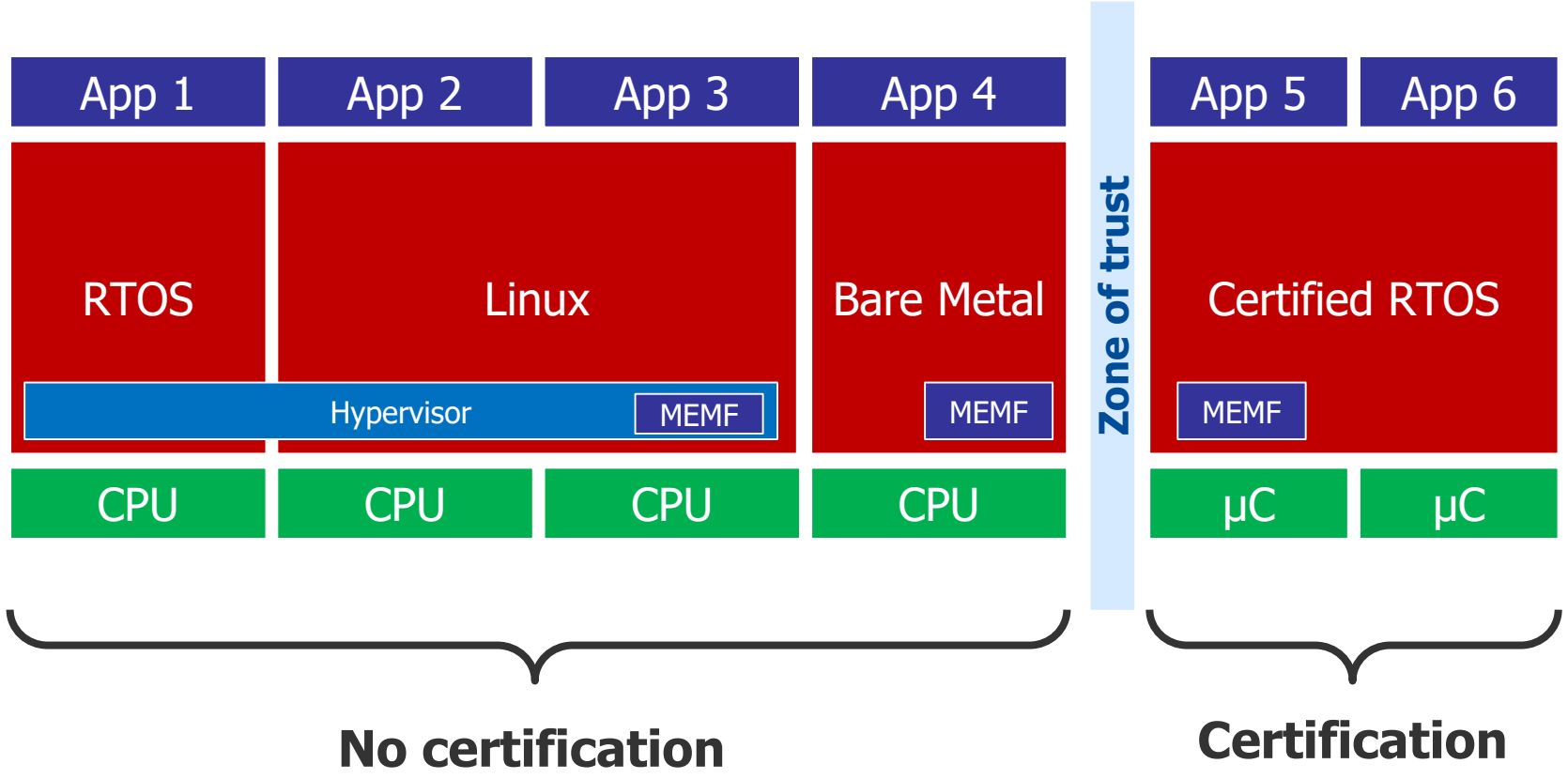
Certification

- Expensive
- Time consuming
- Size of code matters
  - Small code -> less time/cost
- Operating system
  - Typically cannot be certified alone – whole system is certified
  - May be “pre-certification” option
  - OS certification track record is key

Mixed criticality



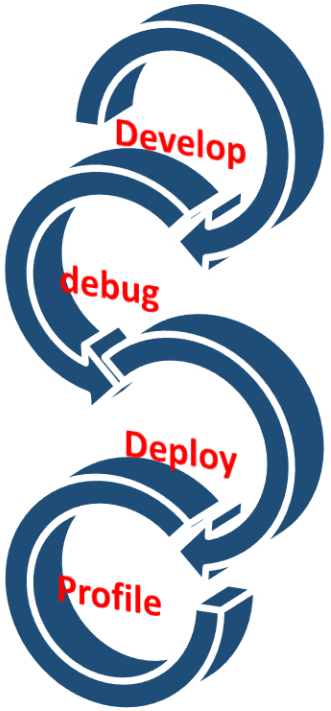
Mixed criticality

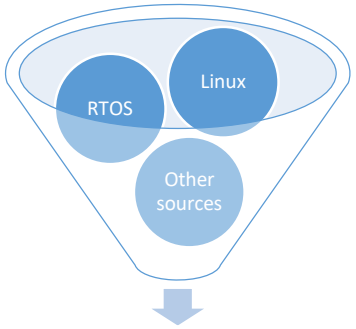


Mentor Embedded comprehensive offering for Multiprocessor Software Development

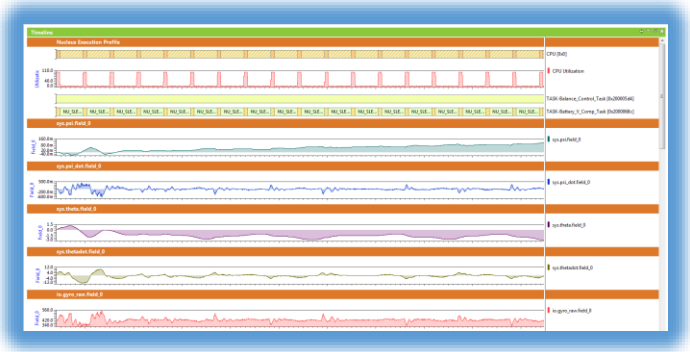
- Mentor Embedded Linux Flex OS
- Mentor Embedded Linux Omni OS
- Nucleus RTOS
- Nucleus SafetyCert RTOS
- Mentor Embedded Hypervisor
- Mentor Embedded Multicore Framework
- Mentor Embedded Multicore Framework Cert

Sourcery CodeBench Development Tools





Sourcery Analyzer



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