

# Enabling the Full Power of a Multiprocessor SoC

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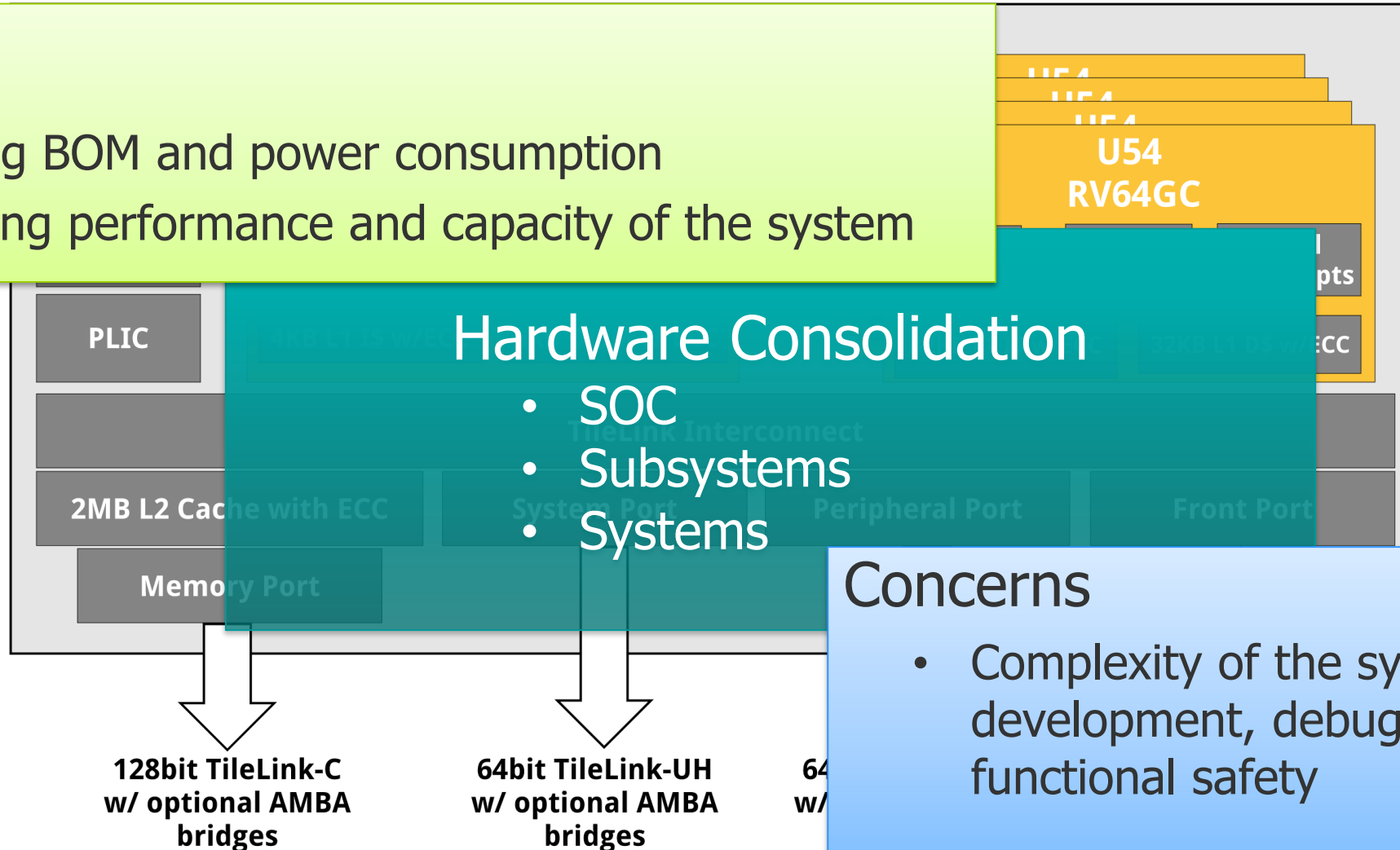
Embedded Platform Solutions

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# Embedded Industry: Consolidation

## Benefits

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

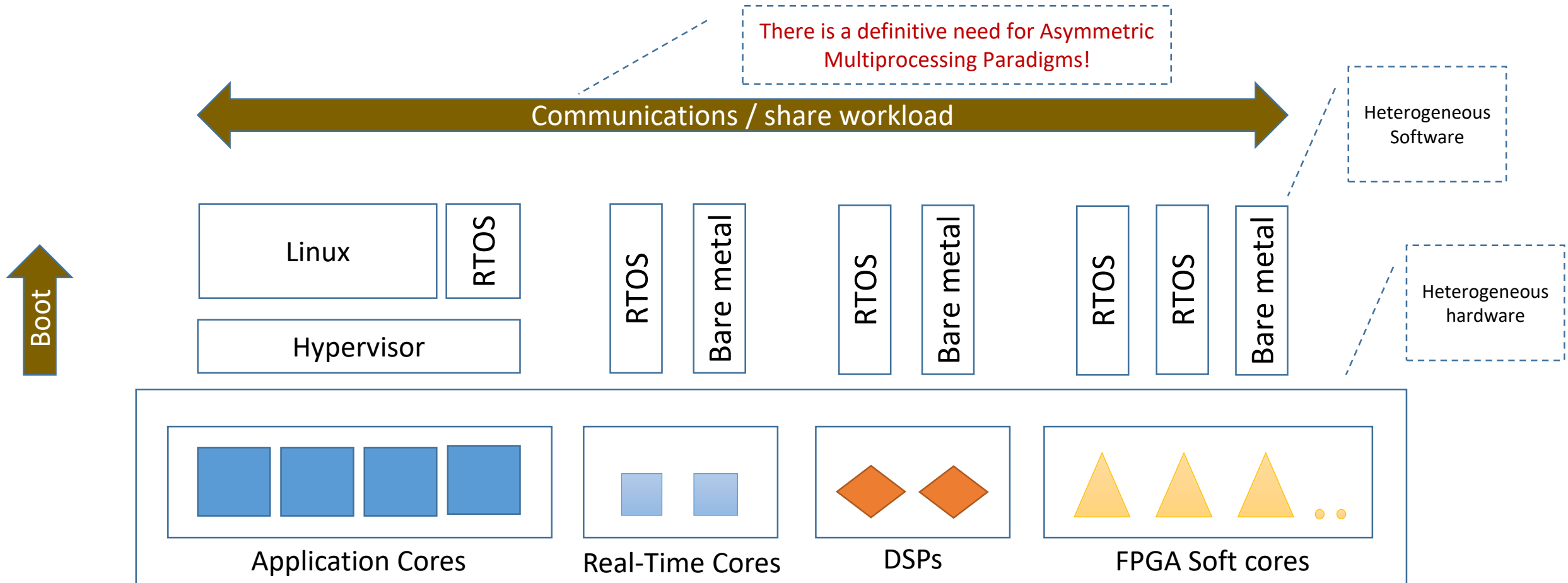


A block diagram of SiFive's U54-MC Coreplex. (Image source: SiFive)

## Concerns

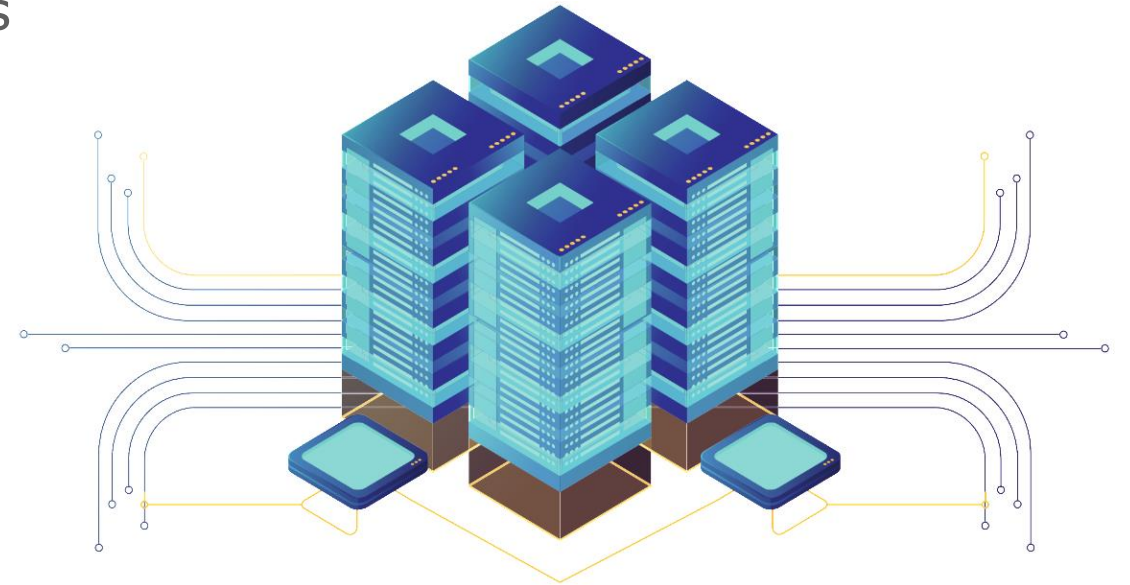
- Complexity of the system design, development, debugging, isolation, functional safety

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

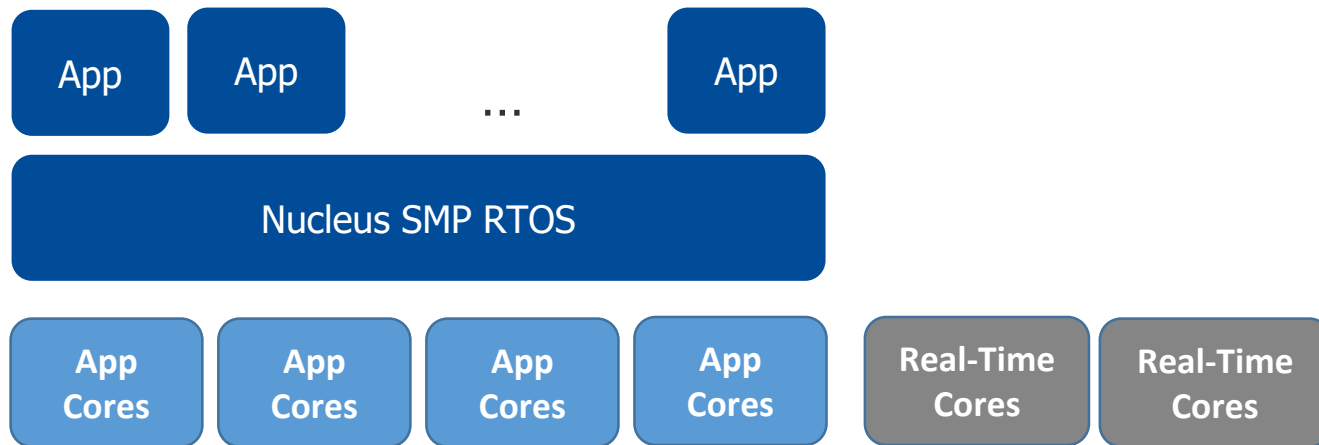


# Multicore Hardware Types

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

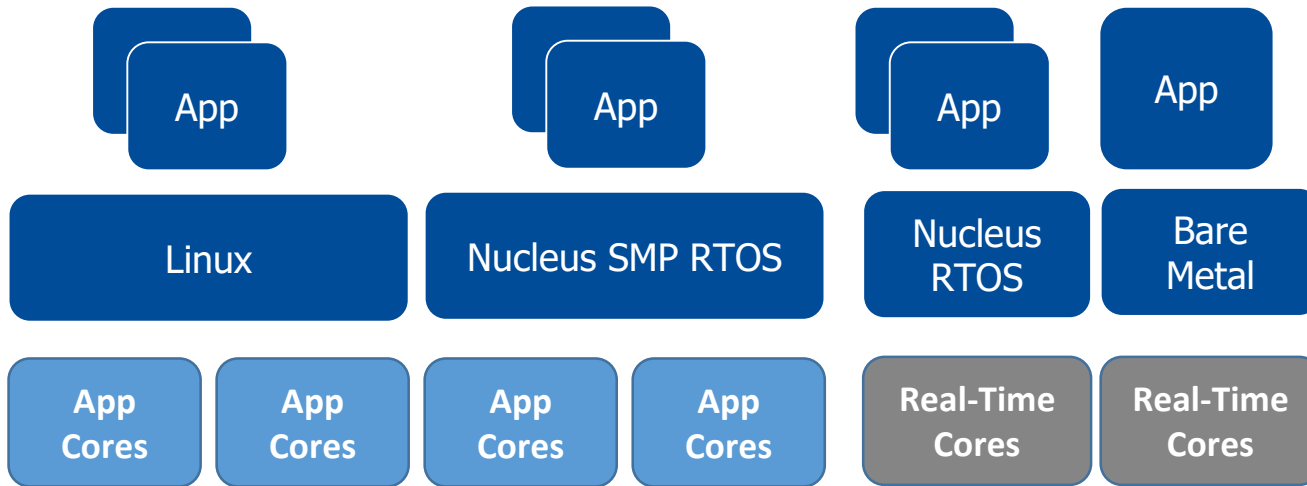


# Symmetric Multi Processing (SMP)



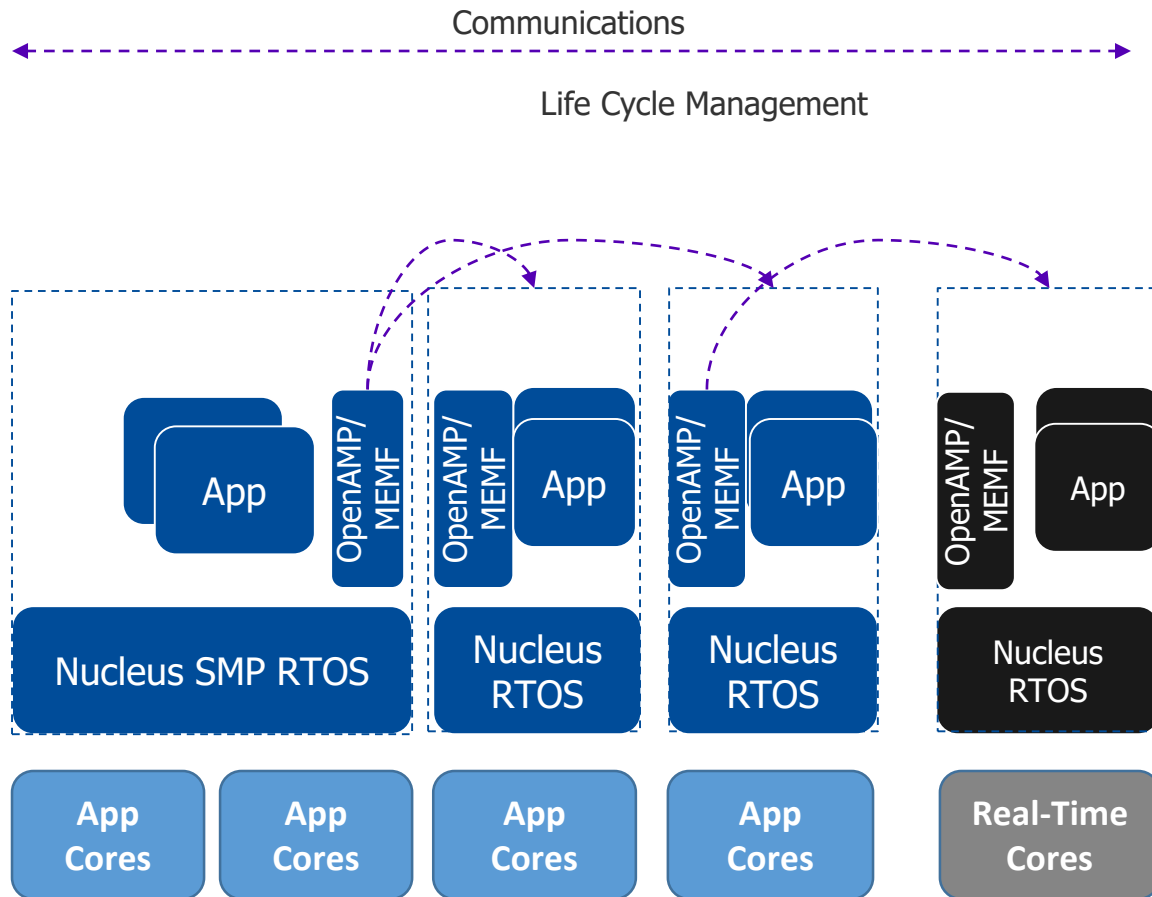
- Provides overall higher compute bandwidth
- Maximum parallelization possible governed by Amdahl's law
- OS scheduler balances workload across available cores in a homogeneous, cache-coherent core cluster
- Facilities provided to affine tasks to specific cores/core-groups
- A number of embedded RTOS 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 chooses 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

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



# Multicore Management

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

# Multicore Management

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- **Unsupervised**

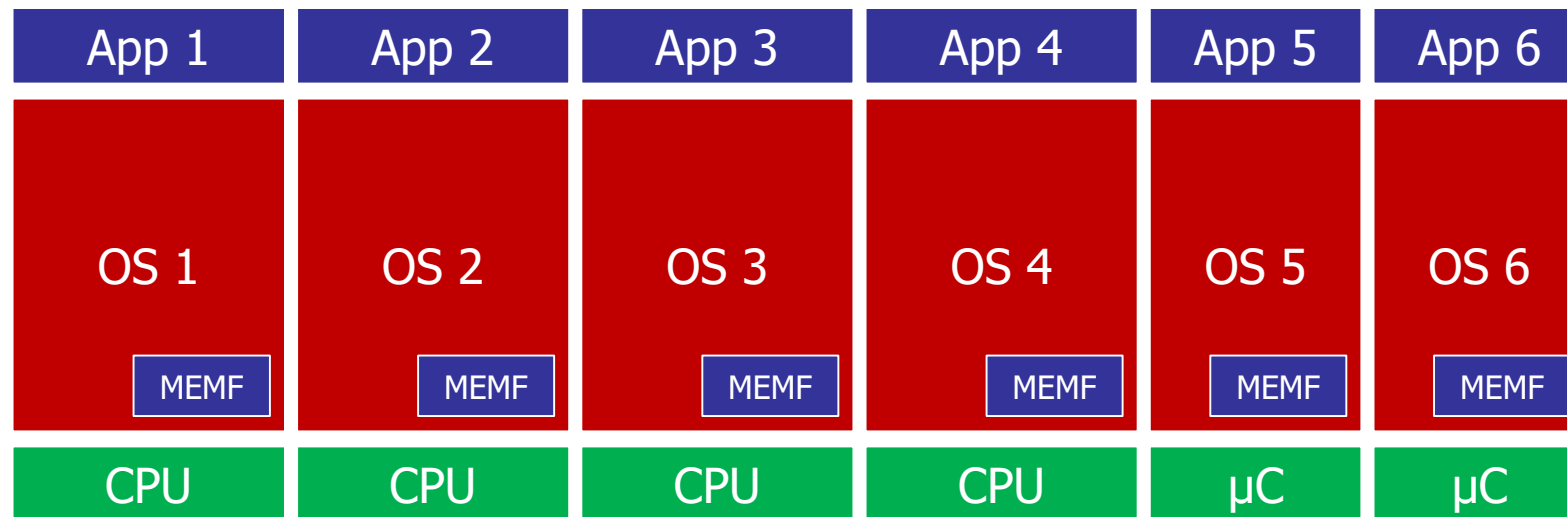
- Framework
  - OpenAMP / Multicore Framework

- Supervised

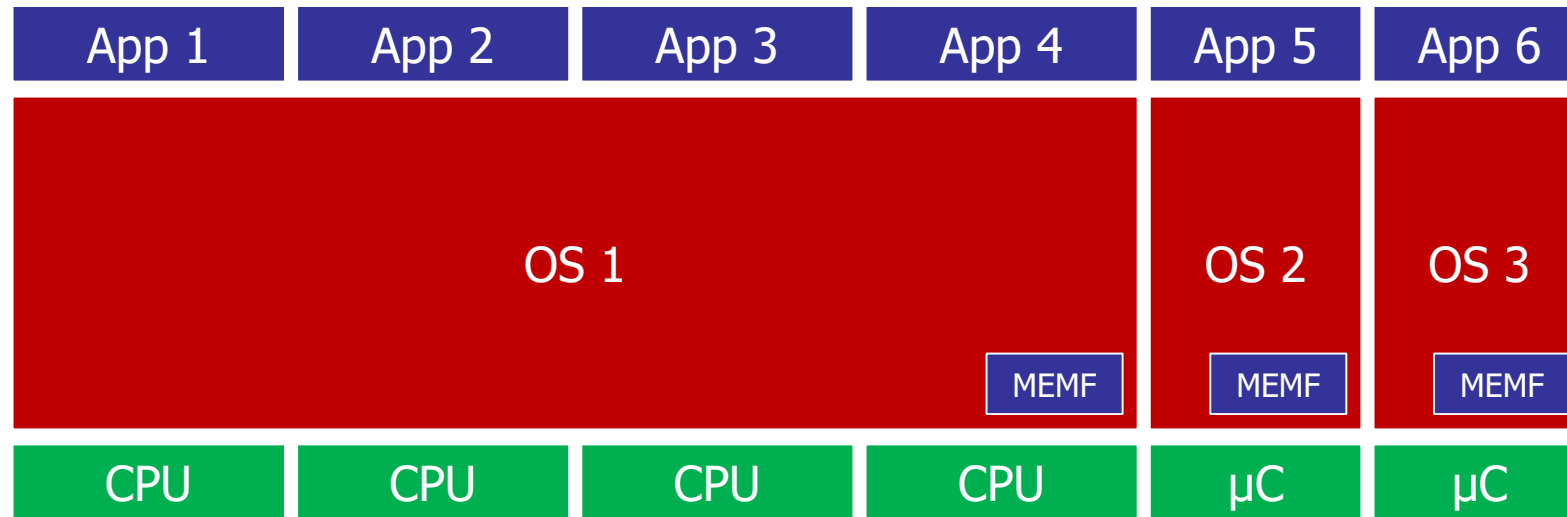
- Hypervisor

- Hybrid

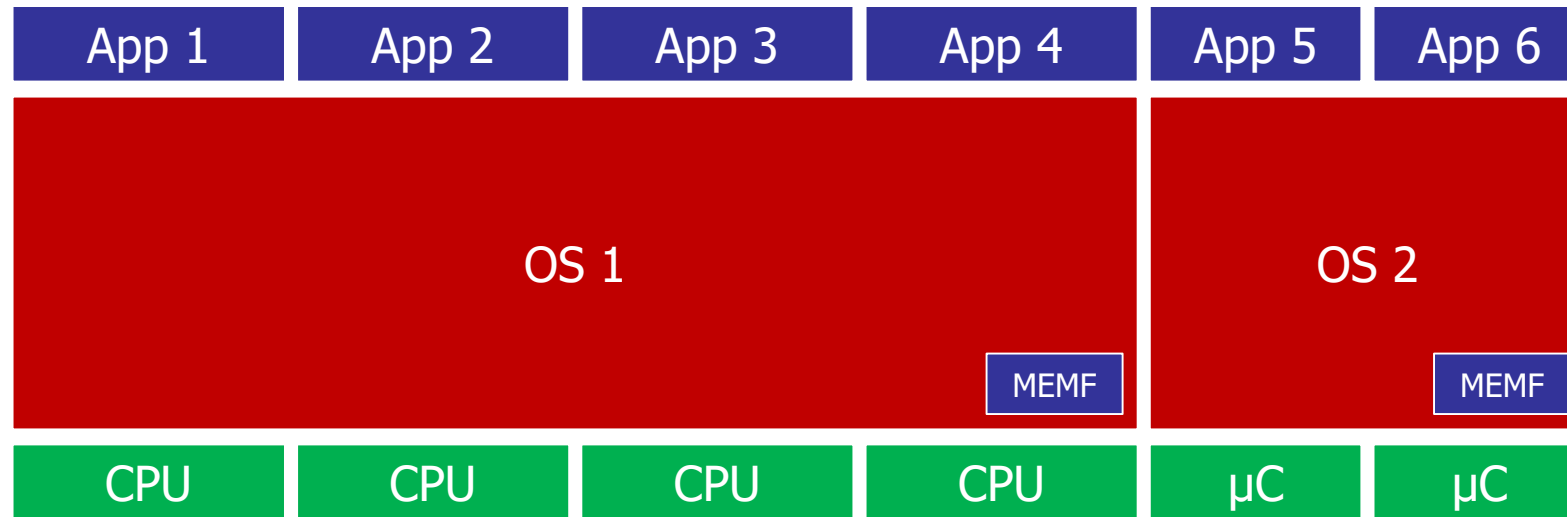
# Unsupervised



# Unsupervised



# Unsupervised

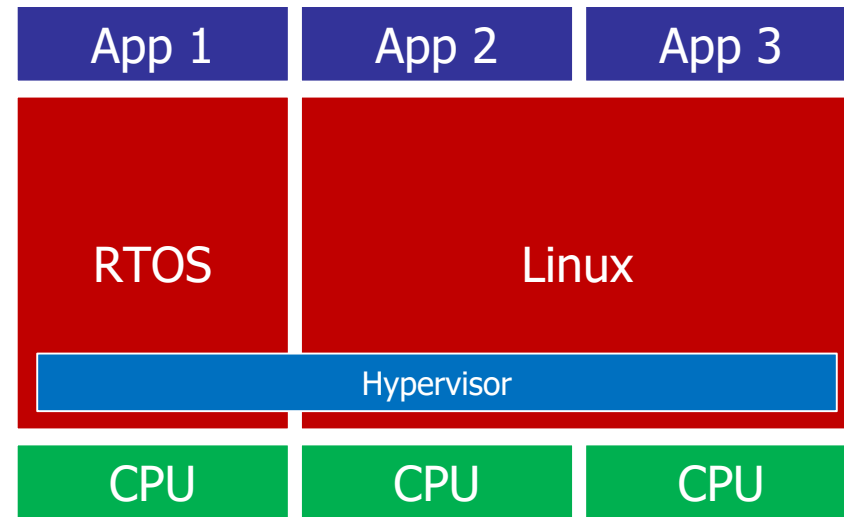


# Multicore Management

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

# Supervised - Hypervisor



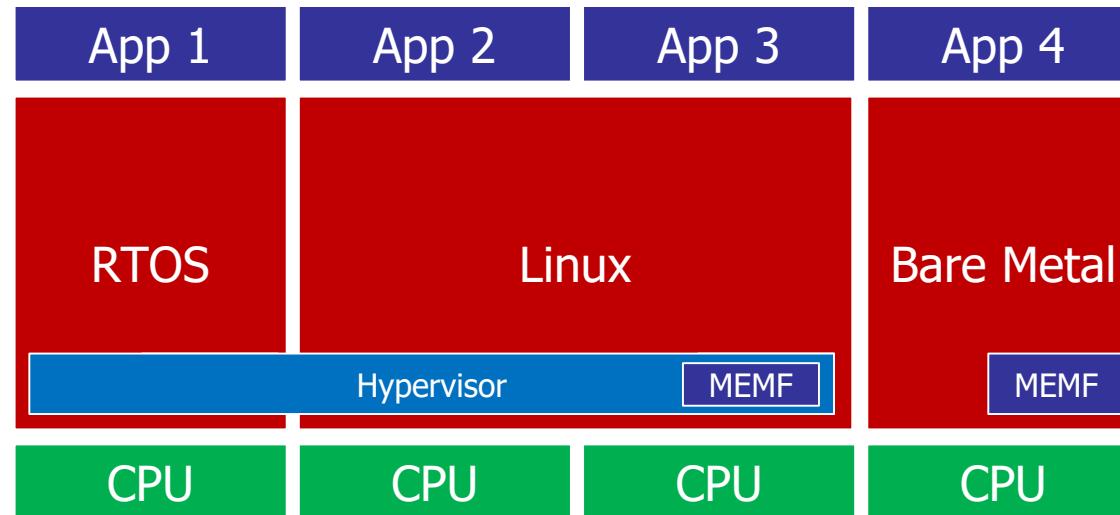
# Multicore Management

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



# Hybrid



# System Implementation

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Mixed time domain

Mixed criticality

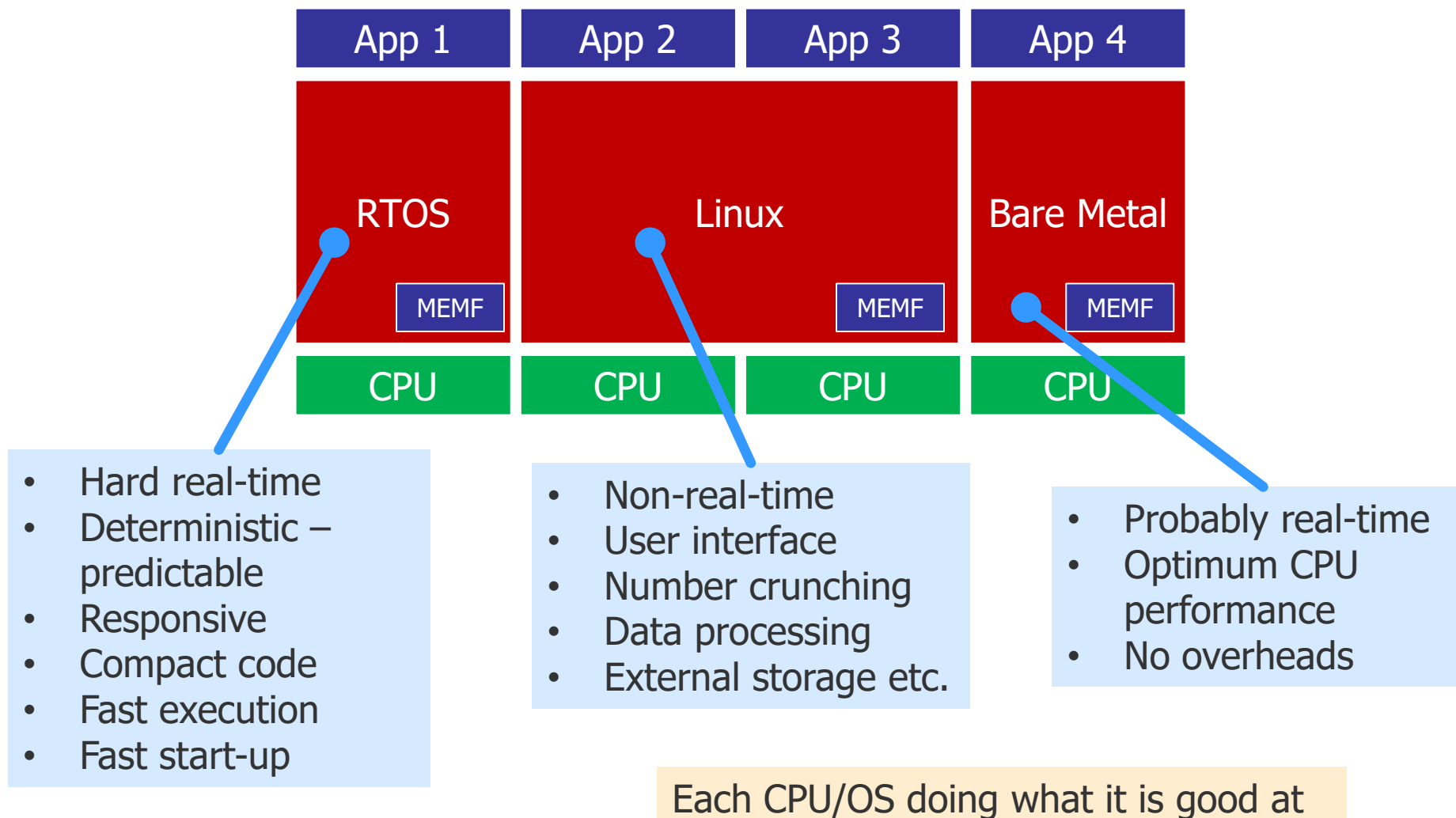
# System Implementation

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**Mixed time domain**

Mixed criticality

# Mixed time domain



# System Implementation

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Mixed time domain

**Mixed criticality**

# Critical systems

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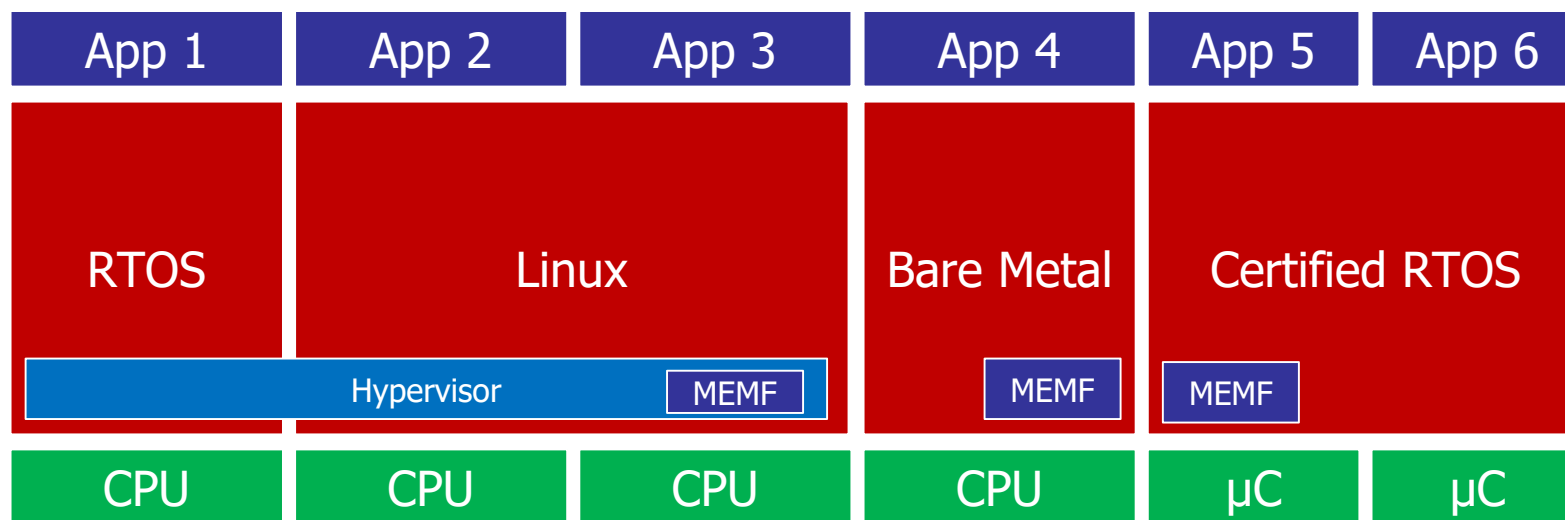
- Secure systems
  - Banking infrastructure
  - POS terminals
  - ATMs
  - Medical
  
- Safety critical systems
  - Automotive
  - Mil/aero
  - Medical
  
- Certification

# Certification

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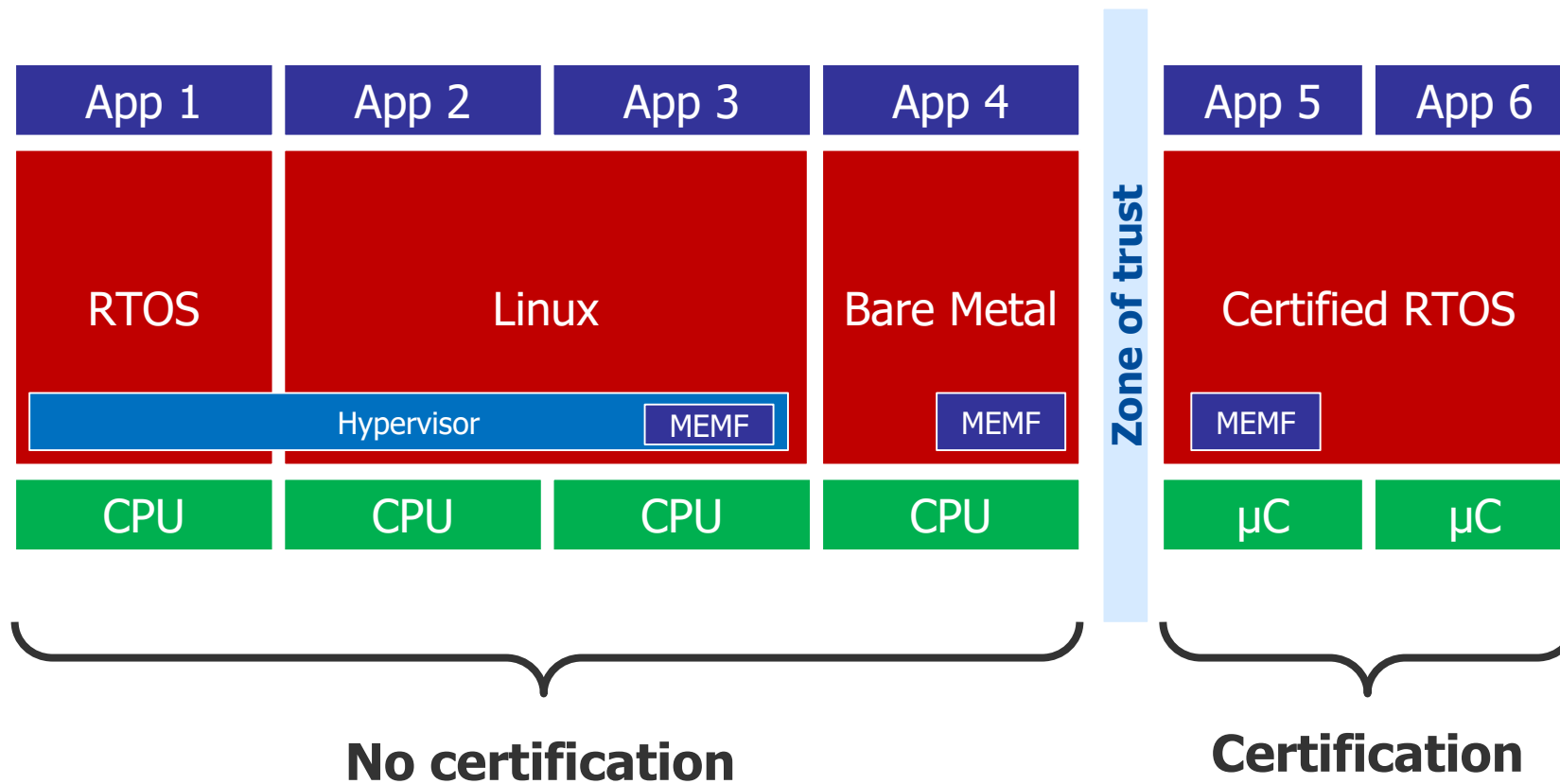
- Expensive
- Time consuming
- Size of code matters
  - Small code -> less time/cost
- Operating system
  - Typically cannot be certified alone – whole system is certified
  - May be “pre-certification” option
  - OS certification track record is key

# Mixed criticality

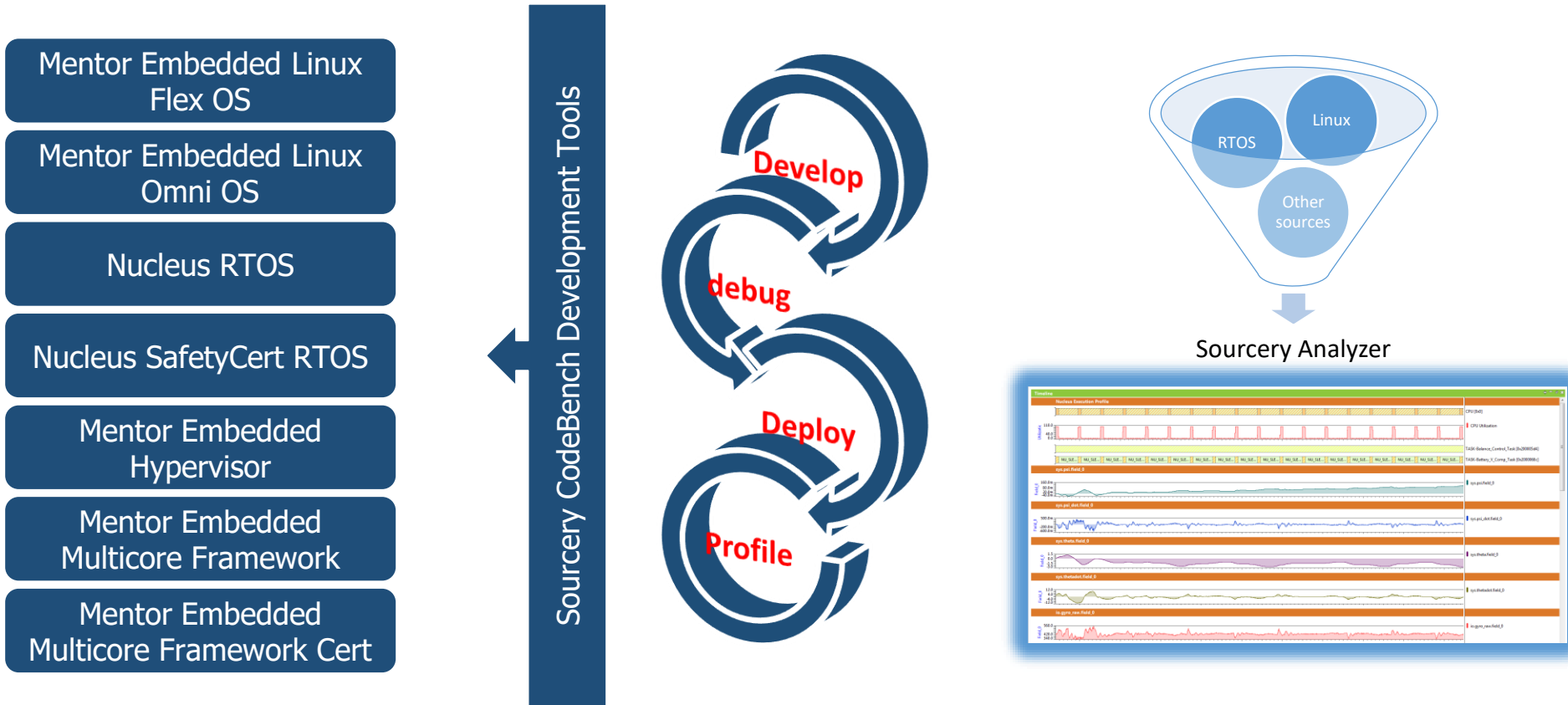




# Mixed criticality



# Mentor Embedded comprehensive offering for Multiprocessor Software Development



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