OpenAMP: “**Open A**symmetric **M**ulti-**P**rocessing” Project

Runtime coexistence and collaboration
Runtime hardware resource assignment
Resource sharing and IPC between runtimes
Control mechanisms to start and stop runtimes
Typical system: Linux + RTOS on one system-on-chip

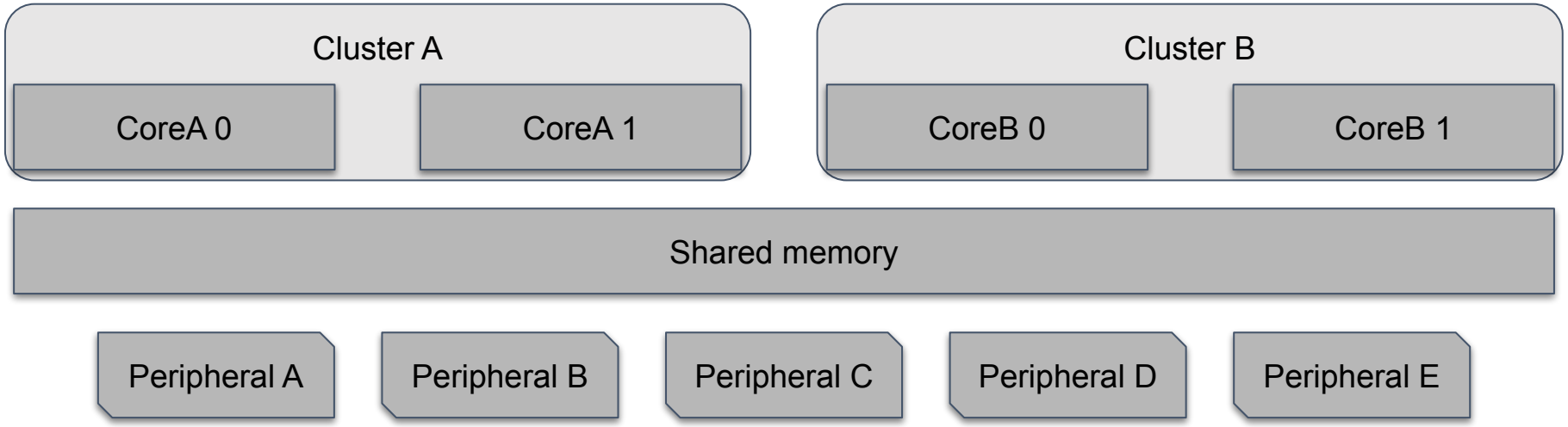
www.openampproject.org.

OpenAMP Project Intro

Standardizing Asymmetric Runtime Integration

OpenAMP Embedded Targets

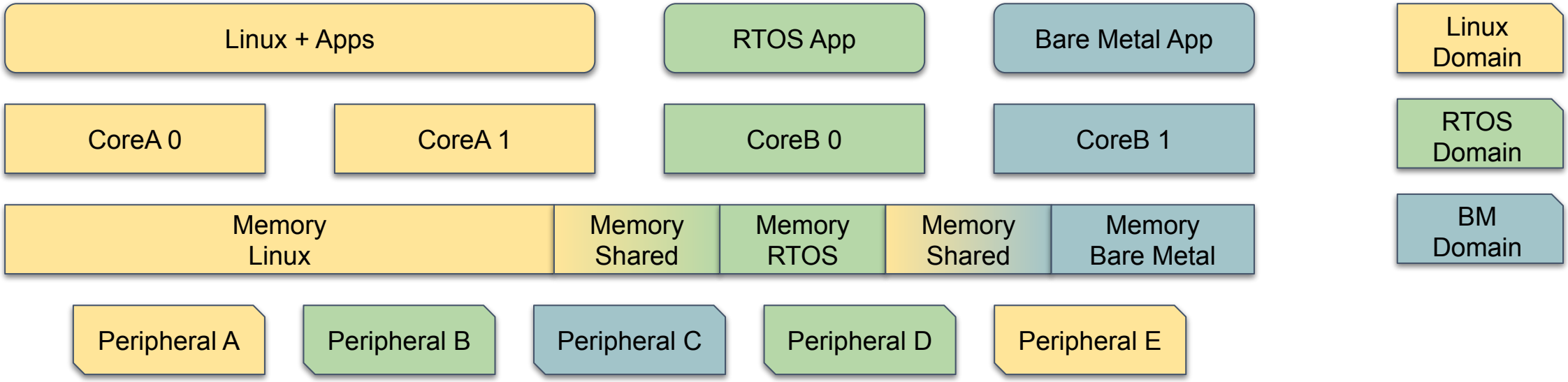
Modern Embedded Targets integrate multiple HW resources
e.g. multiple core clusters, shared memory and peripherals



OpenAMP Embedded Runtimes

Embedded Targets have multiple Runtimes that need to collaborate

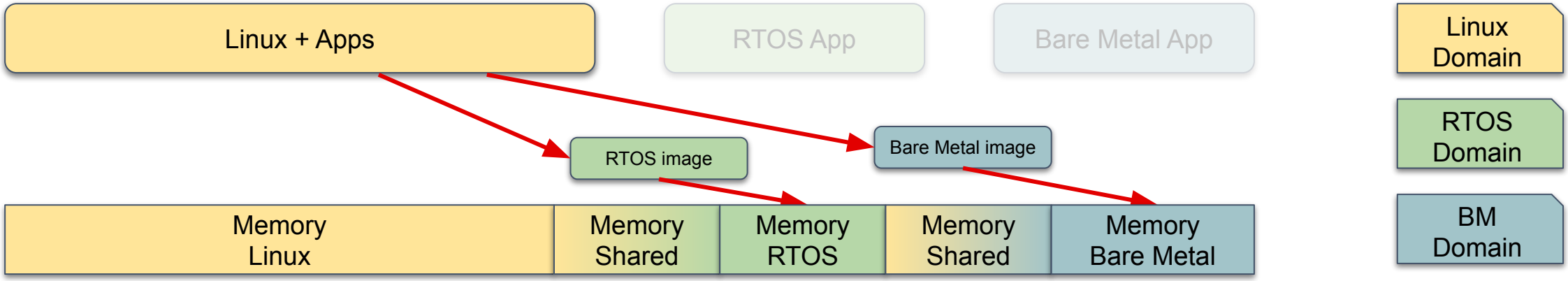
OpenAMP HW Assignment



The HW resources need to be assigned into Runtime Domains

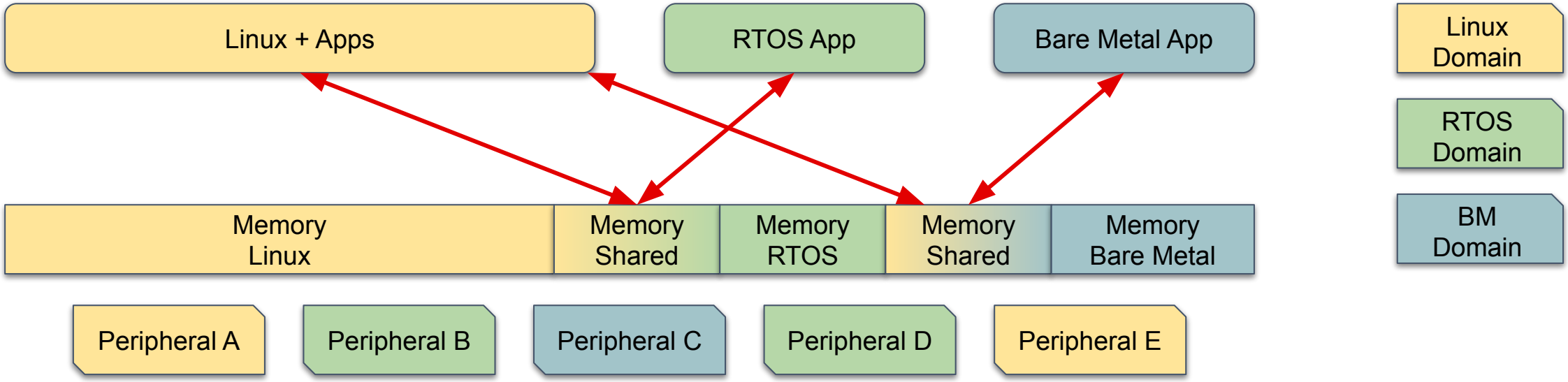
OpenAMP Runtime Control

The Runtimes need to be managed,
e.g. loaded into memory and started



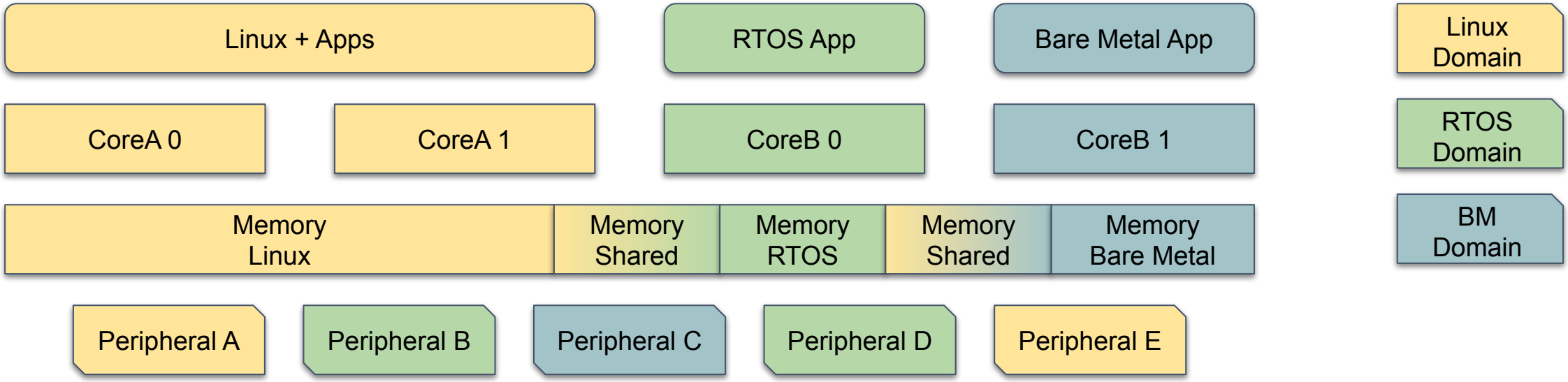
OpenAMP Resource Sharing and IPC

The Runtimes need to share data, services, and virtual devices



OpenAMP Mission

OpenAMP provides standards, runtime libraries and tooling built on top of existing open source projects to simplify runtime collaboration



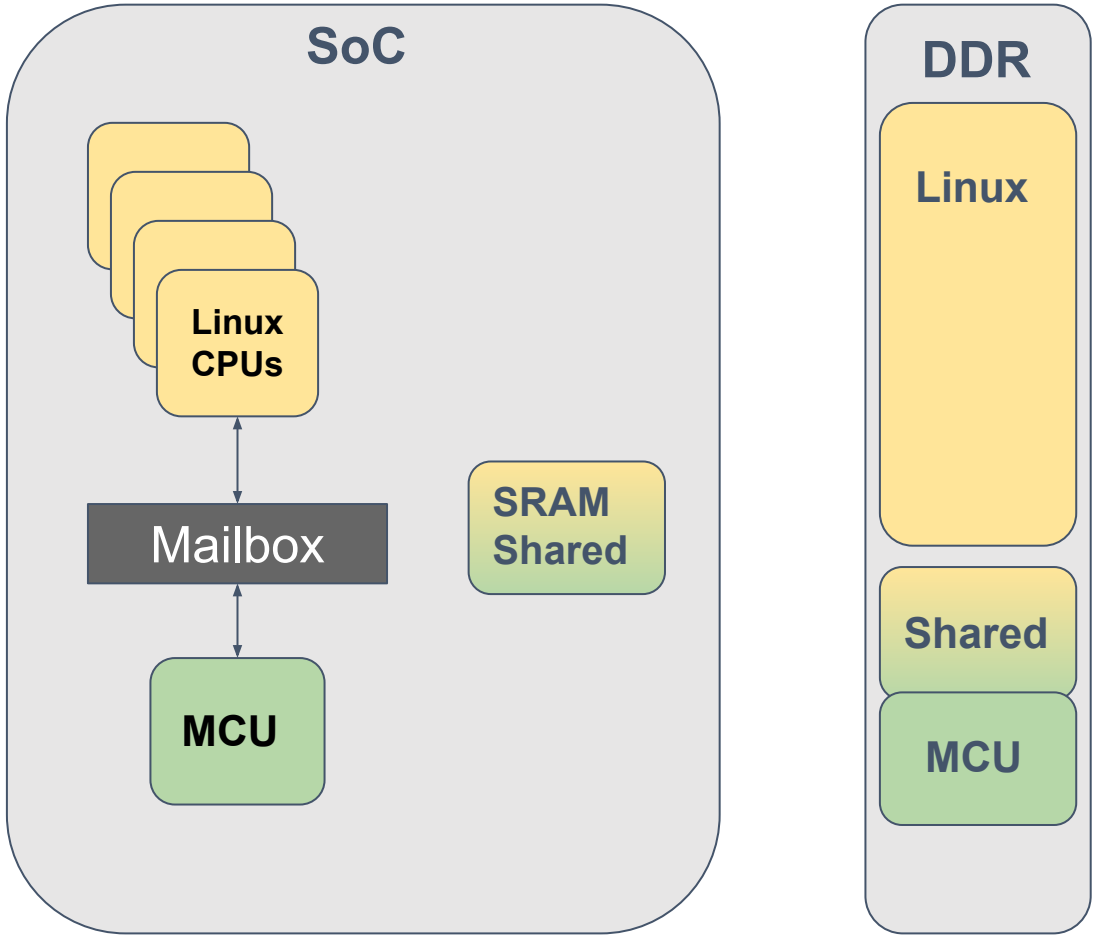
OpenAMP Technologies

- Remoteproc
  - A subsystem for loading and controlling coprocessors, used in Linux, U-Boot, and the open-amp library
- RPMsg
  - A simple IPC message system with multiple ports and name server
- Virtio-msg
  - A virtio transport that can be used in AMP systems (and more)
  - Leverage existing virtio protocols and drivers:
    - virtio-net, virtio-blk, virtio-vsock, virtio-console, virtio-fs
    - virtio-i2c, virtio-gpio, virtio-spi
- System Devicetree
  - Extension of Devicetree to express a whole AMP system
  - Used for coordinated configuration and partitioning of the system
  - Lopper: a tool set for System Devicetree

- Other technologies that align with the mission can be added over time

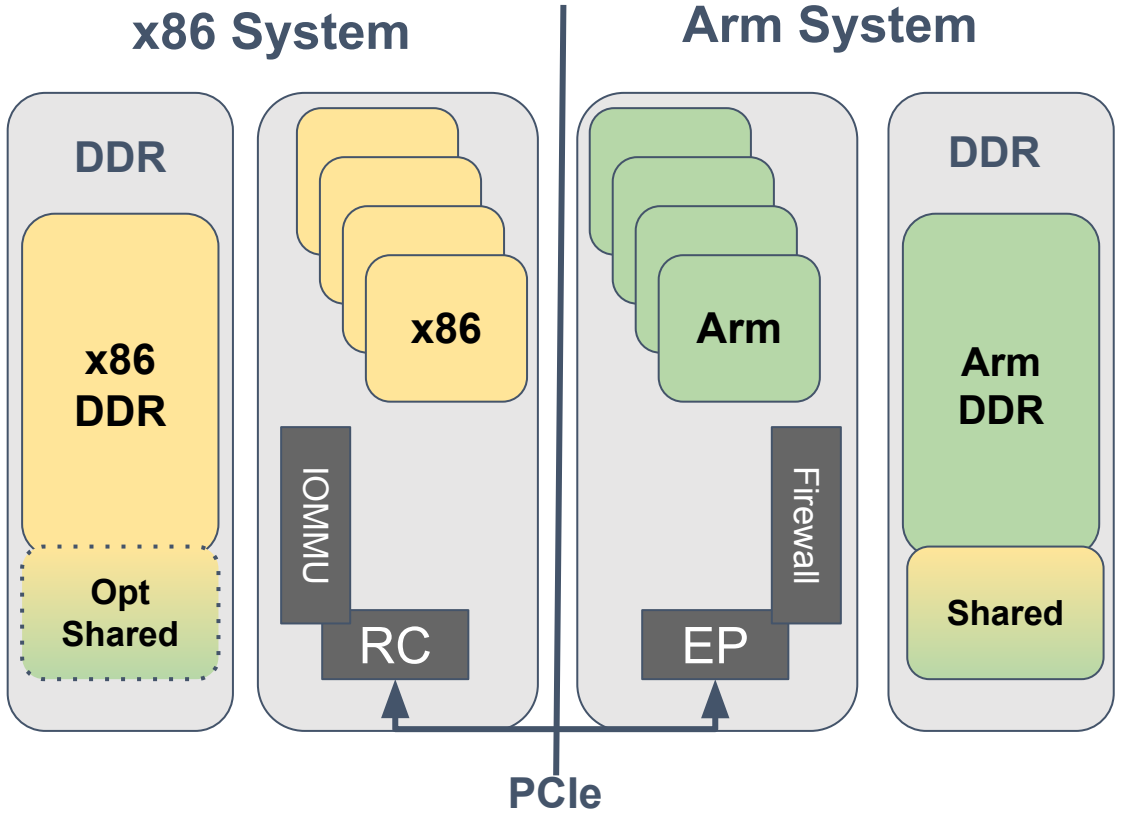
HW Example: AMP SoC

- A single SoC
- CPUs that are SMP Linux capable
- Other CPUs are MCU like, used for
  - Real time or IO offload
  - Safety or Security critical functions
  - Digital Signal Processing
  - Low Power standby w/ IO
- Examples:
  - NXP iMX8M+: 4x A53s + 1 M7 + DSP
  - STM32MP15: 2x A7s + 1 M4
  - TI TDA4VM: 2x A72s + 6x R5s + 3 DSPs
  - ZynqMP: 4x A53s + 2x R5s [+FPGA]



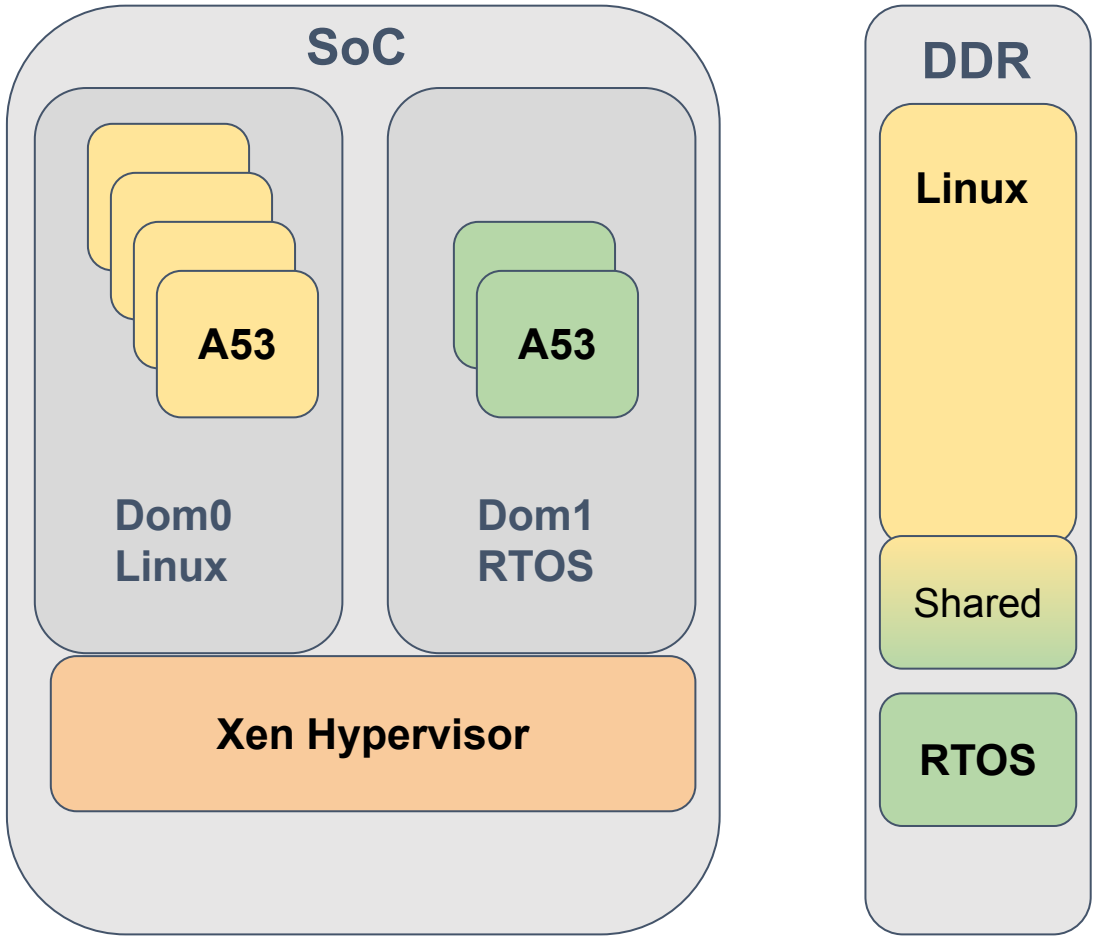
HW Example: AMP via PCIe (and similar)

- x86 host with Arm SoC on a PCIe card
- Two PCIe RC systems connected with a non-transparent bridge
- UCIe and Chiplet ecosystem
  - Making these AMP systems more common and more customizable
- Two QEMUs using IVSHMEM
  - Good stand-in for the cases above
  - Approximation of a non-transparent bridge
  - Shared memory, MSI interrupts, and a doorbell MMR on each side

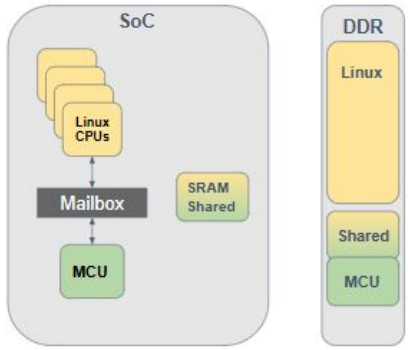


HW Example: Mixed Critical system w/ hypervisor

- Example hypervisor: Xen
- Dom0less creation of critical RTOS domains at boot time
  - Real-time
  - Higher level of Functional safety
- Linux based Dom0 boots in parallel
- Other physical CPUs and memory can be used by Dom0 to create non-critical DomUs.

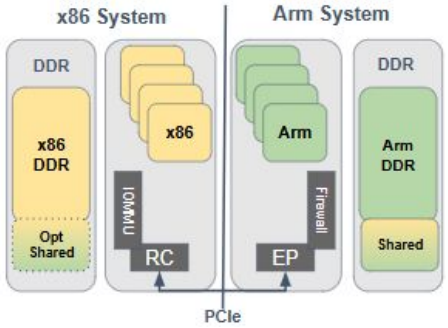


SW Examples



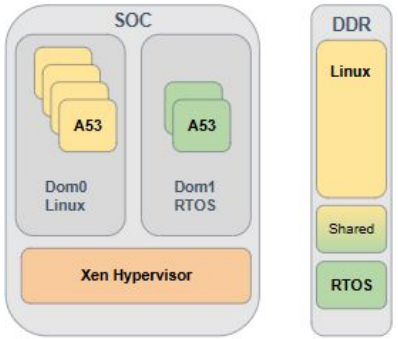
AMP SoC:

- Linux on Cortex-A, Zephyr on Cortex-M/R
- Devices & memory optionally assigned w/ System Devicetree using Lopper
- Start Zephyr through remoteproc
- Communicate through rpmsg or virtio protocols
- e.g. Zephyr exposes portion of I^2C bus via virtio-msg based virtio-i2c



AMP via PCIe (and similar):

- Each system boots independently
- Arm system access the x86 rootfs using virtio-fs over virtio-msg
- e.g. x86 uses a the Arm as a smart-nic using virtio-net over virtio-msg



Mixed critical system with Xen hypervisor:

- Xen has multiple ways to do paravirtual devices, but OpenAMP virtio-msg allows:
  - low complexity for RTOS implementation
  - very low vCPU interference for Real-time and Functional Safety
  - minimal hypervisor requirements
- Same model can apply to any hypervisor
- Devices, CPUs & memory partitioned w/ System Devicetree using Lopper

Check it out and get involved!

Community Project Website

www.openampproject.org

Member companies:

Thank You