

OpenAMP Framework

Ed Mooring, Felix Rubinstein

Date: 03/04/2018



Linaro
connect

Bangkok 2019

Executive Summary

- OpenAMP is an open-source framework to interact with heterogeneous SoCs
 - Facilitates use of processing resources for complex designs
- Standardization effort and open-source project
 - Multicore Association (MCA) OpenAMP working group
 - Linaro LITE open-source project
- Evolving AMP/OpenAMP Roll-out
 - From foundation to advanced capabilities
 - APU as master
 - RPU as master
 - Authentication, Decryption of executables
 - Multiple memory types and coherency, zero copy, etc.
 - Arbitrary executable management
 - OpenAMP executable management

Agenda

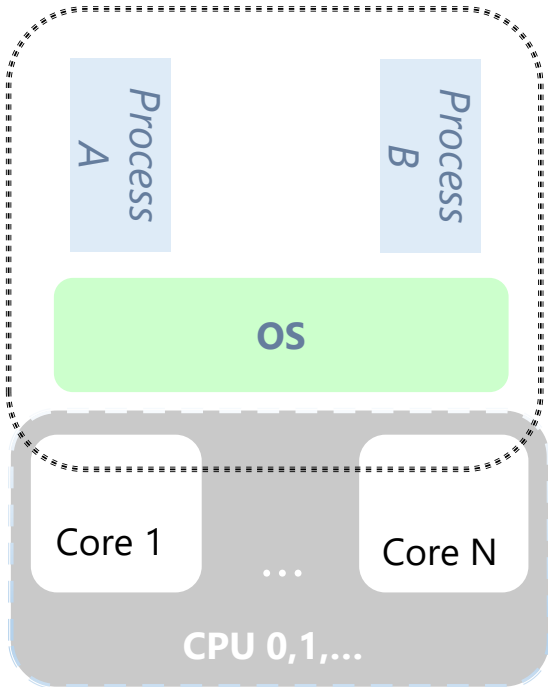
- Glossary
- SMP vs. AMP
- OpenAMP Goals
- Life-Cycle Management
- Inter-Process Communication
- Startup Process
- Vendor Support
- Status
- Conclusion

Glossary

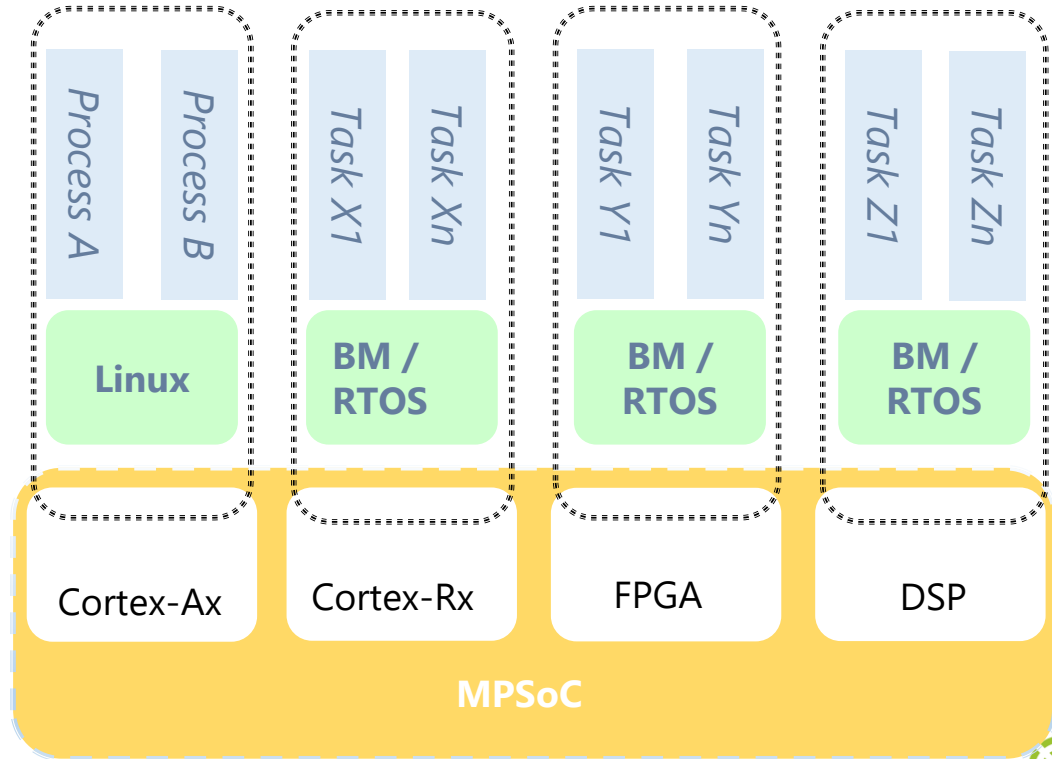
- **SMP: Symmetric Multi-Processing**
- **AMP: Asymmetric Multi-Processing**
- **APU: Application Processor Unit**
- **RPU: Realtime Processor Unit**
- **LCM: Life Cycle Management**
- **IPI: Inter-Processor Interrupt**

SMP vs. AMP

SMP



AMP

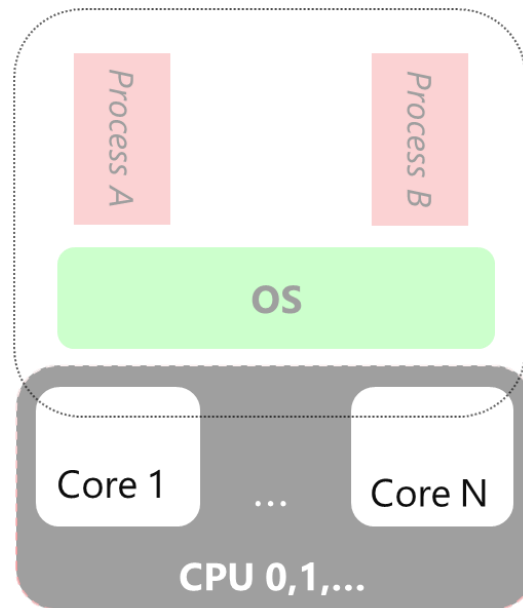


SMP vs. AMP

- **SMP:**

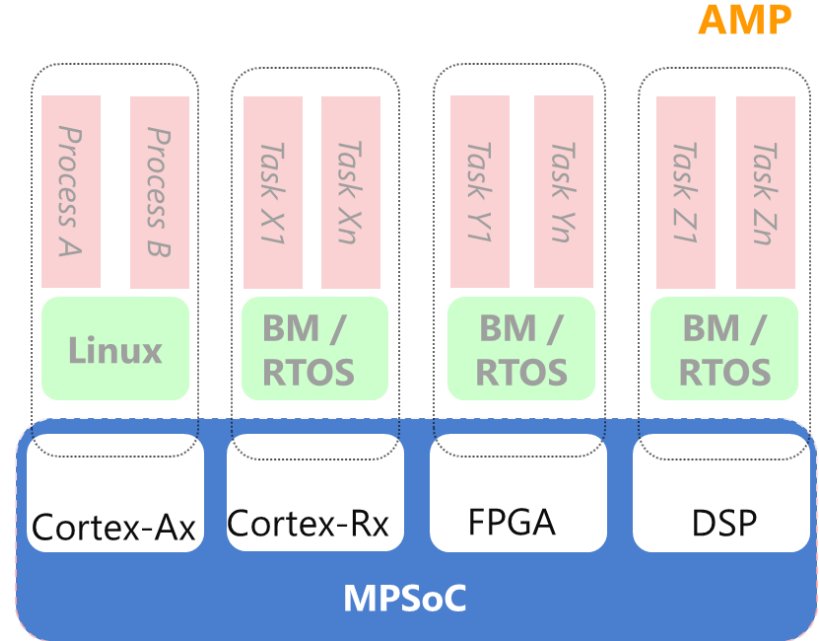
- Homogeneous CPUs running a single OS image, e.g. Linux
- CPUs are equal in terms of scheduler and have access to all resources
- Rich HW support for shared memory: (IO)MMU, coherency

SMP



SMP vs. AMP

- AMP:
 - Heterogeneous processors running multiple and/or different OS images: Linux, RTOS, bare metal
 - Some processors are specialized and have different access to resources
 - Less expensive solution



What is OpenAMP?

- OpenAMP standardizes how Operating Systems interact:
 - In particular between Linux and RTOS/bare-metal
 - In particular in a multicore heterogeneous systems
 - Includes:
 - Lifecycle APIs to start/stop/restart other OSes (RemoteProc)
 - Inter-Process Communication APIs to share data (RPMsg)
 - Shared memory protocol for OS interactions (VirtIO)
- Guiding principles
 - open-source implementations for Linux and RTOSes
 - Prototype and prove in open-source before standardizing
 - Business friendly APIs and implementations to allow proprietary solutions

OpenAMP libraries

- Lifecycle Management (LCM) – allows a master to control/manage remote processors: power on/off, reset, load firmware
- Inter-Processor Communication (IPC) for shared memory management when sending/receiving data from/to master/remote
- Proxy operations – Remote access to systems services. A transparent interface to remote contexts from Linux user space applications running on the master processor
- Depends on [libmetal](#) acting as an OS environment and hardware abstraction layer
- [Ongoing](#) work to decouple RemoteProc and RPMsg so that they can be used independently

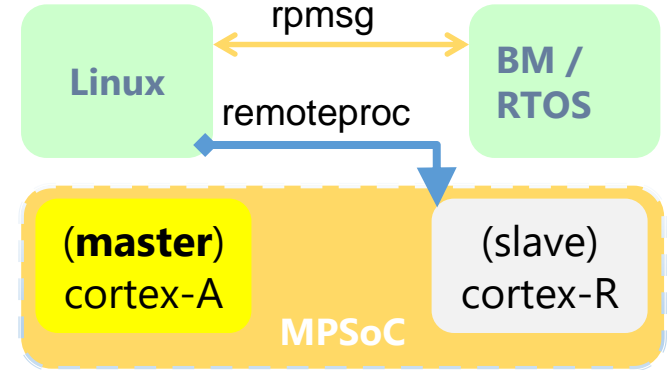
OpenAMP Topology

- Both star and daisy chain topologies are supported, or any combination thereof. The CPU with dual-responsibility (remote & master) provides chaining
- Linux is not required to be on any CPU
- Linux is not required to be the master
 - Linux as remote is currently only supported between Cortex-A cores

Linux AMP vs OpenAMP

- **Linux AMP**

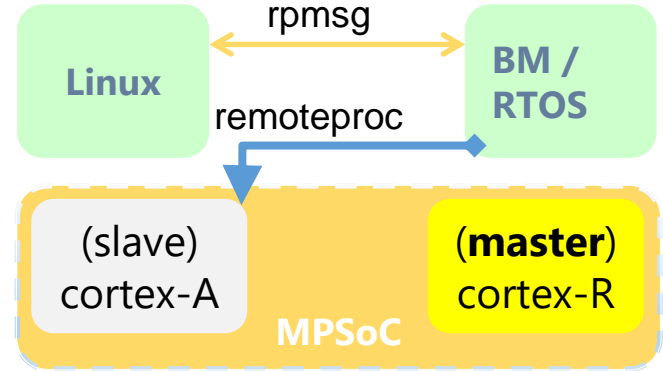
- Kernel modules. No support for firmware on remote processors. Apps on a remote must understand rpmsg/remoteproc.
- Masters must run Linux
- Low level device-specific code is not supported



Linux AMP vs OpenAMP

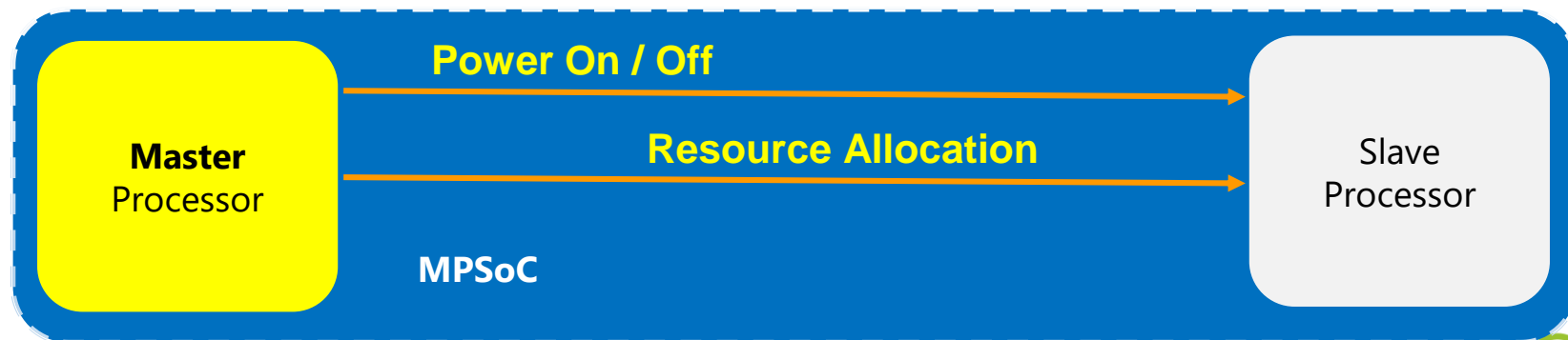
- **OpenAMP**

- User libraries. Adds support for the RemoteProc and RPMsg to RTOS and bare metal
- Master no longer needs to be Linux-based
- Abstracts the device-specific behavior



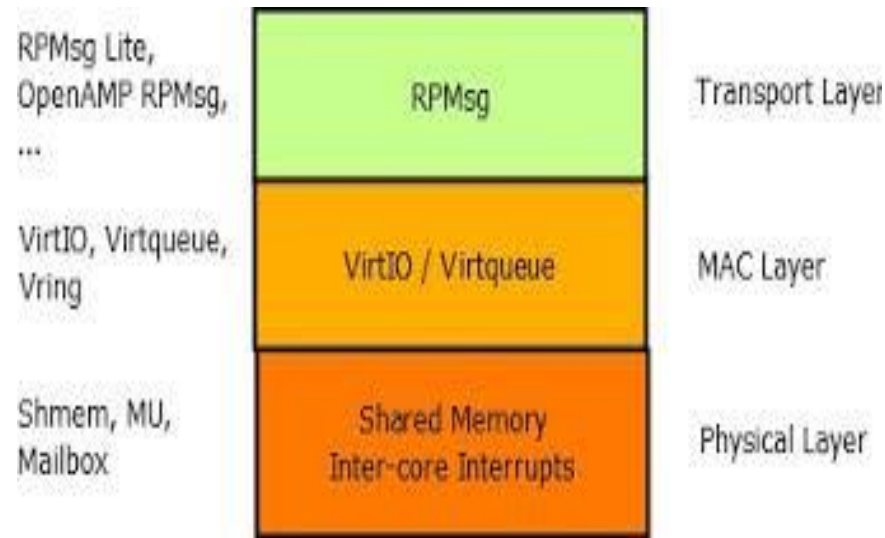
Remote LCM with RemoteProc

- **RemoteProc – Remote Processor**, provides support for a master to run firmware on a remote processor.
- **RemoteProc** is a framework that allows a master to control/manage remote processors (power on/off, reset, and load firmware). A RemoteProc driver is used for lifecycle management of remote firmware.
- **RemoteProc**
 - Provides API to control remote processor
 - Abstracts hardware differences between involved processors
 - Establishes communication channels between master and remote processors using the RPMsg framework
 - Declares a minimal set of device-specific low-level handlers



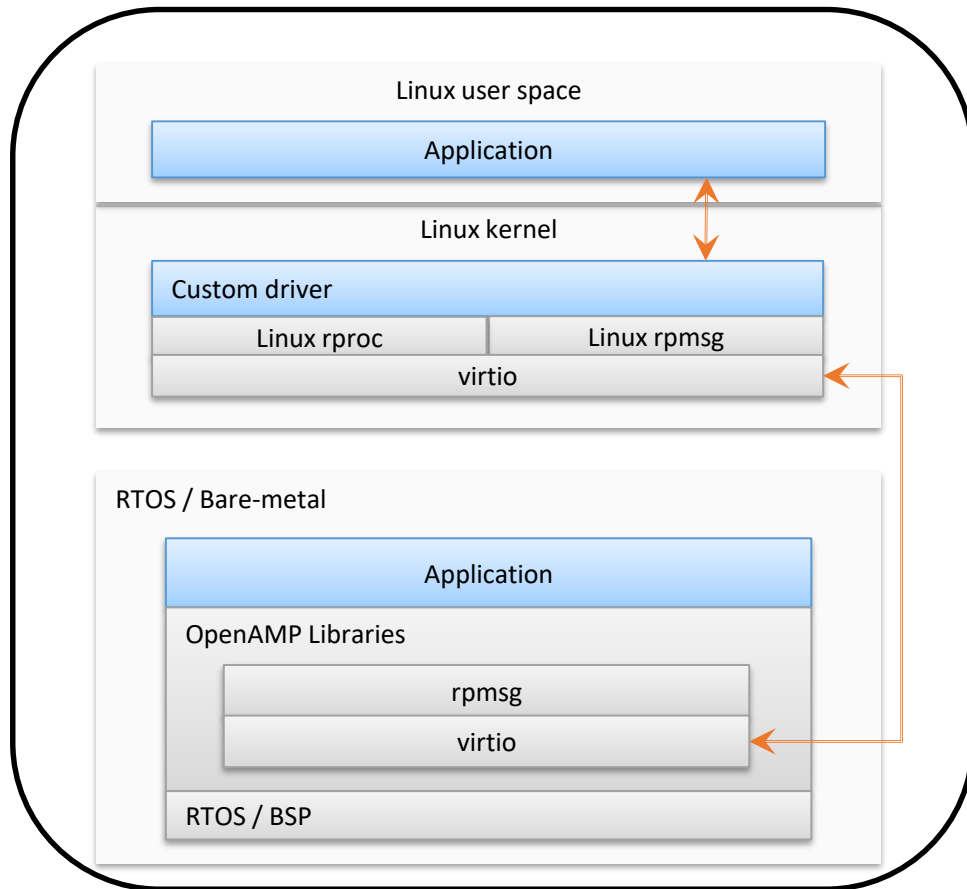
Master/Remote IPC with RPMsg

- RPMsg (Remote Processor Messaging)
 - Provides inter-processor communication (IPC) between master and remote processors.
 - An RPMsg represents a communication channel between the master and a specific remote processor
 - Defines only vendor agnostic aspects of communication
 - E.g. API and the format of messages.
 - Relies on RemoteProc for device-specific handlers



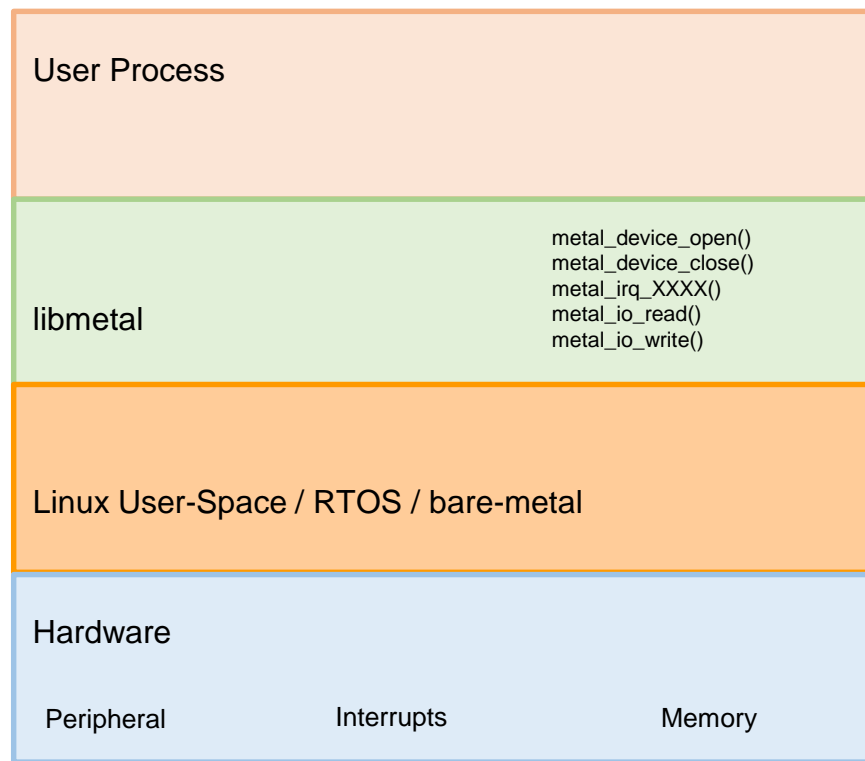
VirtIO

- VirtIO library
 - An abstraction layer over devices in a para-virtualized hypervisor
 - Implements the [OASIS virtIO standard](#) for shared memory management
 - A virtualization standard for network, disk device (etc.) drivers
 - Applicable to OpenAMP configurations



Libmetal Overview

- libmetal
 - Provides common APIs for:
 - Device access
 - Interrupt handling
 - Memory management
 - Synchronization primitives
 - Across:
 - Linux user space (based on UIO and VFIO support in the kernel)
 - RTOS (with and without virtual memory)
 - Bare-metal environments
- Fundamental to OpenAMP architecture
 - RemoteProc, RPMsg and VirtIO use libmetal



OpenAMP Remote Startup Process

- OpenAMP architecture
 - Assumes the master is already running and remote processor is in standby or powered down
- Remote Processor Firmware Loading
 - OpenAMP master loads firmware into the memory location
- Remote Processor Start
 - OpenAMP master starts remote processor
 - Example: wake-up remote, release remote from reset, power-on remote, etc.
 - Master waits for remote
 - Master establishes a communication channel to the remote processor

Vendor Support

- Vendor handles the low-level porting for their specific platform(s)
- Vendor supplies example applications for their platform(s)
 - Application includes demonstration of resource table
 - Example application demonstrating basic IPC (e.g., echo)
 - Example application demonstrating master off-loading
- Vendor supplies Linux RPMsg driver for their platform(s)
- Vendor supplies example kernel module and user-space application for interacting with remote device

Status

- OpenAMP is an active, evolving community project
 - Project home: github.com/OpenAMP
 - Source structure is fluctuating and standardization is a work in progress
 - Roadmap for advanced use-cases and features
 - IPC performance needs improvement (WIP)
- Availability
 - Commercial
 - uC/OS, Thread-X, Enea OSE, Mentor Nucleus
 - Open Source
 - Zephyr
 - Linux
 - FreeRTOS
 - Porting of the framework still necessary for many commonly used platforms

What's Supported Today

- Range of use cases:
 - Topologies: **peer-to-peer**, master-slave and **hierarchical**
 - Interfaces: message passing, file-system, block, graphics, network
- Provide consistent and portable application interfaces across:
 - Environments: **Linux kernel and user-space, FreeRTOS, Zephyr, bare-metal**
 - Processor architectures: **Cortex-A53**, Cortex-A72, **Cortex-R5, MicroBlaze**, x86, **MIPS32**
 - Secure and **Non-Secure** modes
 - Threads and Processes (on Linux and RTOSes)
 - Virtualized guests and containers (with hypervisors)

Conclusion

- OpenAMP provides a software framework for developers to
 - Enable MPSoC Life Cycle Management (LCM)
 - Load firmware across a multi-processor system
 - Establish communication between the processors
- OpenAMP provides these features in a platform agnostic manner

Thank you

Join Linaro to accelerate deployment of your Arm-based solutions through collaboration

contactus@linaro.org



Develop & Prototype on the
Latest Arm Technology



96boards is a range of specifications with boards and peripherals offering different performance levels and features in a standard footprint.



Linaro
connect

Bangkok 2019