

The OpenAMP Project & its working groups:

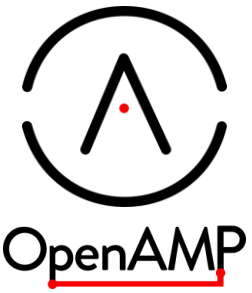
Standardizing interactions between operating environments
in a heterogeneous embedded system

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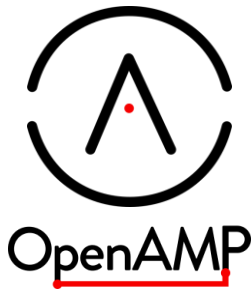
ELC North America 2020

Agenda

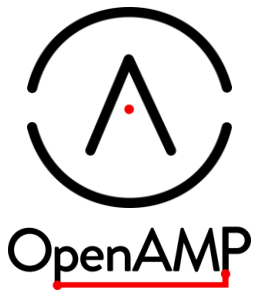


- ▶ What is OpenAMP trying to solve?
- ▶ OpenAMP Intro
- ▶ OpenAMP Project working groups
- ▶ Examples of OpenAMP in industry
- ▶ Learning more & getting involved
- ▶ Q/A

Acronyms



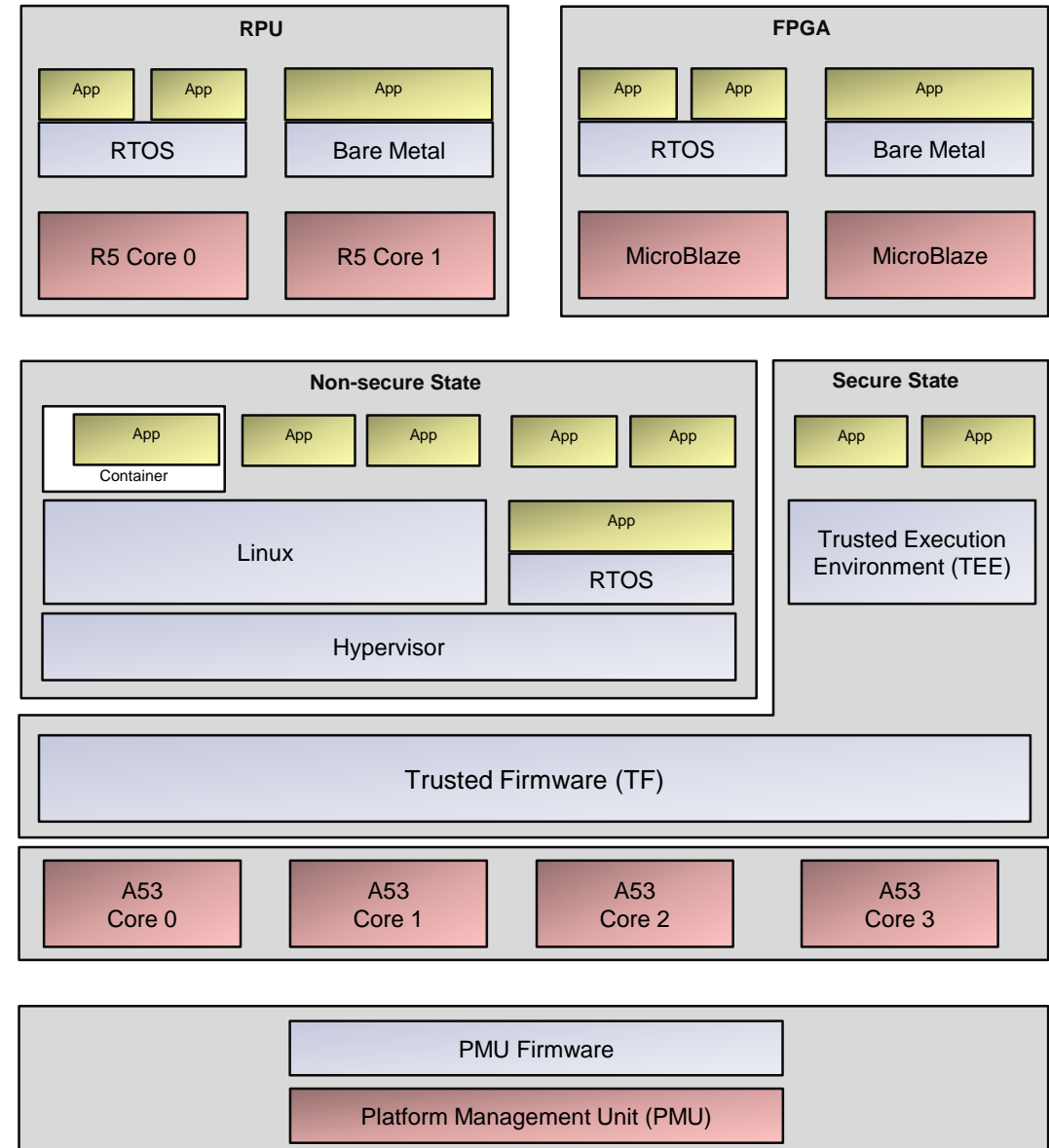
- ▶ AMP: Aysmmetric Multi-Processing
- ▶ API: Application Programming Interface
- ▶ APU: Application Processor Unit
- ▶ EL: Execution Level
- ▶ FPGA: Field-Programmable Gate Array
- ▶ FuSa: Functional Safety
- ▶ HCI: Host Controller Interface
- ▶ IPC: Inter-Processor Communication
- ▶ LAVA: Linaro Automation & Validation Architecture
- ▶ MPSoC: Multi-Processing System-on-Chip
- ▶ OE: Operating Environment
- ▶ OS: Operating System
- ▶ PMU: Platform Management Unit
- ▶ RPU: Real-Time Processor Unit
- ▶ RTOS: Real-Time Operating System
- ▶ SEL: Secure Execution Level
- ▶ SoC: System-on-Chip
- ▶ TEE: Trusted Execution Environment
- ▶ TSC: Technical Steering Committee
- ▶ TZ: TrustZone
- ▶ WG: Working Group



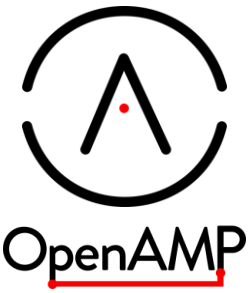
What is OpenAMP trying to solve?

Heterogeneous Embedded System

- ▶ Multiple core clusters
 - A53, R5, PMU, MicroBlaze
- ▶ Multiple Execution Levels (EL)
 - EL0 – User space – Linux apps, Containers, RTOS apps
 - EL1 – OS space – Linux kernel, RTOS + RTOS apps
 - EL2 – Hypervisor – Xen, ...
 - EL3 – Firmware – Trusted Firmware
- ▶ Multiple Security Environments
 - TrustZone (TZ) – HW protecting resources (e.g. memory)
 - Trusted Execution Environment (TEE) – SEL1
- ▶ Multiple Operating Environments (OE)
 - Linux – including Android
 - Free and commercial RTOS's
 - FreeRTOS, Zephyr, VxWorks, Integrity, Nucleus, uC/OS, OSE, ThreadX
 - QNX/Neutrino, Sciopta, eT-kernel, Lynx, PikeOS, ...
 - Bare metal (no OS) is common on smaller cores
 - Hypervisors – Xen, Jailhouse, commercial
 - Firmware/boot loaders – Trusted FW, PMU FW, uboot, ...

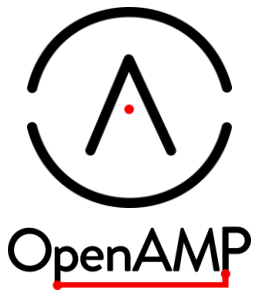


Simplifying SW for Heterogenous Environments



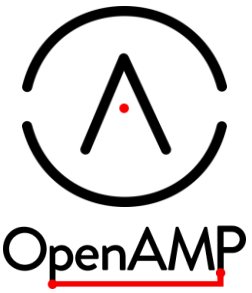
- ▶ Today, most heterogeneous environments are cobbled together ad-hoc
 - Everybody coming up with their own shared memory scheme
- ▶ There is a need to standardize how environments interact
 - Configuring the environments
 - Managing (lifecycle) the environments
 - Passing messages between environments
 - Share resources between environments
 - Porting any OS using a standardized abstraction layer
- ▶ Open source implementation is fastest way to standardization
 - Especially if based on already existing open source projects

OpenAMP is solving these kinds of problems



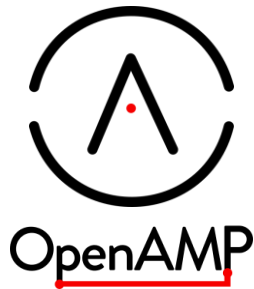
OpenAMP Intro

Vision



The OpenAMP Project seeks to standardize the interactions between operating environments in a heterogeneous embedded system through open source solutions for Asymmetric Multi-Processing.

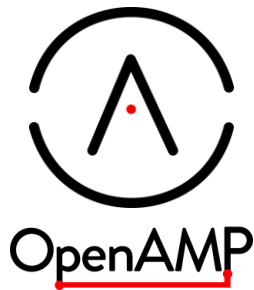
The OpenAMP Project History & Launch



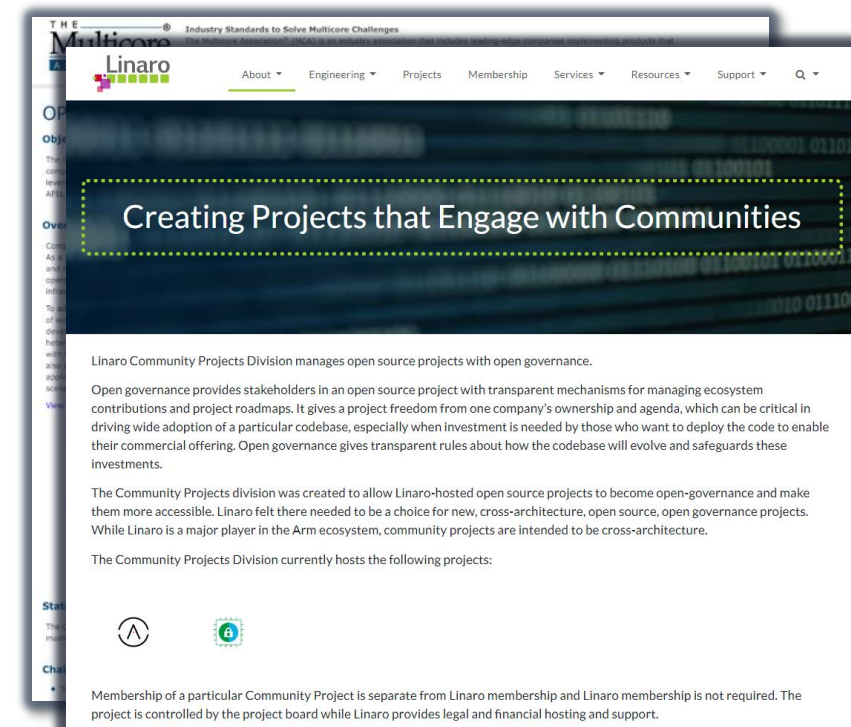
- ▶ OpenAMP is an open AMP framework that includes two efforts:
 1. A standardized way of using AMP
 2. A clean-room open source implementation/project
- ▶ OpenAMP began as Multicore Association Working Group in 2014
 - Focused on communication between 2 different cores with RPMsg and Remoteproc
 - open-amp and libmetal
- ▶ OpenAMP Project re-launched as a Linaro Community Project in September 2019
 - Overlap in membership
 - Independent organization
 - Infrastructure
 - Budget w/ low fee

A screenshot of the OpenAMP website. The page title is 'OPEN ASYMMETRIC MULTI PROCESSING (OpenAMP)'. It includes sections for 'Objective', 'Overview', 'Frequently Asked Questions', 'COMPARISONS', 'Features', and 'Benefits'. A diagram titled 'System Wide Applications' shows a flow from 'Linux', 'RTOS A', 'RTOS', 'Bare Metal', 'RTOS C', 'Bare Metal', 'Bare Metal', 'Bare Metal', 'Bare Metal' to 'OpenAMP Software', which is divided into 'High Performance Processing Cores', 'Real-time Cores & Hardware Accelerators', and 'Programmable Logic'. The 'Status' section mentions that the OpenAMP working group meets weekly to establish standardization. The 'Chairperson' is listed as Tomas Evensen, Xilinx.

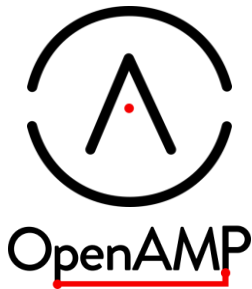
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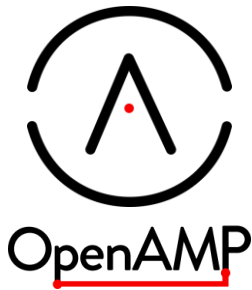


OpenAMP, the framework



- ▶ OpenAMP currently includes the following components:
 - Lifecycle operations - Such as start/stop another environment
 - Messaging - Sending and receiving messages
 - Low level abstractions – Sharing memory, inter-processor interrupts, ...
 - Proxy operations - Remote access to services, e.g. file system
 - Under development: Resource configuration using System Device Trees
- ▶ Built on top of existing open source projects/standards
 - Remoteproc, RPMsg, Virtio, Device Trees
- ▶ Accelerate adoption by working in open source
 - Linux, RTOS, and bare metal implementations

The OpenAMP Project going forward



▶ Latest status on the project

- Increased scope: OpenAMP framework + more working groups
- Official maintainer roles
- Technical Steering Committee
- Board
- Governance
- Budget
- Logo!

▶ Member points-of-view:

- Arm processors, non-Arm processors
- Linux, RTOS, bare metal
- High-performance systems, resource-constrained systems

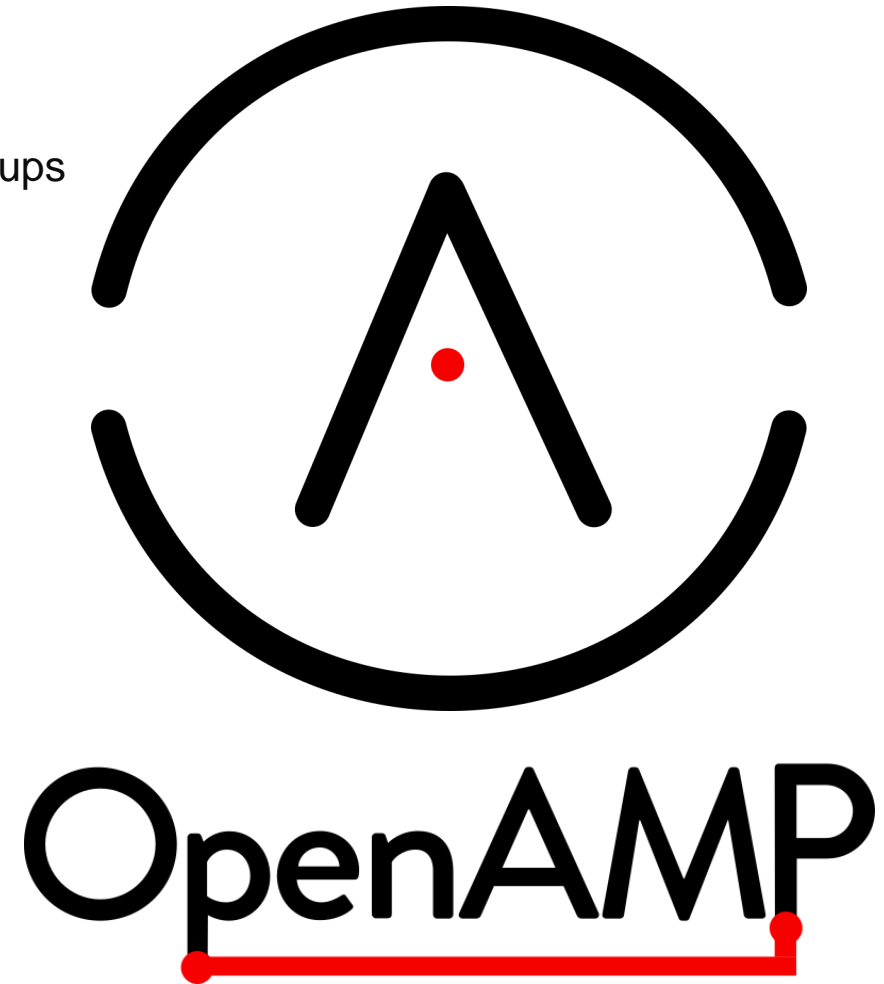
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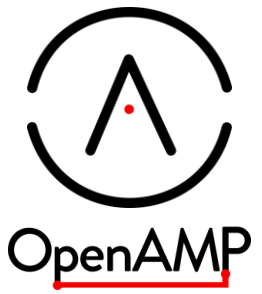
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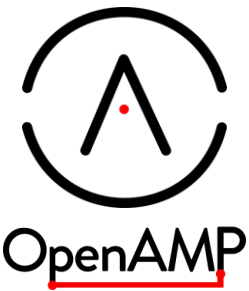
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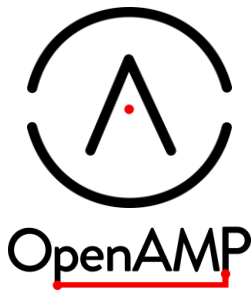
OpenAMP Project working groups

OpenAMP-rp working group

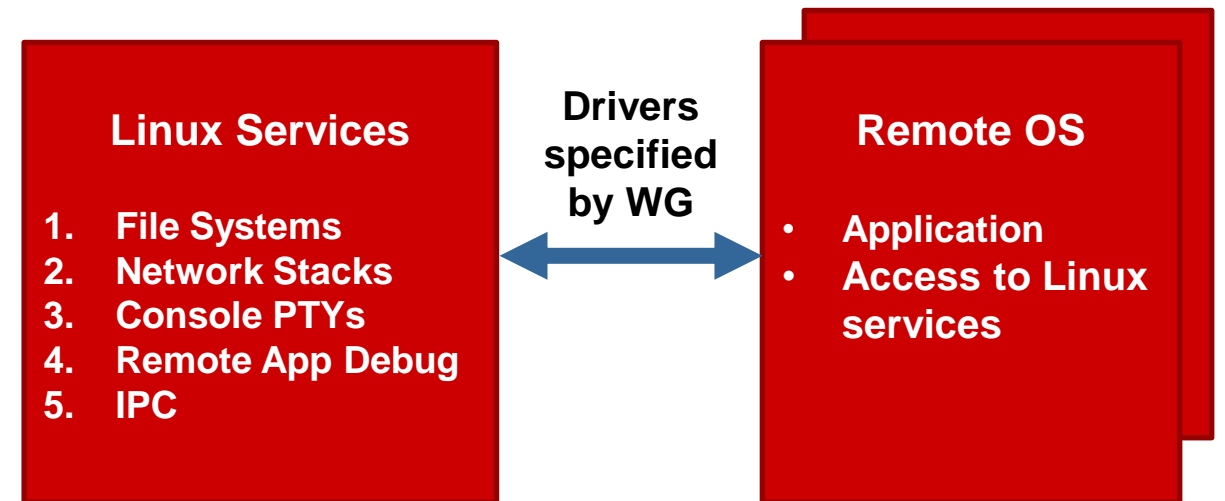


- ▶ Works on original parts of OpenAMP
 - Remoteproc, RPMsg, Virtio, libmetal
- ▶ Repositories
 - <https://github.com/OpenAMP/open-amp> (latest release 2020.04)
 - <https://github.com/OpenAMP/libmetal> (latest release 2020.04)
- ▶ Active work
 - Big buffers
 - Improving testing through integration with LAVA Continuous Integration
 - Getting outstanding patches upstreamed to Linux kernel
 - Addressing backlog of pull requests
 - Back to April, October release cadence

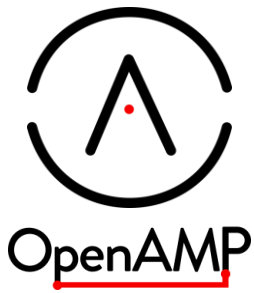
Ramping up: Application Services working group



- ▶ What is needed to build on top of OpenAMP?
- ▶ Application developer issues that resonated most with members
 - Remote file access
 - Remote console
 - Proxy ports (e.g. proxy debug)
 - Messaging APIs (e.g. sockets)
- ▶ Working group (WG) will leverage common OS drivers & API standards where possible



System Device Tree working group



▶ Defines new Device Tree bindings

- Describe Heterogeneous systems
 - Multiple CPUs clusters → multiple address views
- Configure Execution Domains
 - Define the software execution context for each CPUs cluster
 - Execution level, memory ranges, devices available (by configuration)
 - RTOS'es can use it at build time and/or run time

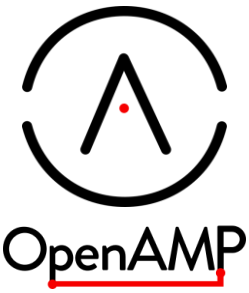
▶ Repositories

- <https://github.com/devicetree-org/lopper>
 - Lopper is a tool to prune the System Device Tree into a traditional device tree for a specific processor in the system
 - Reference Implementation of the System Device Tree bindings

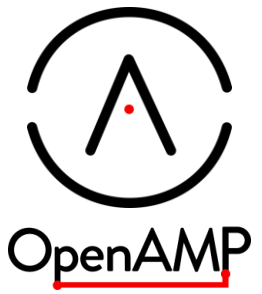
▶ Upcoming work

- Xilinx and STMicroelectronics to propose together bindings for bus-firewall configurations
- Submit proposals to devicetree-spec@vger.kernel.org

Future: Hypervisor interfaces working group

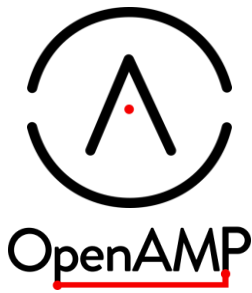


- ▶ Document & "standardize" hypercall interfaces
- ▶ Implementable by any vendors / embedded hypervisors
- ▶ Documentation reusable for Safety Certifications
- ▶ Collaborate with existing Open Source efforts (e.g. Xen FuSa)



Examples of OpenAMP in industry

Examples of OpenAMP in industry



▶ Xilinx

- Default AMP solution for Zynq-7000, Zynq UltraScale+ MPSoC, and Versal devices
- Cortex-A application processor units (APUs), Cortex-R real-time processor units (RPU). Microblaze “soft” processors in programmable logic. Either APU or RPU can act as the master.

▶ Mentor Graphics

- Core for the Mentor Embedded Multicore Framework and Multicore Framework Cert product offerings.
- Expands on OpenAMP: Linux as a Remote, Large Buffer, Zero Copy, Proxy support for Ethernet
- Communication between the safe and non-safe domains in Mixed Safety-Criticality systems

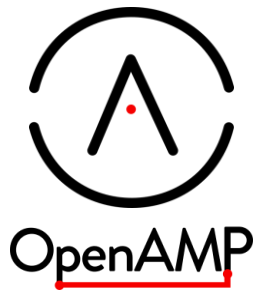
▶ TI

- Enhancing the Linux kernel implementation of RemoteProc & RPMsg
- Defining the wire protocol between processors
- Contributed a limited scope version of remoteproc loader into U-Boot

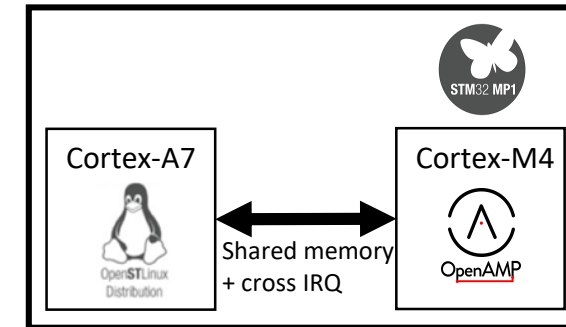
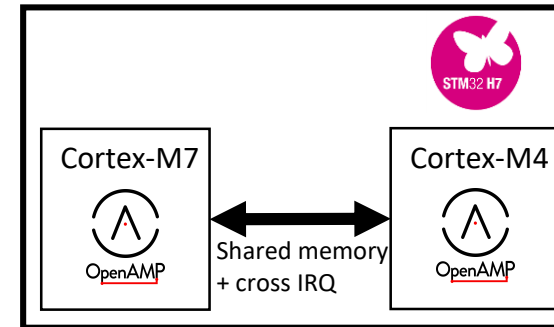
▶ Kalray

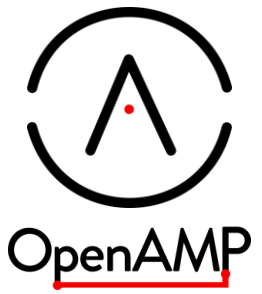
- Standard message passing solution within homogeneous Manycore architecture on MPPA®3 processor
- MPPA®3 as accelerator: virtio over PCIe
- Within MPPA®3 processor: virtio with shared memory

Examples of OpenAMP in industry



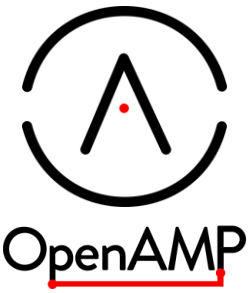
- ▶ Zephyr
 - OpenAMP integrated & available
- ▶ Nordic Semiconductor
 - Bluetooth Host Controller Interface (HCI) based on OpenAMP in Zephyr
- ▶ Linaro
 - Hosting OpenAMP project through Community Projects division
 - Involvement in Zephyr, openamp-rp, LAVA testing
- ▶ STMicroelectronics
 - IPC in multicore and multi-SoC STM32 solutions
OpenAMP-OpenAMP, Linux RPMsg-OpenAMP
 - OpenAMP library used with baremetal, FreeRTOS, Zephyr
- ▶ Wind River
 - To accelerate the ability of developers to create edge compute applications
- ▶ Arm
 - Active role in System Device Tree discussion





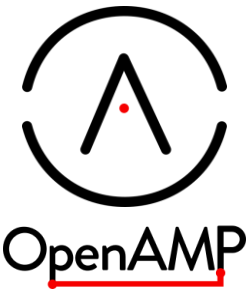
Learning more & getting involved

More information



- ▶ GitHub project
 - <https://github.com/OpenAMP/>
 - Also, Lopper lives at devicetree-org: <https://github.com/devicetree-org/lopper>
- ▶ OpenAMP Wiki
 - <https://github.com/OpenAMP/open-amp/wiki>
 - Notes from calls
 - Features being worked on & under consideration
- ▶ Community Project Website
 - <https://www.openampproject.org/>
- ▶ Mailing lists
 - Sign up for the mailing lists at lists.openampproject.org

How to participate

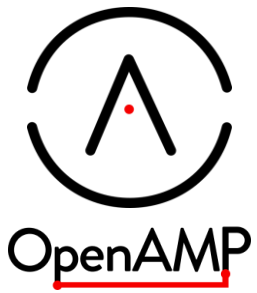


- ▶ All are welcome to join the calls for the TSC & working groups!
 - Call invitations are sent to the mailing lists

- ▶ You can participate!
 - Not necessary to be from an OpenAMP Project member company

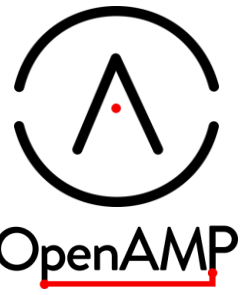
- ▶ Your company can become an OpenAMP Project member
 - Not necessary to be a Linaro member company
 - Member fees support administration for the project & infrastructure
 - OpenAMP Project membership gets the company
 - Vote on TSC
 - Vote on Board

How to become a member company



- ▶ Company representative signs Membership Agreement and Charter
- ▶ \$2500 annual fee
- ▶ Current member companies (alphabetical order):





Thank You