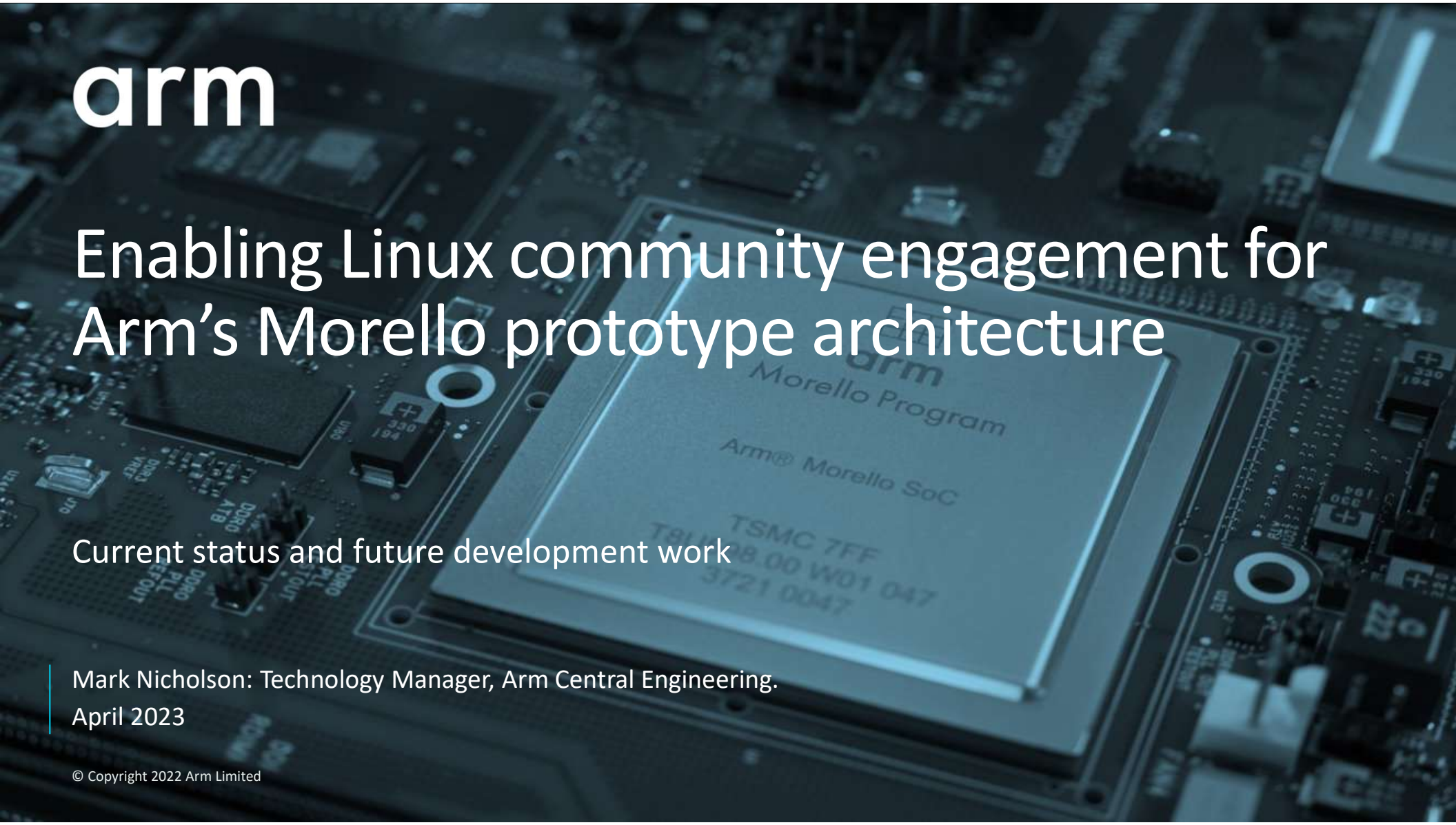


Enabling Linux community engagement for Arm's Morello prototype architecture

Current status and future development work

Mark Nicholson: Technology Manager, Arm Central Engineering.

April 2023

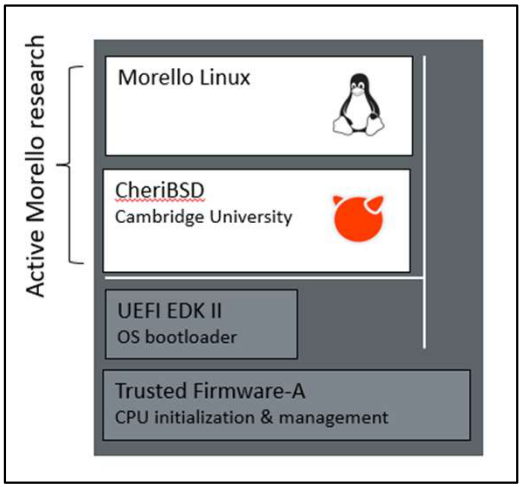
Past, Present and Future

A (non exhaustive) set of activities

- PAST: Arm build foundations
  - SoC bringup, firmware stack development
    - Enabling the board to boot standard 64bit OS images
  - Morello specific Clang/LLVM tooling development

- PRESENT: Cambridge University CheriBSD port for Morello
  - Currently allowing researchers to investigate a wide range of workloads above an OS
    - Benefits from decades of work (on various architectures/platforms)
    - Hybrid and purecap enlightened kernel variants
    - Large library (1000s) of ported packages

- FUTURE: Enabling a Morello Linux environment
  - To deploy any future Architecture, we need to investigate Linux environments
  - Requires environments & infrastructure that enable open source ecosystem collaboration

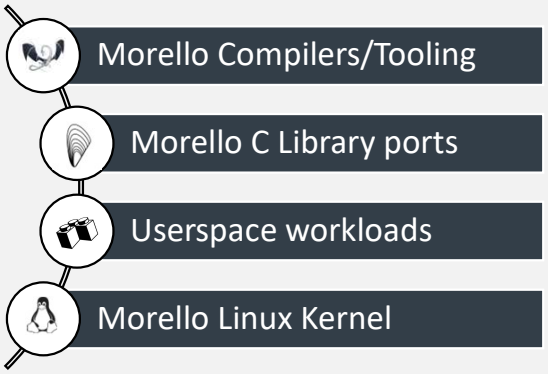


Morello Linux – world building overview

AIM: Enable userspace workloads in a Linux environment built around a new purecap ABI

- Contributions from the ecosystem are needed both to:
  - Help build this world and inform its shape
  - Enable/expand research activities dependent on it

- Existing collaborators include Microsoft Research, The Good Penguin and (of course) Linaro



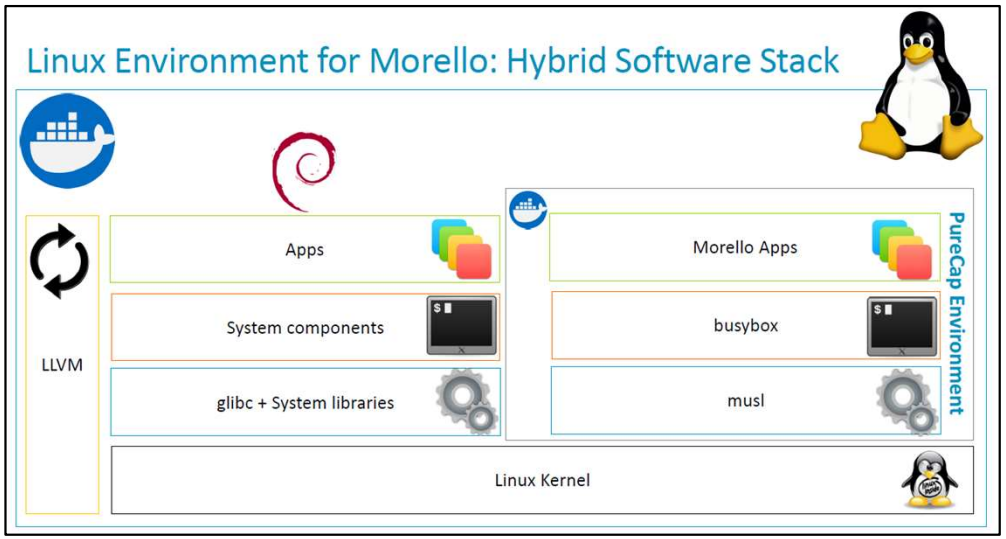
Hybrid Kernel: modified kernel-user interfaces
- C64 (purecap) default userspace ISA
- A64 support retained as COMPAT

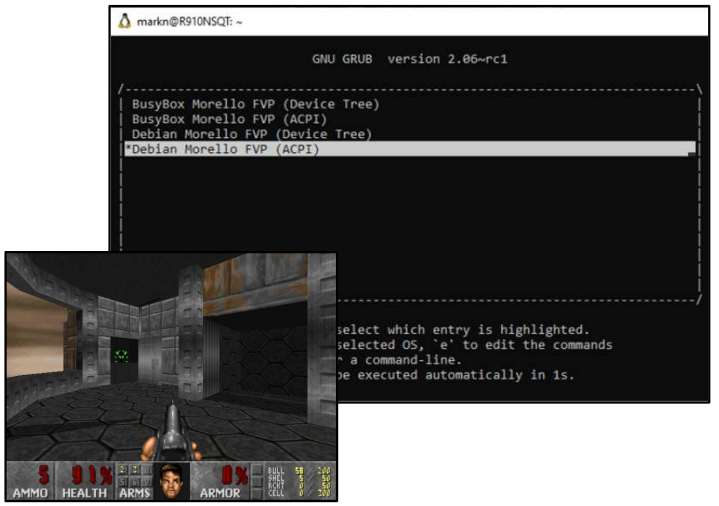
Implemented against a PCuABI specification

Getting Started today (in about 10mins or less)

What will the first release of a Morello Linux Environment look like?

- The Morello quickstart environment: https://linux.morello-project.org/docs/
  - Containerised native Morello Linux environment that can be booted on the FVP model
  - Allow users to explore the same environment available on the Morello board
- The Morello SDK https://sdk.morello-project.org/
  - Containerised host (aarch64 and x86_64) development environment allowing porting of new applications
  - Includes several examples builds, including a port of morello-doom





Morello Linux Environment roadmap

Functionality will evolve incrementally (not, everything everywhere all at once)

- Table describes a roadmap of Morello development activities
  - Component development against mainline will be continuous
  - Drops represent major integration points for the pre-configured environments

	Features	**Use Cases**
Integration Drop 1: May 2023 Initial Release	*Initial release of Morello Linux command line environment* • 64bit Debian filesystem • Containerised purecap rootfs, basic examples & musl libC • Supporting test & development frameworks	• Research on userspace workloads built with Morello LLVM and musl libC • Support for ecosystem contributions to Morello Kernel
Integration Drop 2: Sep 2023	• musl libc: Public CI framework & review infrastructure • Debian env: Panfrost (MESA & Kernel) framework 64bit port • Kernel: 64bit COMPAT framework testing complete	• Support for ecosystem contributions to musl libC development • Support for 64bit UI/GUI dependent activities in Debian environment • Support for package manager in 64bit Debian environment
Integration Drop X: Future uncommitted	• Yocto: meta-morello filesystem images • GNU: Initial support for Morello GCC/GlibC • Kernel: Security enforcement at kernel-user boundary • Kernel: Support for interfaces to driver modules • Kernel: Support for KVM • Kernel: Support for eBPF internal interfaces	• Yocto: Richer purecap filesystem & framework for recipe contribution • GNU: Wider set of Linux workloads with GNU tooling and GlibC • Kernel: Memory safety scenarios involving kernel confused deputies • Kernel: Workloads dependent on purecap userspace driver interfaces • Kernel: Activities dependent on virtualization environments • Kernel: Workloads reliant on features from eBPF privileged in kernel context

Resources and further reading

Morello Linux Open Source Software

- Project landing page
- Morello Linux Mailing lists and contributions process documentation
- Pure-capability kernel-user ABI (PCuABI) specifications
- Getting started: Instructions and docker image for Debian
- Morello SDK: A Morello development environment for aarch64 and x86_64
- Pre-built debian images SoC & FVP
- Morello SoC firmware
- Morello FVP firmware

Arm Morello Program

- Introduction to the Morello program (2019): Richard Grisenthwaite on Digital Security by Design (slides)
- Arm's Morello Developer pages (Architecture specifications, Technical resources, Blogs)

University of Cambridge CHERI general

- CHERI architecture webpages
- CHERI whitepaper a technical introduction