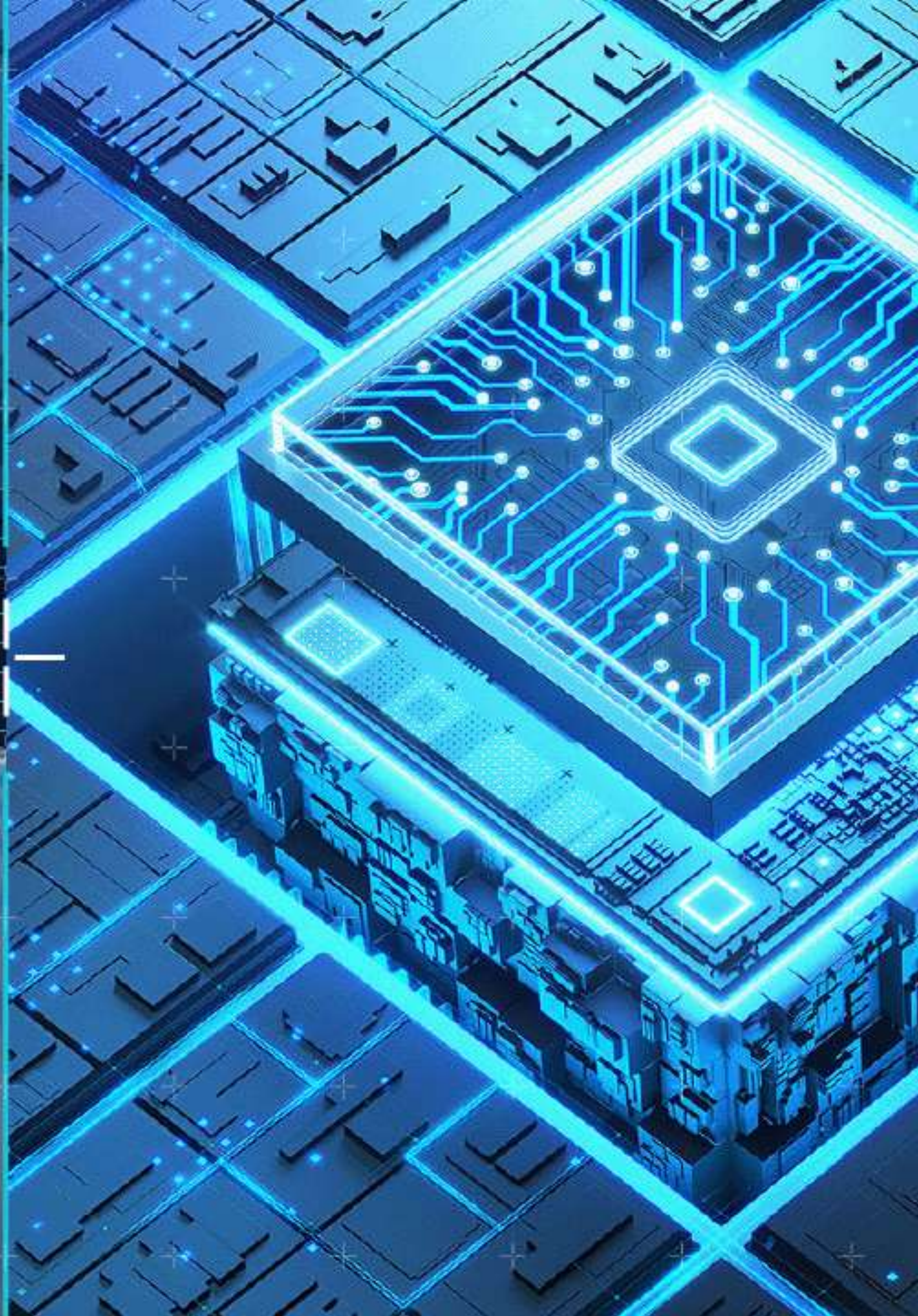

arm

Open-Source SW Ecosystem on Arm for Infrastructure

openEuler Arm SIG Meetup

Jun He
21-Jun-2024

Agenda

- Overview
- Foundation OSS projects
- Infrastructure Workloads & Solutions
- Developer Ecosystem

Overview

Arm Neoverse Software Ecosystem

1000s of OSS

Native Build Projects

100+ ISVs

Commercial Support

200K+ Docker

Hub Images

1M+ CI/CD

Build Minutes/Month

PERFORMANCE

Scalable Neoverse CPU Cores

EFFICIENCY

Best $/throughput in the industry

PLATFORM DIVERSITY

Widest possible choice of Platforms

OPTIMIZATION

Purpose built use cases

Participation in Consortia and Initiatives

Collaborate with partners and ecosystem

- Open Source and standardization initiatives (SPDX, OpenChain)
- Cloud Native ecosystem (CNCF)
- Networking and 5G initiatives (O-RAN)
- Contribute to developing reference software implementations
- Confidential computing and security
- Software-defined infrastructure and datacenter management

CLOUD NATIVE COMPUTING FOUNDATION

THE LINUX FOUNDATION

OPENCHAIN

SPDX

LF NETWORKING

AKRAINO EDGE STACK

LF EDGE

CONFIDENTIAL COMPUTING CONSORTIUM

OPEN PROGRAMMABLE INFRASTRUCTURE PROJECT

OpenGrid ALLIANCE

O-RAN ALLIANCE

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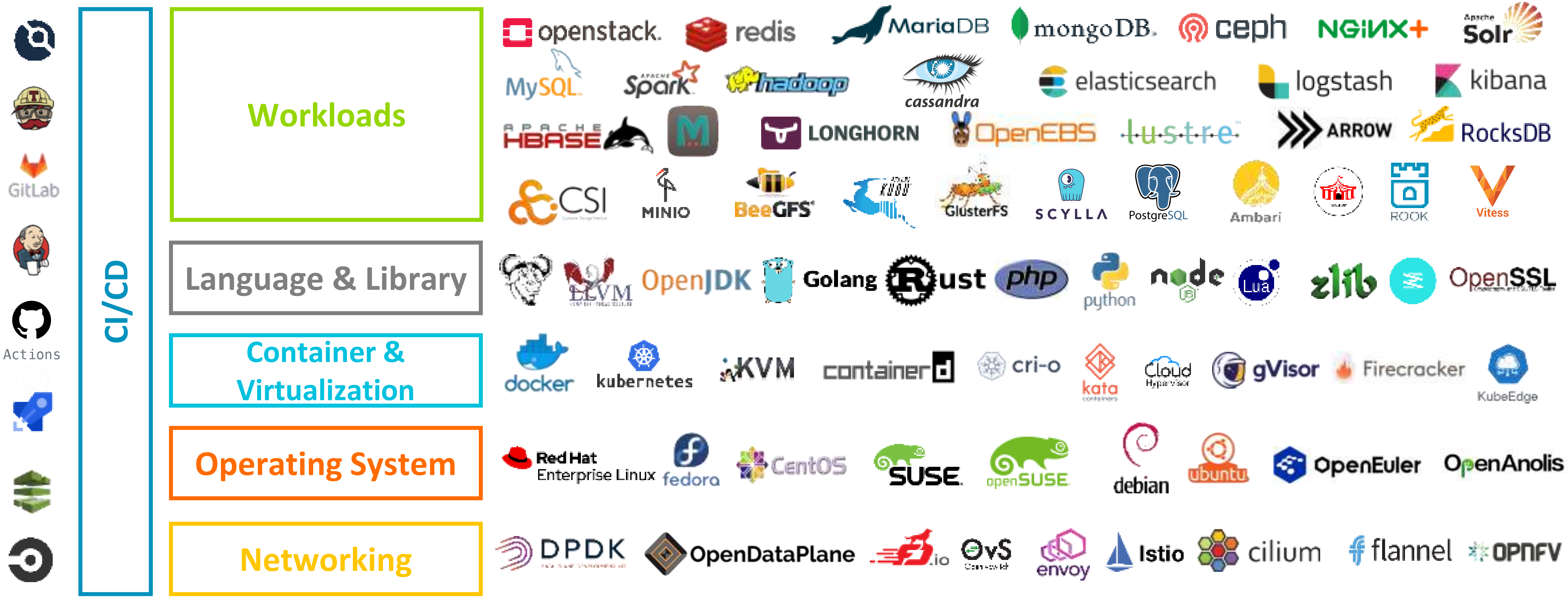
Arm Contributing to 100+ Infra related Open-Source Projects

Enabling a Frictionless Cloud-Native Developer Experience



CI/CD

Workloads

Language & Library

Container & Virtualization

Operating System

Networking

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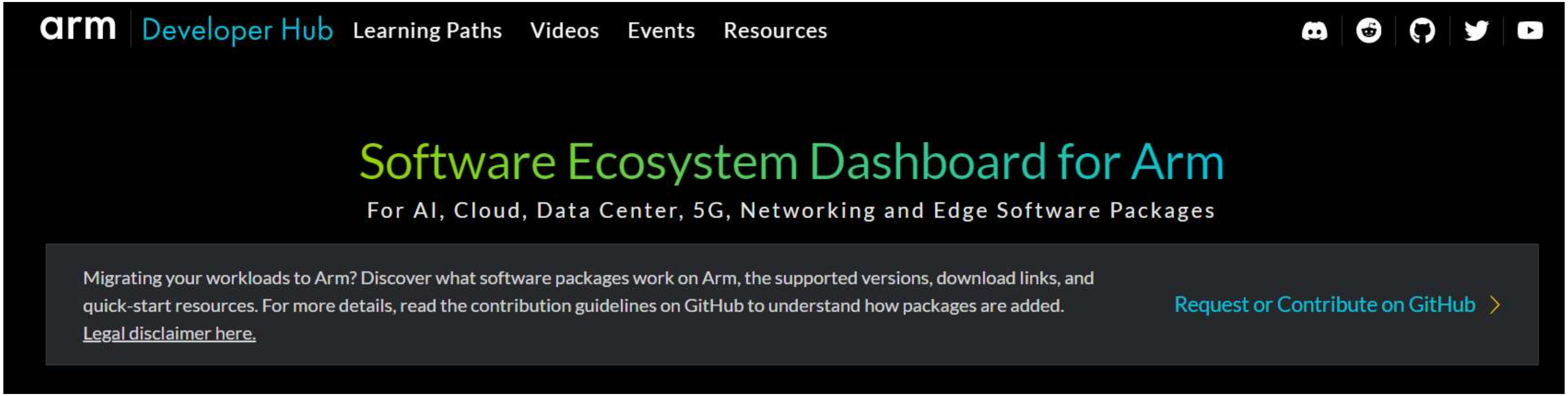
Software Ecosystem Dashboard

- A centralized information hub for global Arm infra software developers and users



Software Ecosystem Dashboard for Arm

For AI, Cloud, Data Center, 5G, Networking and Edge Software Packages

Migrating your workloads to Arm? Discover what software packages work on Arm, the supported versions, download links, and quick-start resources. For more details, read the contribution guidelines on GitHub to understand how packages are added. Legal disclaimer here.

https://www.arm.com/developer-hub/ecosystem-dashboard/servers-and-cloud-computing/

Foundation OSS Projects

Linux Kernel

- v3.7
  - The first mainline Kernel supporting Arm64
- v4.19
  - The first SLTS release with Arm64 support
- V6.6
  - The latest LTS kernel with the projected EOL in Dec 2026
- V6.9
  - The latest stable kernel released in May 2024

Kernel	Arm feature
6.5	Arm v8.8: Feat_MOPS/memcpy HWCAP and user space support Arm 8.9: Feat_PIE Stage 1 support Consolidate all arm specific initialisation into acpi_arm_init() KVM: Force 63bit counters for M2 CPUs, initialize HCRX_EL2 | switch HCRX_EL2 between host and guest
6.1	Arm v8.6 ECV vDSO support Arm 8.9 HWCAP support: Range Prefetch and Scalar Integer Instructions Arm 9.2 SME 1.0 : ptrace support KVM: Fixes for single-stepping in the presence of async exception, and fix for SME trapping in VHE configuration
5.15	Arm 8.4 MPAM public snapshot Arm 8.5 MTE : optimisations for kernel entry/exit path Refactoring support for VirtIO transport for SCMI init/exit calls hyperV support and KVM improvements
5.10	Armv8.5 MTE: User-space heap tagging enablement Arm v 8.6 PAC2 +FPAC in-kernel enablement SMMU support for ASID spinning, SCMI system protocol support NUMA Kconfig: maximum number of NUMA nodes bumped from 4 to 16 [node-shift : 4] Perf PMU drivers: addition of the Arm CMN-600 PMU porter driver, support to handle CPU PMU IRQs as NMI
4.19	Support for qspinlock on arm64 GICv3 updates and LPI allocation refactoring GCC "stackleak" plugin Support for chained PMU counters KVM: Support for Group0 interrupts in guests

More details: https://developer.arm.com/Tools%20and%20Software/Linux%20Kernel#Editions

Compilers

GCC

GCC	Key Arm feature enabled
GCC 13	Arm Neoverse V2 support Armv9.1-a/9.2-a/9.3-a architectures support LRCPC support through +rcpc extension Common Short Sequence Compression instructions (CSSC) support through the +cssc extension LSE2 support
GCC 12	Support ShadowCallStack sanitizer currently only for AArch64 target Cortex-A710 support with new cpu flag The 64-byte atomic load/store intrinsics support through +ls64 Optimized the ACLE Advanced SIMD intrinsics
GCC 11	Support Linux Kernel Concurrency Sanitizer (KCSAN) Arm Neoverse N2, V1 support with new cpu flag Improve inlined memcpy and memset Support conditional selects to perform conditional stores AArch64 intrinsics code-gen improvement Support the full set of intrinsics defined by ACLE Q3 2020
GCC 10	Full support for SVE/SVE2 AArch64 BFloat16 instructions (BF16) Matrix Multiplier Extension (I8MM, F32MM, F64MM) Floating-point to integer instructions (FRINTTS) Transactional Memory Extension (TME of Armv9) MTE and RNG through ACLE intrinsics A new option to determine if LSE can be used at runtime

GCC	Key Arm feature enabled
GCC 9	Arm Neoverse N1 support Armv8.5-a architecture support Statistical Profiling Extensions (SPE) only at assembler level Random number instructions (RNG) only at assembler level Complex number SIMD extension (FCMA, >= armv8.3-a) Memory Tagging Extension (MTE, >= armv8.5-a) Branch Target Indicators (BTI) Execution and Data and Prediction instructions (SPECRES) Speculation Barrier instruction (SB) Speculative Store Bypass Safe (SSBS) New -mbranch-protection option for PAuth as well as BTI Stack clash protection support
GCC 8	Armv8.4-a architecture support Rounding Double Multiply Accumulate instructions (RDM) Weak release consistency extension (LRCPC) Dot Product extension (DotProd) AES/SHA2/SHA3/SHA512 cryptographic extension SM3/SM4 cryptographic extension Floating Point Multiplication instructions (FHM) on Armv8.2-a and above

More details:
https://developer.arm.com/Tools%20and%20Software/GNU%20Toolchain#Supported-Devices

Compilers

LLVM

LLVM	Key Arm feature enabled
LLVM 17	Added Assembly Support for FEAT_GCS (Guarded Control Stacks), FEAT_CHK (Check Feature Status), and FEAT_ATS1A. Support for preserve_all calling convention is added. Added support for missing arch extensions in the assembly directives .arch <level>+<ext> and .arch_extension.
LLVM 16	Added support for the Cortex-A715/Cortex-X3/Neoverse V2 CPU. Added support for assembly for RME MEC (Memory Encryption Contexts). Added codegen support for the Armv8.3 Complex Number extension. Implemented Function Multi Versioning in accordance with Arm C Language Extensions specification.
LLVM 14	Added support for the Armv9-A, Armv9.1-A and Armv9.2-A architectures. The compiler now recognises the “tune-cpu” function attribute to support the use of the -mtune frontend flag Auto-vectorization now targets SVE by default when available.
LLVM 13	Introduced assembly support for Armv9-A’s Realm Management Extension (RME) and Scalable Matrix Extension (SME). Produce proper cross-section relative relocations on COFF Fixed the calling convention on Windows for variadic functions involving floats in the fixed arguments

LLVM	Key Arm feature enabled
LLVM 12	Native 64-bit Arm LLVM toolchain for Windows-on-Arm Add some specific CPU flags for Neoverse V1 & Neoverse N2, Cortex-A78C, Cortex-R82, Fujitsu A64FX Support a new flag ‘-moutline-atomics' for LSE dynamically detection Add vector-length specific ACLE support(SVE/SVE2) SVE/SVE2 (VLS intrinsics) Experimental vector-length-agnostic (VLA) auto-vectorization
LLVM 11	SVE/SVE2 (VLA intrinsics) Bfloat16 (intrinsics) Matrix Multiplication Extension (intrinsics)
LLVM 10	Transactional Memory Extension (TME) (asm/disasm, intrinsics)
LLVM 9	Memory Tagging Extension (MTE) Branch Target Indicators (BTI) SVE2 (asm/disasm)
LLVM 8	Pointer Authentication (PAuth)

More details:
https://developer.arm.com/Tools%20and%20Software/LLVM%20Toolchain#Supported-Devices

C/C++/Fortran toolchain for Neoverse Platforms

Neoverse IP Platform	N1/V1	V1/N2	V1/N2	N2/V2	Poseidon and future cores
GNU Toolchain (GCC, Glibc, and GDB)	**GCC10**	**GCC11**	**GCC12**	**GCC13**	**GCC-next**
	• +10% SpecInt17 • Arm v8.6-v9.0 • SVE2 support	• SVE2 improvements • V1 and N2 support	• Armv8.8-v9.3 • SVE2 code-gen +% • Intrinsic perf +% • Auto-vec at -O2	• Armv8.9-v9.4 • SVE2 code-gen +%	• Architecture enablement • Vectorized math routines • SVE2 code-gen +% and libraries • Workload specific tuning
LLVM Toolchain (Clang, LLDB)	**LLVM 10/11**	**LLVM 11/12**	**LLVM 13/14**	**LLVM 15/16**	**LLVM-Next**
	• Armv8.6-v9.0 • SVE asm • N1 support	• Armv8.7-v9.1 • +2-5% SpecInt17 • V1 and N2 support	• Armv8.8-v9.3 • +3% SpecInt17 • SVE2 auto-vectorization	• Armv8.9-v9.4 • SVE2 core scheduling model • Complex number auto-vec	• Architecture enablement • SPEC INT CPU +% • SVE2 code-gen +% • New LLVM Fortran Frontend • LLVM backend +% to benefit other languages
Arm Compiler for Linux (for HPC users) (Arm Compiler + Arm Perf Libraries)	**20.x**	**21.x**	**22.x**	**23.x**	**Version-Next**
	+5% to 46% for HPC workloads • SVE2 support • Sparse matrix libraries	• SVE/2 improvements • LLVM 11 based	• V1 support • SVE/2 improvements • LLVM 13 based compilers • BLAS/LAPACK improvements	• Demeter support • LLVM 16 based compilers • ArmPL Batched/Sparse functions	• Demeter +% for HPC workloads • New LLVM Fortran frontend-based compiler • SVE/2 improvements
	2020	2021	2022	2023	2024 onwards

** All % perf numbers are based on best possible flags and are relative to the previous compiler version*

Runtime Languages

Java

AArch64 support since JDK8
AArch64 intrinsics improved in JDK11
Windows/MacOS support since JDK17
VectorAPI with NEON and SVE support
Foreign function & Memory API contribution
Optimized ZGC performance
Multiple downstream forks

Python

First AArch64 commit in 2012
PyPy AArch64 support in 2019
PEP-599/600 accepted
https://speed.python.org/

.NET

NEON intrinsics added in v5
LSE atomics improved in v7
Conditional Ops improvement
Consecutive register allocation support in v8

Rust

NEON intrinsics was stabilized in 2021
RFC for SVE support is in discussion

PHP

PHP8.1 released – fully enabled on AArch64
PHP-JIT CI and bug fixes

Golang

Arm64 support since 1.8.5/1.9
Memory sanitizer support in 1.11
Stack frame pointers support on all OSs
Optimized function arguments passing in 1.17
Address sanitizer support in 1.18
PGO support since 1.21

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Major Operating Systems Available on Arm

Red Hat

RHEL 9.4 released in April 2024

RHEL 8.10 released in May 2024

Fedora 40 released in April 2024

CentOS 7.1 AltArch is the first release with Arm64 support

SUSE

SLES 15 SP5 for Arm64 released in June 2023

openSUSE Leap 15.5 released in June 2023 and 15.6 will be available in June 2024

openSUSE Tumbleweed available on Arm64

debian

Debian 12.5 for Arm64 released in February 2024

Debian 11.9 released in February 2024

Debian 8 is the first release with Arm64 support

ubuntu

Ubuntu 24.04 for Arm64 released in April 2024

Ubuntu 16.04 is the first release with Arm64 support

OpenEuler

Latest openEuler 24.03 released in June 2024

openEuler 20.03 LTS released in Mar 2020 with full Arm64 support

Arm joined openEuler community in 2020

OpenAnolis

Latest OpenAnolis 23.1 released in June 2024

Anolis OS 8.4 released in July 2021 with full Arm64 support

Arm joined OpenAnolis community in 2021

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Infrastructure Workloads & Solutions

Database

RDBMS

MySQL

PostgreSQL

MariaDB

No-SQL

mongoDB

cassandra

neo4j

CouchDB relax

elasticsearch

Solr

Key-value

redis

MEMCACHED

etcd

RocksDB

Time-series

influxdb

Prometheus

Wide-Column

cassandra

APACHE HBASE

SCYLLA

Vector-DB

milvus

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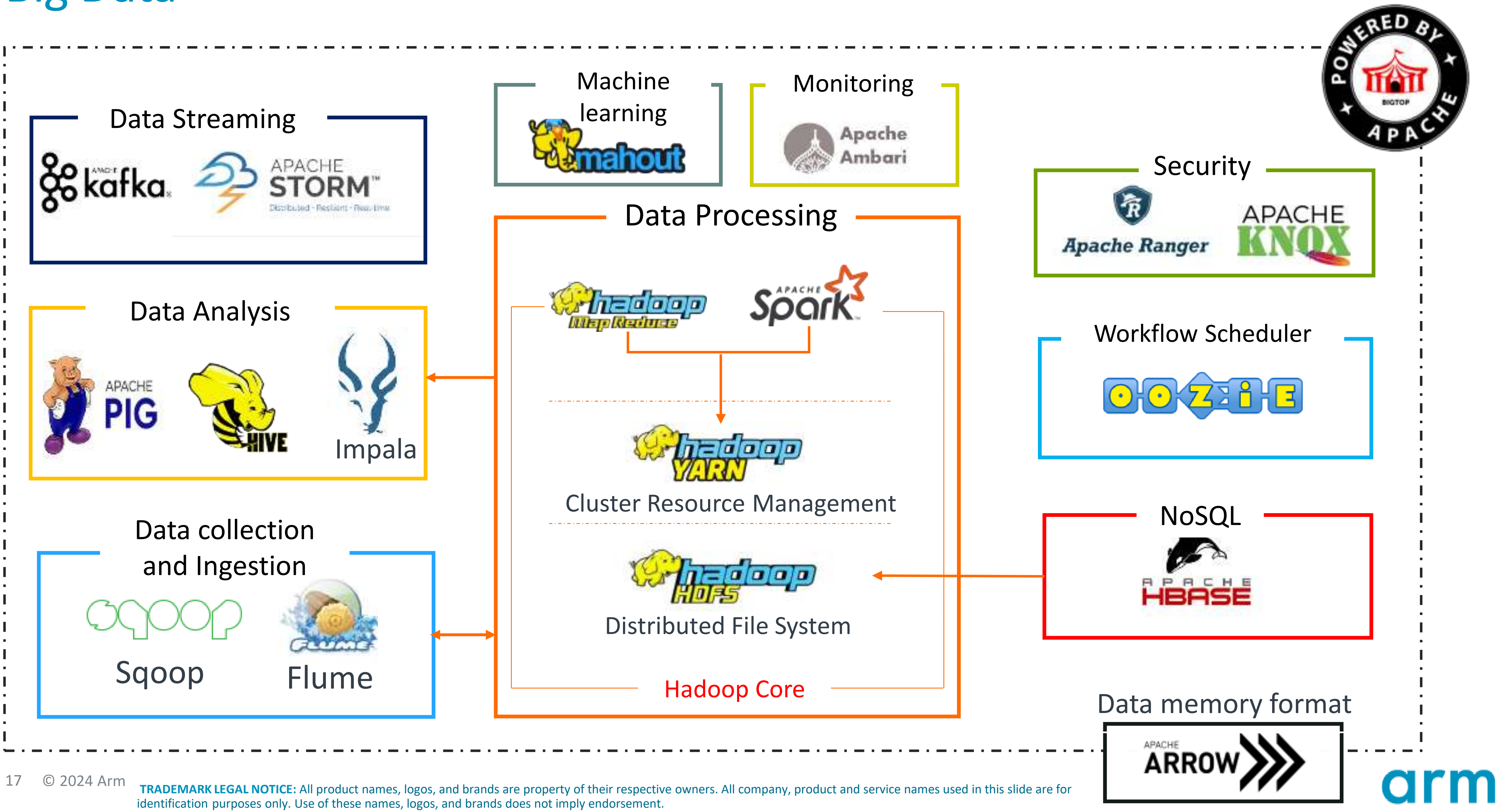
Big Data



Data Streaming

Machine learning

Monitoring

Security

Data Analysis

Data Processing

Workflow Scheduler

Impala

Cluster Resource Management

Data collection and Ingestion

NoSQL

Distributed File System

Sqoop

Flume

Hadoop Core

Data memory format

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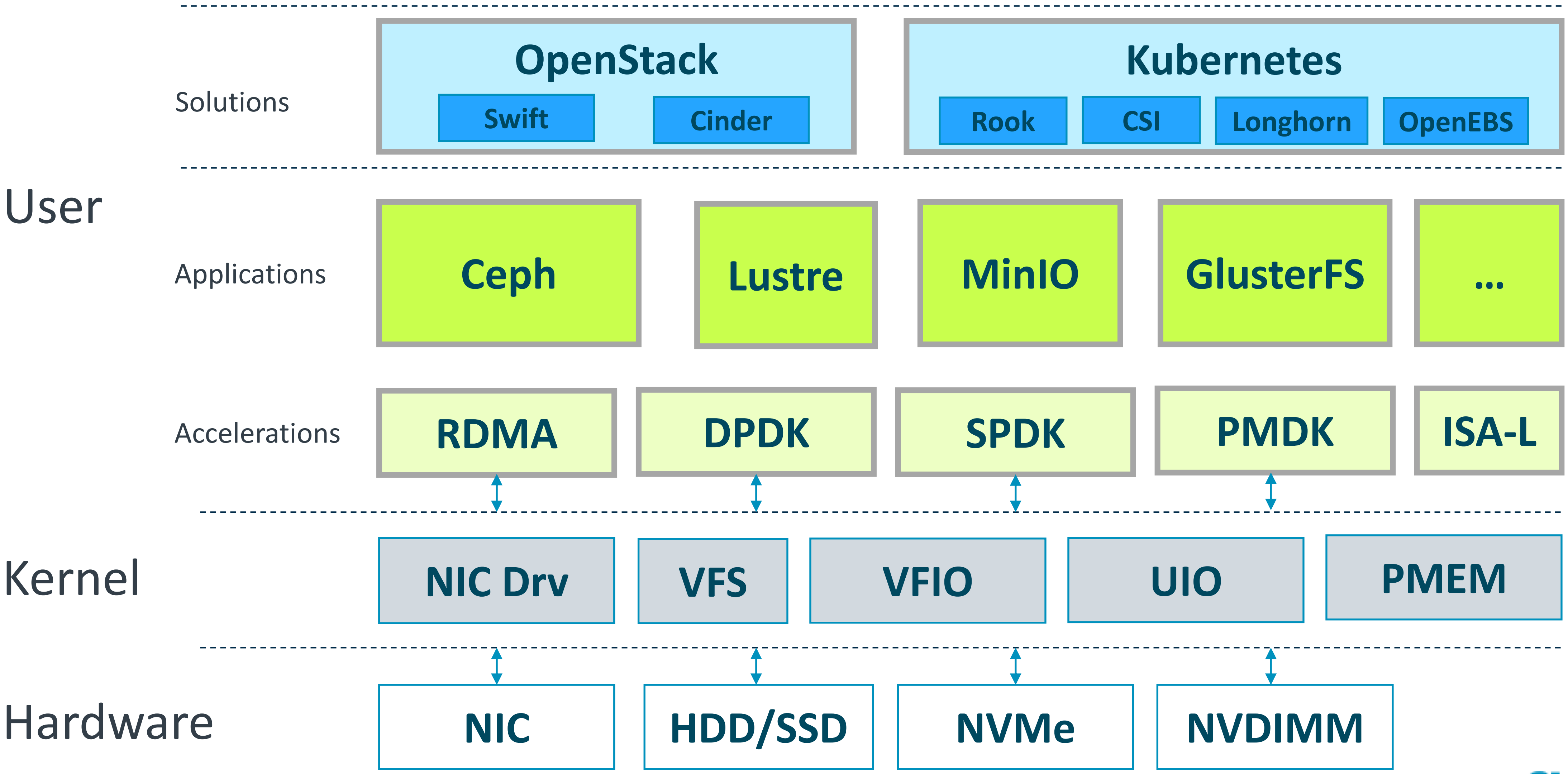
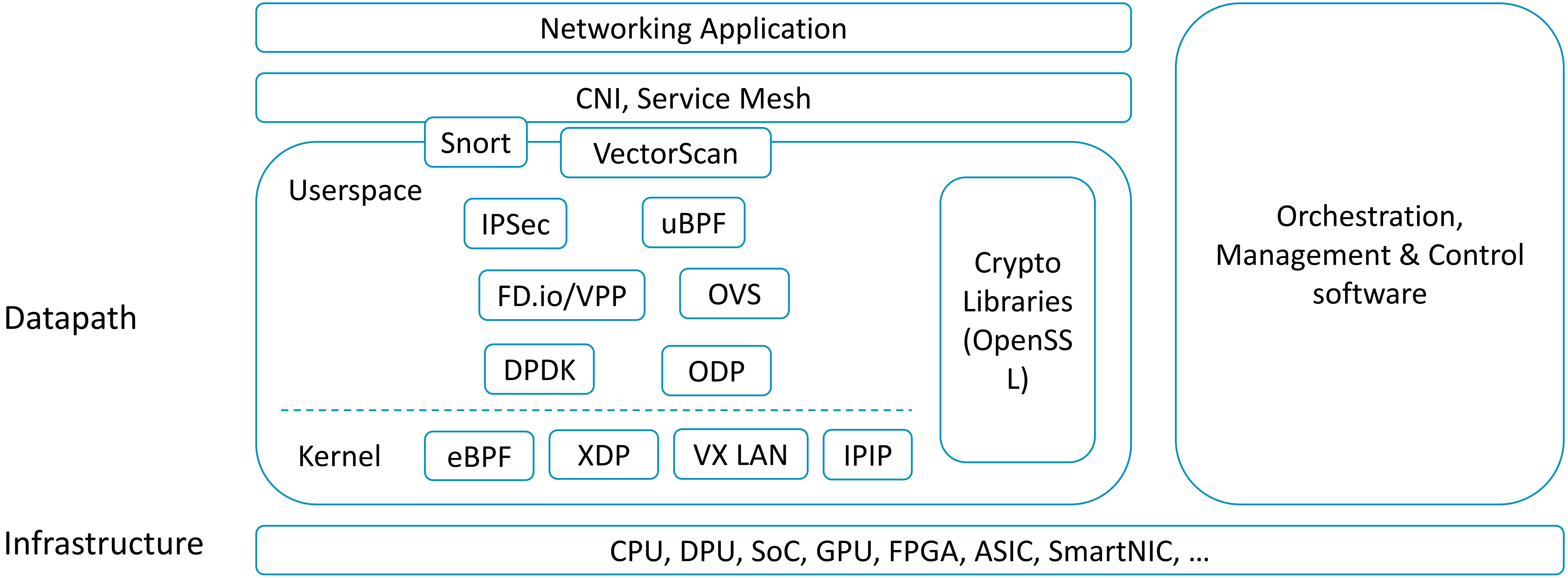
Storage


User
Solutions
OpenStack
Swift
Cinder
Kubernetes
Rook
CSI
Longhorn
OpenEBS
Applications
Ceph
Lustre
MinIO
GlusterFS
...
Accelerations
RDMA
DPDK
SPDK
PMDK
ISA-L
Kernel
NIC Drv
VFS
VFIO
UIO
PMEM
Hardware
NIC
HDD/SSD
NVMe
NVDIMM

Networking



Networking Application

CNI, Service Mesh

Orchestration, Management & Control software

Datapath

Userspace

Snort

VectorScan

IPSec

uBPF

FD.io/VPP

OVS

DPDK

ODP

Crypto Libraries (OpenSSL)

Kernel

eBPF

XDP

VX LAN

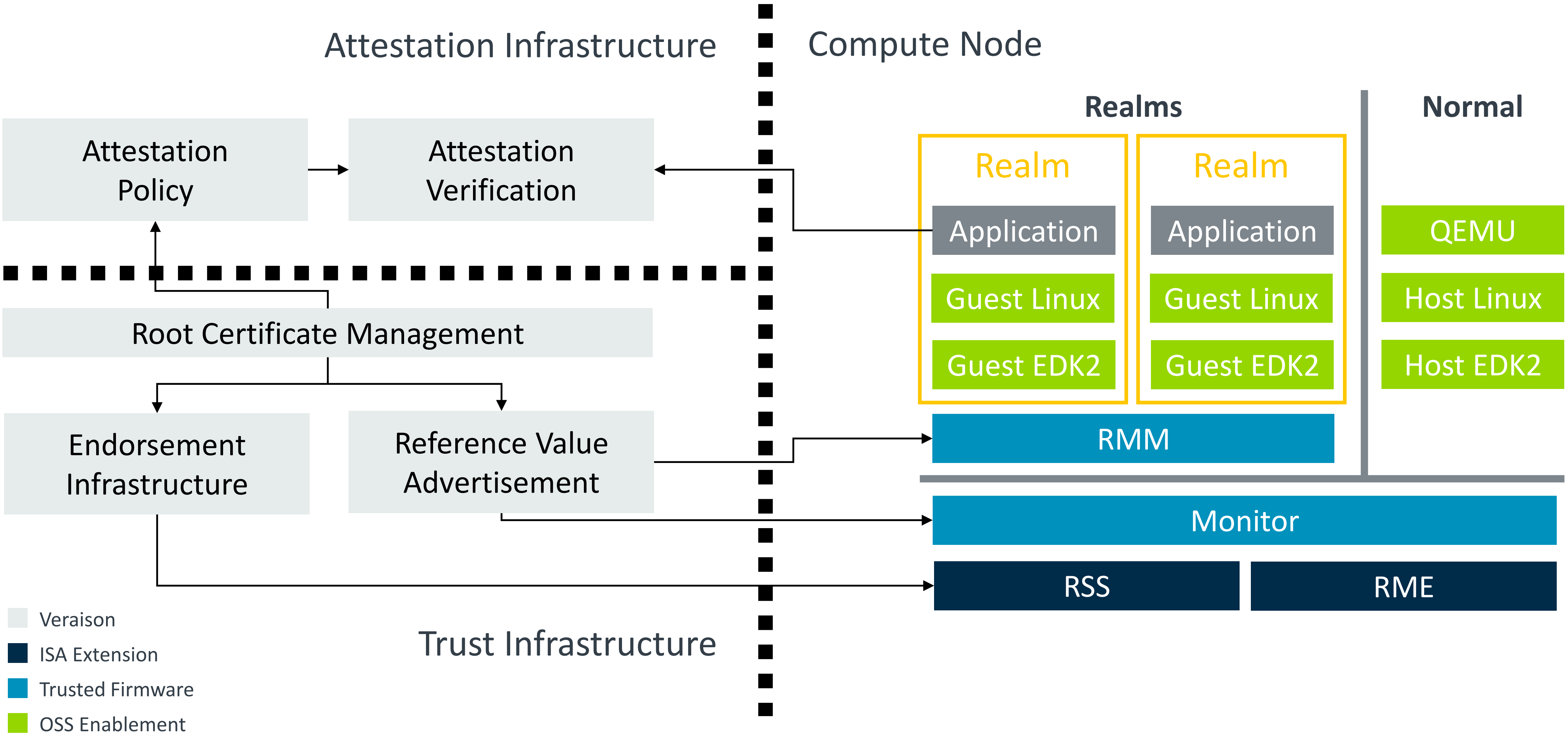
IPIP

Infrastructure

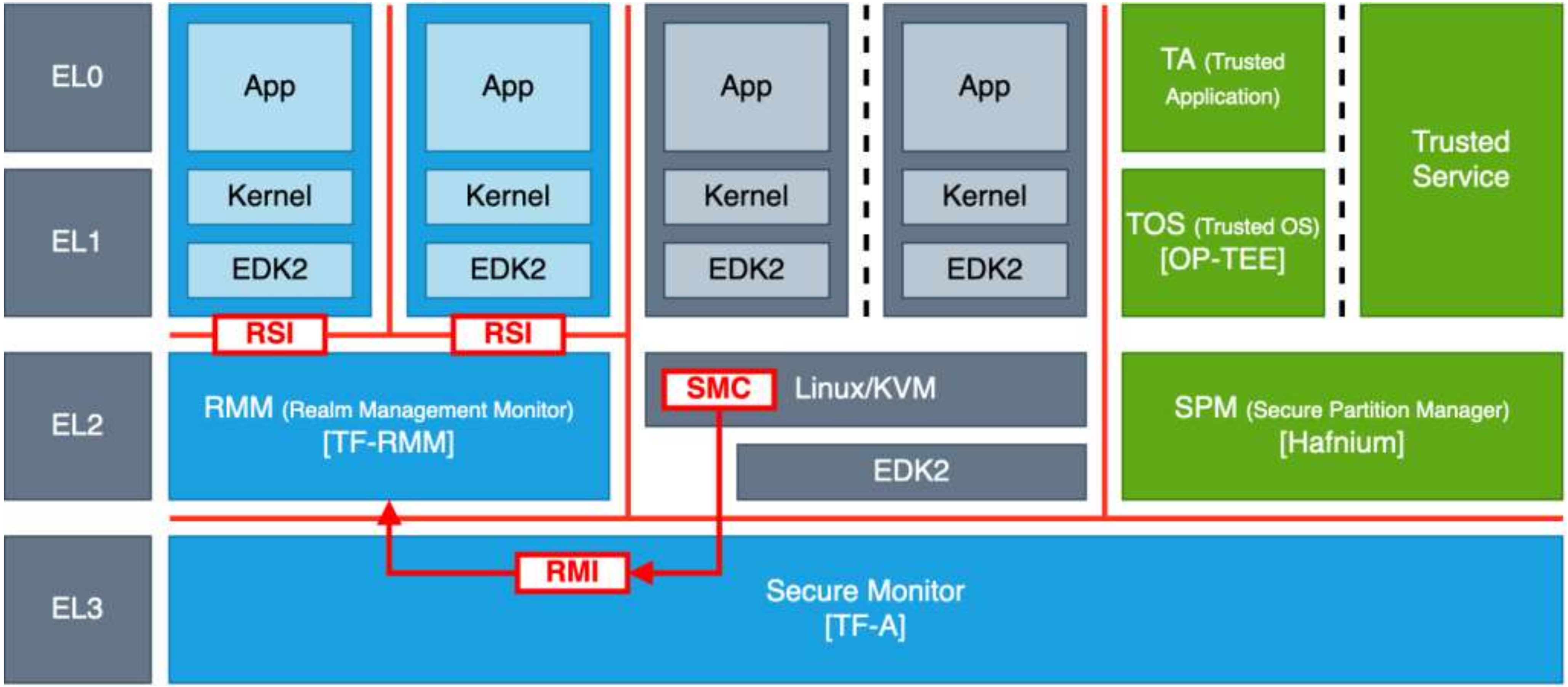
CPU, DPU, SoC, GPU, FPGA, ASIC, SmartNIC, …

DPDK fd.io OvS Open vSwitch envoy Istio CNI cilium OpenDataPlane SNORT AKRAINO O-RAN magma SONiC OpenSSL

Arm CCA


Attestation Infrastructure
Compute Node
Attestation Policy
Attestation Verification
Root Certificate Management
Endorsement Infrastructure
Reference Value Advertisement
Trust Infrastructure
Realms
Normal
Realm
Application
Guest Linux
Guest EDK2
Realm
Application
Guest Linux
Guest EDK2
QEMU
Host Linux
Host EDK2
RMM
Monitor
RSS
RME
Veraison
ISA Extension
Trusted Firmware
OSS Enablement

Arm CCA - Open Source Components



SMC: Secure Monitor Call
RMI: Realm Management Interface
RSI: Realm Service Interface

KVM tianocore TrustedFirmware .org

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ML Software Stack on Arm Neoverse

Open Source □
Accelerator Vendor ▨
nVidia 🟩
Arm 🟦

Models

Large Language Models | Generative AI | Vision | NLP | Recommender | ...

Frameworks / Runtimes

TensorRT | PyTorch | TensorFlow | ONNX | PaddlePaddle | llama.cpp, gemma.cpp

Libraries / Backends

CUDA | Custom

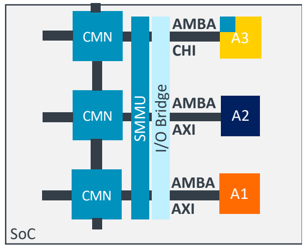
Arm Compute Library (ACL) (via oneDNN in some cases) | KleidiAI | XLA/MLIR

Hardware

Neoverse Host

+

Accelerated Compute



Neoverse On-CPU ML

NEON | SDOT | FP16 | BF16 | SVE | SME

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Developer Ecosystem

Developer Ecosystem

Enabling a Frictionless Developer Experience

Global

- Arm Developer Hub
- Learning Paths
- Arm Community
- Arm Developer Program
- Arm Software on GitHub
- Arm repositories on DockerHub
- AWS Graviton Getting Started
- Oracle Landing page
- Ampere Solutions
- …

China

- Jishu Community

Arm技术博客

Arm相关的技术博客，提供最新Arm技术干货，欢迎关注

Arm服务器

分享arm服务器软件应用经验、调试方法、优化思路、工具使用等。

- "Arm Community" on WeChat

Arm社区

ARM Limited

浙江

Arm与其生态系统的创新、深刻独到的行业与技术洞察、以及Arm全球社区的最新动态分享平台。

Channel: Arm社区

- Kunpeng Developer Community
- Ali Yitian Developer Community

Q & A

Thank You

Danke

Gracias

Grazie

谢谢

ありがとう

Asante

Merci

감사합니다

धन्यवाद

Kiitos

شكرًا

ধন্যবাদ

תודה

ధన్యవాదములు