



FreeBSD, ARM Servers & Cavium's ThunderX

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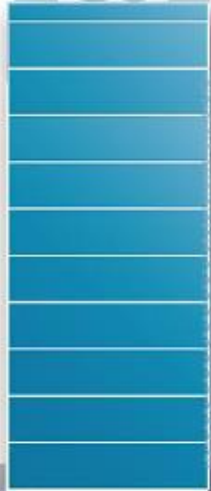
Agenda

- **Intro to ARM and ARM Servers**
- **Intro to ThunderX – 64bit implementation of ARMv8**
- **FreeBSD on ThunderX**

ARM Continues to Grow in Unit Volume

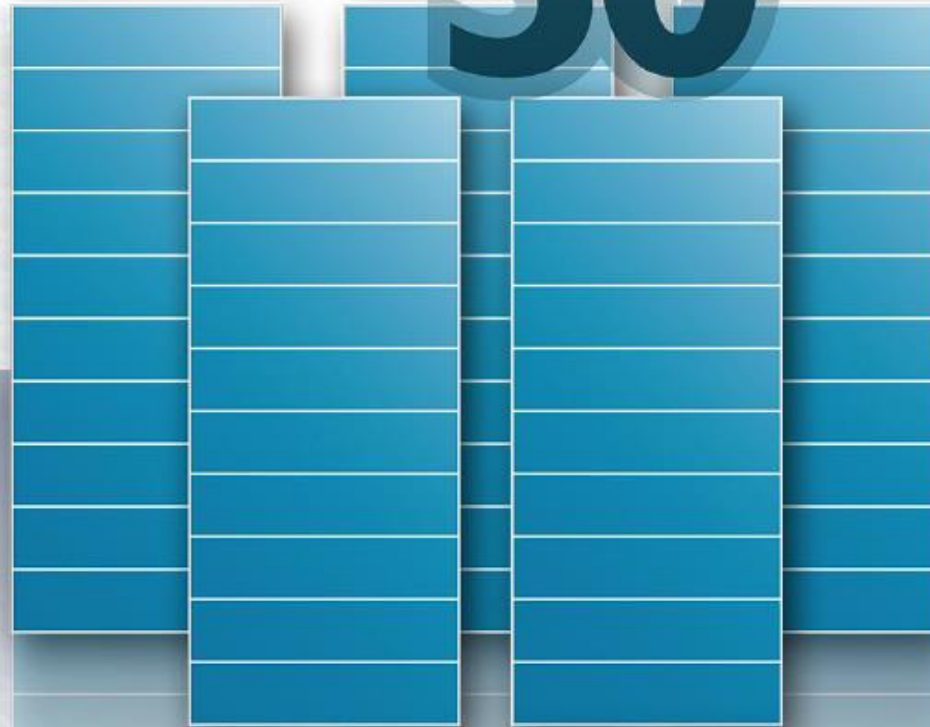


10.4 Billion



ARM Chips shipped in 2013
by ARM Partners

50 Billion



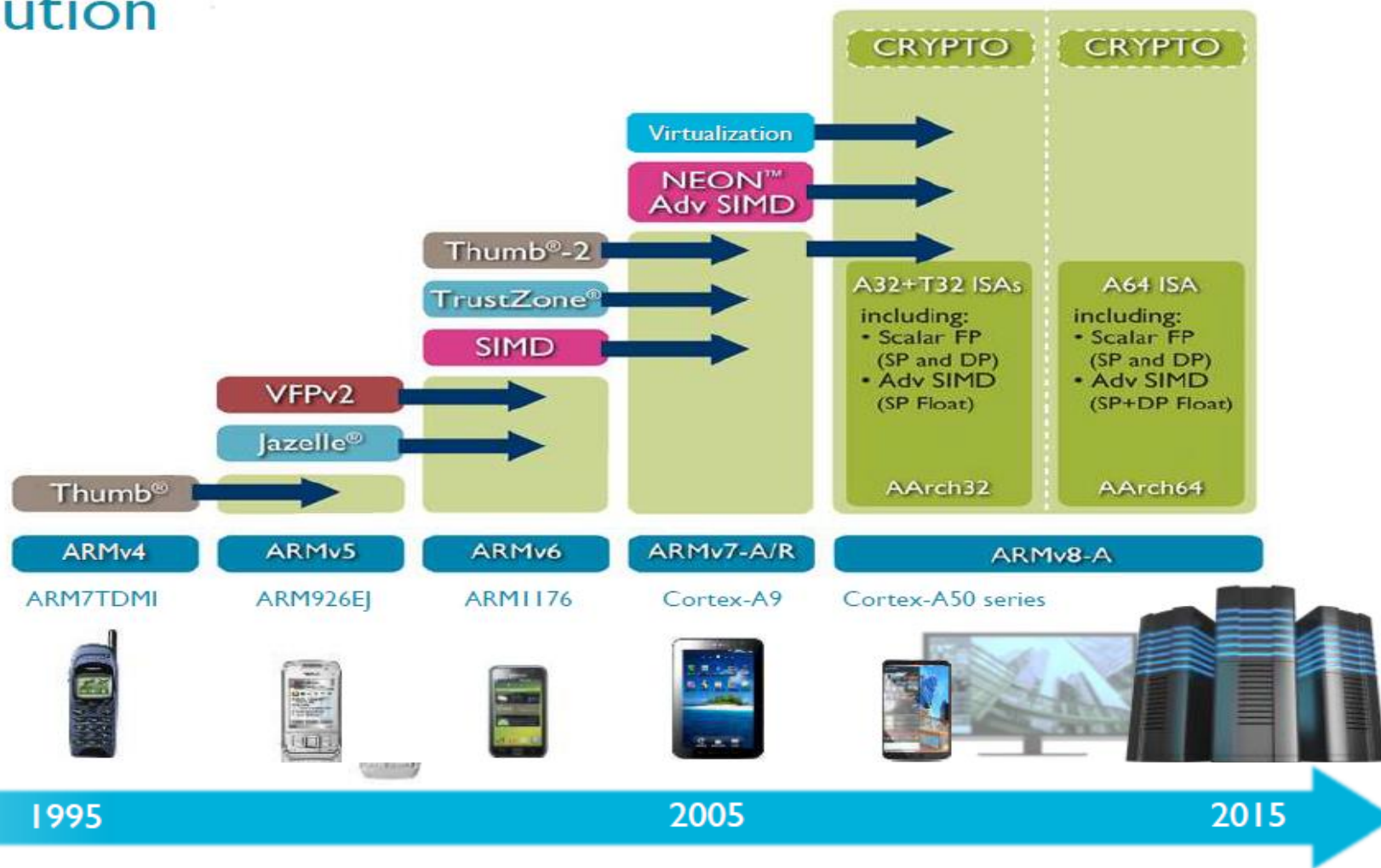
ARM Chips Shipped to Date by
ARM Partners

- **ARM designs and licenses IP**
 - Standard License
 - Architectural License
- **ARM enables ecosystem via**
 - Foundation Models
 - Reference Systems
- **ARM designs and sells tools and supporting collateral**



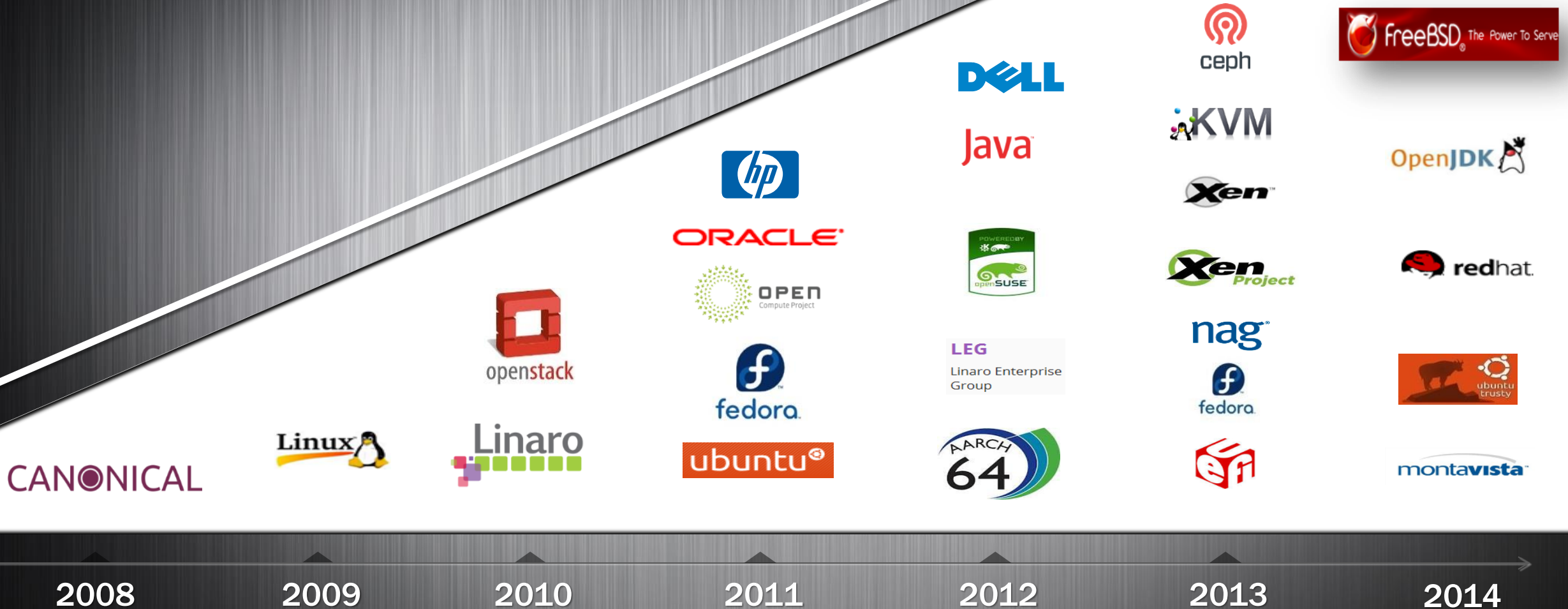
AArch64 - ARMv8

Architecture Evolution

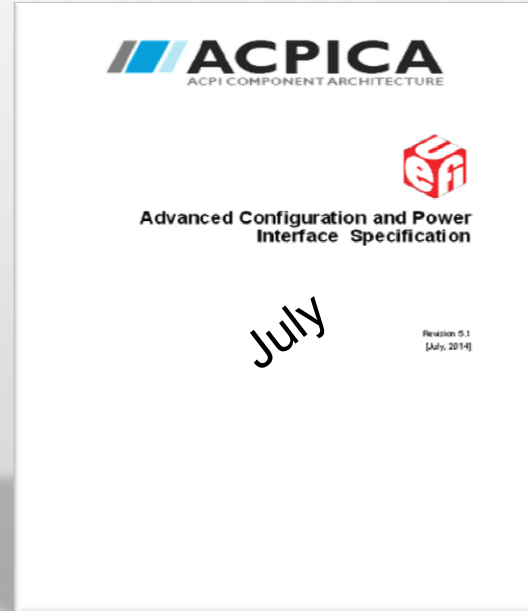
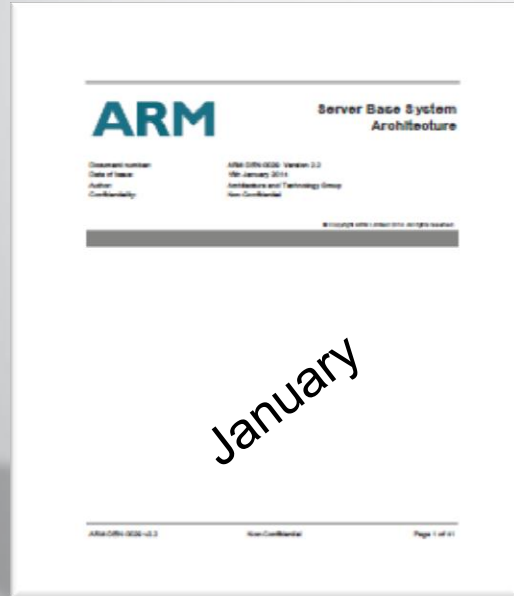


ARM Server History

EcoSystem Building Momentum



Intersecting Server Standards w/ ARM



Core Requirements for Server Deployment and Adoption

Cavium: Multi-Core Processor Company

Enterprise and Service Provider



Mobile Infrastructure



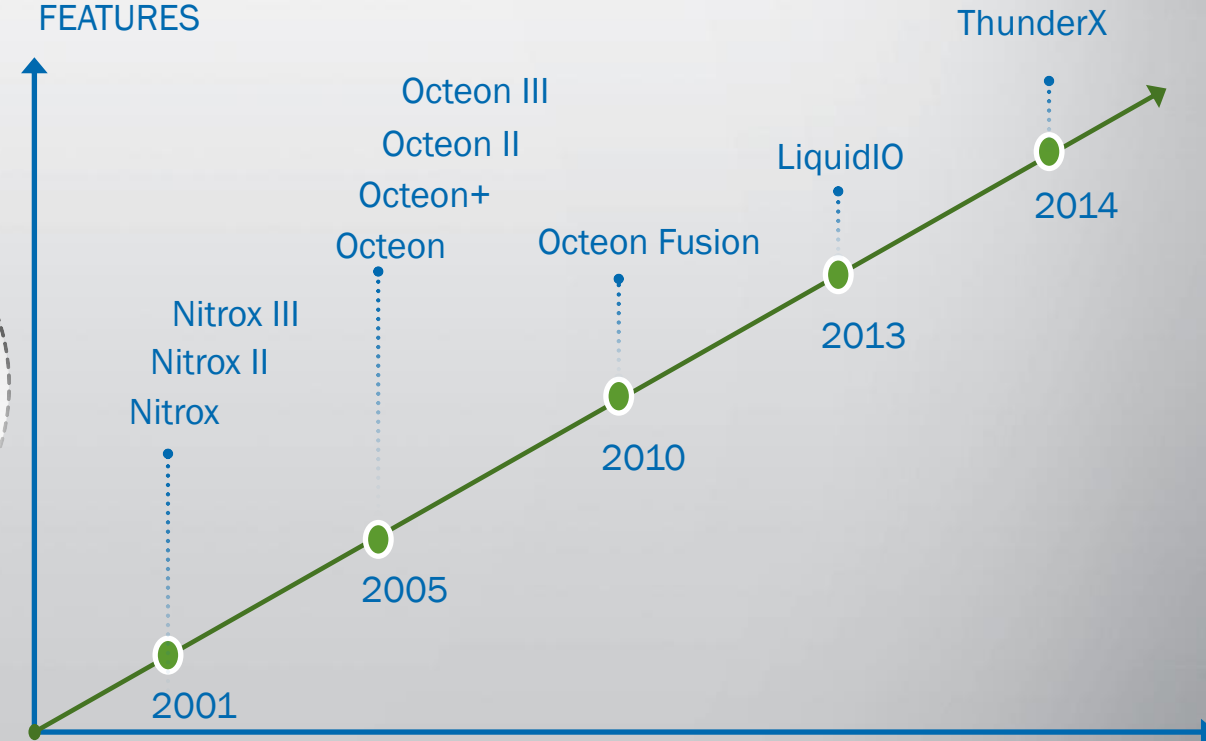
Data Center and Cloud



BIG IRON INFRASTRUCTURE



PERFORMANCE/
FEATURES



Cavium's Proven Technology Track Record

Introducing **THUNDERX™**

Family of ARMv8 based Workload Optimized Processors for Next Gen Data Center & Cloud

- Up to 48 custom ARMv8 cores @ 2.5GHz
- Single & Dual socket configuration
- Up to 4 DDR3/4 Memory Controllers
- Integrated I/O's – Multiple 10/40GbE, Gen3 PCIe, SATAv3 & GPIOs
- Integrated Standards based low latency Ethernet fabric
- virtSOC™: Virtualization from Core to I/O
- Integrated Accelerators for virtualization, storage, security and networking
- 4 Workload Optimized Processor Families:



ThunderX_CP: Compute Servers

ThunderX_ST: Storage Servers

ThunderX_NT: Network/Telco Servers

ThunderX_SC: Secure Servers

Reference Platforms – Enabling Partners & Customers

- **Compute**

CN88xx processor

1S & 2S configs

- **Memory**

DDR4 registered DIMM slots

Up to 512 GBytes

- **IO**

Multiple 10 GbE ports, Provision for 40 GbE

Multiple SATA HDDs

Multiple Gen3 PCIe

- **Form Factor**

ATX (1S)

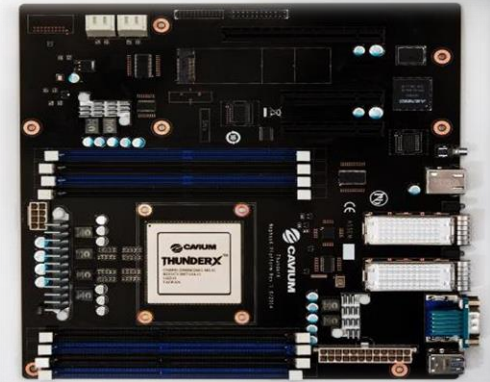
1/2 SSI (2S)

- **Chassis**

1U

2U/4N (“Twin”)

- **Availability: Q4’2014**





Cavium to Sponsor FreeBSD ARMv8 Based Implementation

Collaboration to Deliver First FreeBSD Reference for ThunderX™ Workload Optimized Processor Family

SAN JOSE, CA and Boulder, CO., October 1, 2014 – Cavium, Inc., (NASDAQ: CAVM), a leading provider of semiconductor products that enable intelligent processing for enterprise, data center, cloud, wired and wireless networking announced today that it is collaborating with the FreeBSD Foundation to develop and deliver the first ARMv8 reference design and implementation of the FreeBSD Operating System based on the ThunderX workload optimized processor family for next generation Data Center and Cloud workloads (http://cavium.com/ThunderX_ARM_Processors.html).

FreeBSD is the most widely used open-source BSD distribution, accounting for more than three-quarters of all installed systems running open-source BSD derivatives. FreeBSD is widely used in infrastructure applications such as storage, web and media streaming applications and environments. With a repository of over 24,000 applications FreeBSD provides a broad array of options for developers, system administrators and end users.

In collaborating with the FreeBSD Foundation Cavium will contribute directly to the Foundation, supply engineering expertise and provide reference ThunderX hardware for the development community. This collaboration is expected to result in Tier 1 recognition of the ARMv8 architecture along with an optimized implementation for the Cavium ThunderX processor family. ThunderX delivers many unique and differentiated capabilities to the ARMv8 server market including support for 48 cores in a single SoC with GICV3, cache coherent dual socket support using Cavium Coherent Processor Interconnect (CCPI™), end to end virtualization through virtSoC™ technology and integrated hardware accelerators for security, storage, networking and virtualization applications.

"Collaborating with Cavium allows the Foundation and the FreeBSD Project to deliver a high quality ARMv8 server solution that delivers the high performance platform that FreeBSD developers, vendors and users have come to expect," said George Neville-Neil, FreeBSD Foundation Board Member. "We applaud Cavium for stepping forward to work directly with the open source community via the FreeBSD Project and are looking forward to using ThunderX as the basis of our reference implementation."

"The collaboration between Cavium and the FreeBSD Foundation to deliver a reference BSD implementation for data center and cloud infrastructure continues to build the momentum for open source on the ARMv8-A architecture," said Lakshmi Mandyam, director, server systems and ecosystems, ARM. "Cavium's contribution to the FreeBSD project will complement the efforts of ARM and its partners to enable scalable performance and compelling energy efficiency improvements for next-generation infrastructure deployments."

- Collaboration w/ ARM, Cavium, FreeBSD Foundation
- ARM provides direct support for initial ARMv8 enablement
- Cavium provides direct support for ThunderX reference implementation
- Establish ARMv8 as FreeBSD Tier1 Architecture

Phase 1 – Enable FreeBSD on ARMv8 Architecture

- Toolchain – generate ARM64 object files via the in-tree Clang compiler
- Bootloader - boot via a UEFI w/ device configuration by ACPI and by FDT
- System startup and low-level infrastructure - implement
 - Assembly language machine dependent startup routines
 - System cache setup
 - Exception handling
 - Atomic operations
 - Busdma
 - Context switching
- Virtual memory subsystem (PMAP) w/ all required machine dependent functions spec'd by pmap(9) man pg
- Basic peripherals - support for all generic timer(s), interrupt controller(s), and system UART(s)
- Kernel debugger(KDB) - implement the machine-dependent portions of the kernel debugger, including register and memory access, stack trace printing routines, and related functionality

Phase 2 - FreeBSD Reference Implementation on ThunderX

- 3 primary I/O interfaces will be implemented/validated:
SATA (Gen 3 - standard AHCI interface); Ethernet (10 Gb & 40 Gb interfaces); PCIe (Gen 3)
- GICV3 extension for 48 core support
- Full support for Dual SOC NUMA via ThunderX CCPI
- Dtrace Support at parity w/ X86
- HWPMC Support at parity w/ x86
- Basic SOL
- Out of Band Mgt via IPMI:
Remote Power over LAN
Sensor monitoring

EcoSystem/End User Enablement

- Userland Package Build:
Implement ARMv8 support in the FreeBSD ports tree that results in the metadata and infrastructure for building 3rd party software
- Standard FreeBSD documentation implemented and distributed
- Changes under this project shall be made available under the 2-clause BSD license, and pushed to a public repository (FreeBSD subversion projects branch, github repository, or similar) on an ongoing basis throughout the project's development
- Cavium will collaborate with the FreeBSD Foundation to provide reference server HW to ensure sufficient infrastructure for Tier1 support of ARMv8 Architecture
- Current status:
ARMv8 development in progress – goal for completion this quarter
ThunderX development – will run in parallel with ARMv8 – initial delivery in Q1 2015

Beyond Initial Enablement



- Optimizations
 - Multicore Scaling
 - Accelerator Support
- Expanded use cases
 - Storage
 - Web Tier
 - Cloud
- Large End User Deployment
- Enhanced Community involvement