# FreeBSD In The Embedded World

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# Introduction

- What is an embedded system?
- Contemporary embedded world
- Industry trends
- Embedded FreeBSD
- How we do it (at Semihalf)

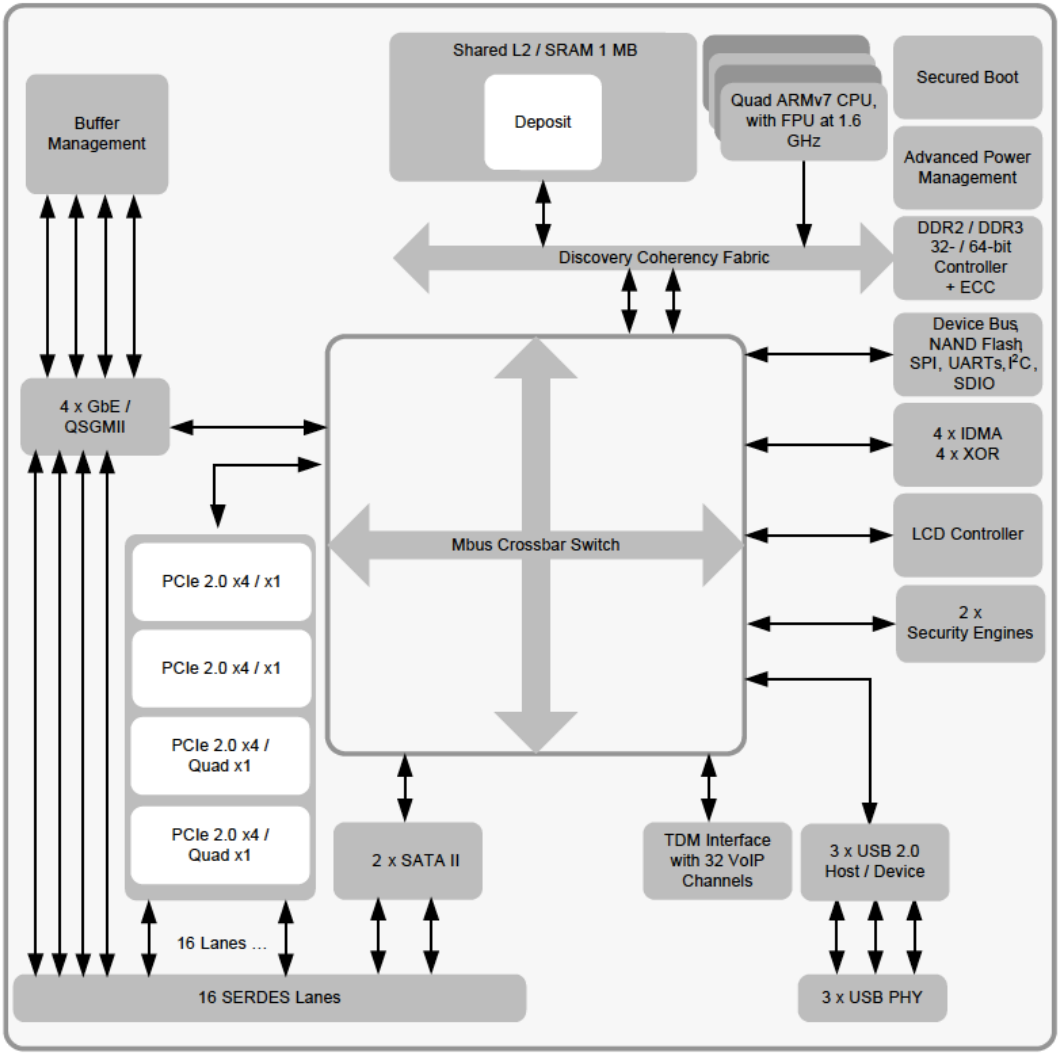
# What is an embedded system?

- No strict definition
- Historical view
  - Simple, small footprint systems
  - Single function, limited software
  - No general purpose software components
  - Highly integrated (system-on-chip)
  - Special acceleration engines
- Greatly diversified platforms
  - No „*standard*" platform, everything is custom

# Embedded world today

- More integrated and smaller than ever
- No longer tiny and simple
- Hardware (silicon) changing rapidly
- Top technologies
  - 28nm, 20nm, 14nm
  - Multicore
    - 10's and 100's cores in one package
    - MMU, caches, 64-bit
  - Modern i/f
    - DDR3/4
    - SerDes, PCI-Express, USB3, SATA3

# System-on-chip example



# A subjective (Semihalf) view

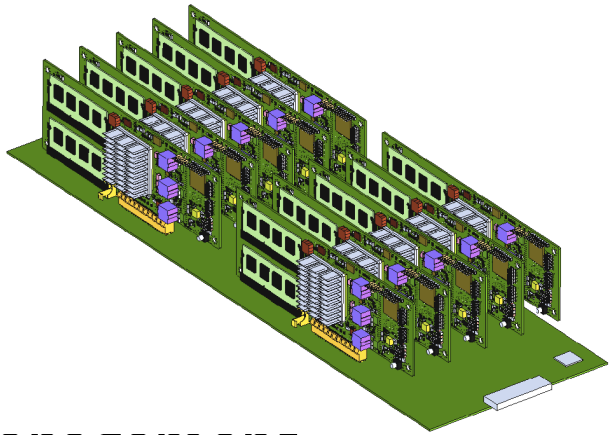
- High end processors
  - Networking, storage
- Focus on RISC
  - ARM, MIPS, PowerPC, not much x86
- Focus on ARM
  - Moving into high end
  - High performance CPU core + peripherals
  - Multicore, virtualization, 64-bit
  - General purpose computing
  - Strong vendors interest and investment
    - Altera, AMD, Apple, Applied Micro, Broadcom, Calxeda, Cavium, Freescale, LSI, Marvell, Nvidia, Qualcomm, Samsung, ST, TI, Xilinx

# Industry trends

- Low power, not only pure performance (single core)
  - ARM winning over MIPS and PowerPC
- Embedded goes into servers
  - Low power, better efficiency
  - Alternative vendors
  - $10 bn market
- Embedded goes into the cloud and data centers
  - Open Compute (Facebook)
  - Note: the *single purpose software* aspect is gone

# Industry trends: microserver

- Rack space requirements
  - Increase density, better scalability
  - New architecture to reduce cost
- Common form factor
  - PCI-E
  - Simple, modular
  - Base board: slots, power, control, management
- SoC, memory, storage, Ethernet
- Multiple vendors
  - AMD, Applied Micro, Calxeda, Intel



# Embedded FreeBSD

- Current state overview
  - ARM, MIPS, PowerPC
- FreeBSD/arm
  - Support for ARMv5, v6, v7
  - SMP (quad core)
  - Popular platforms (Pandaboard, Beaglebone, Raspberry Pi, Plugs etc.)
  - Numerous projects and activities (i.MX port, EABI)
  - In progress: transparent superpages for ARM

# Embedded FreeBSD – strengths

- Modern CPU architectures support
  - ARM, MIPS, PowerPC
- FreeBSD portability
  - Drivers API (newbus, bus_dma, bus_space)
  - Flattened device tree (FDT)
- Toolchains
  - LLVM/clang (still new)
  - External toolchains support
- Testing frameworks
  - Stress2
  - ATF (recently imported from NetBSD)

# Embedded FreeBSD – weaknesses

- Existing support not always ready for production use
  - Bugs, no optimizations, no extensive testing
- Mainstream development not done with embedded in mind
  - New features only tested / verified on x86 and commodity platforms (e.g. strict alignment problems with drivers)
  - Code bloat
- Embedded architectures not considered first-class citizen
  - No *Tier-1* status of any of the embedded architectures so far
- Performance
  - Vendors and potential users test and compare vs. other OSes
  - Latency, throughput, overheads, offloading

# Embedded FreeBSD challenges

- Linux everywhere
  - FreeBSD (*BSD) in general unknown in the industry
- Does BSD license matter for embedded use?
- How to stay relevant (on top)
  - Make one of the platforms *Tier-1*
  - Prepare for the upcoming *ARM server* wave
  - ARMv8 (64-bit) support
  - Grow pre-built systems (snapshots) for vendors to test, validate (GENERIC embedded kernels)
  - Have more developers work on embedded FreeBSD
  - Focus on the industry needs (doing another port is a nice exercise, but…)
  - (Some of the above items are hard)

# How we (Semihalf) embed FreeBSD

- Numerous ports
  - Applied Micro (PacketPro)
  - Freescale (PowerQUICC, QorIQ)
  - Marvell (Orion, Kirkwood, Discovery,Raid-on-chip, Armada-XP)
  - Texas Instruments (DaVinci)
  - Mostly integrated with the public SVN tree
- Flattened device tree (FDT)
  - ARM, MIPS, PowerPC
  - Supported by the FreeBSD Foundation

# Embedding FreeBSD cont'd

- FreeBSD/arm infrastructure
  - ARMv6, v7 support
  - SMP
- NAND Flash support
  - Flash devices drivers framework
  - Log-structured filesystem (NANDFS)
- FreeBSD/arm superpages
  - Work in progress
  - Supported by the FreeBSD Foundation
- Community involvement
  - Speaking at conferences
  - Mentoring GSoC students
  - FreeBSD committers @Semihalf

# Recent highlights

- NetBSD/arm port to Armada-XP
  - ARMv7 (PJ4B CPU core)
  - Single core
  - Major peripherals support
  - Thoroughly tested
  - Being merged with official CVS
- High performance *userspace* TCP/IP stack
  - Derived from FreeBSD networking stack
  - Integrated with massively multicore environment (36-core) running Linux
  - 40Gbps throughput, low latency

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