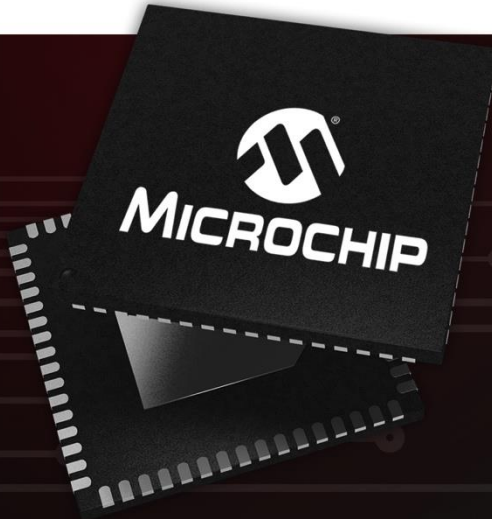




MICROCHIP



A Leading Provider of Microcontroller, Security,
Mixed-Signal, Analog & Flash-IP Solutions



PolarFire SoC – AMP-capable solution for both deterministic real-time and rich OS support
Vishakh Rayapeta, Sr. Staff Applications Engineer
March 13, 2019

Award-winning PolarFire FPGA as an SoC platform

Lowest Power

Low static power technology
Power optimized transceivers
Up to 50% lower than SRAM
FPGAs

Proven Security

Defense-grade security
DPA safe Crypto coprocessor
Built-in anti-tamper

Exceptional Reliability

SEU immune configuration
Block RAM with ECC
Extended temperatures



**10G Bridging &
Aggregation**



**Video & Image
Processing**



**Portable
Equipment**



**Signal
Processing**



Control Plane



**Hardware
Acceleration**



**Low Power
Optics**

Real-time Linux?

Wide spread Linux adoption

- Rich OS with thousands of applications to choose from



Requirements still exist for real-time while running Linux

- Safety-critical
 - The ability to deterministically monitor the execution environment
- Real-time system control
 - Completing tasks deterministically, on time every time
- Securing the IoT
 - Execute a trusted execution environment deterministically for consistent results



• Working with our partner, SiFive

- Architected a complex SoC FPGA that provides determinism and a rich OS within the same multi-core CPU cluster



What is Real-time?

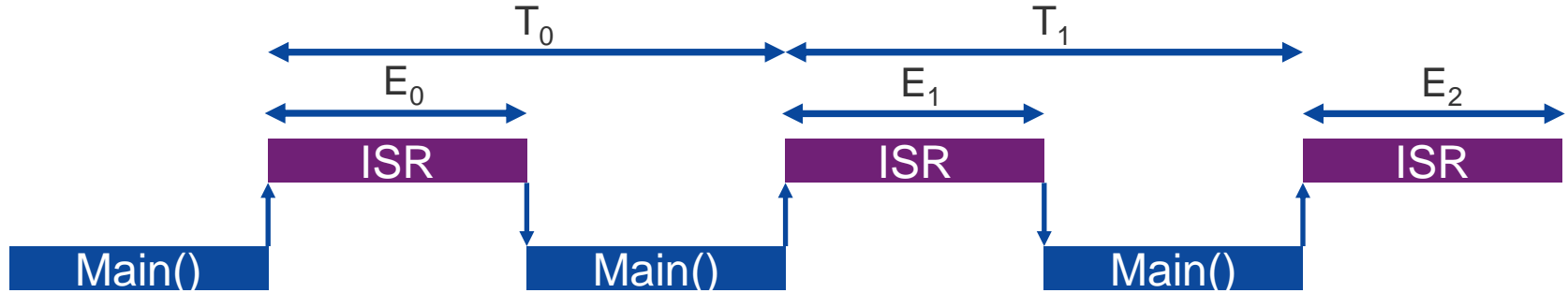
Subjective concept

- Perception of the system reacting immediately to user inputs
- System reacts within x milliseconds to an external input:
 - Usually
 - Most of the time
 - All the time, otherwise
 - The system fails
 - The system can become damaged
 - Somebody might get hurt

The system is able to control a physical process at a speed suitable to the process under control

What we usually mean by Real Time is Determinism

Determinism



Periodic Interrupts

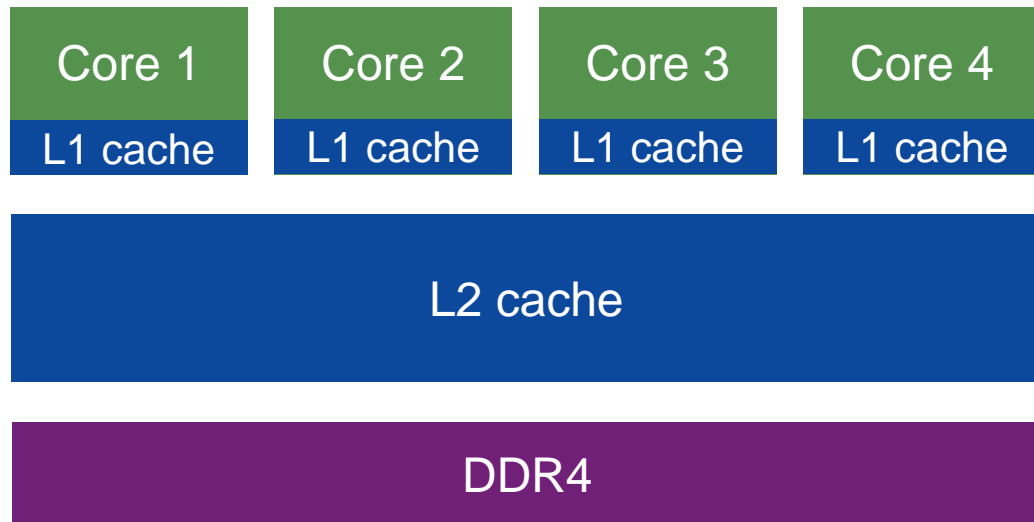
- $T_0 = T_1$

Consistent Execution Times

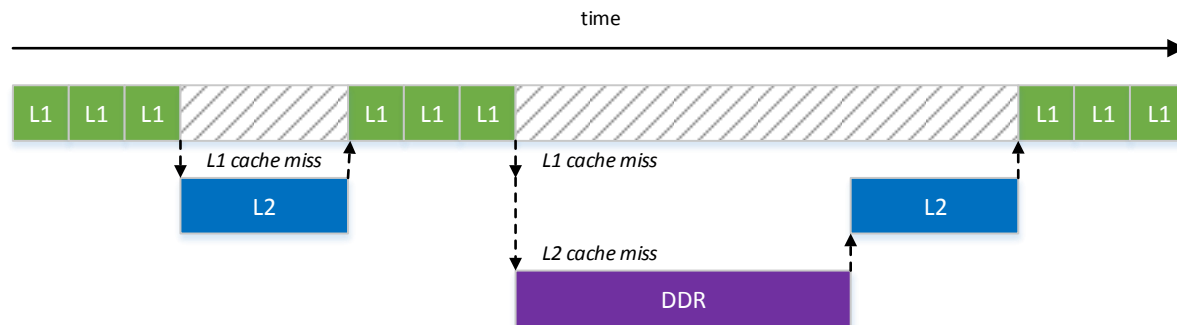
- $E_0 = E_1 = E_2$

Standard Application Processor

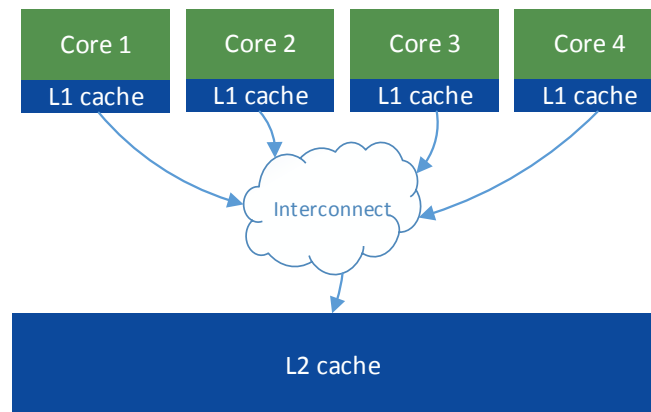
- **Memory Hierarchy**
 - L1 cache
 - L2 cache
 - DDR memory
- **Micro-architecture performance enhancement features**



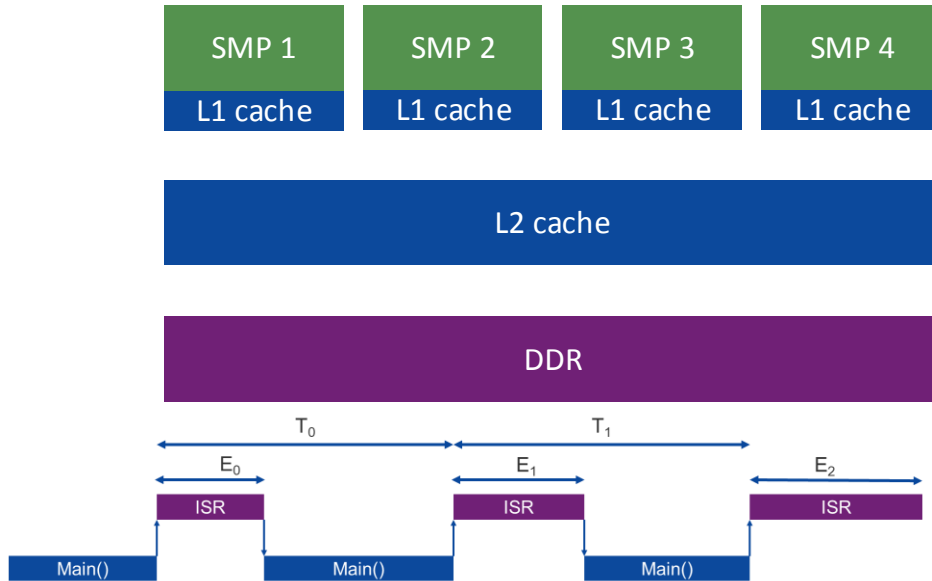
Memory Hierarchy and Determinism



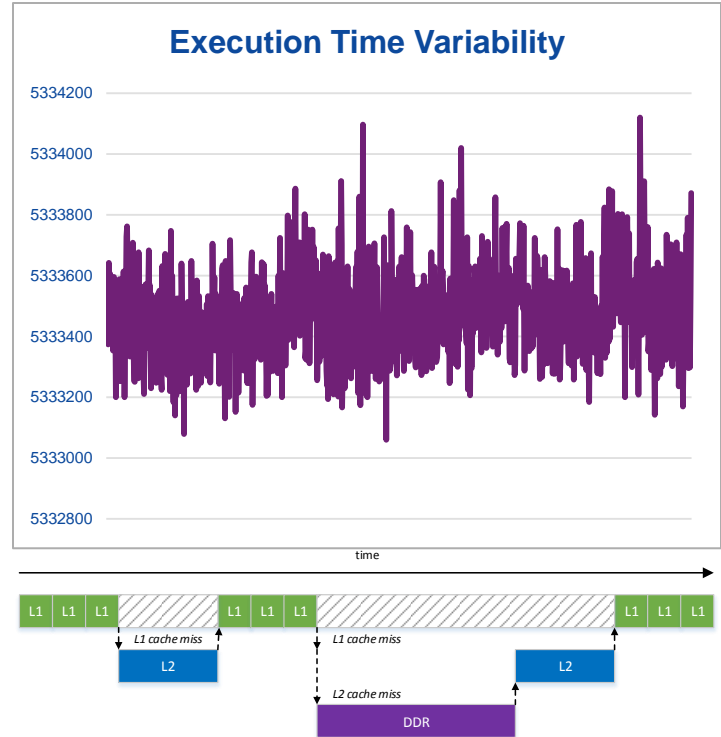
- **Cache misses affect determinism**
 - Retrieving data from DDR is non-deterministic
 - Accessing to L2 cache is non-deterministic



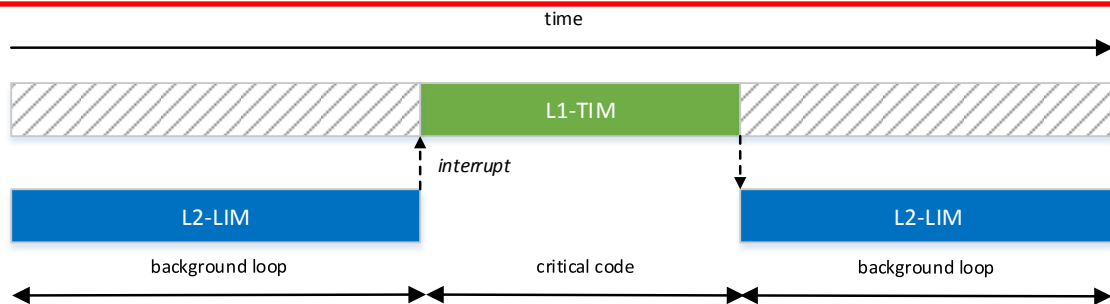
Measured ISR Execution Time in a Quad Core CPU



- Periodic Interrupts
 - $T_0 = T_1$
- Inconsistent Execution Times
 - $E_0 \neq E_1 \neq E_2$

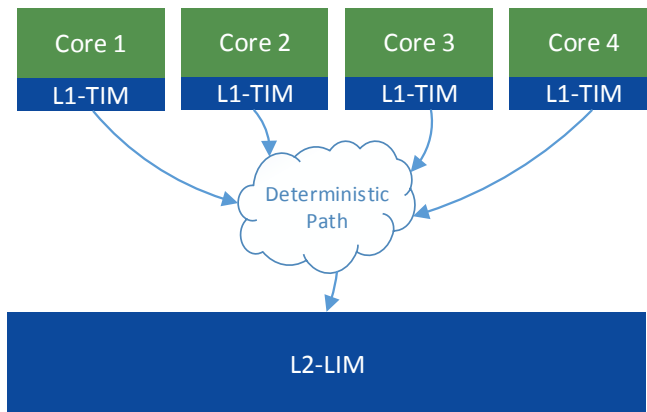


Background - Foreground



Classic real-time system

- Infinite background loop executes main application code
- Time-critical code is executed as a result of an interrupt





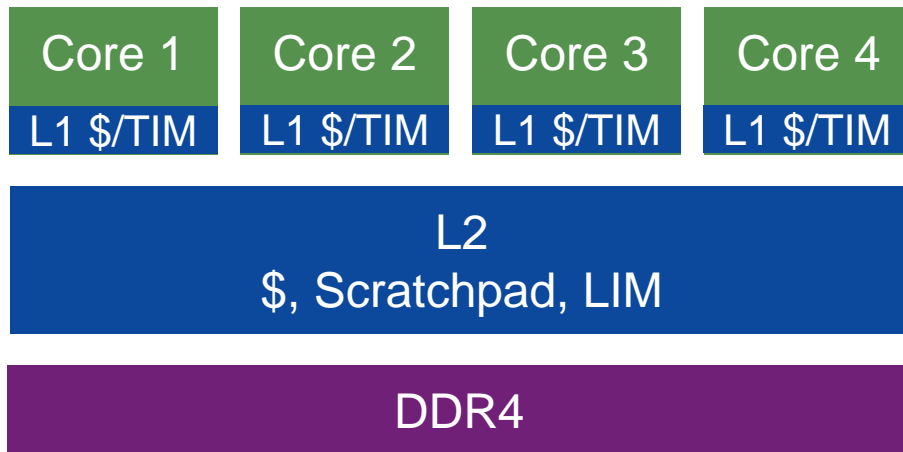
PolarFire SoC Flexible Memory Subsystem

Configurable L1 memory subsystem

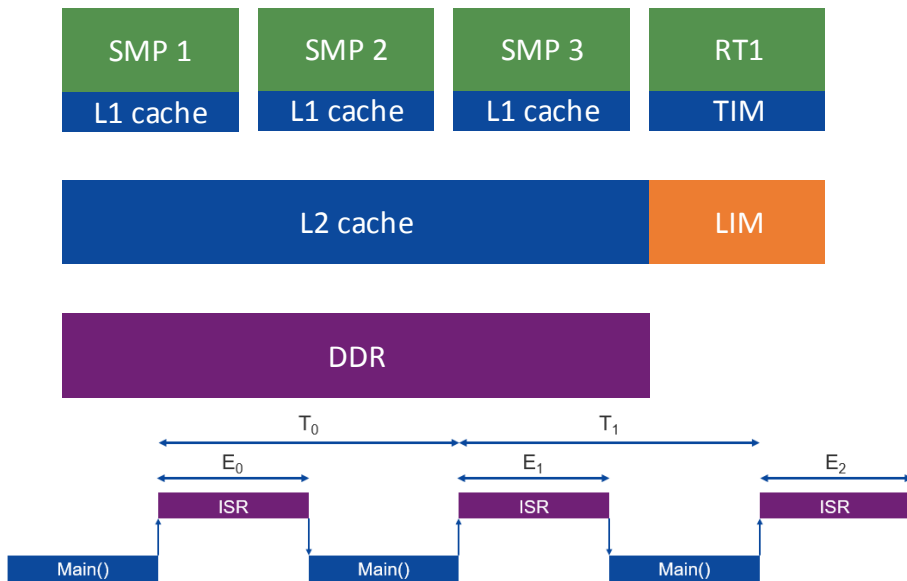
- As cache
- As a tightly integrated memory

Configurable L2 memory subsystem

- As a cache
- As a scratchpad memory
- As a Loosely Integrated Memory (LIM)
 - Direct addressing of memory

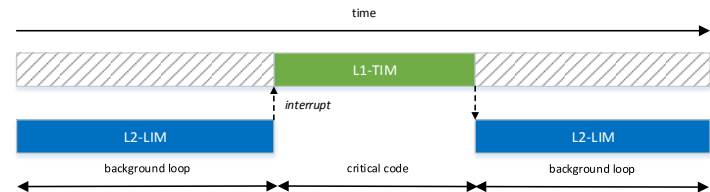
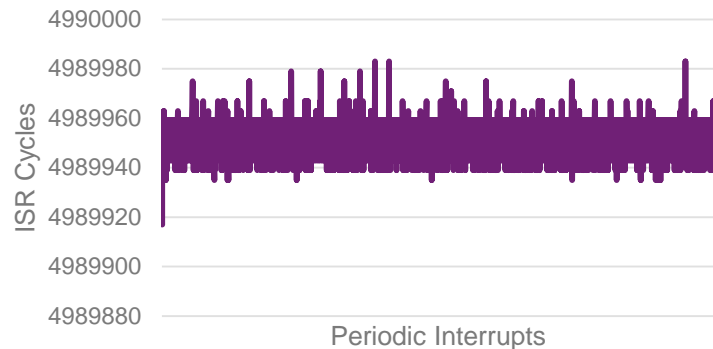


Flexible Memory Subsystem Provides ISR Determinism

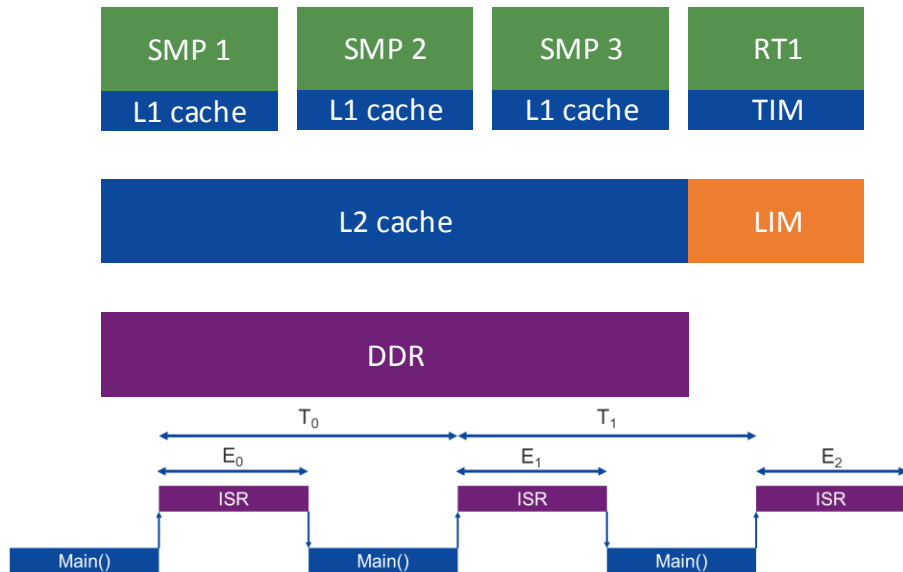


- Periodic Interrupts
 - $T_0 = T_1$
- More Consistent Execution Times
 - $E_0 \approx E_1 \approx E_2$

Execution Time Variability

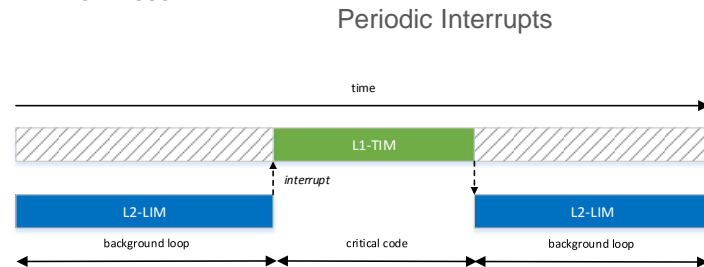
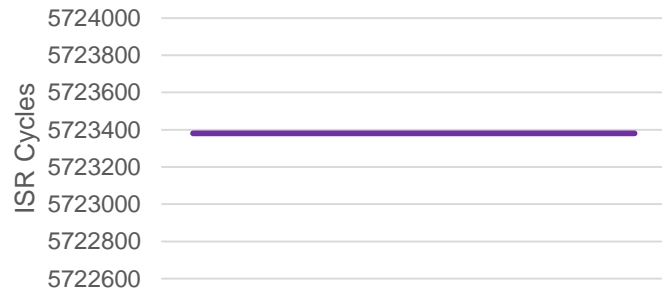


Micro-Architecture Also Impacts Determinism



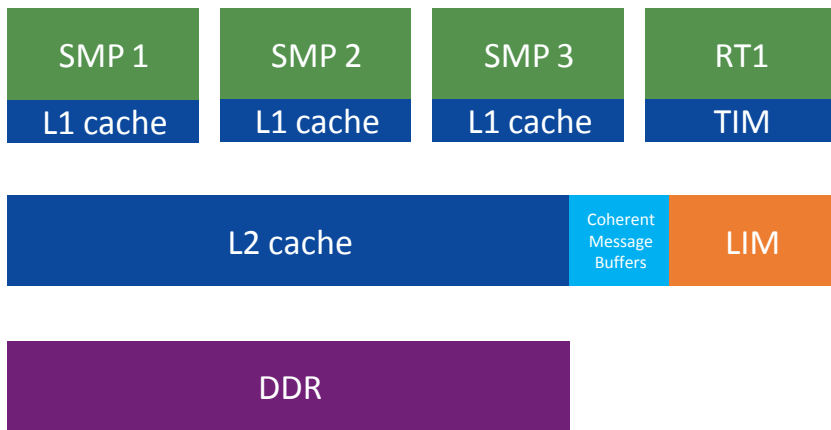
- Periodic Interrupts
 - $T_0 = T_1$
- Consistent Execution Times
 - $E_0 = E_1 = E_2$

Execution Time Variability



Disable branch predictor during critical code execution, or permanently

Coherent Message Passing in AMP systems

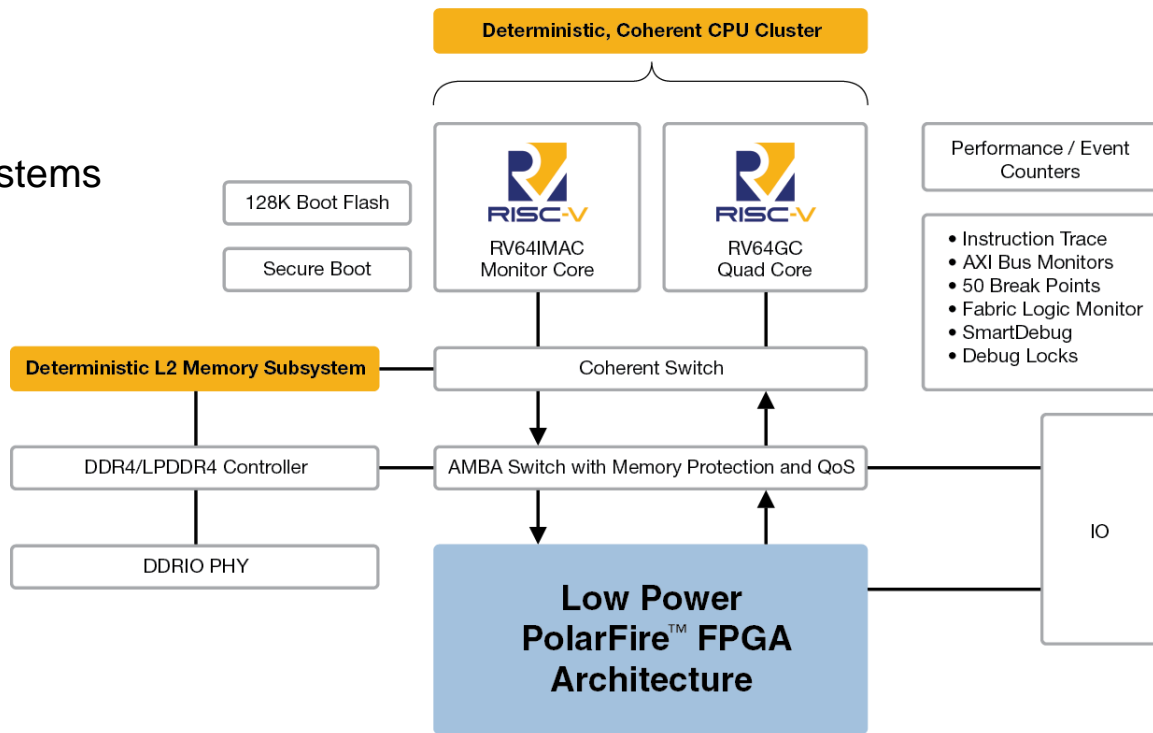


- L2 cache for SMP cluster
- L2 LIM for real-time
- L2 scratchpad for coherent message passing

PolarFire SoC: RISC-V Enabled Innovation Platform

Freedom to Innovate in

- Linux and real-time
- Thermal and power-constrained systems
- Securely connected IoT systems
- High-rel safety-critical systems

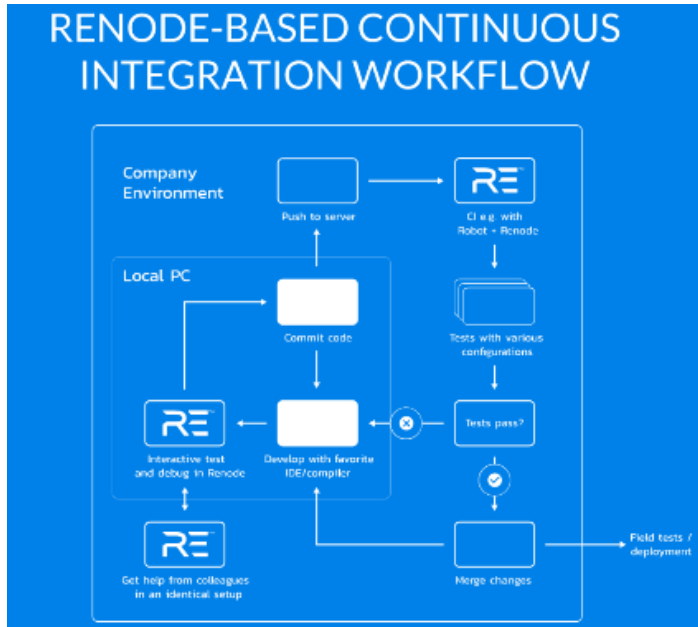


Freedom to Engage with the Mi-V Ecosystem

New Mi-V Embedded Experts Network



Freedom to Start Software Development



RENODE™

Free rapid software development and debug capabilities without hardware

Complete PolarFire SoC processor subsystem model

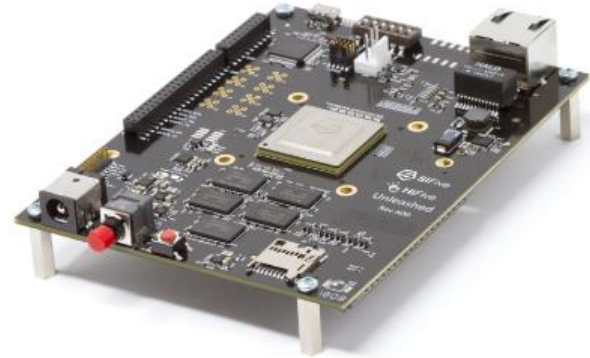


Freedom to begin hardware development

PolarFire SoC Embedded Experts Development Kit



HiFive Unleashed Expansion Board



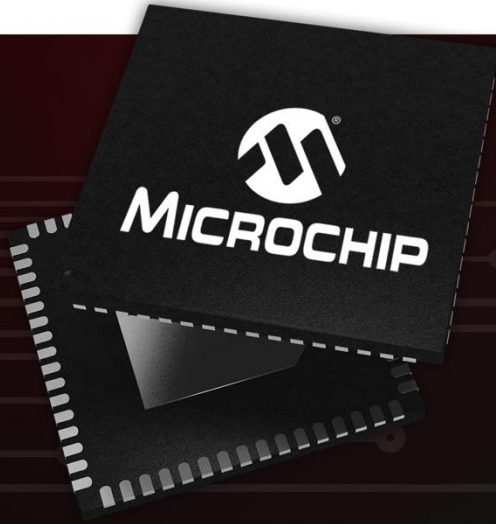
HiFive Unleashed Development Board

Summary

- ***PolarFire SoC* gives designers the freedom to create innovative low-power systems by enabling Linux and deterministic architectures in novel ways**
 - **First SoC FPGA** with deterministic, coherent CPU cluster and a deterministic L2 memory subsystem enabling Linux + real-time applications
 - **First SoC FPGA** architecture integrating a RISC-V processor subsystem and low-power FPGA technology
 - **PolarFire SoC** addresses the industry's need for a mid-range, low-power SoC FPGA with high levels of security and reliability
- **Developers can begin development today**
 - antmicro Renode platform for software development
 - PolarFire SoC Embedded Experts Development Kit for hardware development
 - New Mi-V Embedded Experts Network



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THANK YOU