



Falcon: A Dual-Core Lockstep Microprocessor Based on RISC-V ISA

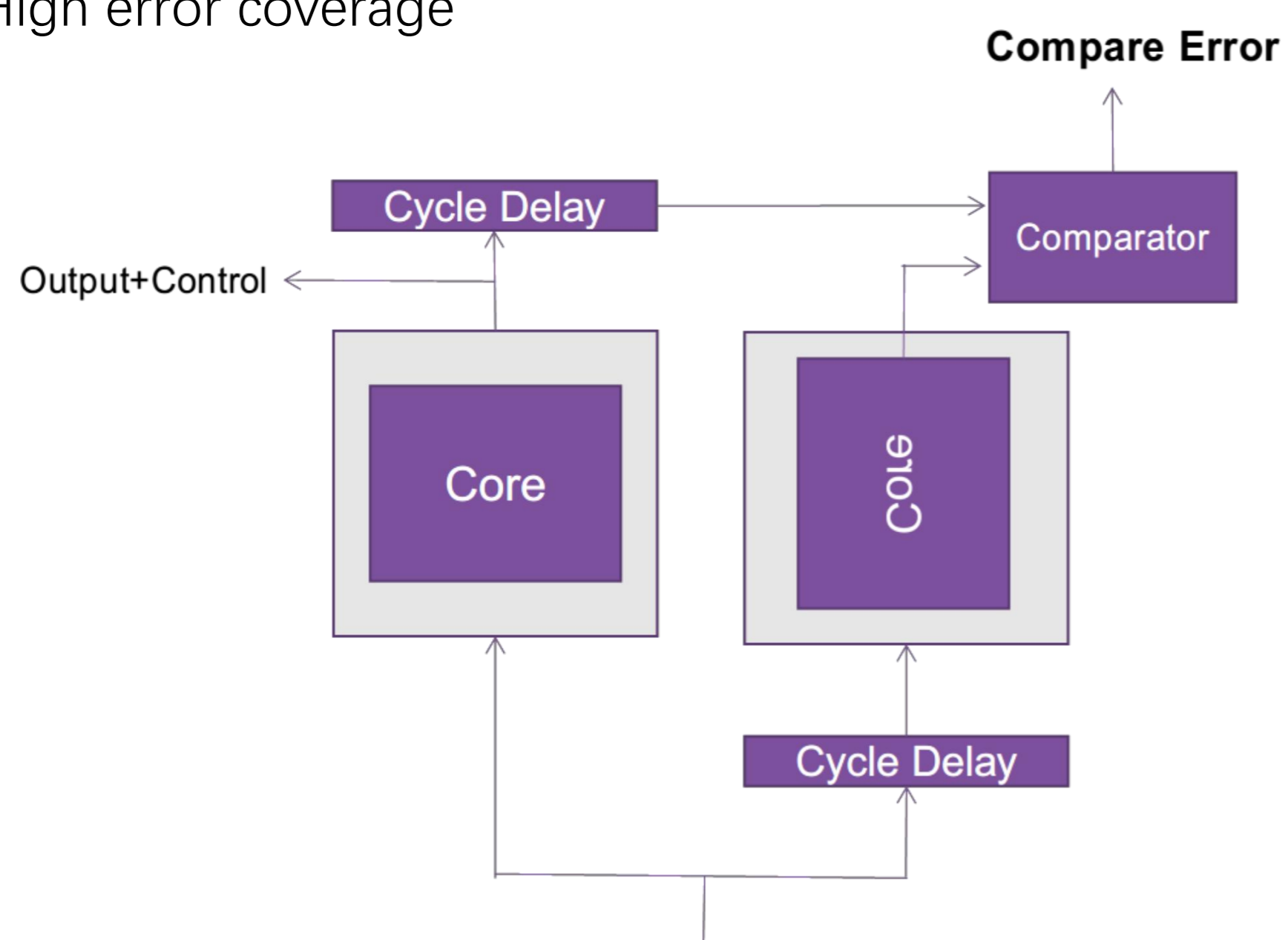
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Dual-Core Lockstep Basic

To meet the requirements of high reliability and safety in the automotive industry → Dual-Core Lockstep

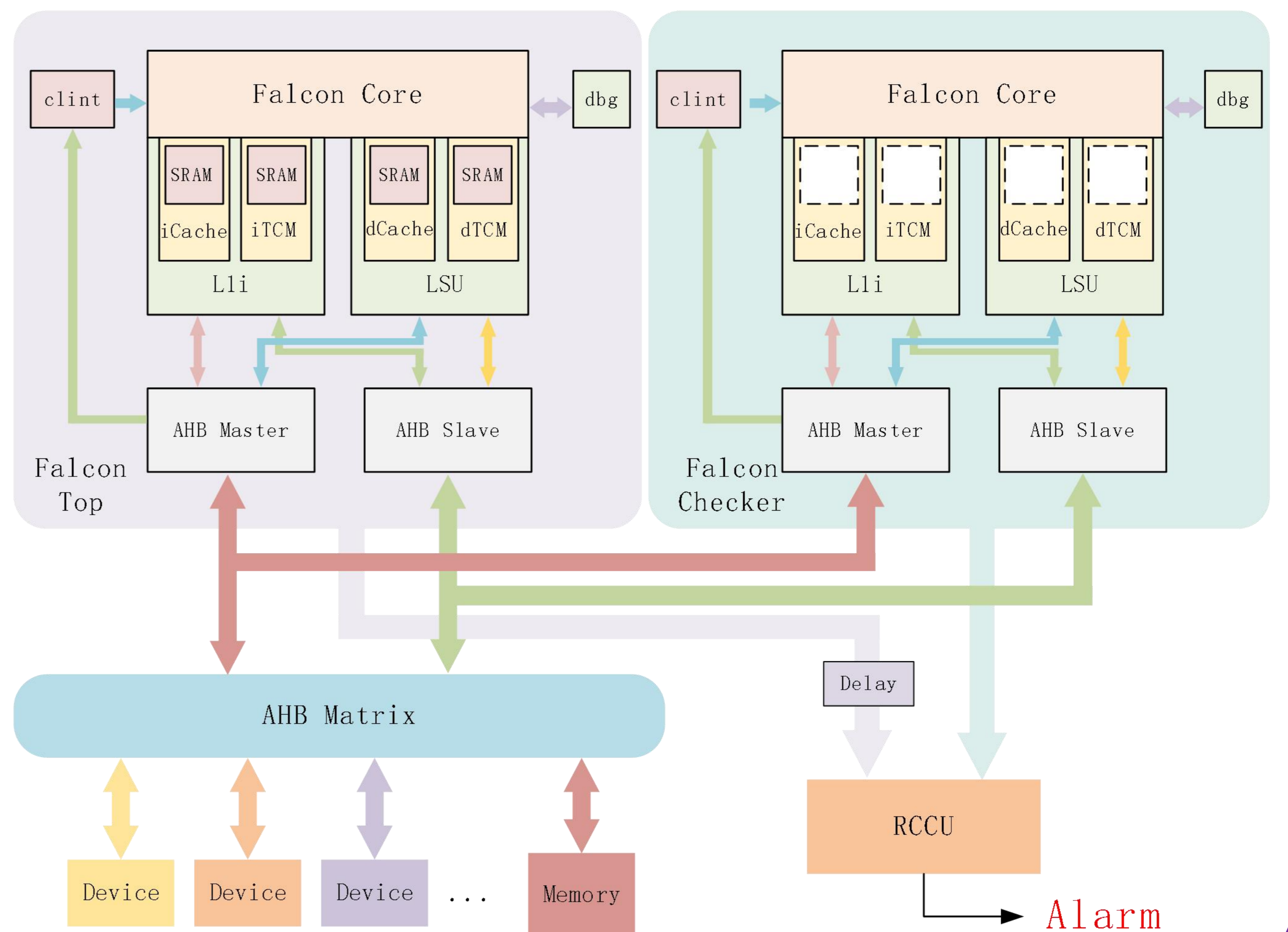
Run two identical processor cores in parallel and comparing their outputs

- Reduced software overhead
- Avoided common-mode failures in space and time
- High error coverage



Dual-Core Microarchitecture

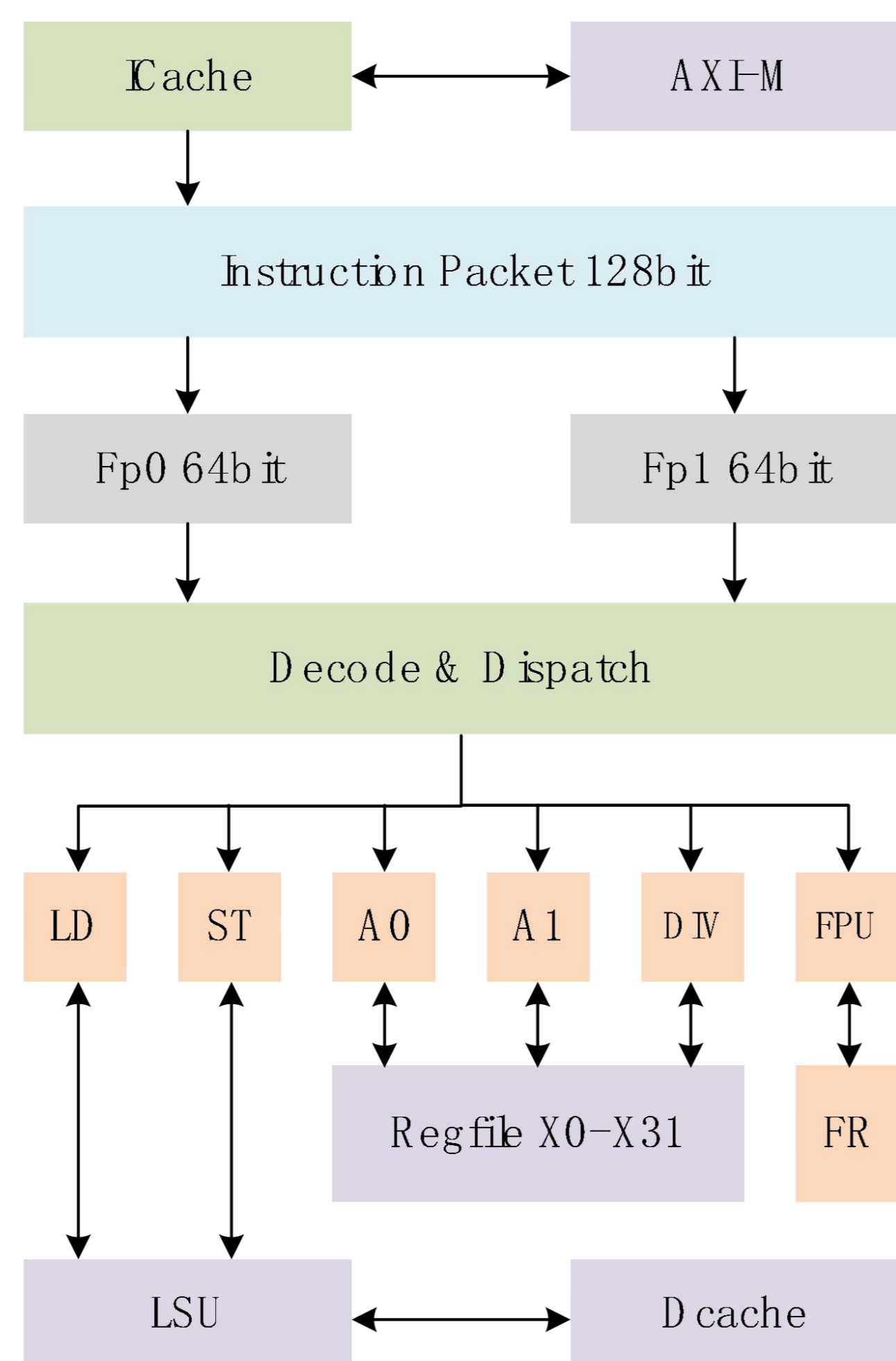
- Building on the single-core microarchitecture
- Adds 16KB Instruction TCM(ITCM) and 64KB Data TCM(DTCM)
- Sphere of Replication(SoR) Level : off-core level
- Redundancy Control and Checker Unit (RCCU) for error detection, and if inconsistency occurs, it is reported to the Interrupt Controller and handled through interrupt for error rollback and recovery



Single-Core Microarchitecture

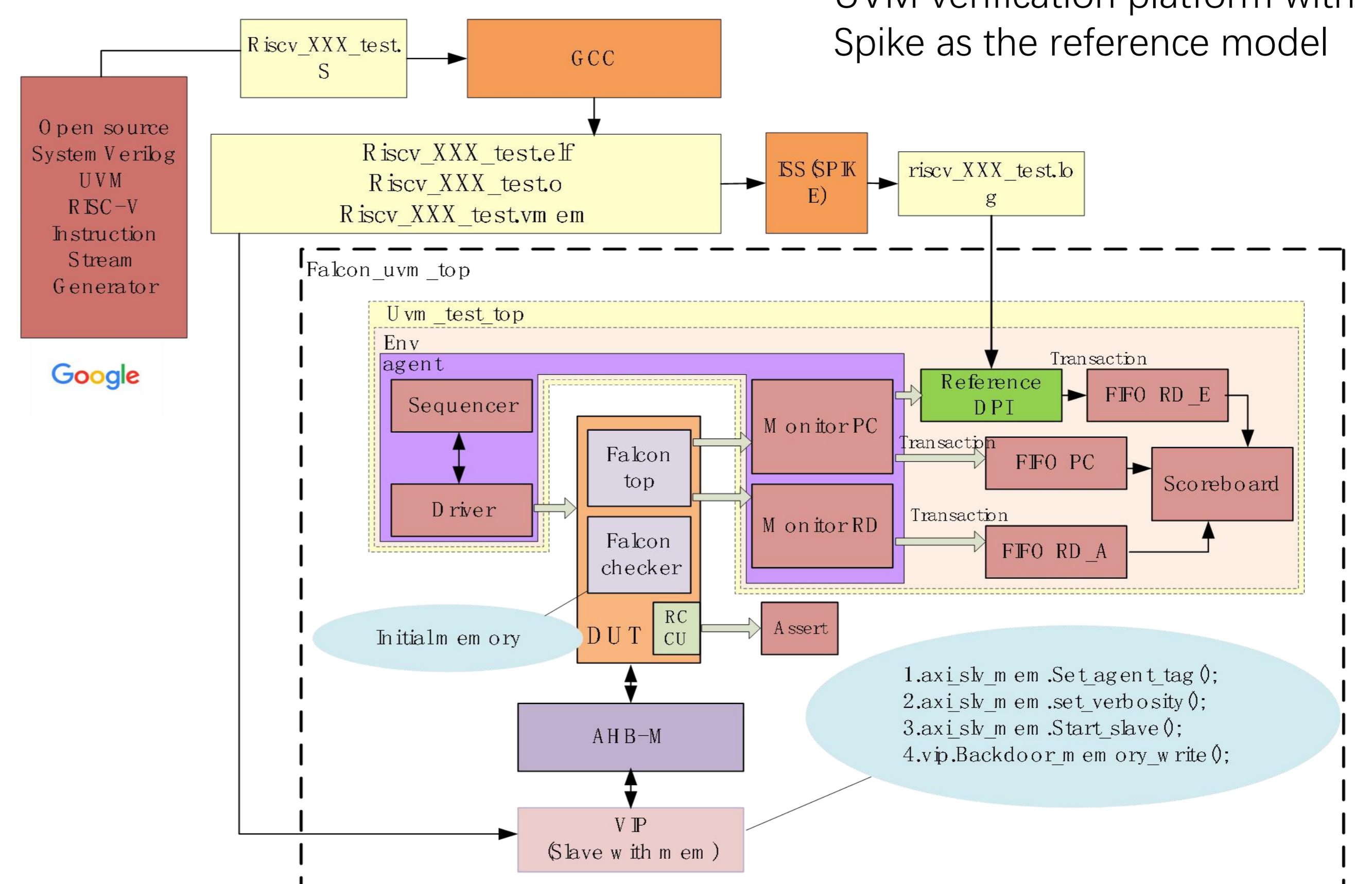
A 32-bit dual-issue in order RISC-V processor

- Support RV32IMAFDC
- 6-stage pipeline arch
- In-order dual-issue
- With branch prediction
- Width low-power design
- MMU integrated
- PMP integrated
- ICache and DCache
- Support for interrupt, debugging and off-chip memory
- Has been verified by SMIC 40nm



Verification

UVM verification platform with Spike as the reference model



RISC-V in Dual-Core Lockstep

- Open-sourced ISA in Dual-core Lockstep Arch
- Performance equivalent to commercial automotive SoCs
- Software compatible with IAR(an embedded software development tools)

Conclusion & Outlook

We have implemented Falcon, a RISC-V-based dual-core lockstep MCU, and completed its verification work successfully. Our work demonstrates that RISC-V can fully leverage its open-source advantages in the automotive safety MCU market and open up a market comparable to ARM and PowerPC.

We plan to complete the tape-out work of Falcon in 40nm Process by the end of this year.

Performance Comparison

Performance comparison table between Falcon and mainstream lock-step cores such as Power e200z7 and ARM Cortex-R5, which proves that Falcon is comparable to market-leading products in terms of performance.

	Falcon	E200z7	ARM R5
ISA	RV32GC	Power ISA Embedded	ARM v7-R, AArch32
Memory Protection	PMP	MPU (optional)	MPU (optional)
FPU Integrated	Integrated	Integrated	Optional
Issue Width	2	2	Selected Dual Issue
Dhrystone (DMIPS/MHz)	1.82	2.27	1.67
Coremark (Coremark/MHz)	2.90	2.00	3.47