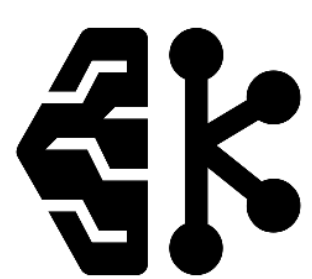
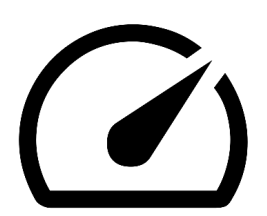


Edge and embedded intelligence calls for **powerful, multi-core processing units**.

- **Agentic Embodied AI:** mixed-criticality perception, planning and control



- **Software-Defined Vehicles:** many ECUs consolidated onto few multi-core SoCs



The **open-source landscape** today:

- **Custom HDLs**
- **Custom protocols**
- **Complex** third-party SoC **integration** and **certification**
- **Many-core platform** using **directory based coherence**
- **Excessive overhead** for embedded low core count clusters

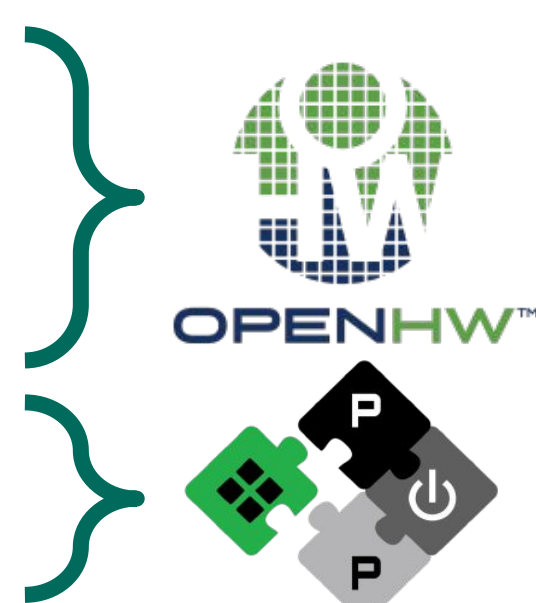


We introduce the **Culsans cluster**:

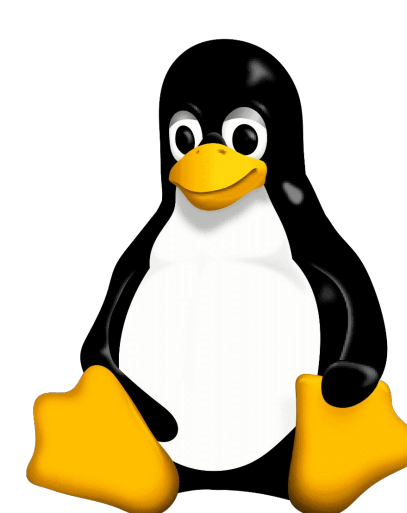
- Synthesizable **SystemVerilog**
- Industry-standard **AMBA4 ACE**
- Based on industry-academia backed OpenHW's **CVA6** and **HPDCache**
- Bring **your own SoC**
- **Snoop-based MOESI** coherence
- Optimal performance and cost for **low core count (2-8)**

Three key components make up the **Culsans tightly coupled cluster**:

- 1 **CVA6S+**: RV64GC 6-stage dual-way superscalar core
- 2 **HPDCache**: pipelined, out-of-order, non blocking cache
- 3 **Cache Coherence Unit (CCU)**

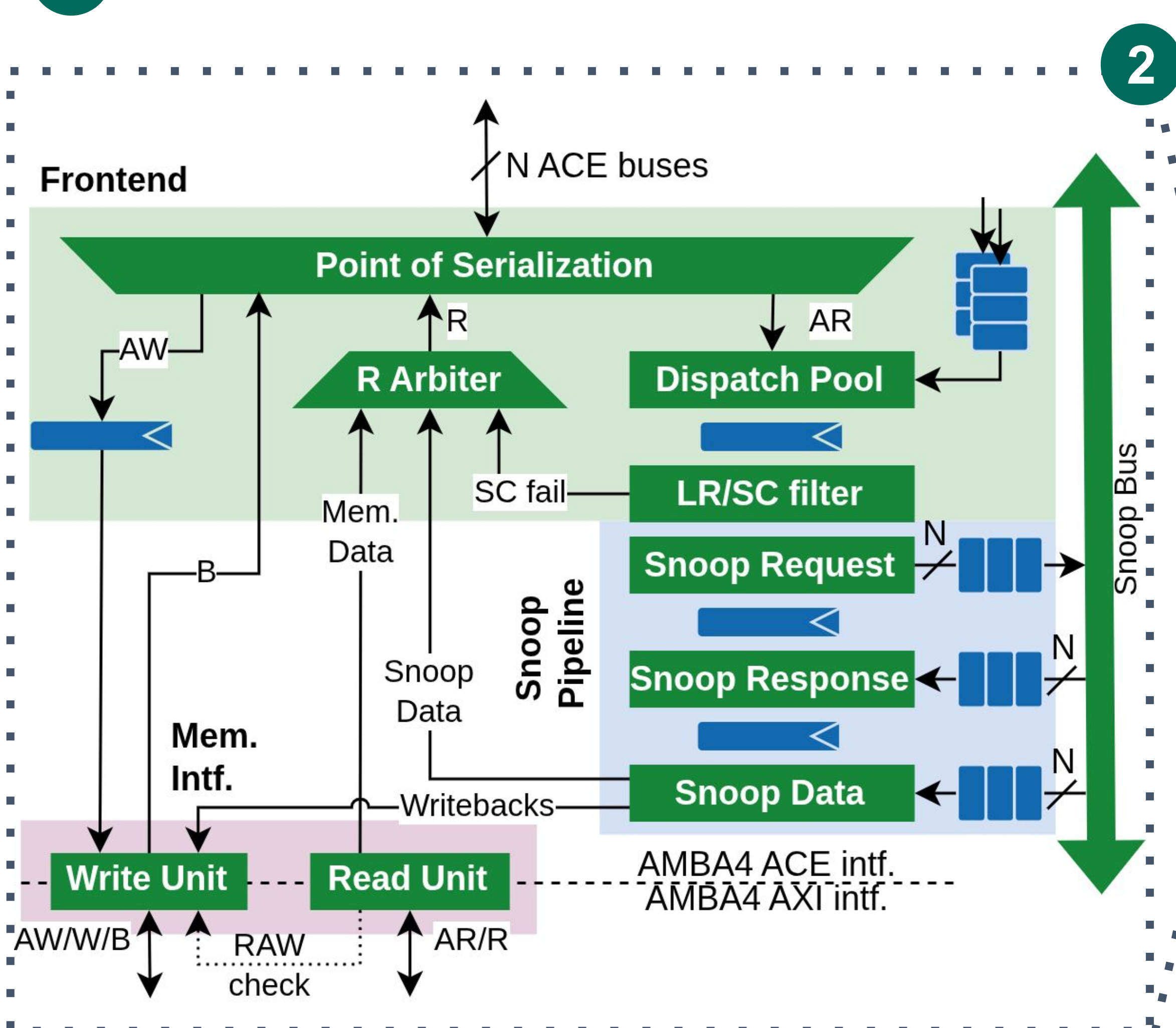


Software stack

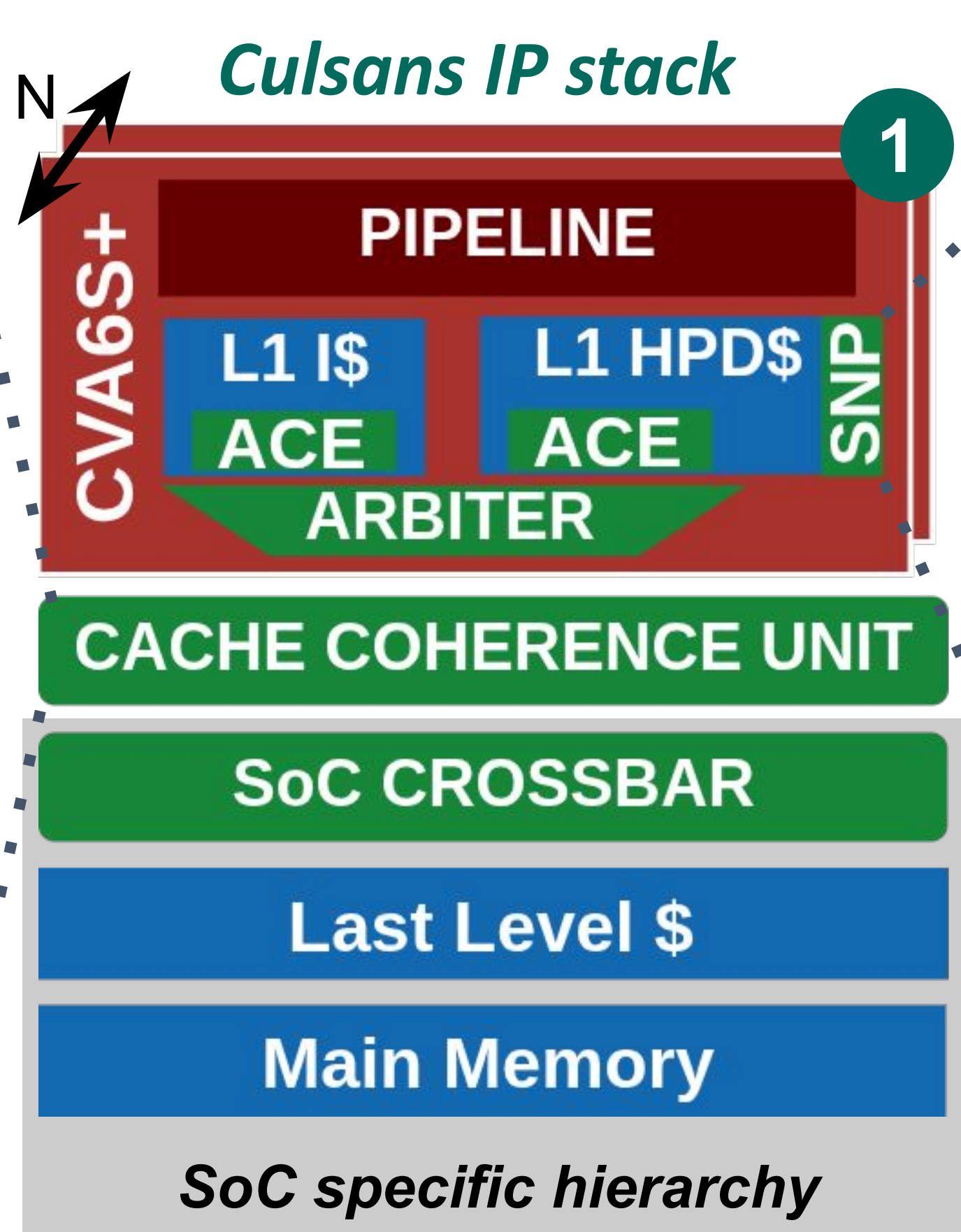


**SMP**  
Linux

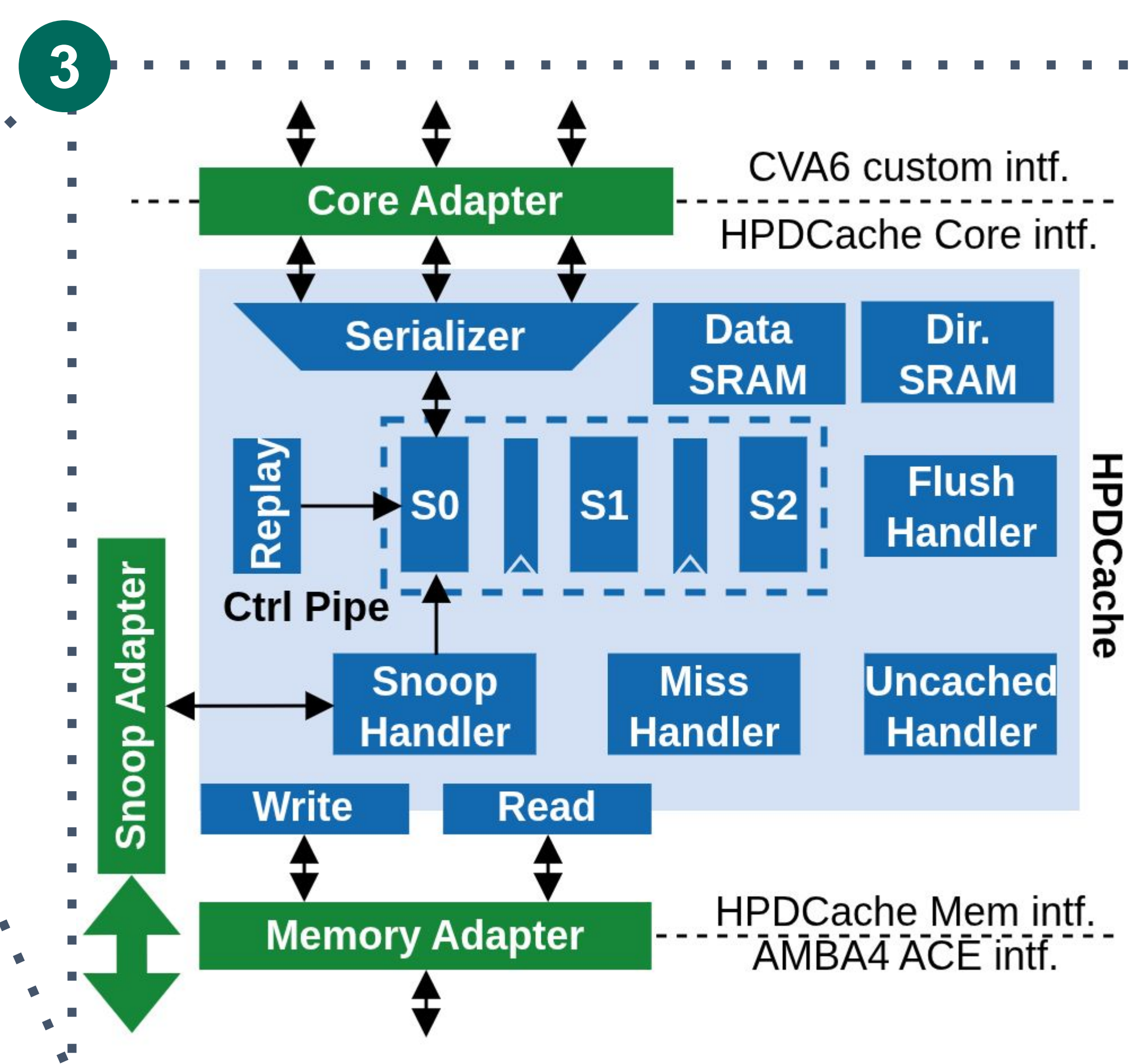
**RTEMS**  
RTOS



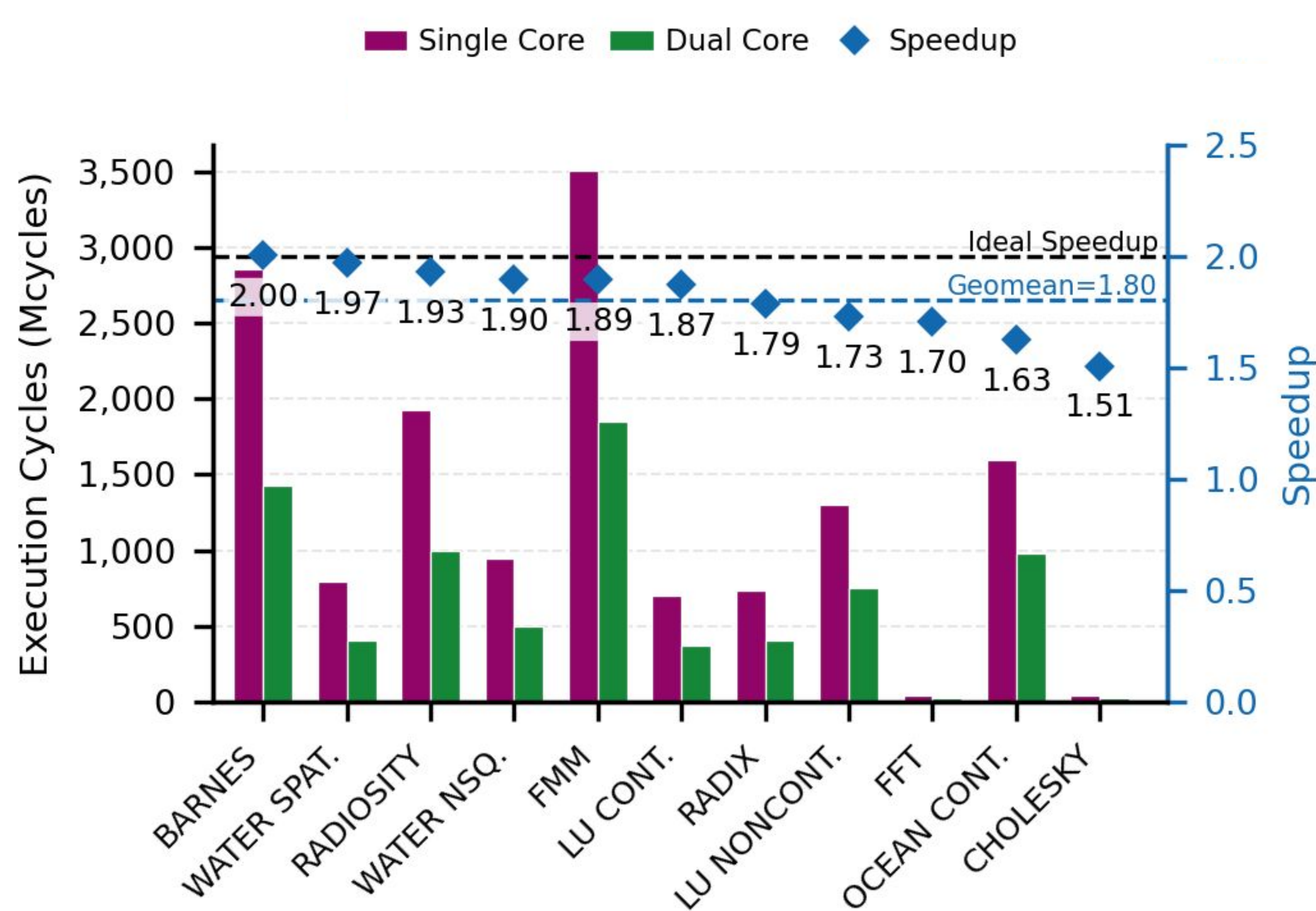
**CCU**: new open-source AMBA4 ACE interconnect implementing **snoop-based MOESI coherence**



Example integration inside the **Cheshire SoC**



**HPDCache**: extended OpenHW's version to support **ACE coherent transactions**

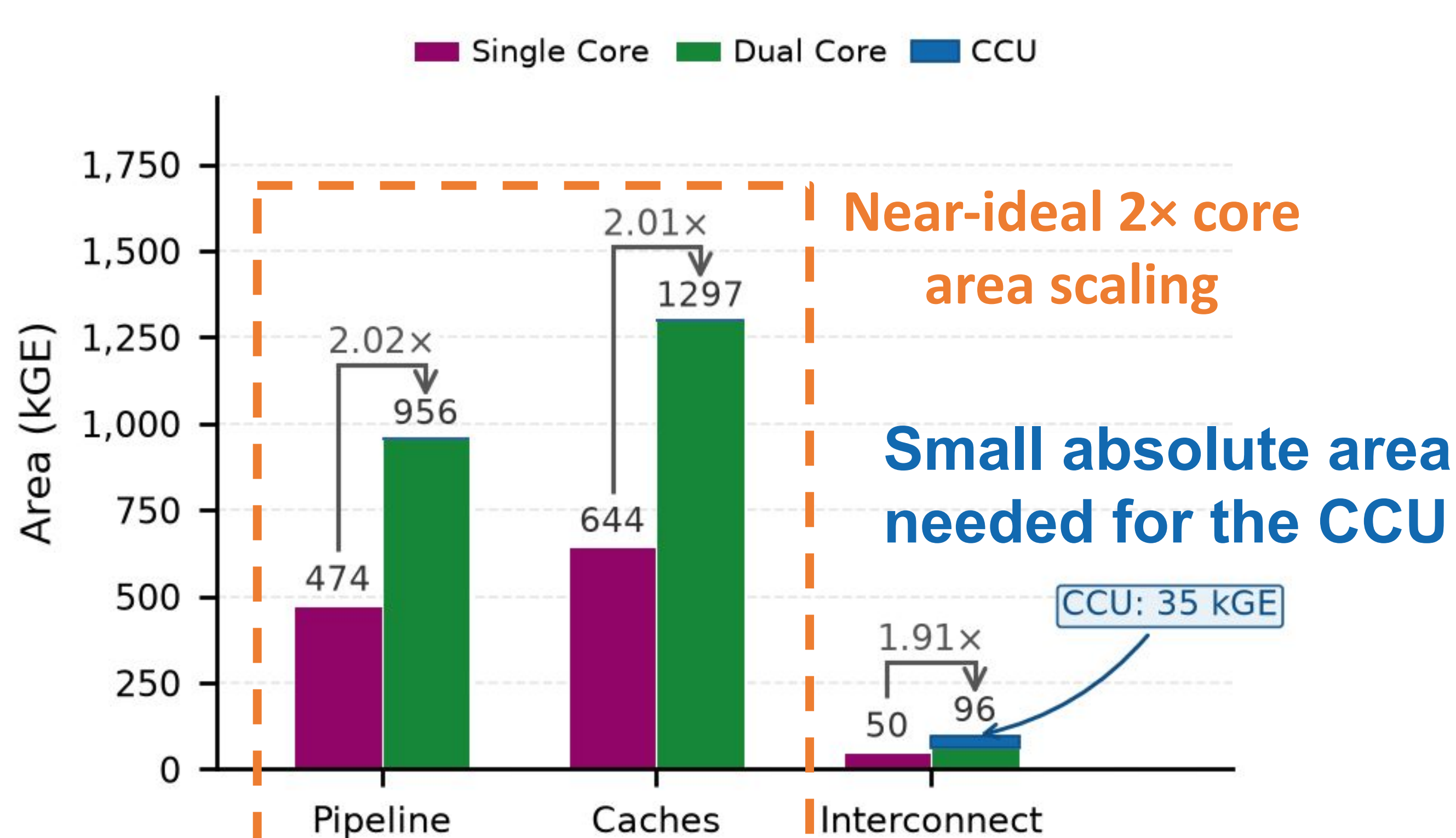


**Speedup** of the **dual-core cluster** over the **single**:

- Benchmarks: **Splash-3** on **SMP Linux**
- Platform: **Cheshire** on **Xilinx VCU128**
- Configuration: **16 kiB I\$, 16 kiB D\$, 128 kiB LL\$**

→ **1.80x geomean speedup** over single core

**GitHub repository**



Area of the **dual-core cluster** over the **single core**:

- Technology: **GF12 nm FinFET - SS, 0.72V, -40°C**
- Topographical Synthesis
- Configuration: **16 kiB I\$, 16 kiB D\$, 128 kiB LL\$**

**Future work**

- Scalability analysis with number of cores
- Power consumption analysis
- PPA versus directory-based solutions