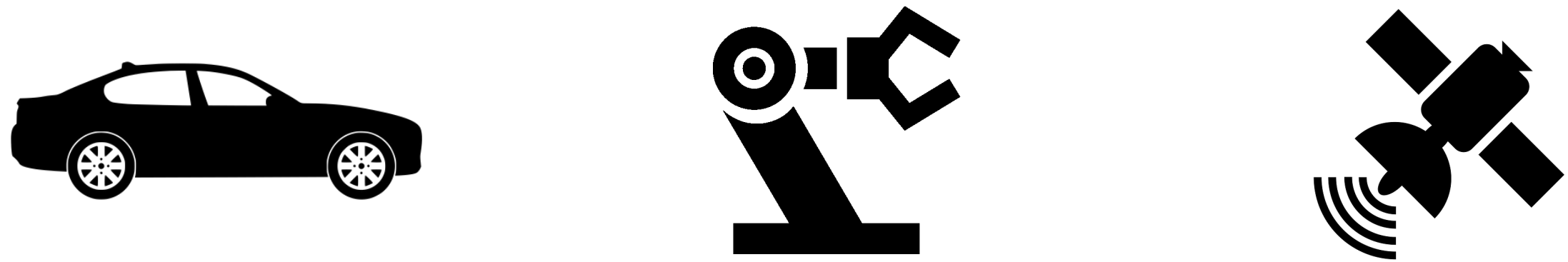


- Growing demand for autonomy in critical embedded applications:** automotive, industrial automation, and aerospace fields are driving the need for **high-performance CPUs**



- RISC-V Open-Source cores:** the ecosystem of open-source RISC-V high-performance cores is growing (BlackParrot, BOOM, XiangShan, and Xuantie C910)

We present **CVA6S+**, extending CVA6S with:

- 1) Better branch prediction
- 2) ALU-ALU forwarding
- 3) Register renaming
- 4) FPU support

We integrate CVA6S+ with the the OpenHW Core-V High-Performance L1 Data Cache (**HPDCache**)

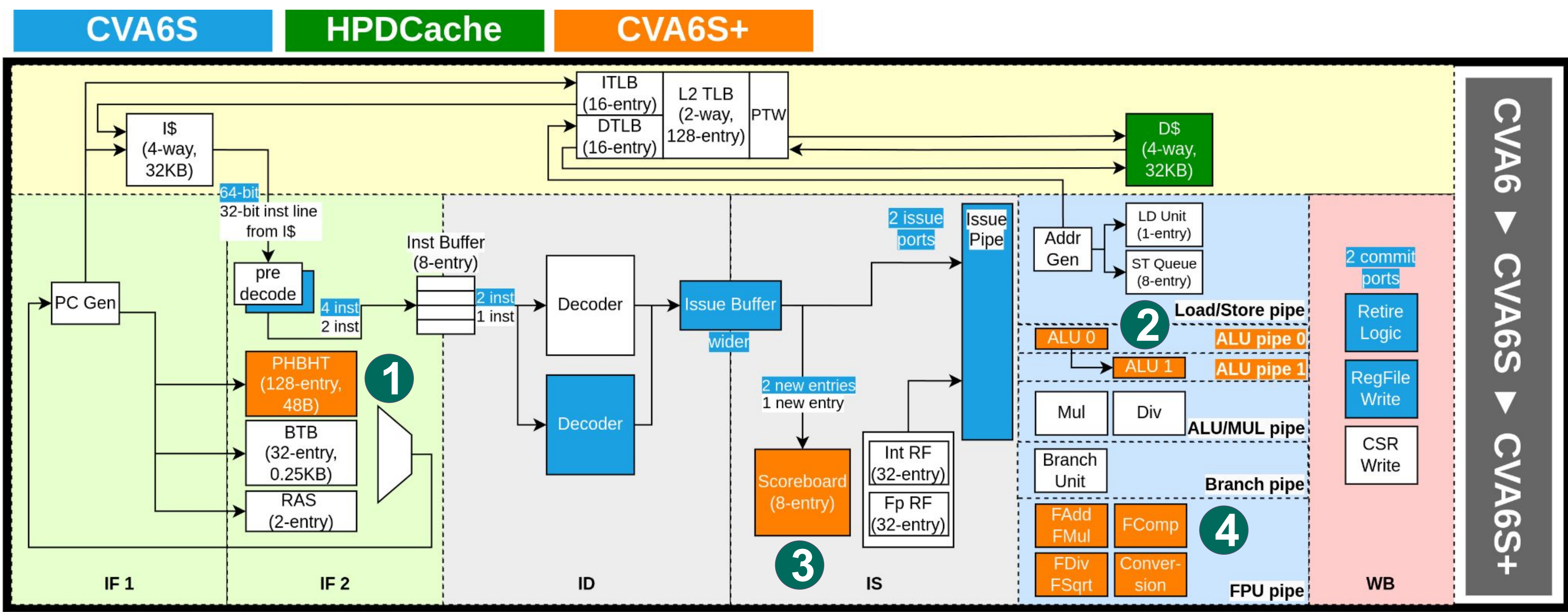
CVA6 is a configurable 64/32 bit RISC-V core maintained by **OpenHW Group** with multiple industrial and academic partners

- 6 stages scalar pipeline: ×2 Fetch (IF), Decode (ID), Issue (IS), Execute (IE), and Writeback (WB)
- In order dispatch, out of order completion, in order commit

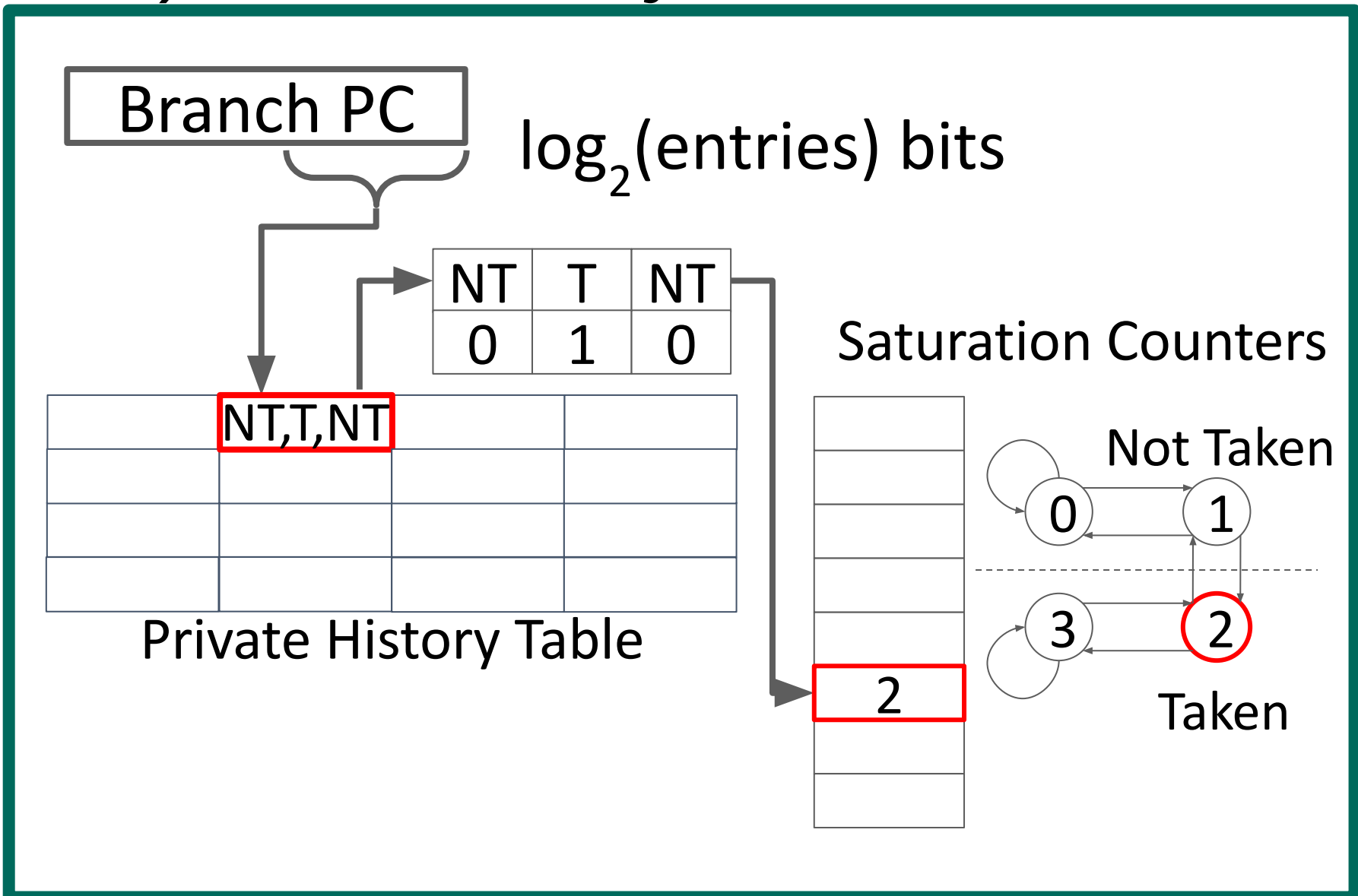
The **IPC** is **limited** by its **simple front-end architecture**



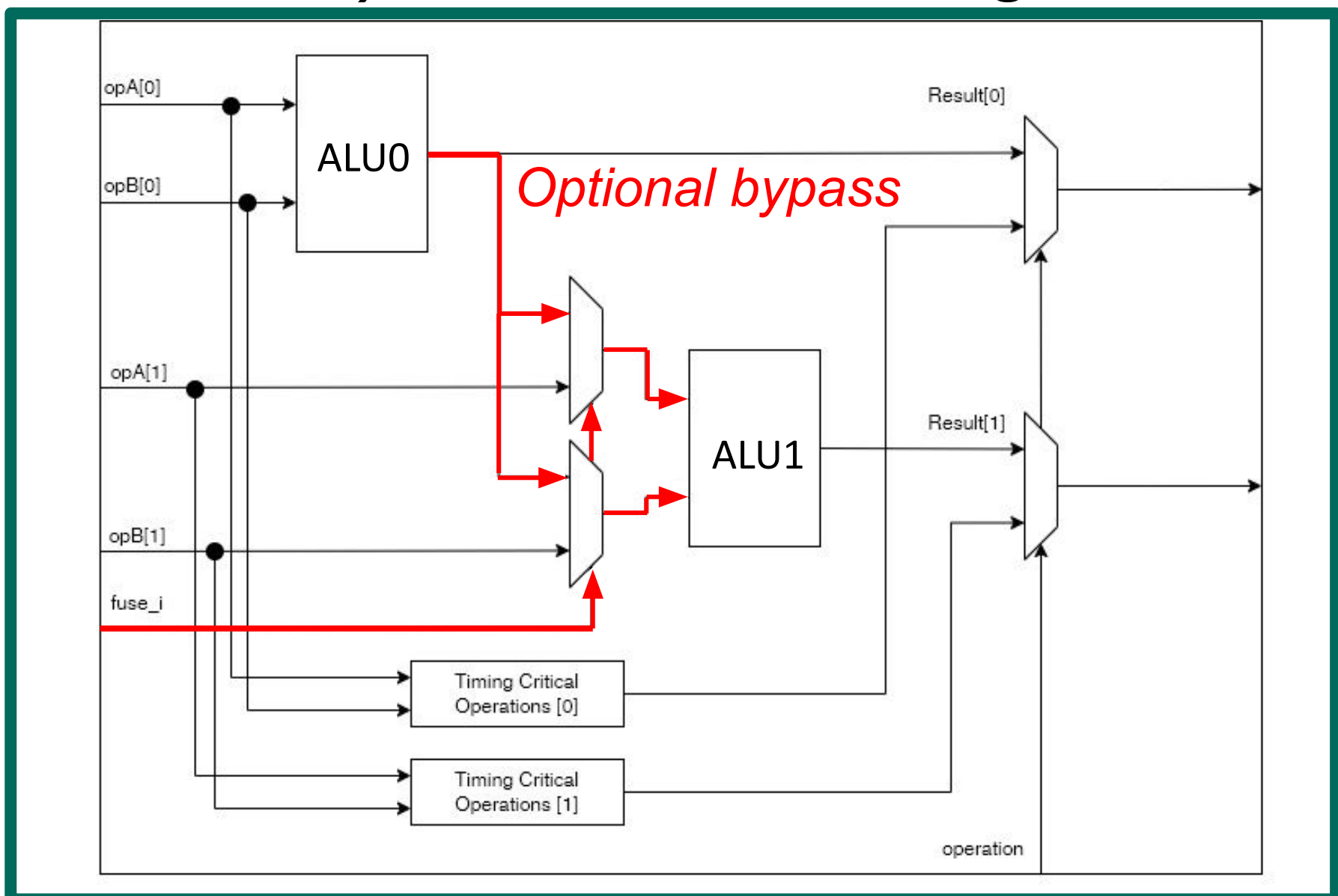
CVA6S is the **superscalar dual-issue** version of CVA6 by Thales



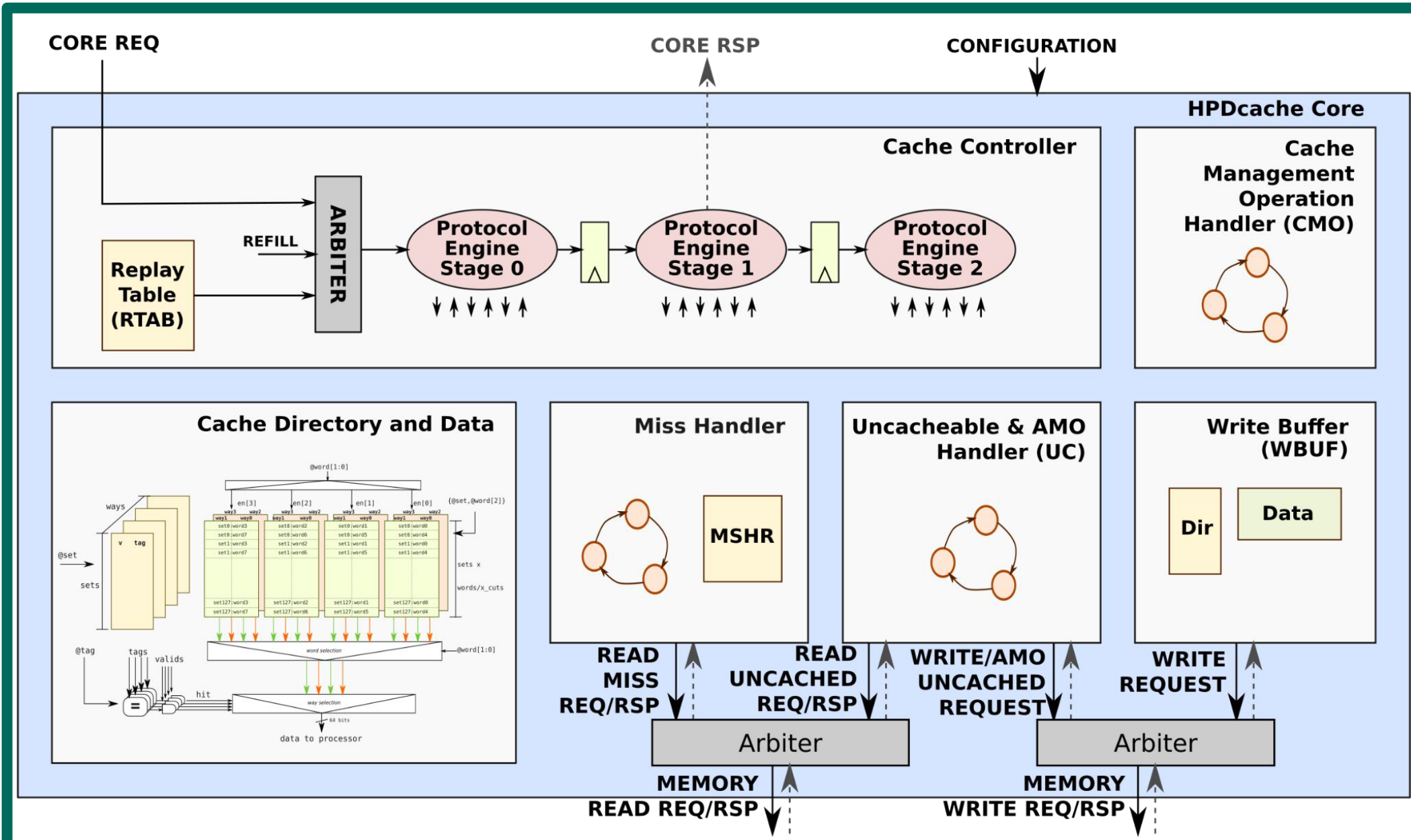
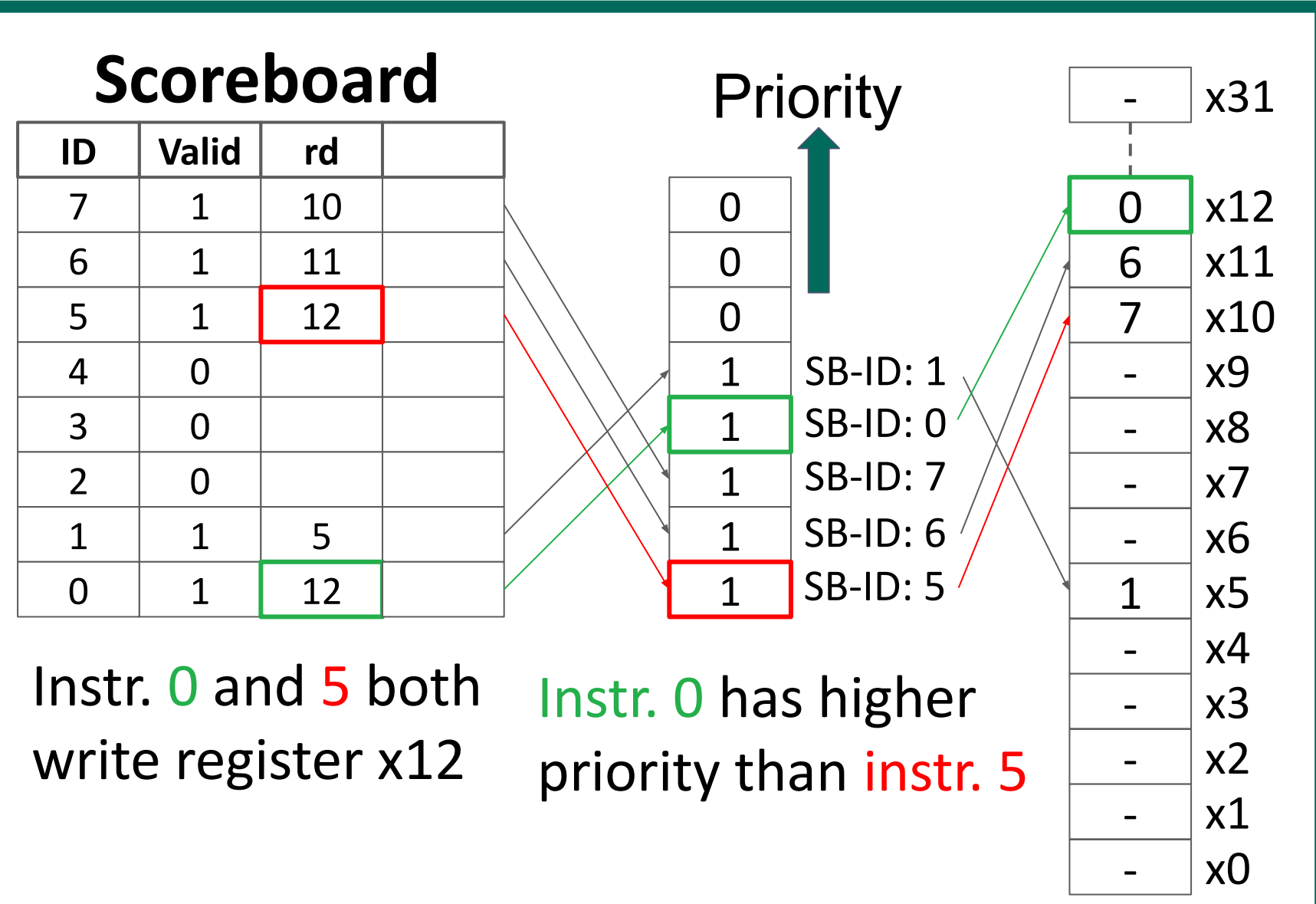
1) Private History Branch Predictor



2) ALU-ALU forwarding



3) Renaming scheme



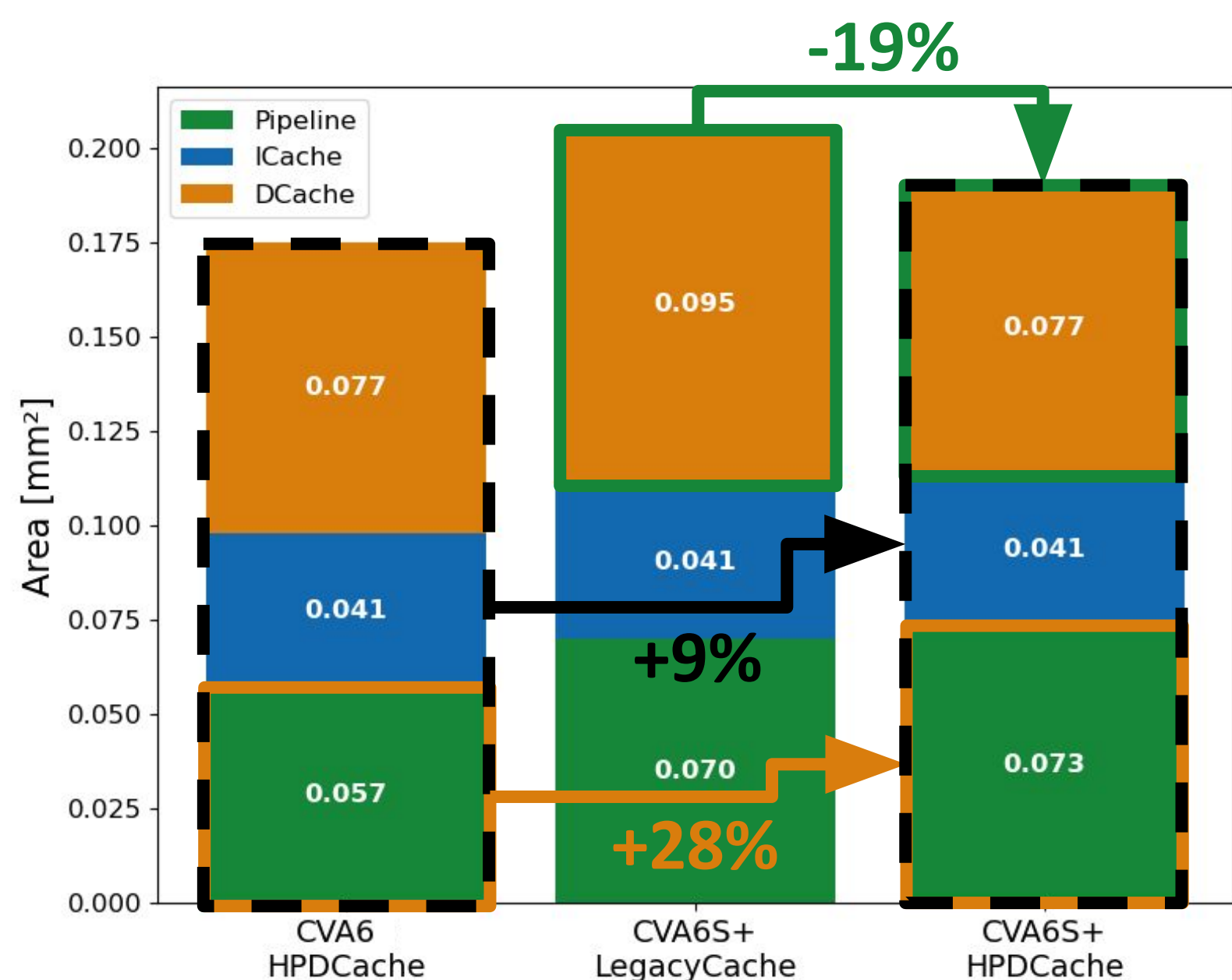
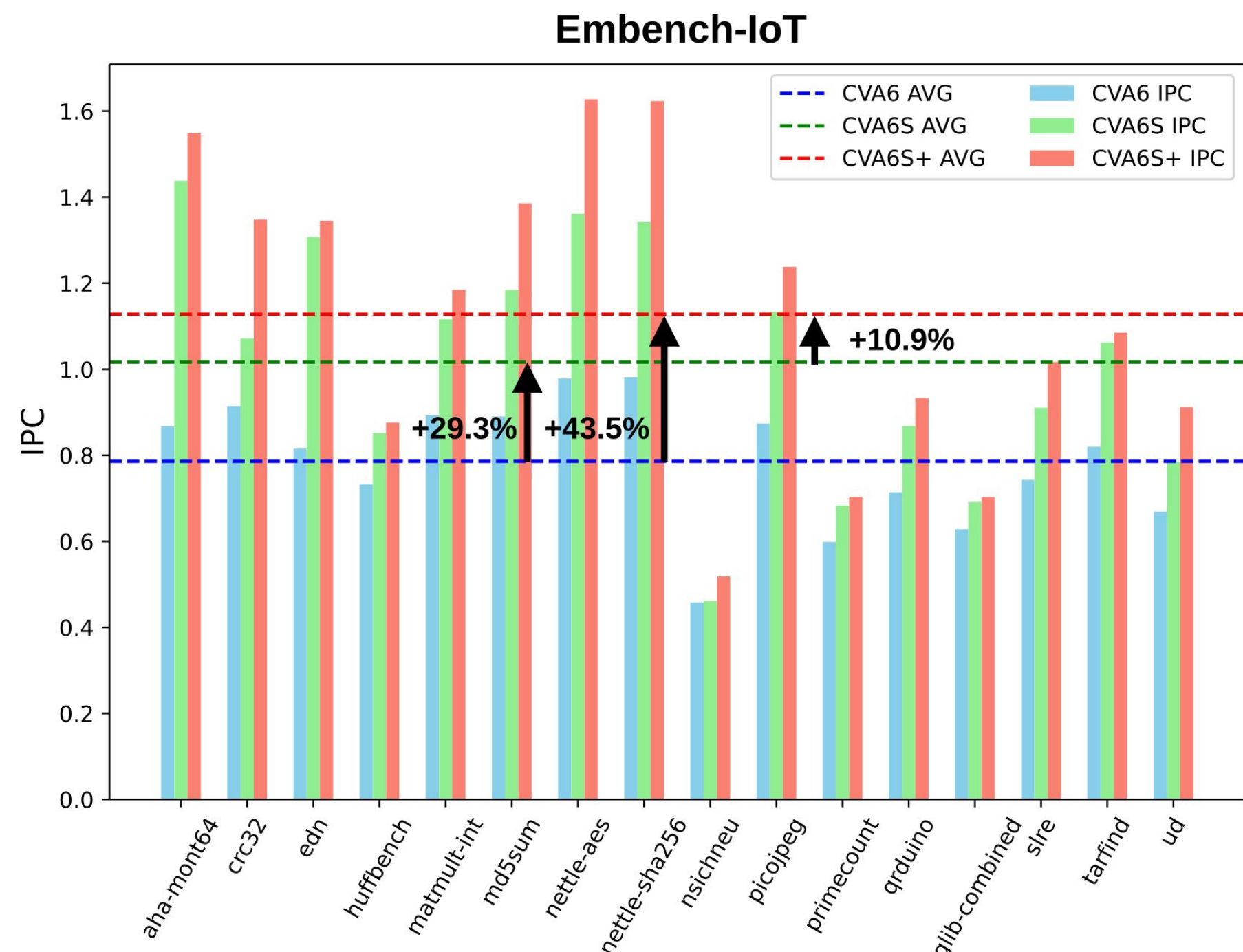
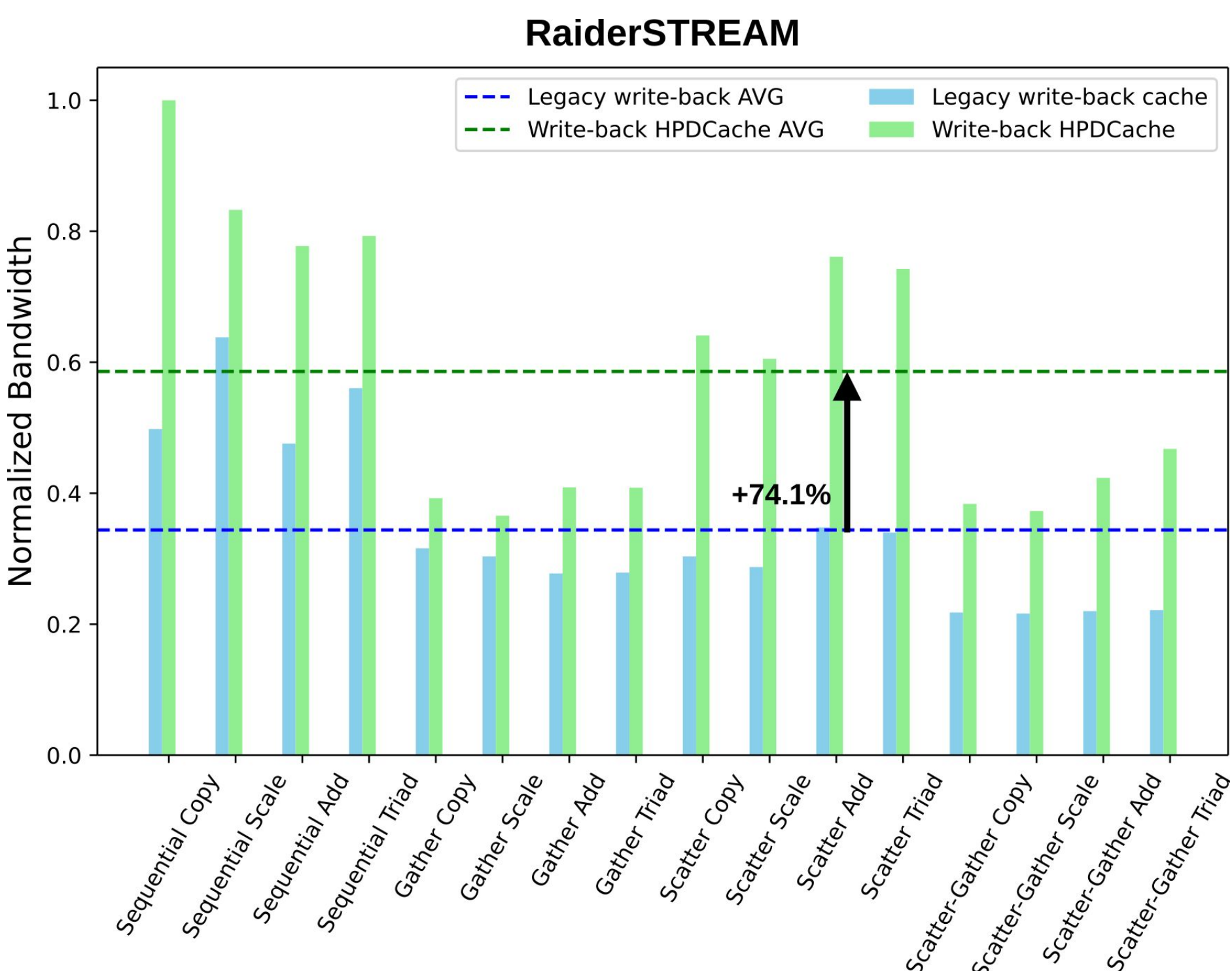
- **Pipelined architecture**, single-cycle read/write hit latency
- **Out-of-Order Execution & Non-Blocking Pipeline**
- Supports both **WB** and **WT** policies on a **cache line-level granularity**

HPDCache overview

- The **scoreboard** is a **circular buffer**
- **RAW hazards** need to know the **newest instruction** to correctly forward data



Rotate the entries based on the **commit pointer** and forward data accordingly



HPDCache vs Legacy cache subsystem

- Same pipeline (CVA6S+)
- **RaiderSTREAM**: working set 2× cache size
- **+74.1% bandwidth** with HPDCache
- **Cache area is reduced by 19%** due to better SRAM organization

CVA6S+ vs CVA6/CVA6S

- Same cache subsystem (HPDCache)
- **Embemch-IoT**: working set fully cached
- **+43.5% IPC** vs CVA6 / **+10.9% IPC** vs CVA6S
- **Pipeline area: +28% / Total area: +9%**
- **Max. Frequency: 1090 MHz** (-0.5% vs CVA6)

