Recent Achievements of the Open-Source CVA6 Core

Sébastien Jacq, Jean-Roch Coulon, Kevin Eyssartier, Jérôme Quévremont

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CORE-V

CORE-V CVA6:

- Open-source RISC-V application core.
- Two flavors: **CV32A6** (32-bit) and **CV64A6** (64-bit).
- Written in SystemVerilog.
- Highly Configurable: optional features and extensions, customizable L1 cache.

Major Thales recent contributions to CVA6:

① Add the CV-X-IF coprocessor interface to extend the supported instruction set.
② Optimize CV32A6 (performance, resources) for FPGA targets in a technology-agnostic fashion.
③ Add Yocto Linux support.

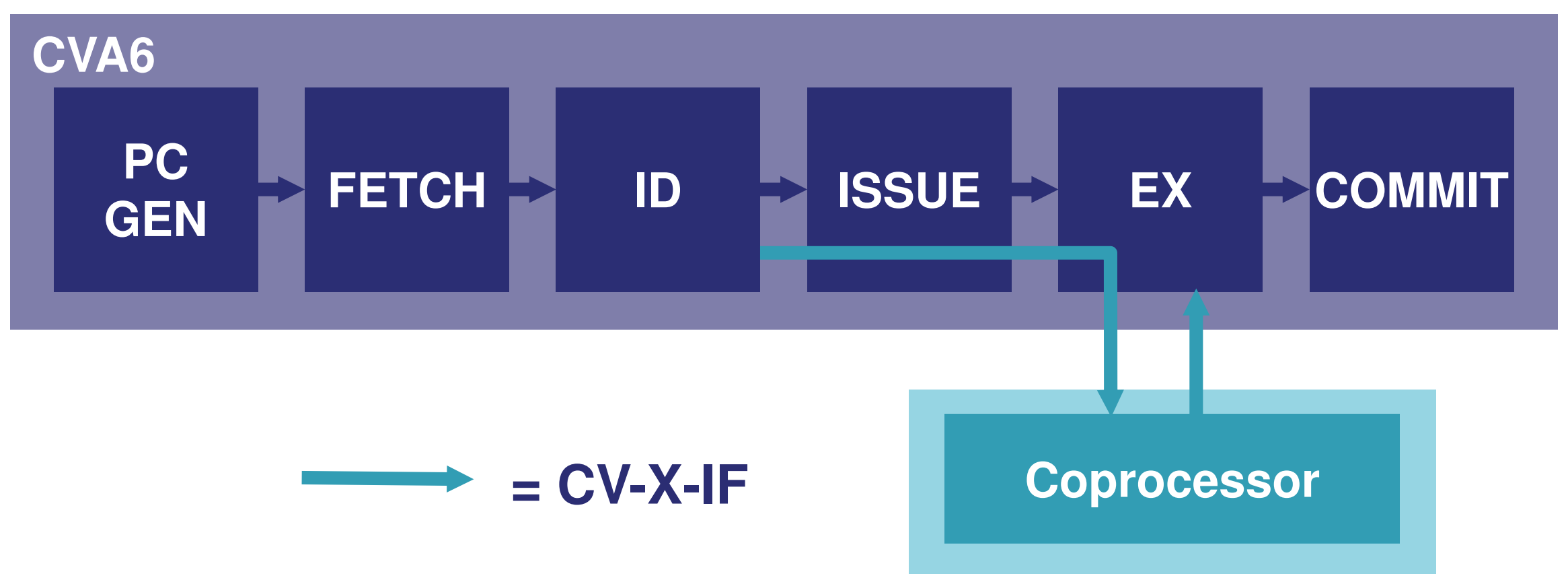
① Domain-Specific Acceleration

Challenge: Extend CVA6 with coprocessors to accelerate applications

- **CV-X-IF** coprocessor interface specified by the OpenHW Group to promote the **interoperability** of CPU cores and coprocessors.
- Domain-specification **acceleration** with custom extensions.
- Support of RISC-V extensions not featured by the core (e.g. SIMD).
- No change to the RTL source code of the RISC-V core.

How it works:

- When the core decodes an instruction that it cannot execute, the instruction is offloaded to the coprocessor.
- Compressed instructions are supported.
- The coprocessor can also submit memory requests.*



Results:

- CV-X-IF available in CVA6.
- Already demonstrated with several coprocessors.
- CV-X-IF implementation can handle speculative execution.*

* Not yet supported in CVA6

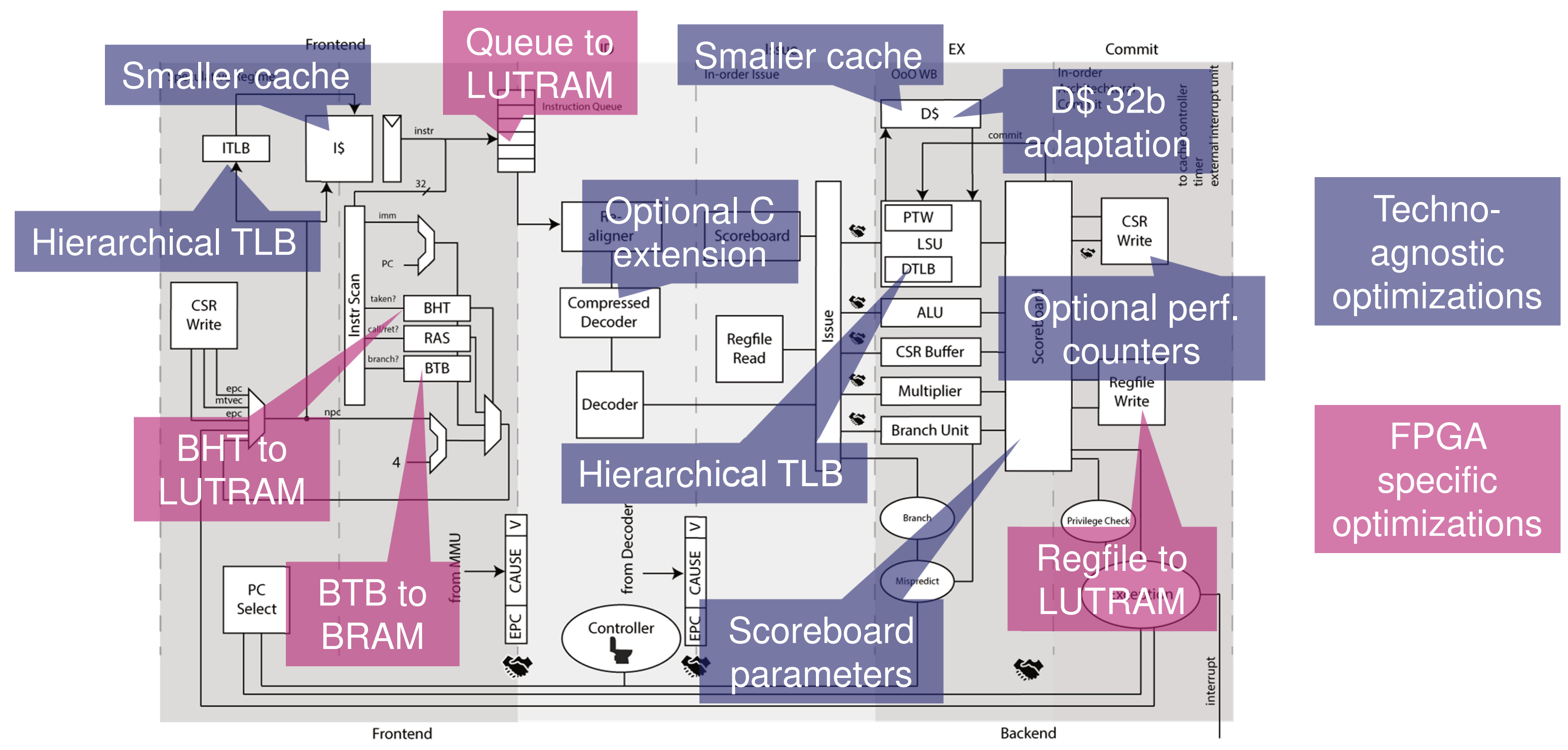
② Optimizations for FPGA targets

Challenge: Optimize CV32A6 for FPGA targets to offer a competitive and **technology-agnostic soft core** for FPGA.

- Alternative to FPGA proprietary soft processor cores (Microblaze, Nios-II…)
- **Same core, same source code** for FPGA and ASIC developments.
- Boosting **multi-sourcing** and the **reuse** of HW/SW architectures, with reduced risks, costs and delays.

How it works:

- Better mapping to FPGA resources.
- Making features optional.
- Selecting relevant parameters for FPGA typical use cases.
- Optimizing the microarchitecture.



Results:

		Original CV32A6	Optimized version	Evolution
FPGA resources	Look-up tables	18,103	8,077	–55%
	Flip-flops	11,484	4,403	–61%
	DSP blocks	4	4	-
	Block RAM	36	12	–67%
Performance	Max. freq.	100 MHz	140 MHz	+40%
	CoreMark/MHz	2.8	2.8	-
	CoreMark	280	392	+40%

on Xilinx Kintex 7 (XC7K325T-2)

③ Embedded Linux Support

Challenge: Extend the SW ecosystem with Yocto support

- Popular generator of **Linux distributions for embedded systems**.
- Access to a **wide catalog** of applications and frameworks.
- Handles the whole embedded **complexity** with a packaged SDK and easy deployment.

yocto PROJECT

How it works:

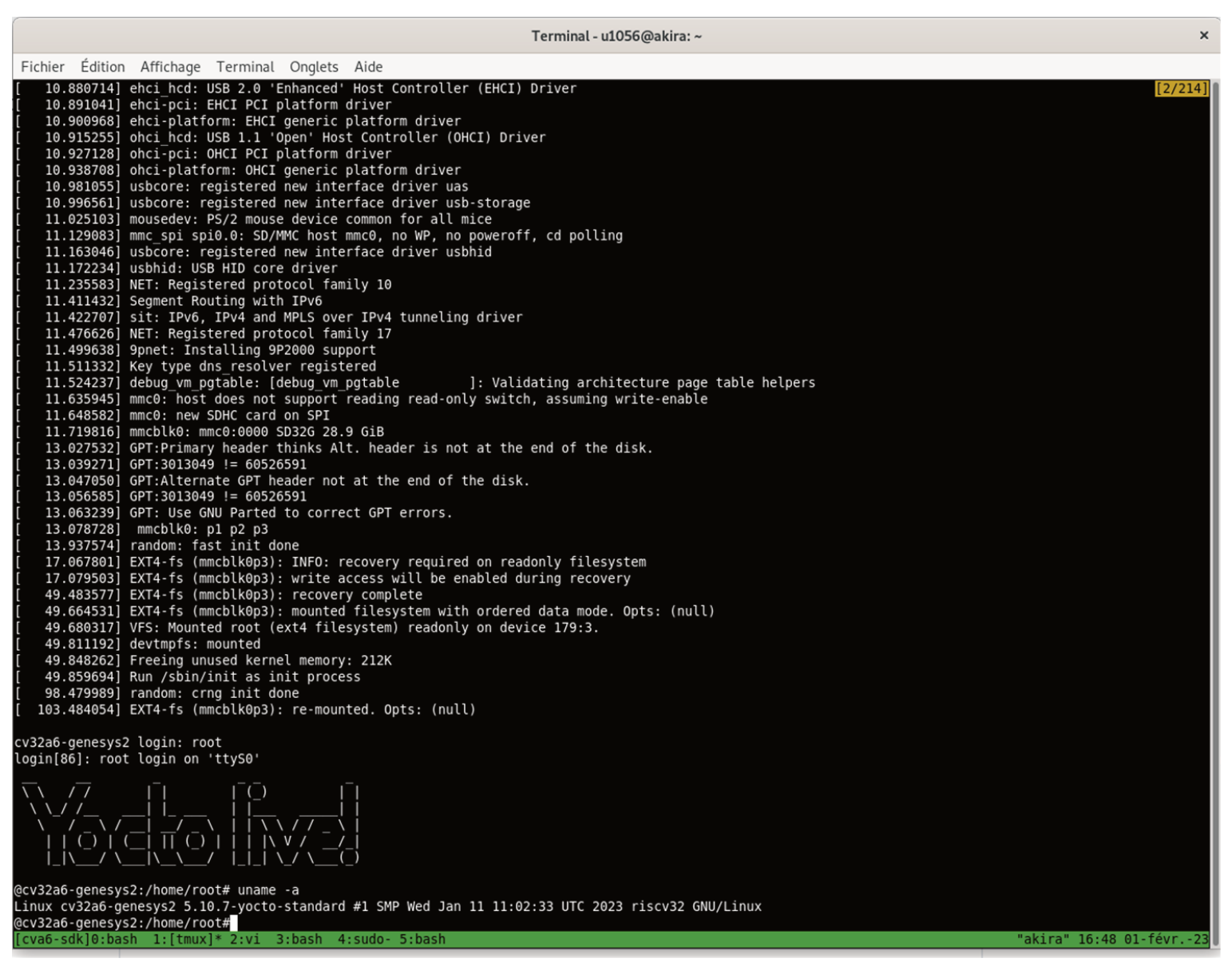
Meta-cva6-yocto contains recipe modifications of:

- U-Boot with SDCard and TFTP support.
- OpenSBI.
- Busybox.
- Linux 5.10.7 kernel.

U-Boot

Results:

- Recently released Yocto support allows contributors and users to **quickly run a Linux distribution** on CV32A6 and CV64A6.
- Eclipse IDE-based Linux and bare metal **debug** also available.



```
[   10.880714] ehci_hcd: USB 2.0 'Enhanced' Host Controller (EHCI) Driver          [2/214]
[   10.891041] ehci-pci: EHCI PCI platform driver
[   10.900968] ehci-platform: EHCI generic platform driver
[   10.915255] ohci_hcd: USB 1.1 'Open' Host Controller (OHCI) Driver
[   10.927128] ohci-pci: OHCI PCI platform driver
[   10.938708] ohci-platform: OHCI generic platform driver
[   10.981055] usbcore: registered new interface driver uas
[   10.996561] usbcore: registered new interface driver usb-storage
[   11.025103] mousedev: PS/2 mouse device common for all mice
[   11.129083] mmc_spi spi0.0: SD/MMC host mmc0, no WP, no poweroff, cd polling
[   11.163046] usbcore: registered new interface driver usbhid
[   11.172234] usbhid: USB HID core driver
[   11.235583] NET: Registered protocol family 10
[   11.411432] Segment Routing with IPv6
[   11.422707] sit: IPv6, IPv4 and MPLS over IPv4 tunneling driver
[   11.476626] NET: Registered protocol family 17
[   11.499638] 9pnet: Installing 9P2000 support
[   11.511332] Key type dns_resolver registered
[   11.524237] debug_vm_pgtable: [debug_vm_pgtable         ]: Validating architecture page table helpers
[   11.635945] mmc0: host does not support reading read-only switch, assuming write-enable
[   11.648582] mmc0: new SDHC card on SPI
[   11.719816] mmcblk0: mmc0:0000 SD32G 28.9 GiB
[   13.027532] GPT:Primary header thinks Alt. header is not at the end of the disk.
[   13.039271] GPT:3013049 != 60526591
[   13.047050] GPT:Alternate GPT header not at the end of the disk.
[   13.056585] GPT:3013049 != 60526591
[   13.063239] GPT: Use GNU Parted to correct GPT errors.
[   13.078728]  mmcblk0: p1 p2 p3
[   13.937574] random: fast init done
[   17.067801] EXT4-fs (mmcblk0p3): INFO: recovery required on readonly filesystem
[   17.079503] EXT4-fs (mmcblk0p3): write access will be enabled during recovery
[   49.483577] EXT4-fs (mmcblk0p3): recovery complete
[   49.664531] EXT4-fs (mmcblk0p3): mounted filesystem with ordered data mode. Opts: (null)
[   49.680317] VFS: Mounted root (ext4 filesystem) readonly on device 179:3.
[   49.811192] devtmpfs: mounted
[   49.848262] Freeing unused kernel memory: 212K
[   49.859694] Run /sbin/init as init process
[   98.479989] random: crng init done
[  103.484054] EXT4-fs (mmcblk0p3): re-mounted. Opts: (null)

cv32a6-genesys2 login: root
login[86]: root login on 'ttyS0'

@cv32a6-genesys2:/home/root# uname -a
Linux cv32a6-genesys2 5.10.7-yocto-standard #1 SMP Wed Jan 11 11:02:33 UTC 2023 riscv32 GNU/Linux
@cv32a6-genesys2:/home/root#
[cva6-sdk]0:bash  1:[tmux]* 2:vi  3:bash  4:sudo- 5:bash                    "akira" 16:48 01-févr.-23
```

Perspectives

These CVA6 results will be further expanded in upcoming projects:

- More performance optimizations of the core
- More acceleration with new CV-X-IF coprocessors
- Richer and improved documentation
- Industrial-grade verification
- Safe & secure features
- Software ecosystem

Acknowledgements

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https://github.com/openhwgroup/cva6/
https://github.com/openhwgroup/meta-cva6-yocto
jerome.quevremont@thalesgroup.com

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