Scalar Crypto Standardization Status Summary

Status at a glance:

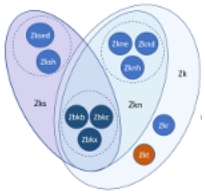
- **Current** Definition-of-Done Status: **Ratified**
  - **We finished public review on Oct 17'th, 2021**
  - See here for a summary of public review feedback.
  - Scalar Crypto Standardization have been **Ratified**
- ~~**Next** Definition-of-Done Status:: **Ratification**~~
- Definition of Done Status Top Sheet

Scalar Crypto Specification:

- Latest Draft Scalar Crypto Specification (v1.0.0)
  - Contains feedback from public review.

Lightweight instruction set extensions for RV32 and RV64 HARTs. Proposed extensions:

- Extensions fully defined in the Scalar Crypto Specification: Zk, Zkn, Zks, Zkr, Zkne, Zknd, Zknh, Zksed, Zksh, Zkt
- Shared with the Bit-Manipulation Specification: Zbkx, Zbkc, Zbkb
- Instruction Group Names Diagram (click thumbnail for full-size image)



Pub

Architecture & Opcode consistency review

- The results of the review can be seen here. Scalar Crypto Arch Review Results.pdf
- After discussion within the task group, the following changes will be made to the spec, with the changes expected to land in 0.9.4 before the end of August.
  - Stop overlapping the aes32 and aes64 opcodes. See riscv/riscv-opcodes#77
  - Clarify the effect of misa.k
  - Some updates to the entropy source and zkt detailed here.
  - Miscellaneous editorial issues.
- Some downstream tasks for our group development partners now we are in public review.

Who	What	Status	Task
PLCT	GCC	Not started	Update extension names: Zkb Zbkb etc.
PLCT	GCC	Not started	Update aes32/64* encodings if applicable.
PLCT	LLVM	Done	Update extension names: Zkb Zbkb etc.
PLCT	LLVM	Done	Update aes32/64* encodings if applicable.
IIT	riscv-config	Not started	Update extension names: Zkb Zbkb etc.
IIT	riscv-config	Not started	Update instruction inclusion in different extensions
IIT	riscv-arch-tests	Not started	Break up K suite into Zk* extensions
IIT	riscv-arch-tests	Not started	Update instruction inclusion in different extensions

Architecture Tests

- Test plan for the scalar-crypto specific instructions is available.
- Imperas have a complete set of tests, written to the existing test plan, for the scalar crypto instructions and the bitmanip instructions we borrow.
  - These have been merged into the main test suite as of PR#177, with many thanks to Imperas for the contribution.
    - Spike, OVPSim and Sail all agree on the test signatures.
  - They form a base we can use to develop prototype implementations / Spike / SAIL / QEMU very easily and quickly.
- Upstream Spike support for enabling it to work with the K test suite is being added in PR#687.
- IIT Madras are *also* looking at writing the scalar crypto tests for integration into the official architectural tests repo as well.
  - Agreed SoW for IITM
  - They are re-implementing the tests as part of the blessed coverage and test generation tooling.

        - Making good progress with the simple test patterns for scalar-crypto specific instructions A/O April 7'th '21
    - We then switch over to using the IIT tests when they are finished, since they will be easier to maintain/extend going forward than the Imperas tests.
- YAML config changes for K have been merged in. See here.
- Update from IIT Madras as on 25-Oct
    - Sample cgf file for Kspec ver 1.0.0-rc4 is in https://github.com/anku-anand/riscv-ctg/tree/kspec-rc4
- Status from IIT Madras as on 17-Jun:
    - All test cases and coverage reports has been generated and presented.
    - If there are any changes in future on these that is required in future, IIT Madras will enhance the scripts as per requirements.
- Status from IIT Madras as on 20-May:
    - Real world test cases as per the test plan has been generated.
    - Currently waiting for the fixed toolchain with K extension from PLCT to test the generated test cases. All the test cases are working fine when we run against the patched toolchain
    - A PR has been raised with a pull request for this suite to be reviewed and merged in the riscv-arch tests github repo.
- Status from IIT Madras as on 12-May:
    - Coverage report for all developed cases in CTG/ISAC has been generated and it is reported as 100%
    - Currently real world test cases are being developed as per test plan and will be completed and send for review by beginning of next week
- Status from IIT Madras as on 05-May:
    - Resolved issues in running the rv64ik toolchain after interacting with PLCT and compile the relevant tests generated from CTG and run them on spike
    - Currently resolving issues in the running the rv64ibk toolchain. Once this is done, will generate the coverage report of the test cases built till now and share with team.
- Status from IIT Madras as on 26-Apr:
    - Completed the coverage points specification for all 32-bit and 64-bit instructions
    - Generated test cases from the coverage points
    - Currently working on trying to install the scalar crypto enabled toolchain.

Compilers / Toolchains

Imperas maintain pre-built toolchains for various in-progress RISC-V extensions here. See the "rvk-*" branches for scalar crypto.

GCC and Binutils

- Experimental / development toolchain available in the riscv-crypto repository.
    - This cannot be up-streamed, but can be used for development work for now.
- Intrinsics proposal from Markku
- PLCT lab have developed complete Binutils and GCC patches.
    - The pull requests into the main RISC-V repos can be found here:
        - Binutils pull request: https://github.com/riscv/riscv-binutils-gdb/pull/254
        - GCC pull request: https://github.com/riscv/riscv-gcc/pull/250 (merged)
    - The PLCT lab continuous integration server can be found here:
        - https://ci.rvperf.org/view/Krypto-Scalar/
        - This is a good place to start for re-producing the PLCT builds of GCC/Binutils
    - Some small changes will be needed as we move to v1.0 of scalar crypto around encodings.

LLVM

- Work will be done by PLCT lab under the group contributor model.
    - Github repository
    - Continuous integration status
- Slides from PLCT Update Weds 10'th Feb
- As of 21'st April '21, LLVM work is mostly complete, waiting on PLCT lab for an update about merging things upstream.
    - Some small changes will be needed as we move to v1.0 of scalar crypto around encodings.
- As of 24'st Jan '22, LLVM upstream is able to compile the assembly code of Zk* and Zbk*

Simulators

Though all listed under "simulators", these are actually a collection of formal model / virtual machine / architectural simulators / DV simulators etc.

SAIL

- Currently working on getting support merged in upstream in PR#99
    - Support for all scalar-crypto dedicated instructions and the entropy source is present.
    - No support for Bitmanip yet.

Spike

- Upstream support has been merged in.
- Instructions are up to date with v1.0.0

riscvOVPSimPlus

- Imperas Commercial Simulator

- Freeware version
- Supports:
  - Crypto-scalar v0.7.2, v0.8.1, 0.9.0, 0.9.2, 1.0.0-rc1, + Bitmanip subsets
  - Bitmanip 0.90, 0.91, 0.92, 0.93-draft, 0.93, 0.94, 1.0.0
  - Functional coverage collection.

QEMU

- Work will be done by PLCT lab under the group contributor model.
  - Github repository
  - Continuous integration status
  - Waiting to hear back from PLCT on status.

Proof-of-Concept implementations

Hardware

Project Name	Base Architecture	Level of implementation	Notes
Stand-alone functional units	RV32/64	Yosys Synthesis	Stand-alone functional-unit style implementations of the dedicated scalar crypto instructions. Free to use as "drop-ins" for prototyping.
scarv-cpu	RV32	Behavioural RTL simulation / Yosys Synthesis / FPGA	Completely Public/Open Source. Useful as a public baseline. Commercial implementations should aim to be better than this!
PQShield security core	RV32	(assumed) Behavioural RTL simulation. Running on FPGA.	Closed / commercial source - PQShield.
Minidice TRNG	N/A	FPGA Implementation	Closed / commercial source - PQShield. Complete implementation of the RISC-V entropy source.
Romain Dolbeau / VexRISC-V	RV32	Running on FPGA.	Uses VexRiscv core as a base. Completely independent implementation from scratch, outside the Crypto TG.
IQonIC Works RV32IC_P5	RV32	In development	"implemented Zkn (...), along with selectable Zb* and Zkb. We also have an optional custom extension that does AES block encrypt/decrypt, and a bus-based AES/cipher-mode accelerator. Work in progress benchmarking them on FPGA to compare relative performance in accelerating crypto library functions."
croyde-riscv	RV64	Behavioural RTL simulation / Yosys Synthesis / FPGA	3-stage RV64 micro-controller. `rv64imck`. Free/Open source. Something commercial implementations should better. Implements everything *except* ZKR.

- ⚠️ We still need RV64 implementations. ⚠️
- Barry Spinney has offered to do advanced node synthesis runs for open source implementations.
  - I (Ben) intend to take him up on this when I get time. No idea when that will be.

Software

Project/Maintainer	Description
Romain Dolbeau	Independent implementations of various important ciphers + modes of operation.
rvkrypto-fips / Markku	"FIPS 140-3 and higher-level algorithm Tests for RISC-V Crypto Extension"
riscv-crypto benchmarks	Initial benchmarks used to develop the scalar crypto extension.

ABI Extensions

- None required