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## ApproxRISC: An Approximate Computing Infrastructure For RISC-V

Tiago Trevisan Jost, Geneviève Ndour, Damien Couroussé, Christian Fabre,  
Anca Molnos

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# ApproxRISC: An Approximate Computing Infrastructure For RISC-V

## Authors:

Tiago Trevisan Jost (tiago.trevisanjost@cea.fr),  
Geneviève Ndour, Damien Couroussé, Anca Molnos,

## Speaker:

Christian Fabre

## Introduction

### □ Motivation

- Many applications are tolerant to a degree of error without a significant loss in quality of results.
- **Approximate Computing (AC)** aims at exploring the **error resiliency** of applications.
- **Lack of support for Approximate Computing** in RISC processors

### □ Challenge

- Help the rapid investigation of **AC** in RISC-V for **energy reduction** purposes

### □ Proposal

- **ApproxRISC**, an infrastructure for approximate computing in RISC-V processors.
  - ISA Extension, Simulator, Compilation

## ISA

### □ ISA Extension

- Set of integer-type instructions for approximate operations.

### □ Multiple level of accuracy

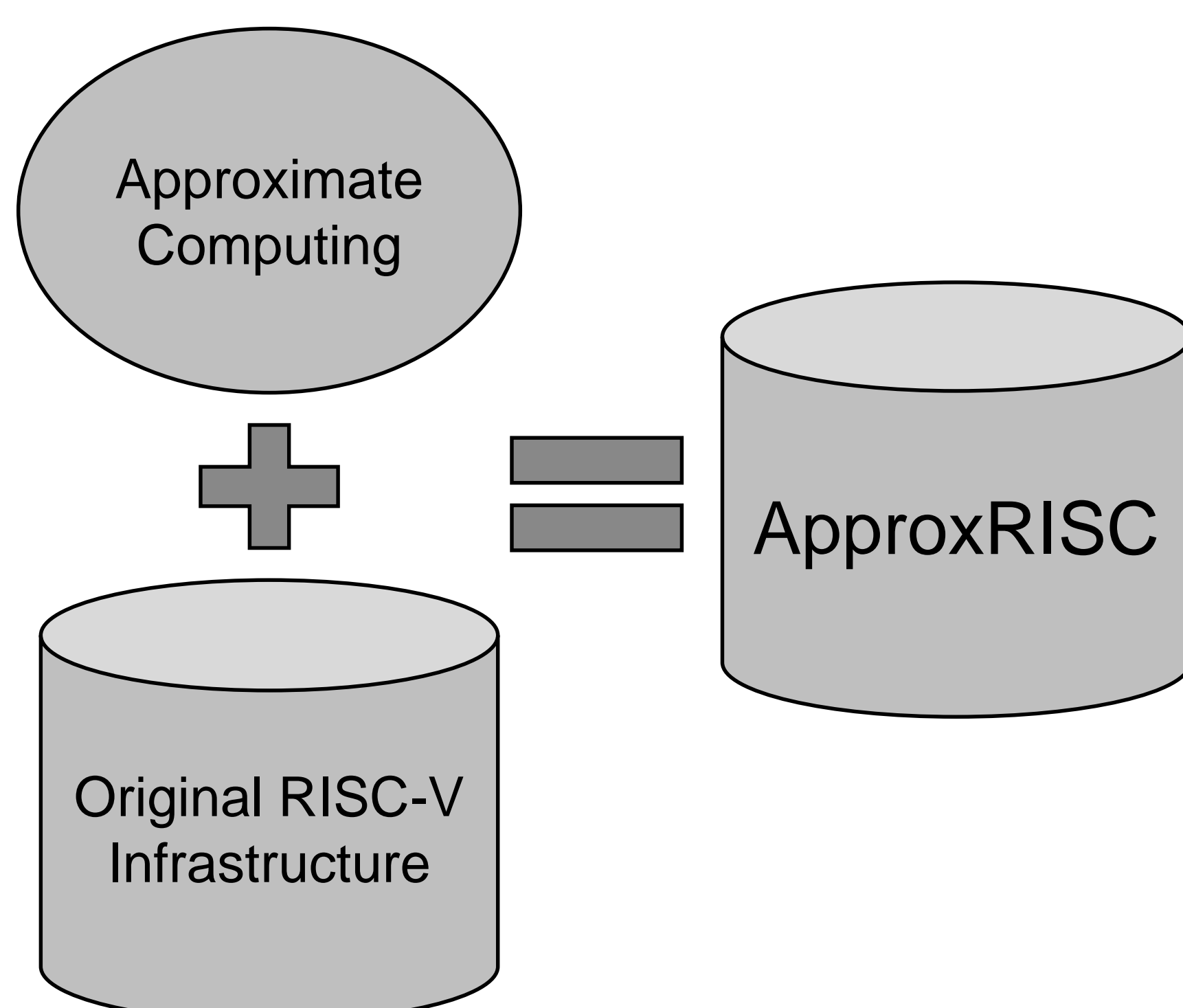
- Processor-wide Approximate Bit Width (ABW) value for all AC instructions.

Instruction	Operation Mode
approx.set.abw	Set the internal ABW
approx.get.abw	Get the internal ABW
approx.add/addi	Approximate Additions
approx.sub/subi	Approximate Subtractions
approx.mul/muli	Approximate Multiplications
approx.udiv/udivi	Approximate Unsigned Divisions
approx.sdiv/sdivi	Approximate Signed Divisions

## ApproxRISC Software

### Modifications to the Original RISC-V Infrastructure

Spike ISA Simulator  
GNU Binutils  
LLVM 3.9



### #Pragmas extensions to LLVM

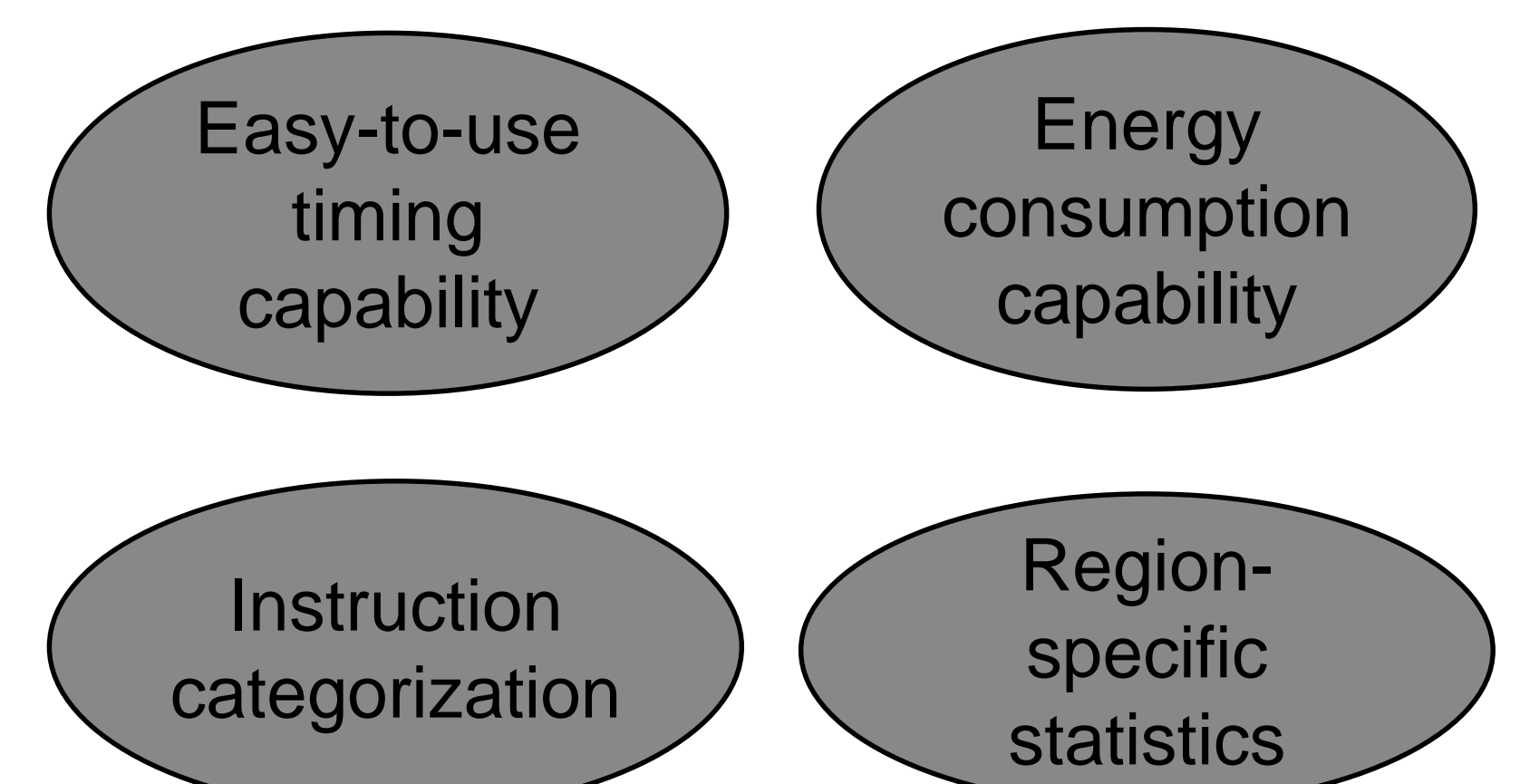
- #pragma approx
  - Only AC integers are supported
- #pragma full\_approx
  - Floating point AC is also supported by means of fixed-point
- Pragma parameters:
  - List of AC variables – explicit & implicit
  - Approximate bit widths.
  - Total width, vs fractional width

```
#define ABW 7
#define WIDTH 32
#define FRAC 10

float Example_full_approx() {
    float a = 44.23, b = 2300.12, d, e = 1000;
    #pragma full_approx(a, b) ABW (WIDTH, FRAC)
    True
    {
        d = a + b + e + 1;
    }
    return e;
}
```

## Spike

### New Features

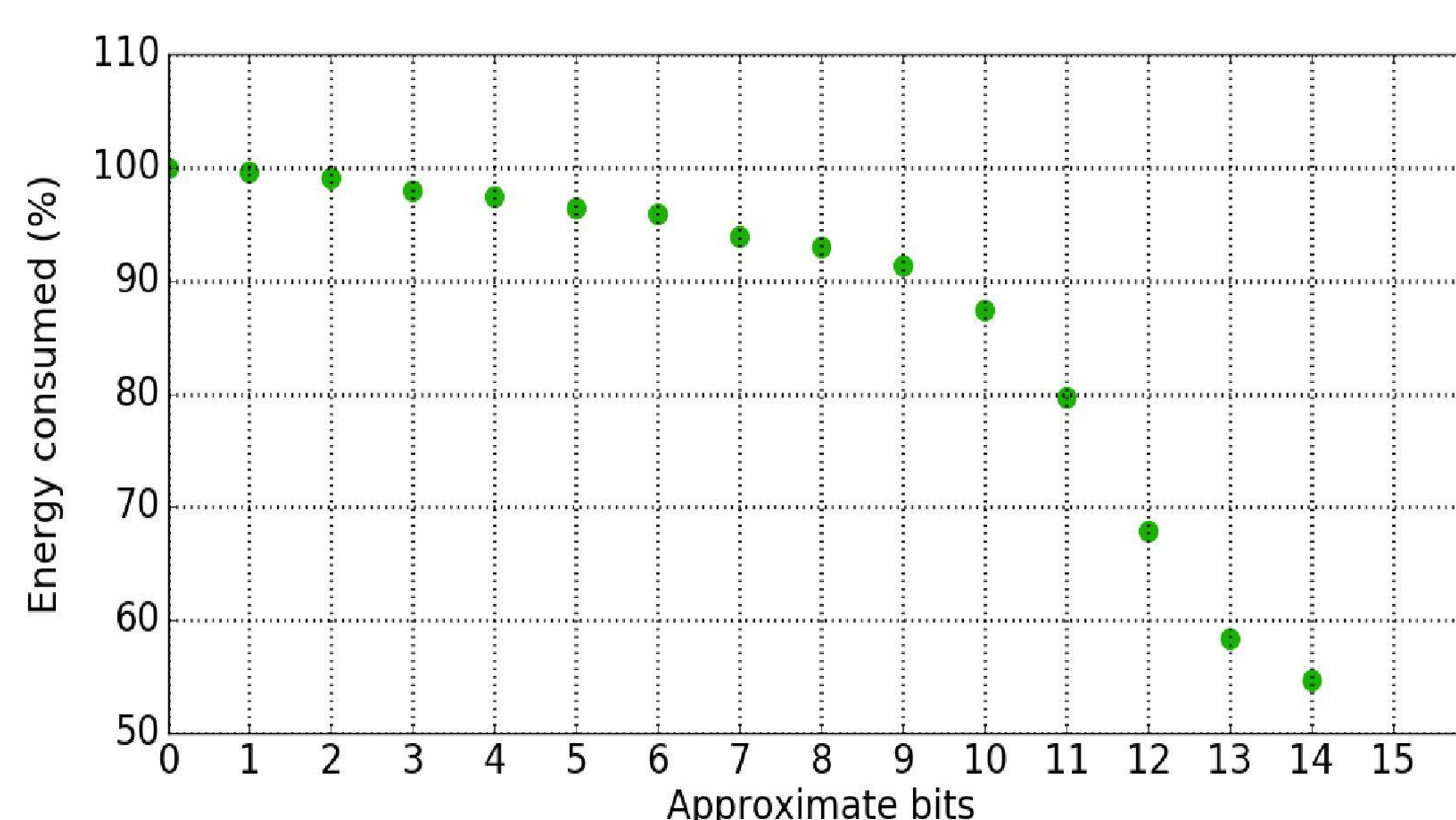


```
int Example_approx() {
    int a = 44, b = 2300, d, e = 1000;
    #pragma approx(a, b) ABW True
    {
        d = a + b + e + 1;
    }
    return d;
}
```

## Experimental Results

### □ Validation

- **jmeint** from AxBench [1]
- Pragmas in the code
- ABW from 0 (full precision) to 14
- Energy model according to [2]
- Up to 50% of energy reduction



## Conclusion

### □ ApproxRISC

- An infrastructure for rapid investigation of approximate computing in RISC-V processors.

### □ Future Works

- Conduct thorough experimentation to show the benefit of AC and our infra
- Exploration of new instructions

### References

- [1] A. Yazdanbakhsh et al. "AxBench: A Multiplatform Benchmark Suite for Approximate Computing". In: IEEE Design Test
- [2] D. J. Pagliari et al. "A methodology for the design of dynamic accuracy operators by runtime back bias". In: DATE, 2017.
- [3] RISC-V Foundation — Instruction Set Architecture (ISA). URL: <https://riscv.org>.

### Acknowledgements

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