RISC-V Opt-VP:
An Application Analysis Platform Using Bounded Execution Trees

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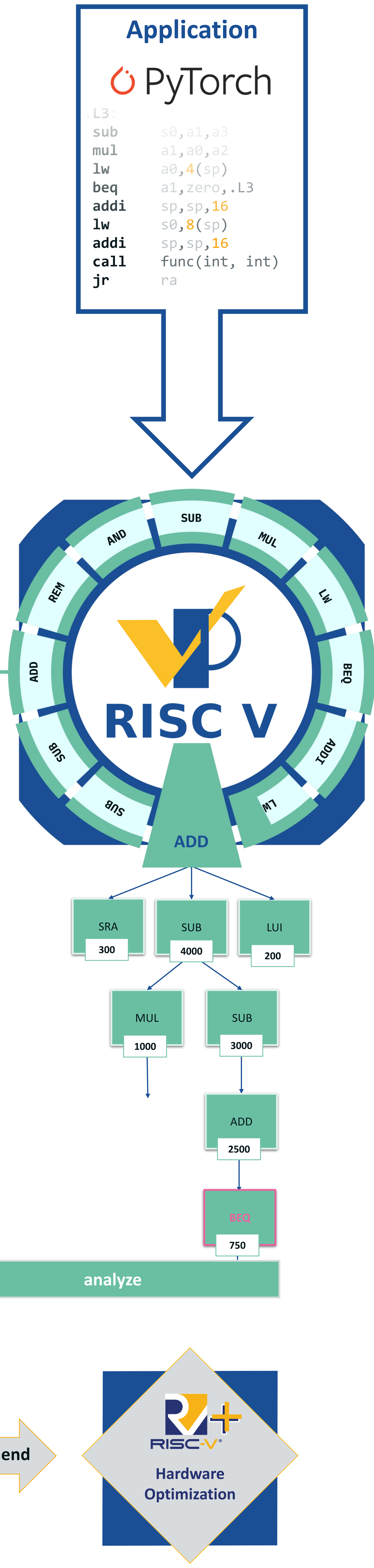
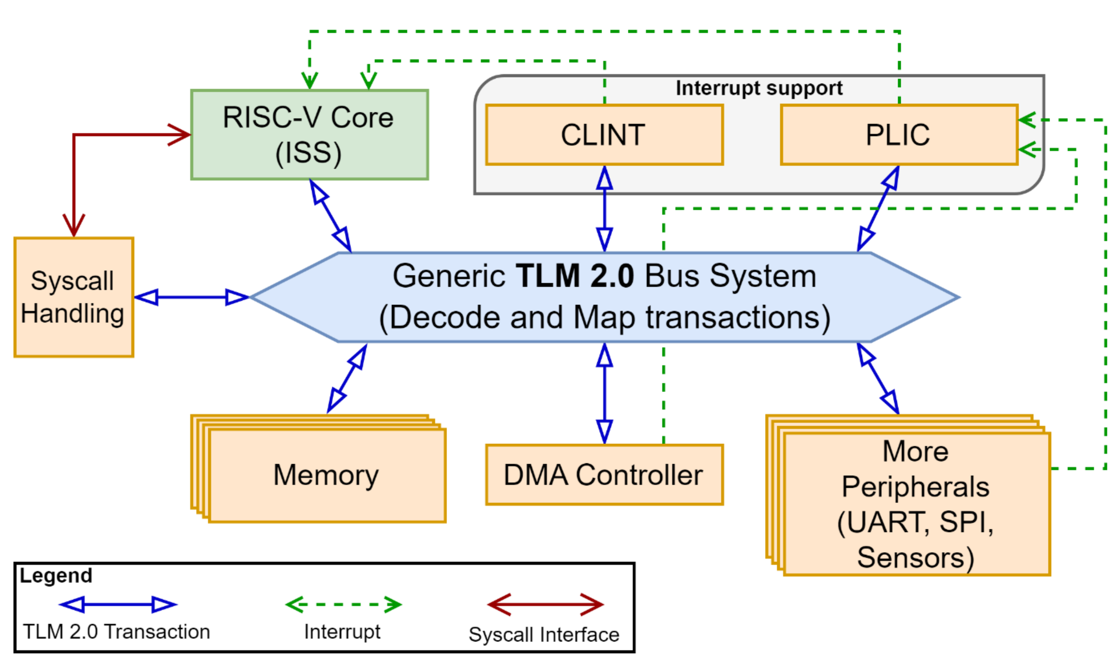
1. Abstract

Tailoring hardware to applications significantly increases their performance, which is required to meet the rising demand for resource-limited devices. While RISC-V facilitates application specific solutions due to its extensibility, **Virtual Prototypes** (VPs) enable early software development before the actual hardware is built. We combined the advantages to create a tool for **analyzing applications for hardware optimization**. Here, **we present the RISC-V Opt-VP**, which generates bounded execution trees to analyze applications. An embedded application case study illustrates that **promising instruction sequences** are found for every application, which can also be **merged to further improve** their execution **coverage**, enabling efficient hardware designs.



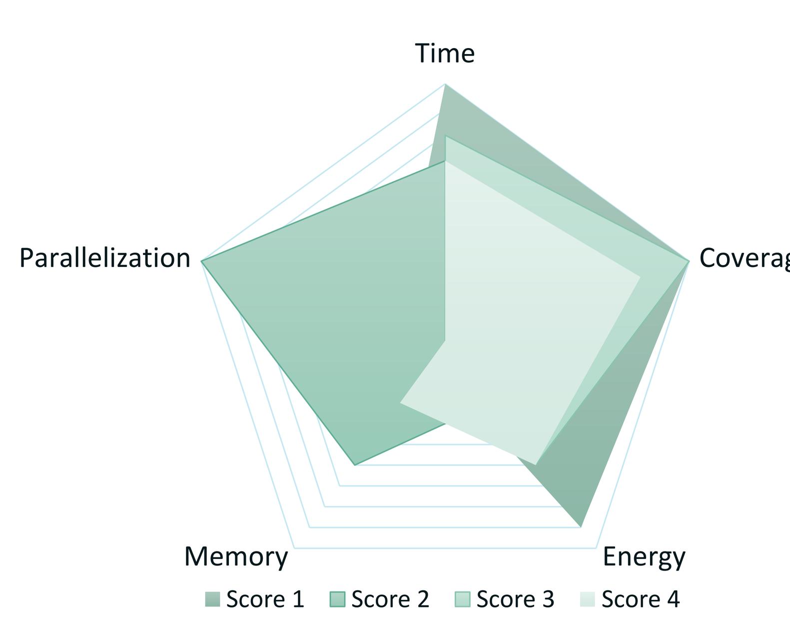
2. Virtual Prototype Driven Tracing

- Extend RISC-V **Virtual Prototype**
- Tracing module interfacing ISS core
- Construct **bounded execution trees**
- Lossless compression of trace information
- Identify promising hardware optimization candidates based on recurring patterns



3. Analysis

- Analyze trees using a set **scoring function**
- Choose a set of **metrics** that matches the target hardware optimization
- E.g. $Score(Seq) = weight_{Seq} \cdot \#Instructions$

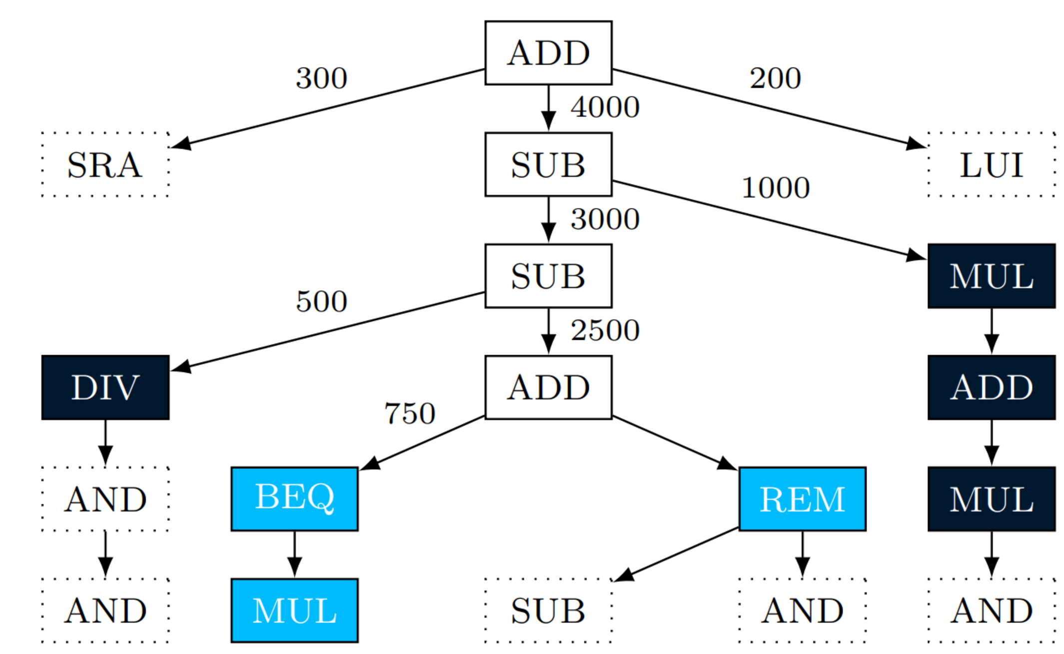


4. Evaluation

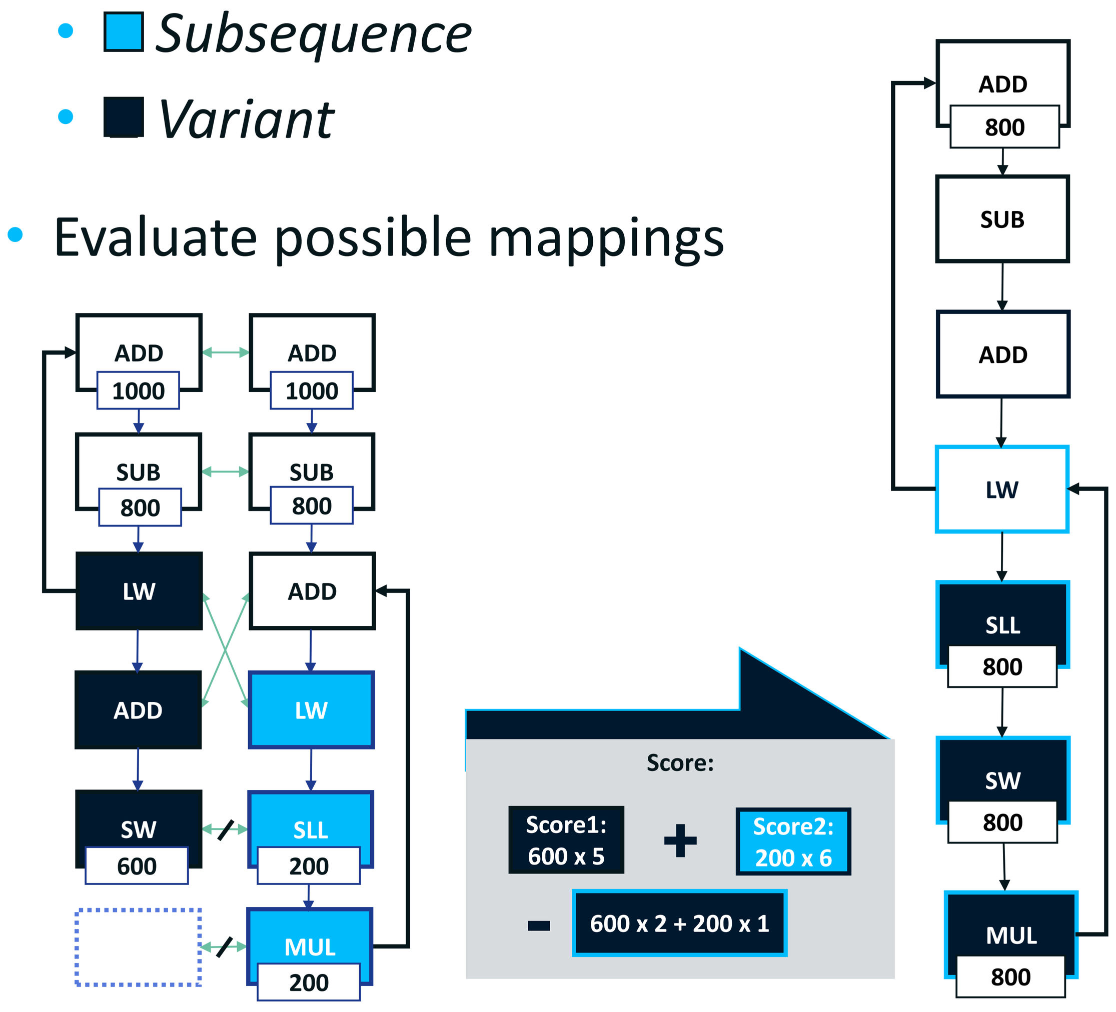
- Analyze Embench and RIOT
- Over 30% expected coverage on average

	Root	Len	Weight	Total #	NP
aha-m64	SRLI	11	162432	4532K	185.0
crc32	JAL	12	175104	3846K	71.5
edn	LH	5	290400	3483K	104.2
huffbench	ADDI	1	661440	2515K	1
matm-int	ADD	5	357200	4426K	80.7
md5sum	SLLI	24	39936	2339K	105.3
minver	SW	5	100114	2818K	88.8
nettle-aes	LW	31	32864	4481K	99.7
slre	SW	7	107007	2570K	204.0
RIOT	ADDI	1	3893	13K	1
Average	-	6.52	339986	30.95%	59.76

5. Sequence Merging



- **Extend** sequences to increase potential merge options:
  - ☐ *Default*
  - *Subsequence*
  - *Variant*
- Evaluate possible mappings



- Create **new merged sequence**
  - Drastically increased coverage (> 600%)
  - Negligible overhead

Available on GitHub:

- https://github.com/agra-uni-bremen/opt-vp
- https://github.com/agra-uni-bremen/opt-seq

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Read the extended abstract:

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