ROIperf: A Framework to Rapidly Validate Workload Sampling Methodologies

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Workshop on Computer Architecture Modeling and Simulation (CAMS 2023)

October 28, 2023

Sampled Simulation

RAIperf

Microarchitectural simulation is slow

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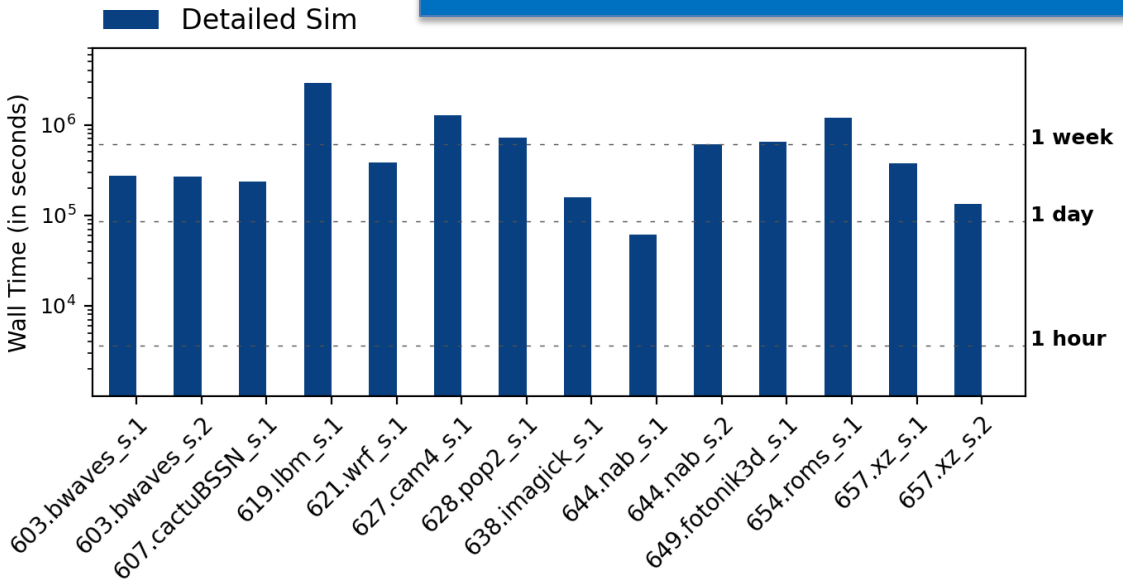

Simulation wall times of SPEC CPU2017 benchmarks (8 threads) using train inputs on Sniper

Solution: Simulate regions of interest (sample)

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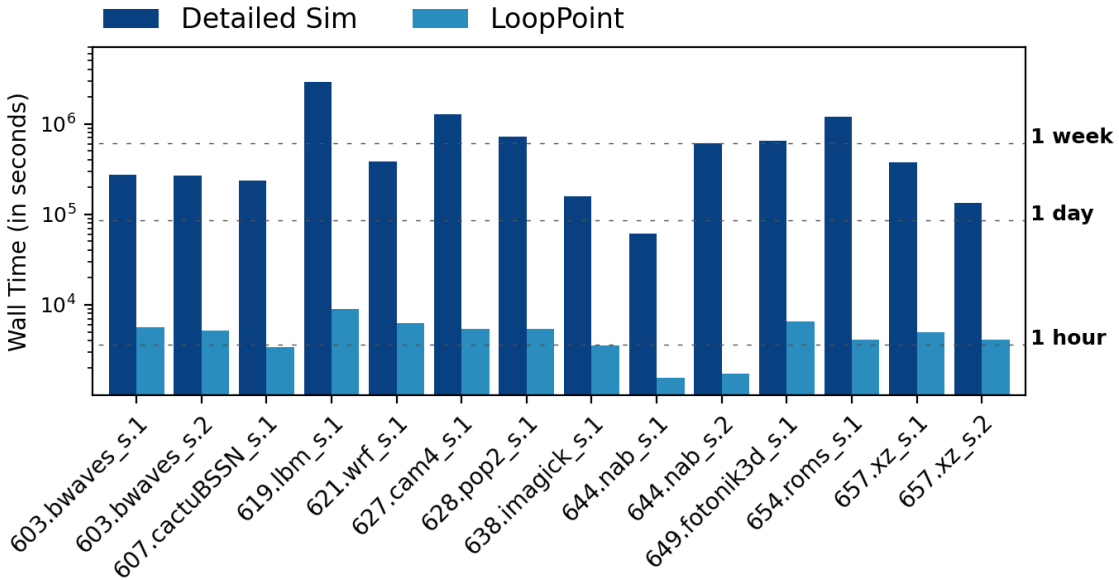
Sampled Simulation



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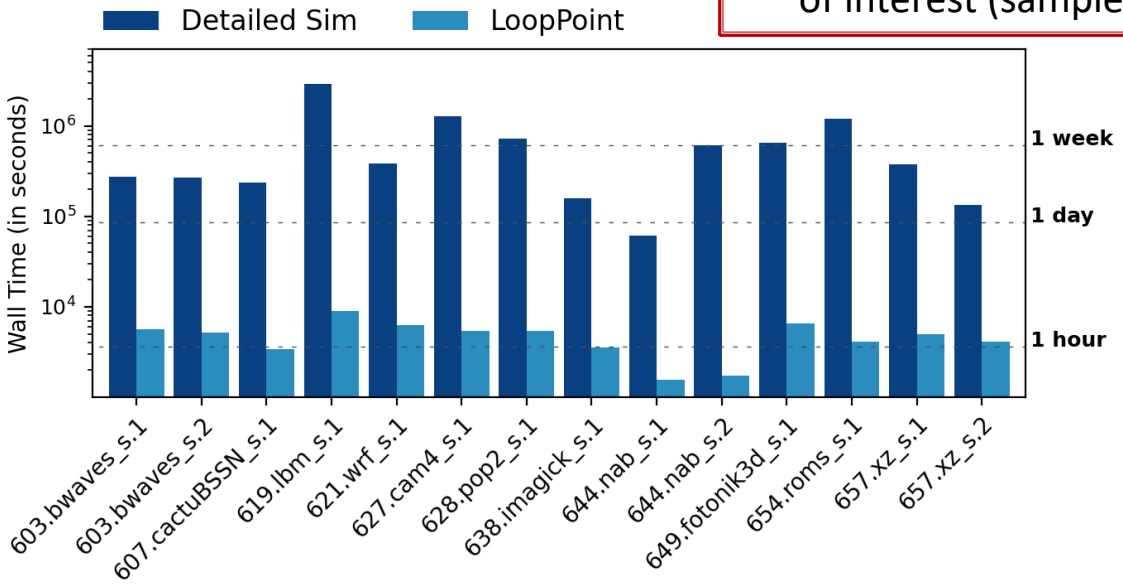

Simulation wall times of SPEC CPU2017 benchmarks (8 threads) using train inputs on Sniper

Application	Train	Ref
603.bwaves_s.1	33.33	1.01
603.bwaves_s.2	32.79	1.03
607.cactuBSSN_s.1	26.81	0.45
619.lbm_s.1	4.86	0.65
621.wrf_s.1	9.28	0.47
627.cam4_s.1	4.78	0.23
628.pop2_s.1	6.27	0.46
638.imagick_s.1	25.93	0.13
644.nab_s.1	21.15	0.32
644.nab_s.2	9.74	N/A
649.fotonik3d_s.1	12.93	1.55
654.roms_s.1	3.98	0.71
657.xz_s.1	21.43	0.74
657.xz_s.2	42.55	1.26

Fraction of regions to be simulated in detail for SPEC CPU2017 benchmarks using 8 threads

Selection of Regions of Interest

AOIperf

Program executions are structured as phases

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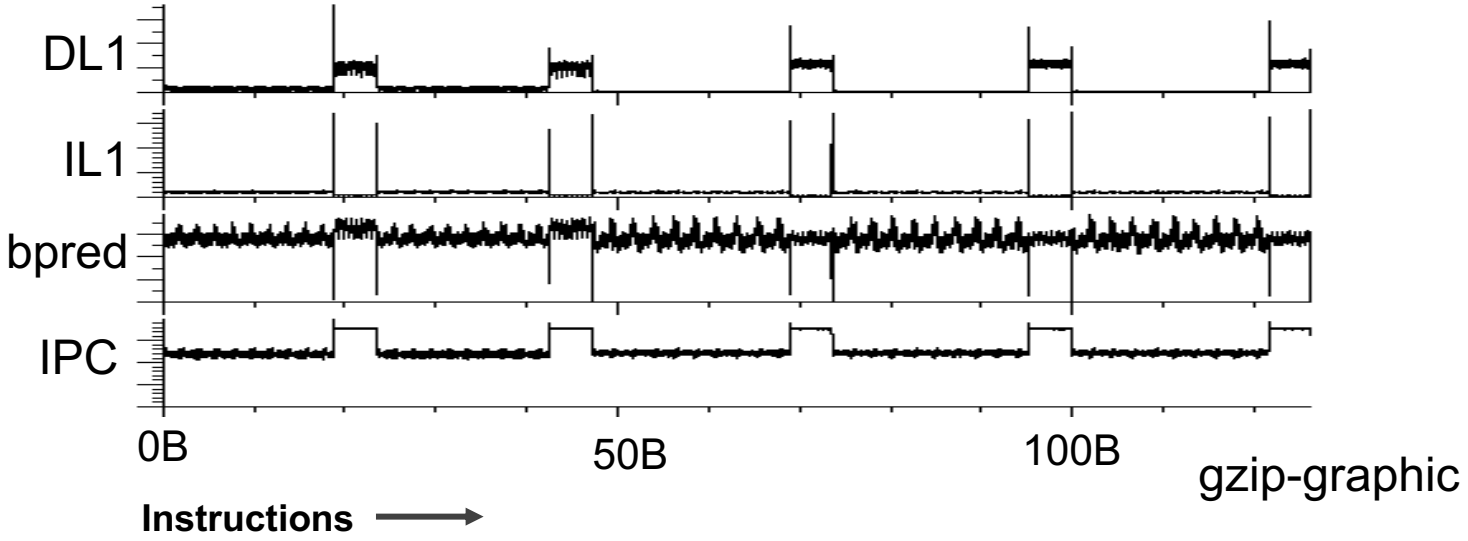

Sherwood, Timothy et al., “Automatically characterizing large scale program behavior”, ACM SIGPLAN Notices, 2002

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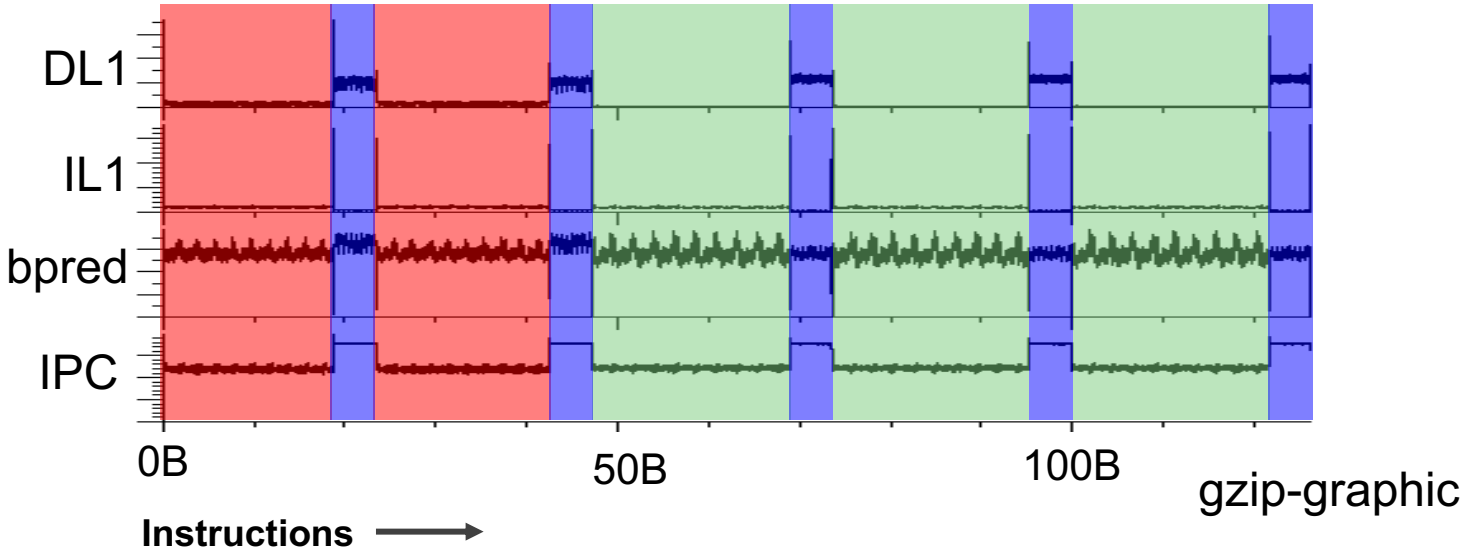

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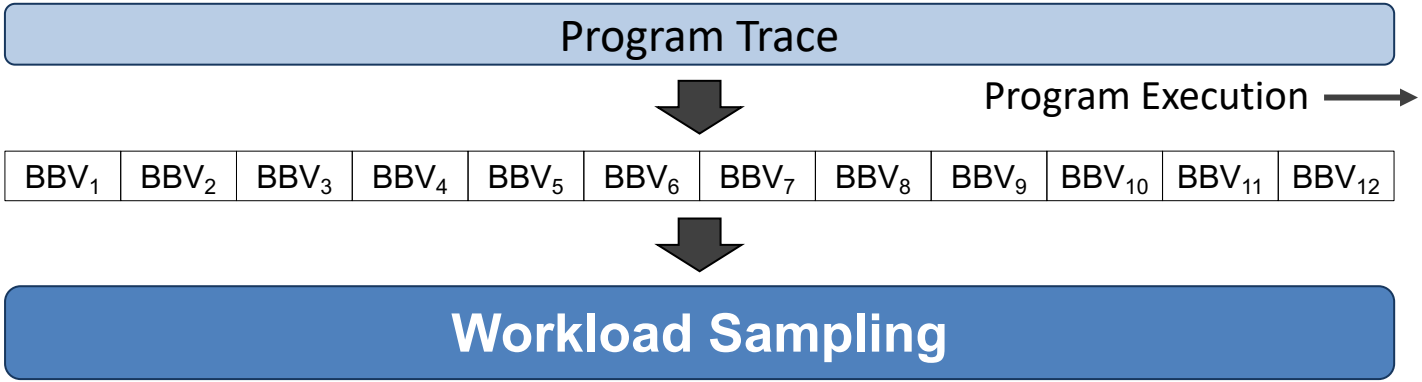

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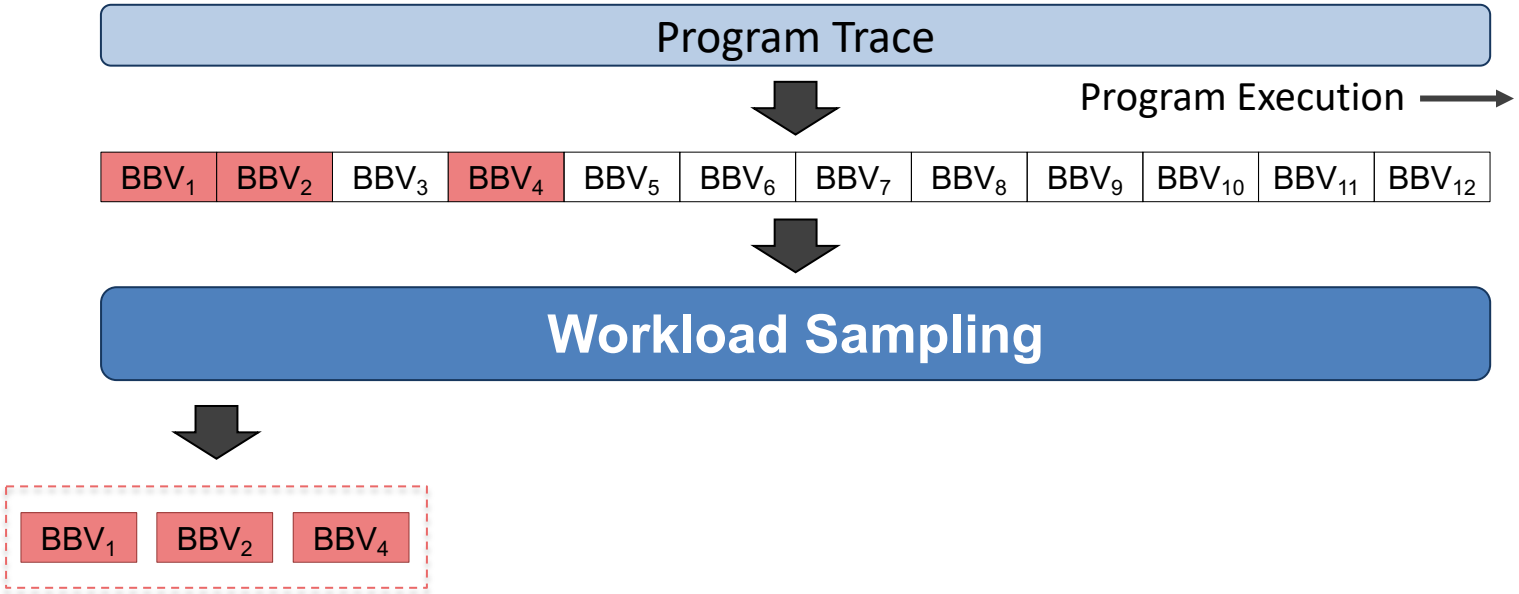

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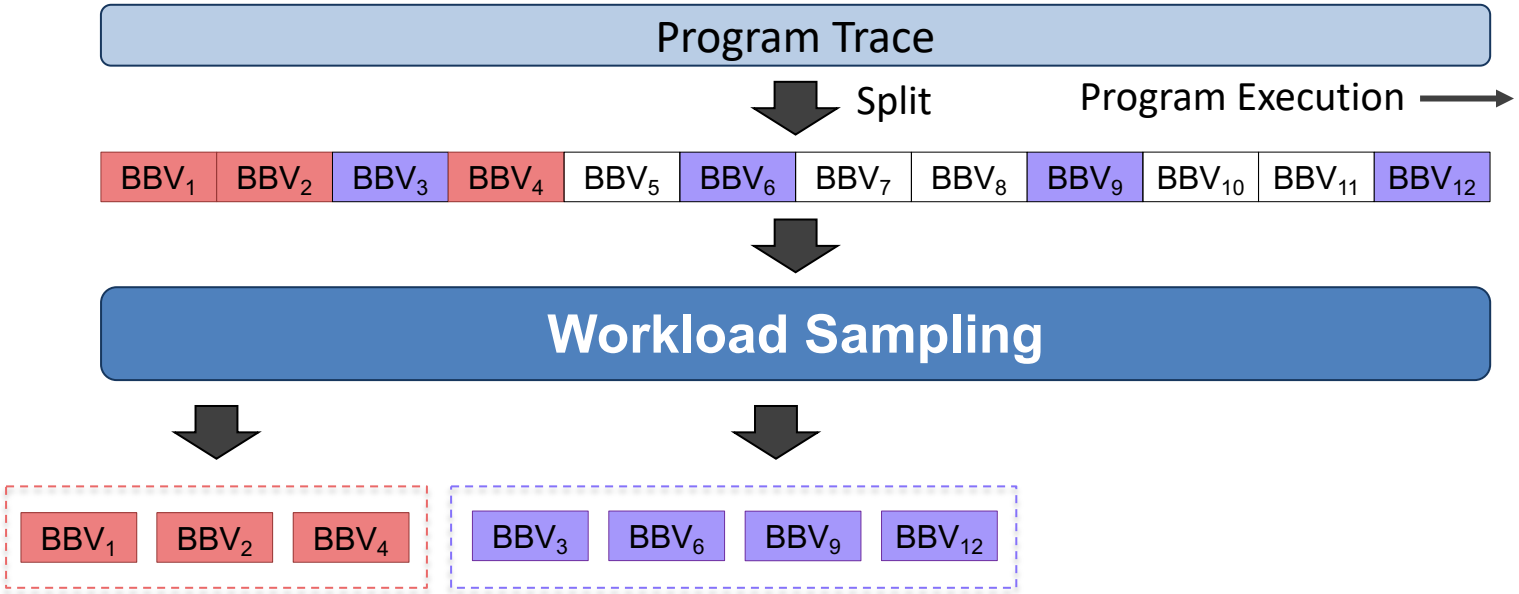

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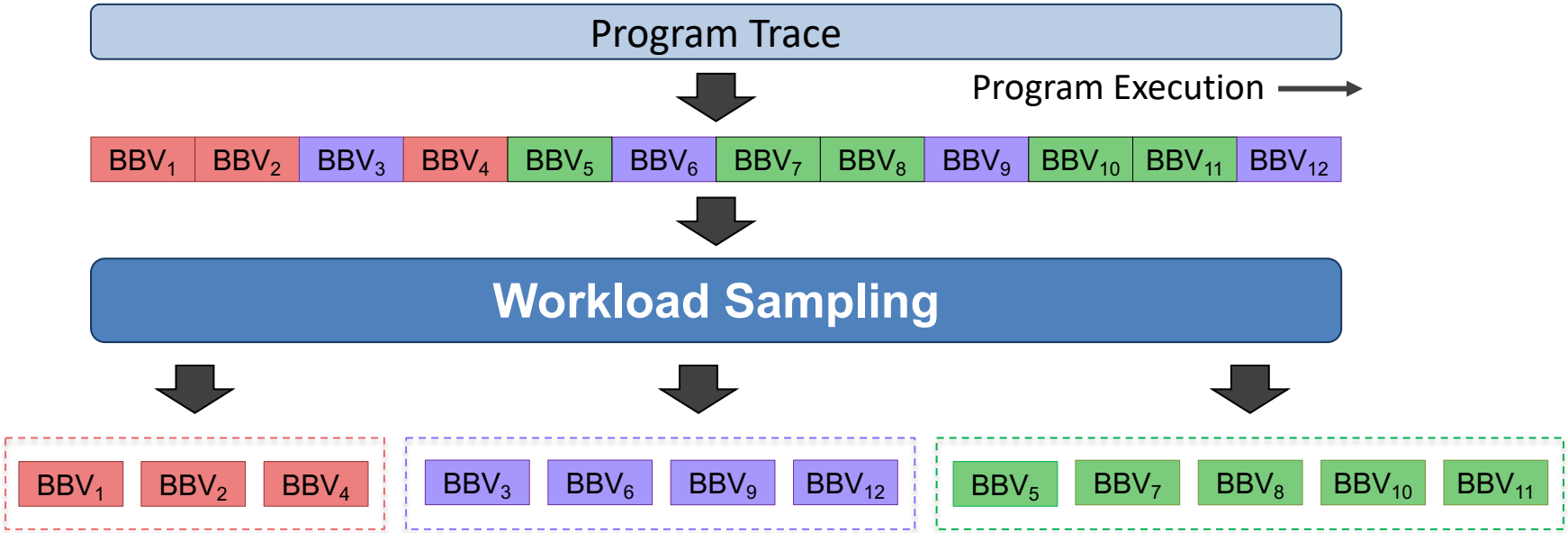

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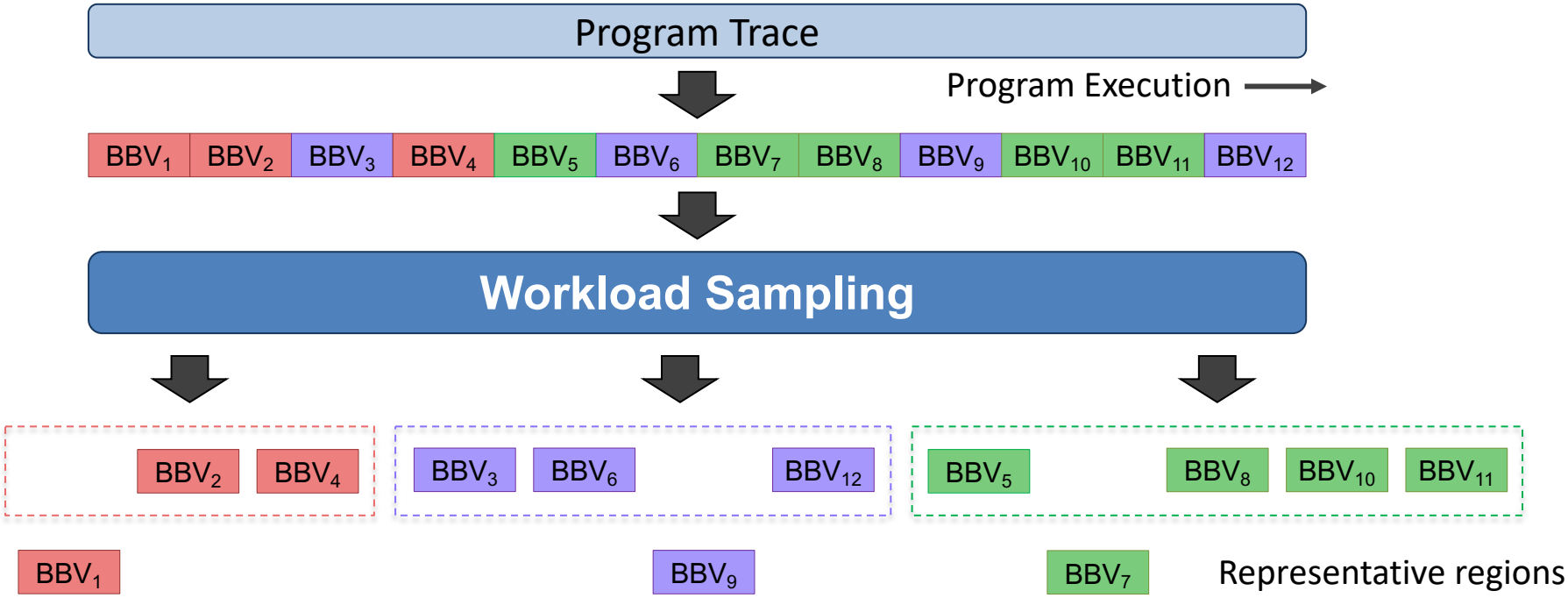
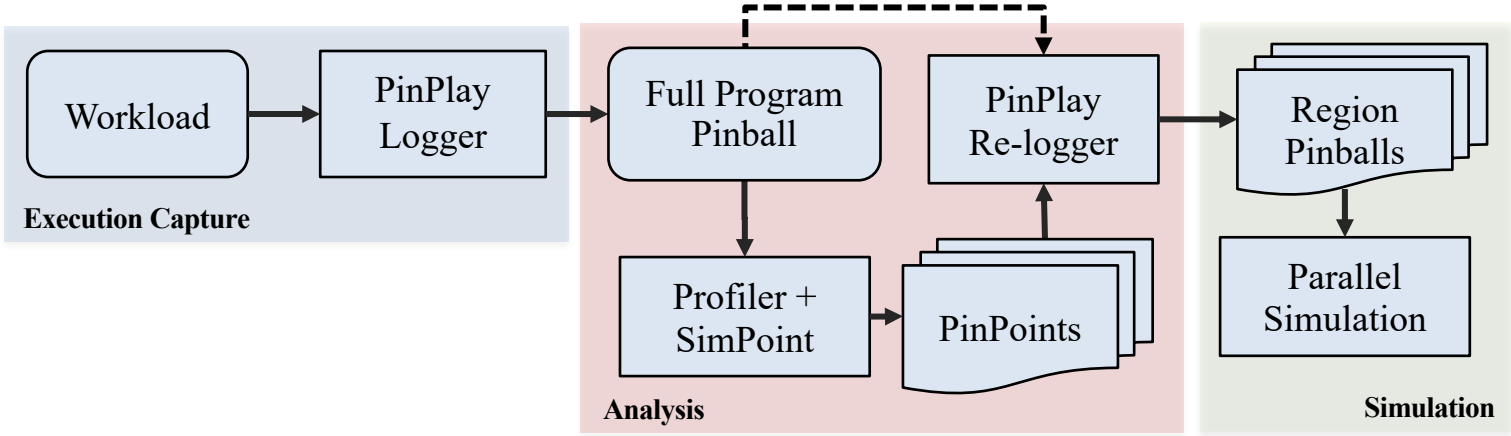
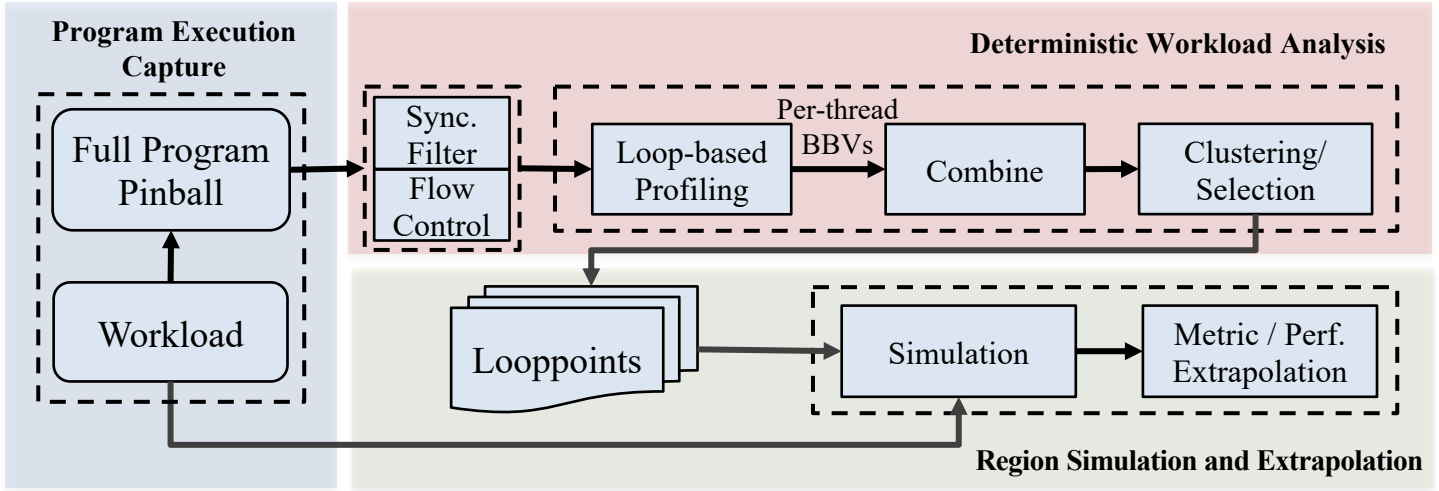


Region Selection: SimPoint



Applicable to Single-threaded Workloads

Region Selection: LoopPoint



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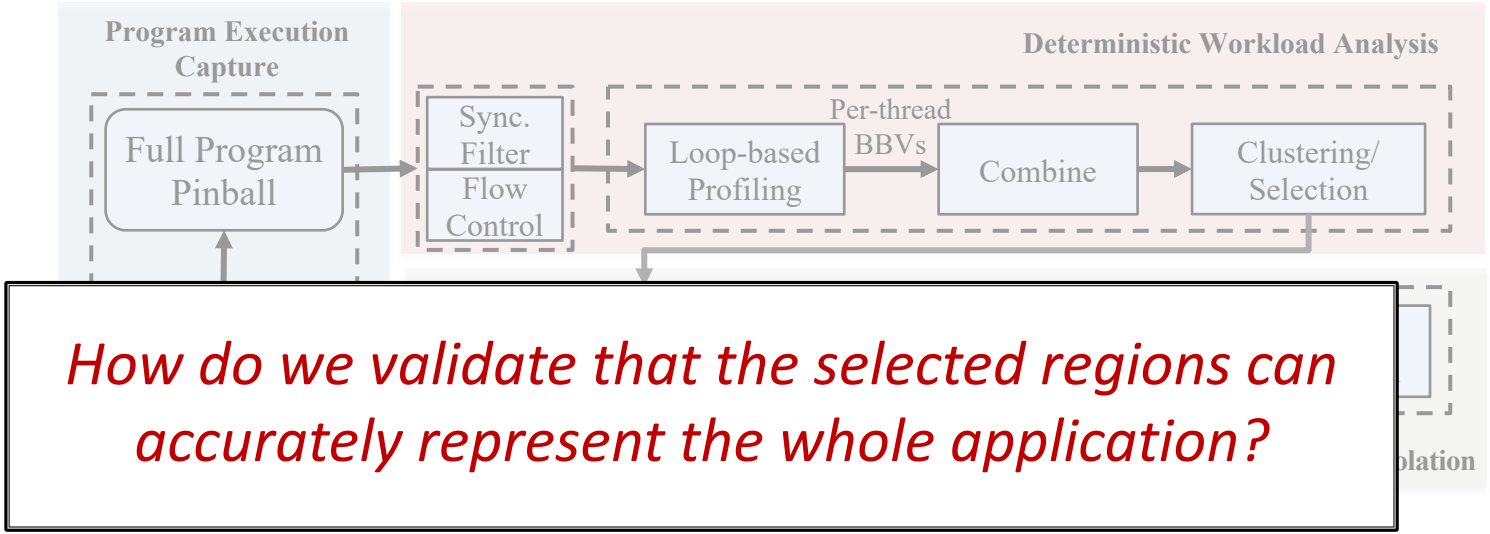


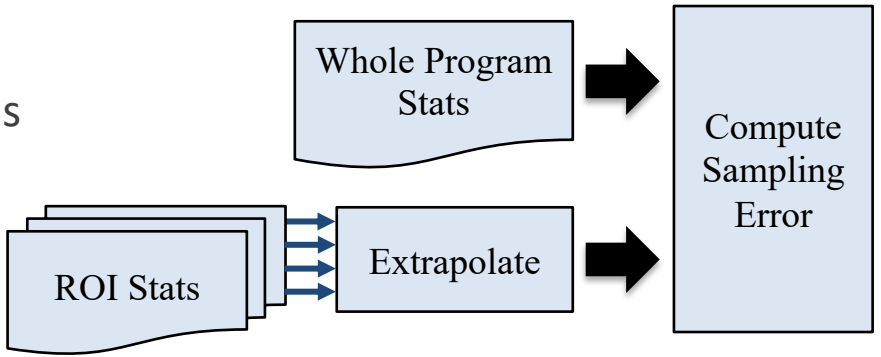
How do we validate that the selected regions can accurately represent the whole application?

Applicable to Multi-threaded Workloads

Validation of Sampling Methodologies

ROIperf

- Estimate the *representativeness* of ROI selection
  - Sampling Error
    - Performance projection using ROIs
- Performance measurement
  - Simulation
  - H/w perf counters using *ROIperf*
- Iterative fine tuning of sampling methodologies



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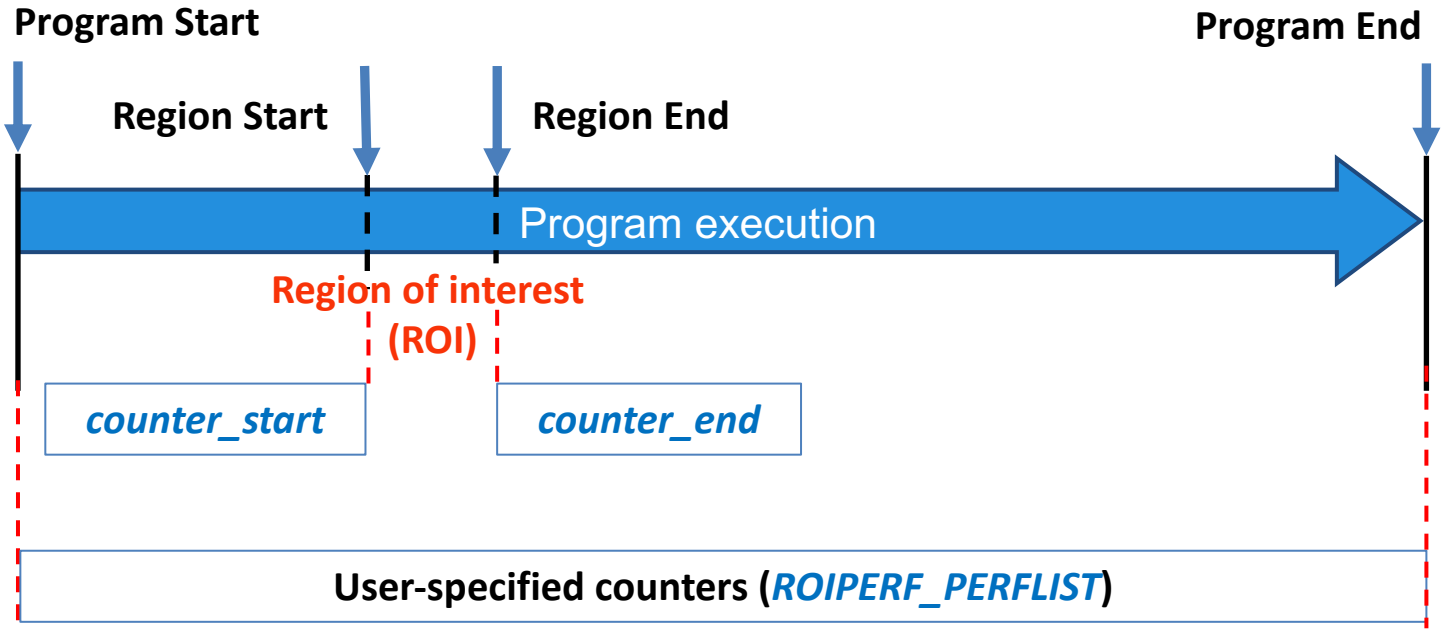
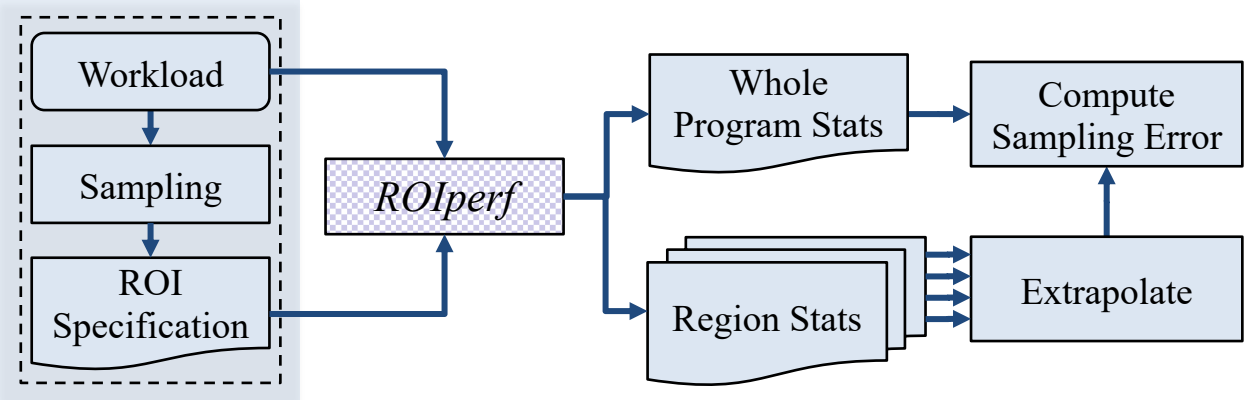
ROIperf Workflow



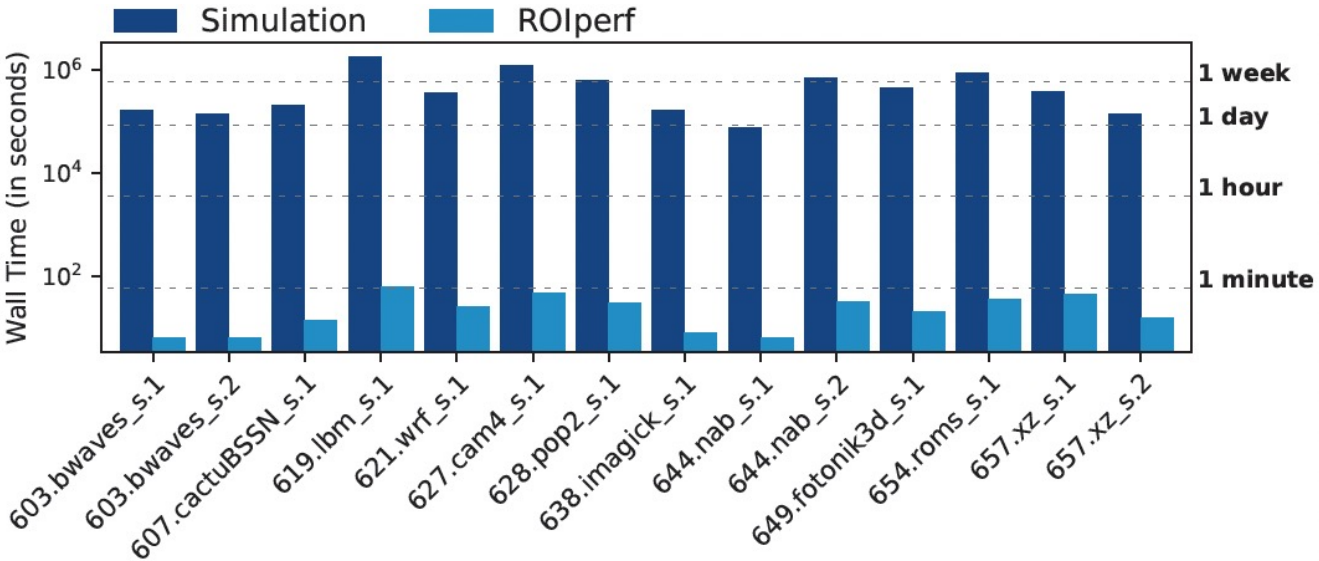
Usage Model



- Pin probe tool – minimize perturbation
- Outputs hardware perf counter values at start and end of ROI (Ex. RDTSC)
- Ref: `/usr/include/linux/perf_event.h`, `perf_event_open()` syscall

Wall Time Comparison for Validation

ROIperf



Simulation and ROIperf wall times of SPEC CPU2017 benchmarks (8 threads) using train inputs on Sniper and Skylake machine, respectively.

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Results

$$\text{prediction error\%} = \left(1 - \frac{\text{extrapolated metric}}{\text{full run metric}}\right) \times 100$$

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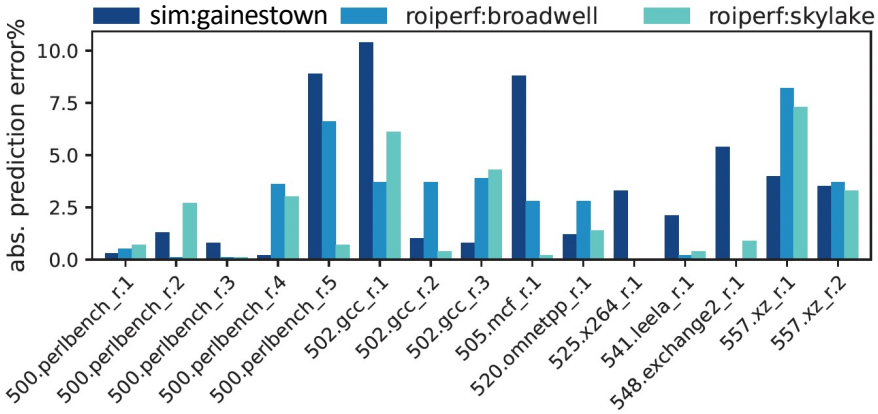
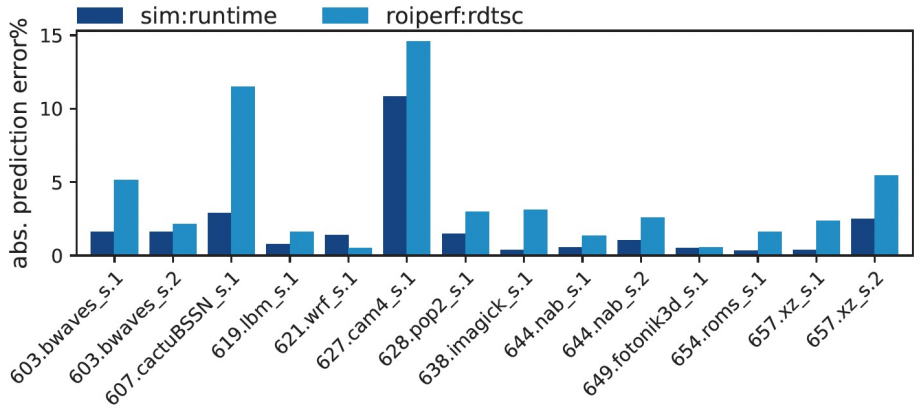
Single-threaded[1] (SimPoint)



Multi-threaded[2] (LoopPoint)



SPEC CPU2017 benchmarks with training inputs

[1]Simulation extrapolation using runtime and ROIperf extrapolation using RDTSC

[2]Passive wait policy used for multi-threaded programs

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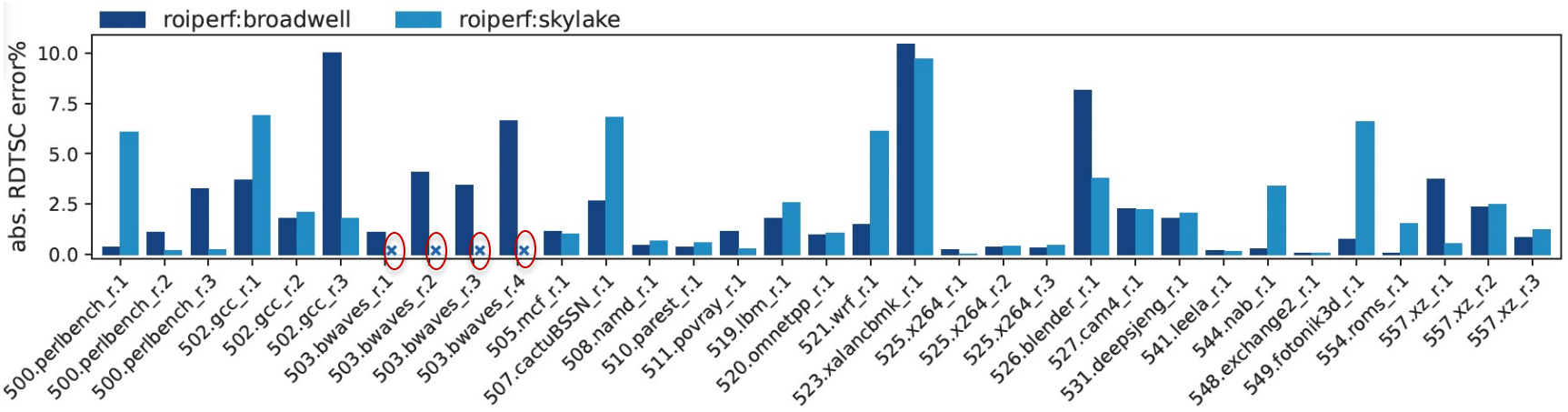
Results

RAIperf

Missing values caused by reproducibility issues!



SPEC CPU2017 benchmarks with reference inputs

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Summary

ROIperf

- ROIperf provides a framework to **rapidly validate ROIs** selected by sampling methodologies on real hardware
- Using ROIperf, **tuning a sampling methodology** for a workload can be quickly performed
- We show the efficacy of ***SimPoint*** for single-threaded and ***LoopPoint*** for multithreaded workloads, respectively.

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