FACULTEIT INGENIEURSWETENSCHAPPEN

Using HPM-Sampling to Drive Dynamic Compilation

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To obtain high performance Java Virtual Machines have two modes of execution

Unoptimized execution

Optimized execution

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Unoptimized execution

Optimized execution

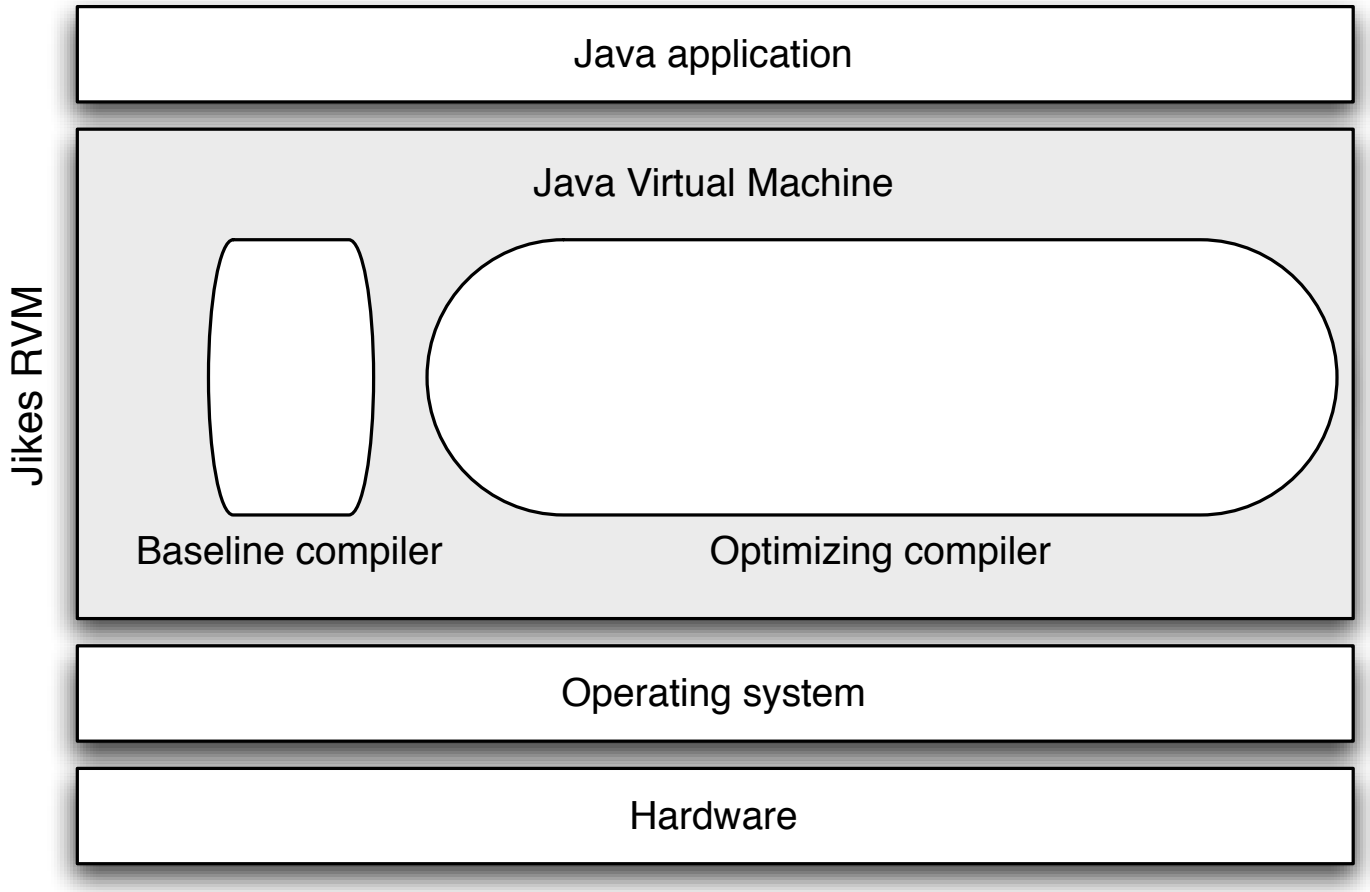
Unoptimized execution

	Interpreter	Quick compiler
Self-93		x
Sun Hotspot	x	
IBM DK	x	
IBM J9	x	
BEA JRocket		x
Jikes RVM		x
Intel ORP		x

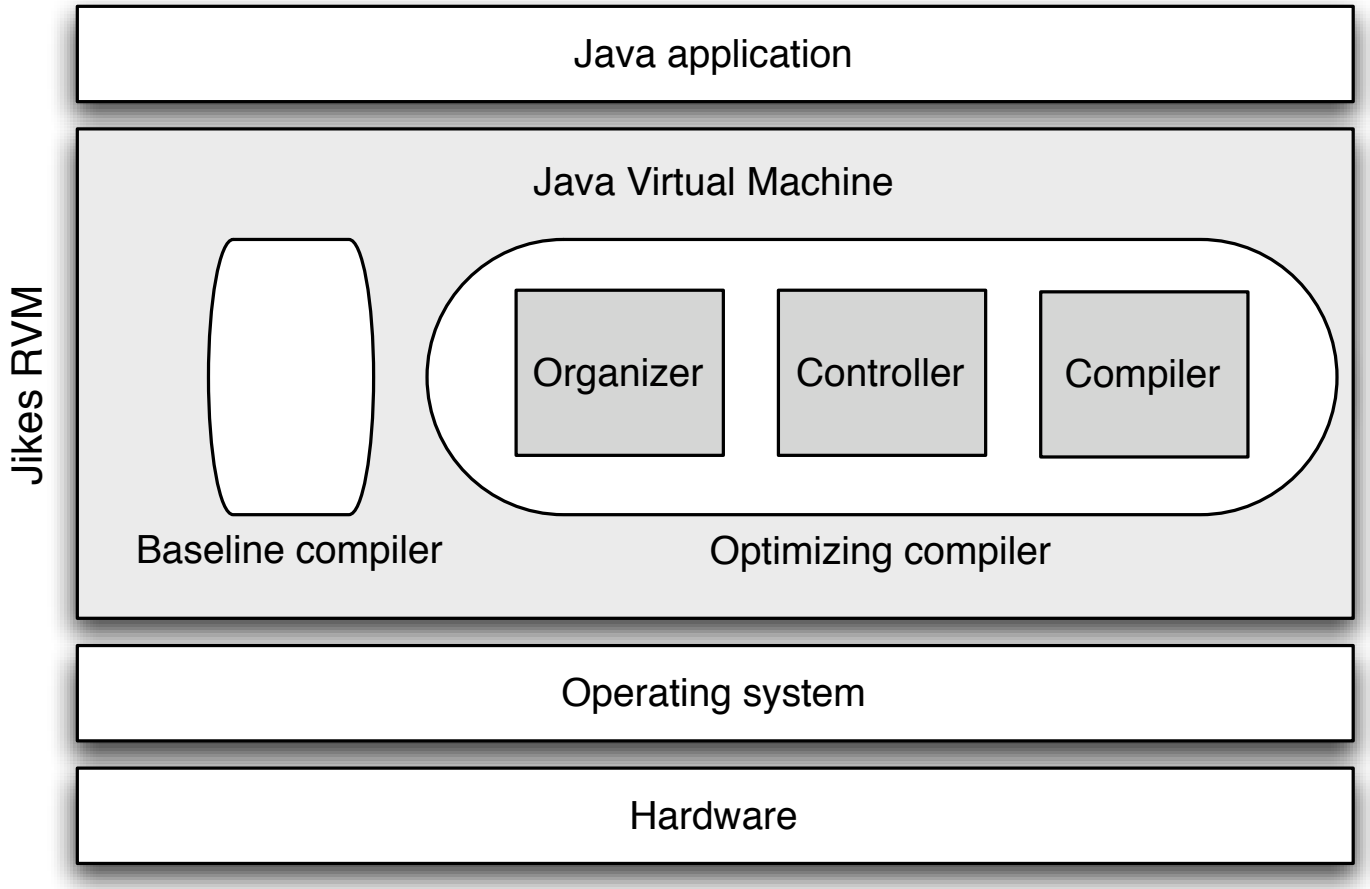
Unoptimized execution

VM	Interpreter	Quick compiler
Self-93		x
Sun Hotspot	x	
IBM DK	x	
IBM J9	x	
BEA JRockit		x
Jikes RVM		x
Intel ORP		x

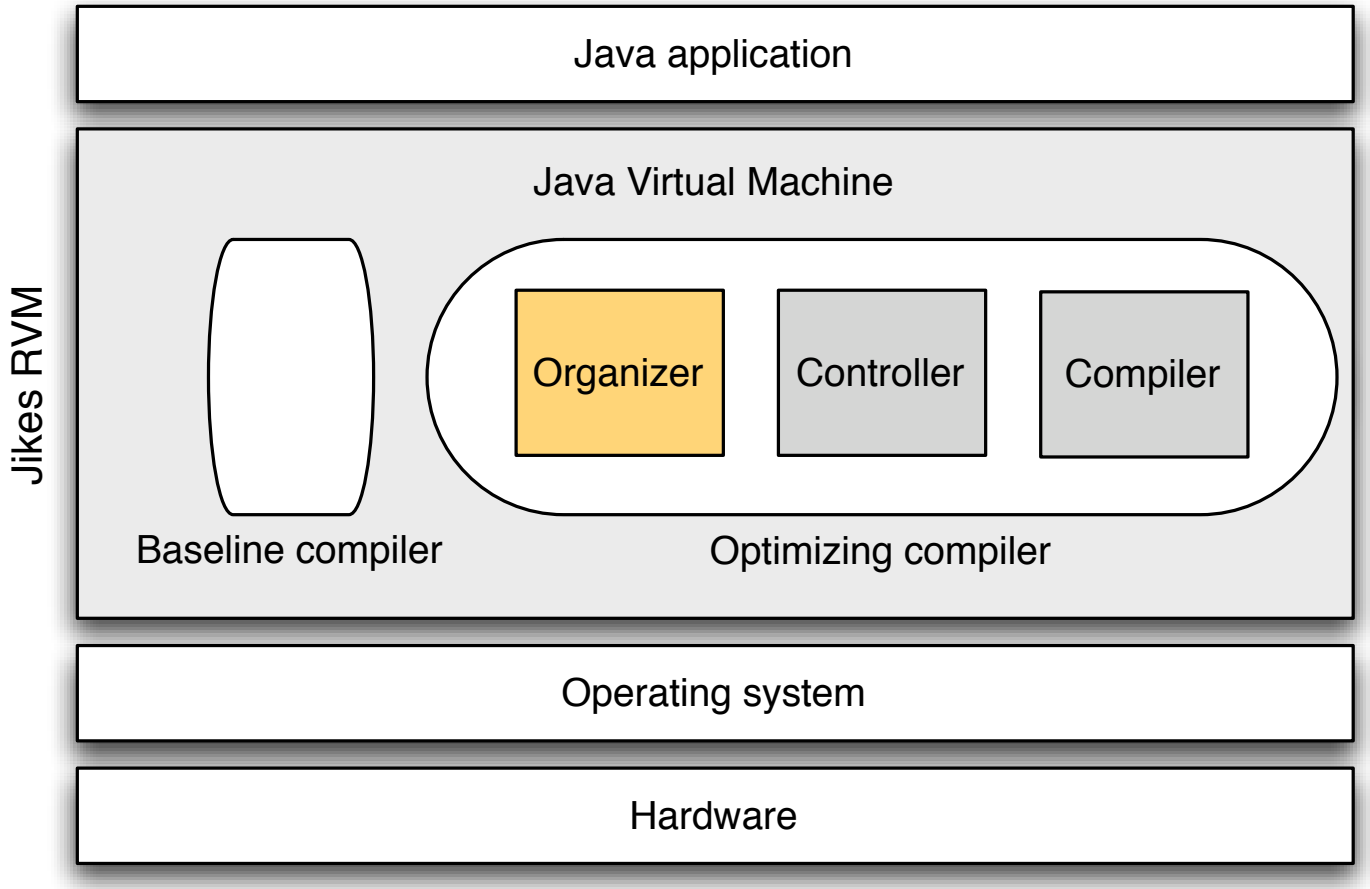
Jikes RVM


Java application
Java Virtual Machine
Jikes RVM
Baseline compiler
Optimizing compiler
Operating system
Hardware

The optimizing compiler has 3 sub-components



This work focuses mainly on the organizer



There are two approaches to find optimization candidates

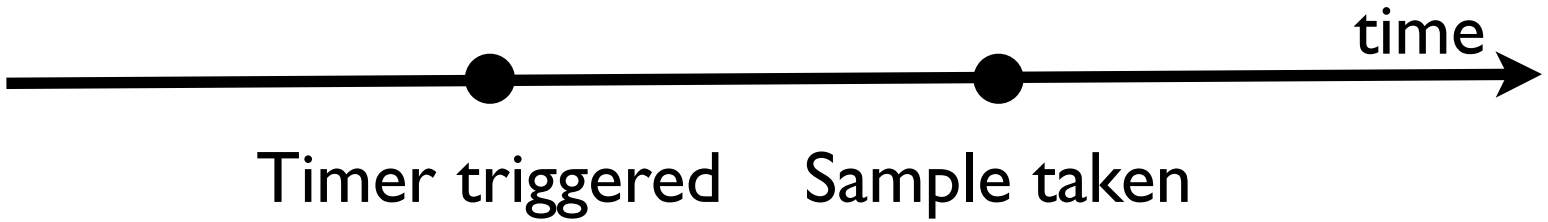
Counter-based sampling

Count the number of method invocations, and optionally loop iterations

Timer-based sampling

Sample the currently executing method at regular intervals using an operating system timer

Timer-based sampling



The size of the gap depends on
(i) how the timer is triggered and
(ii) how the sample is taken

The trigger mechanism initiates the sample-taking process

- *Nanosleep:* thread + while-loop + sleep
- *Setitimer*: interrupt handler
- Hardware performance monitors

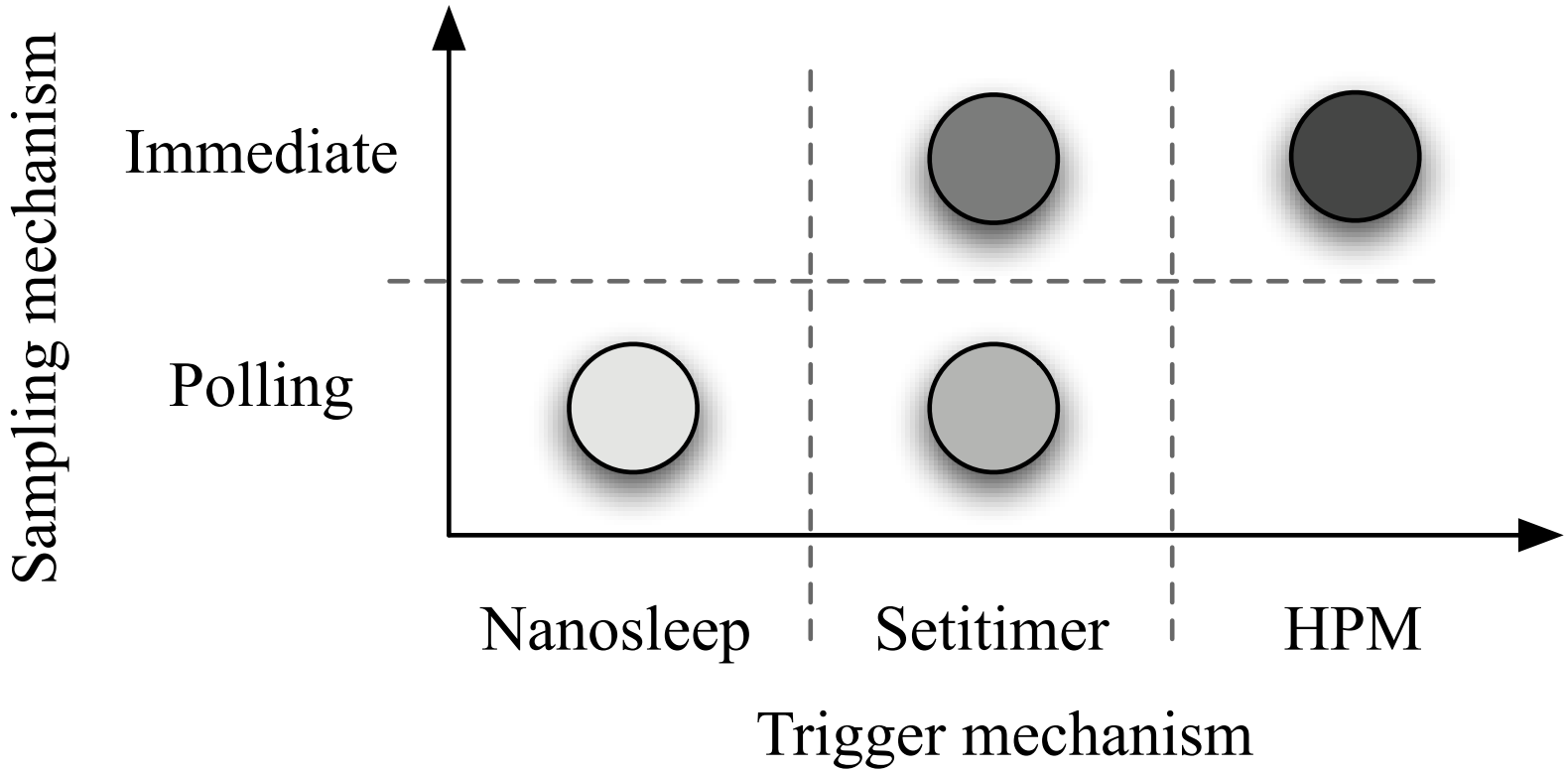
Using hardware performance monitors to initiates the sample-taking process

- HPMs are supported by most processors
- No general OS support yet for HPMs
- Count elapsed clock cycles
- Generate an interrupt when a counter overflows

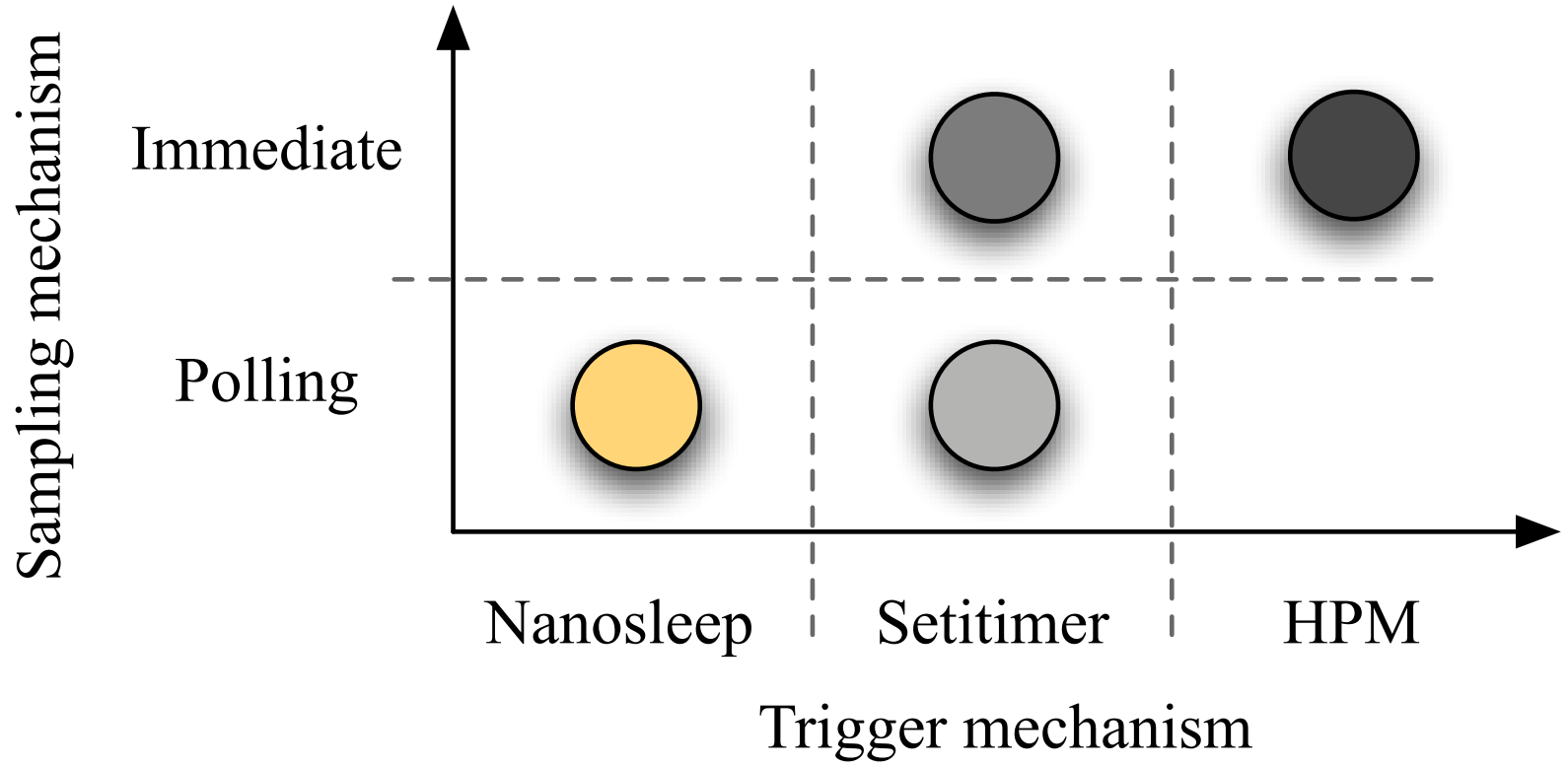
The sampling mechanism determines which method was executing

- *Polling points*: set a flag, grap the method ID when execution reaches a yieldpoint
- *Immediate*: no flag, no yieldpoint, just take a grab the PC from the stack when triggered, and use the PC to lookup the method ID

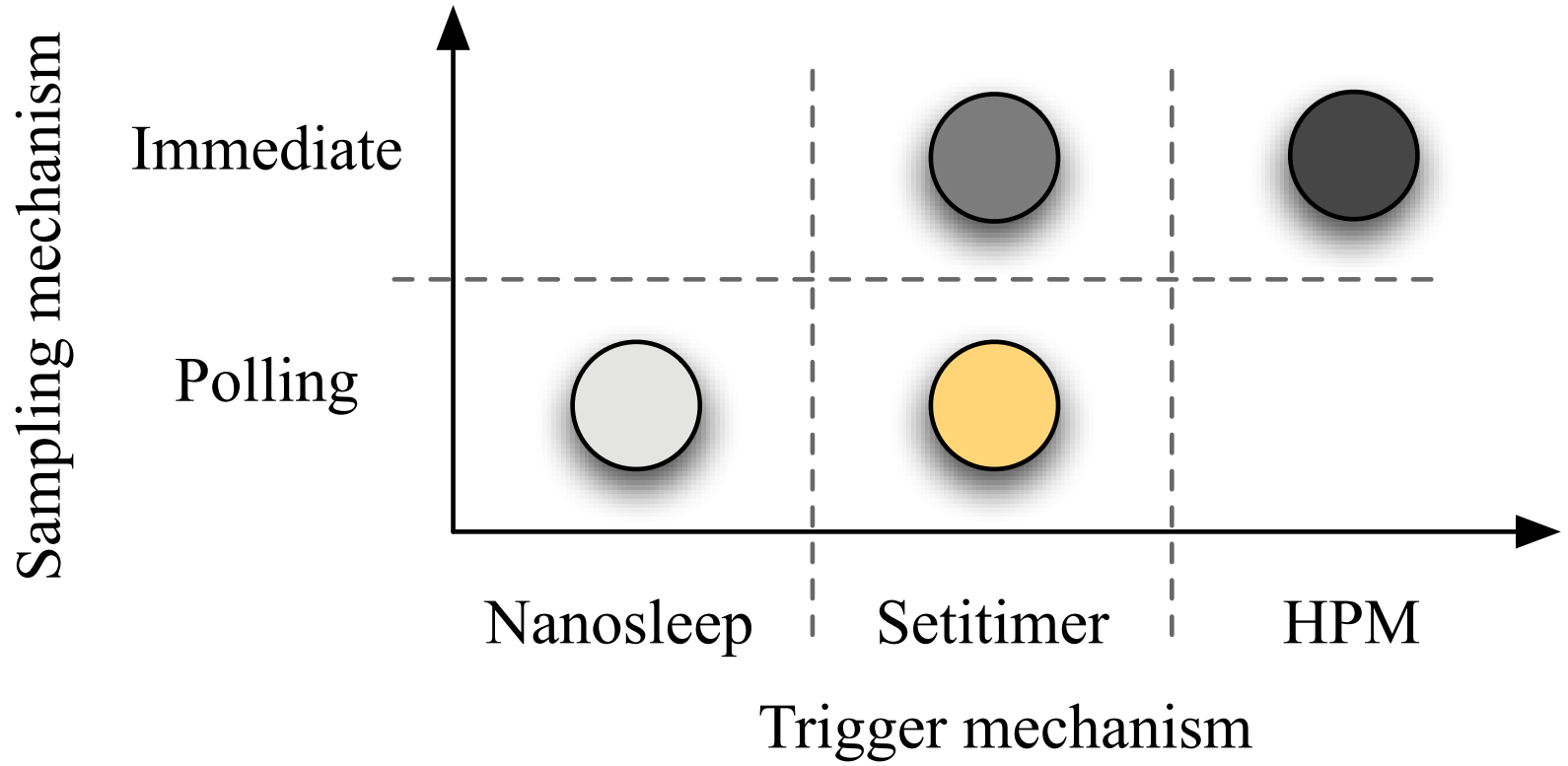
Timer-based profilers exist in many flavours



BEA's JRockit



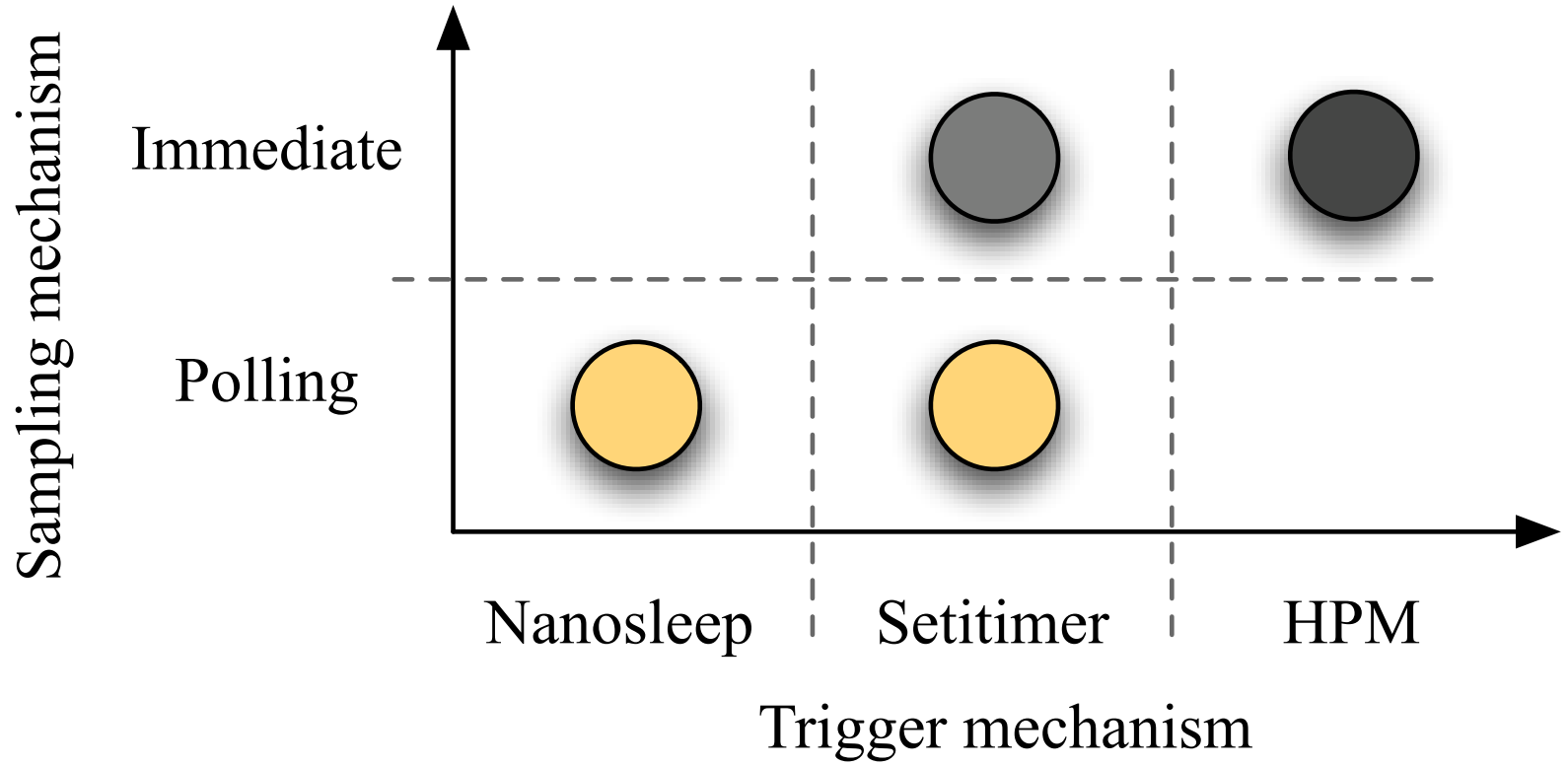
IBM's J9 VM


Sampling mechanism
Immediate
Polling
Nanosleep
Setitimer
HPM
Trigger mechanism

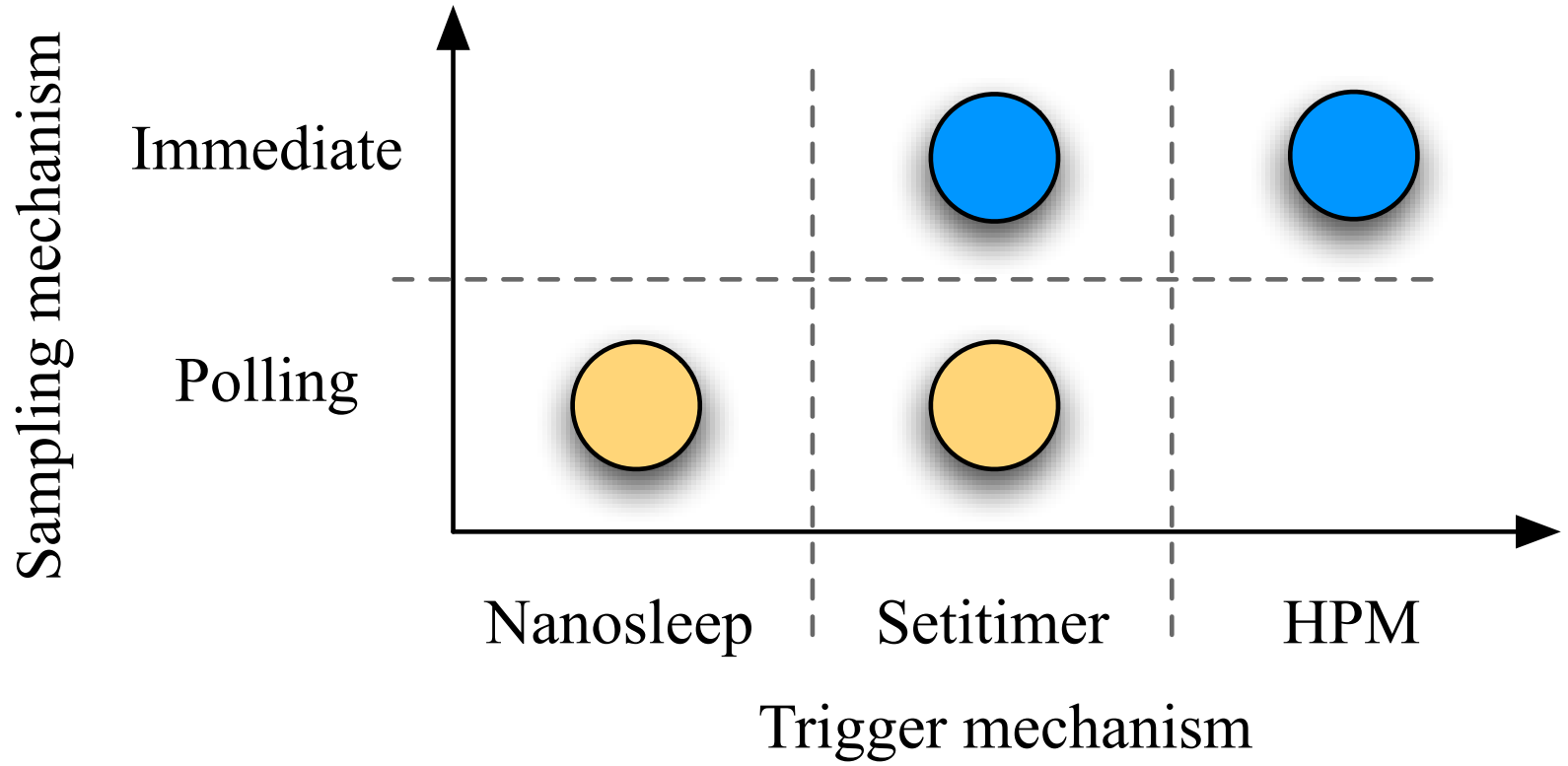
Sun's HotSpot VM

- No information available
- Uses only one level of optimization
- Suspect that it uses a counter-based solution rather than a timer-based solution

IBM's Jikes RVM
(both implemented)



We added those to IBM's Jikes RVM



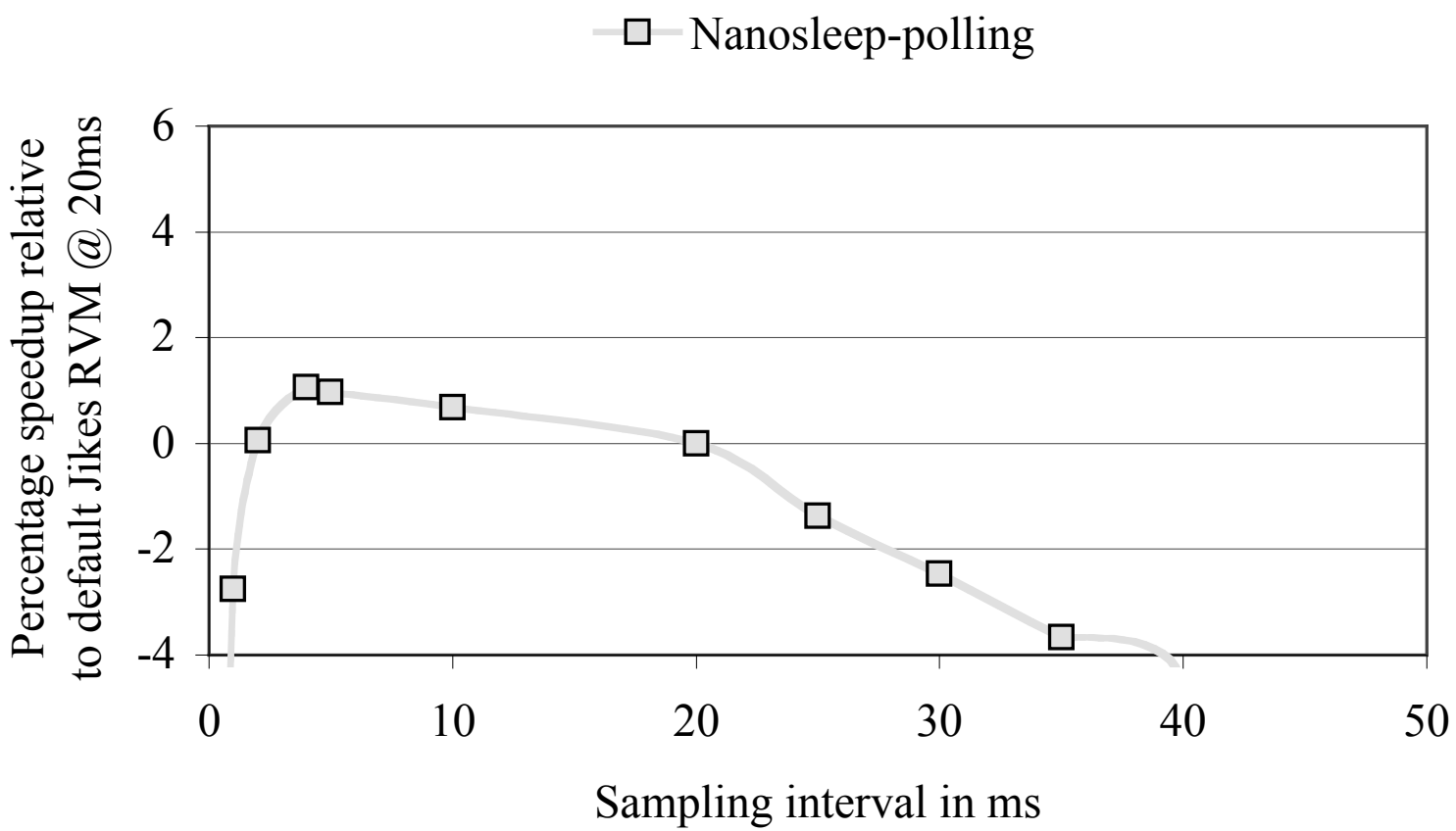
Experimental design

- Three benchmarks suites:
  - SpecJVM98
  - DaCapo
  - PseudoJBB
- Two hardware platforms:
  - AMD XP 3000
  - AMD XP 1500

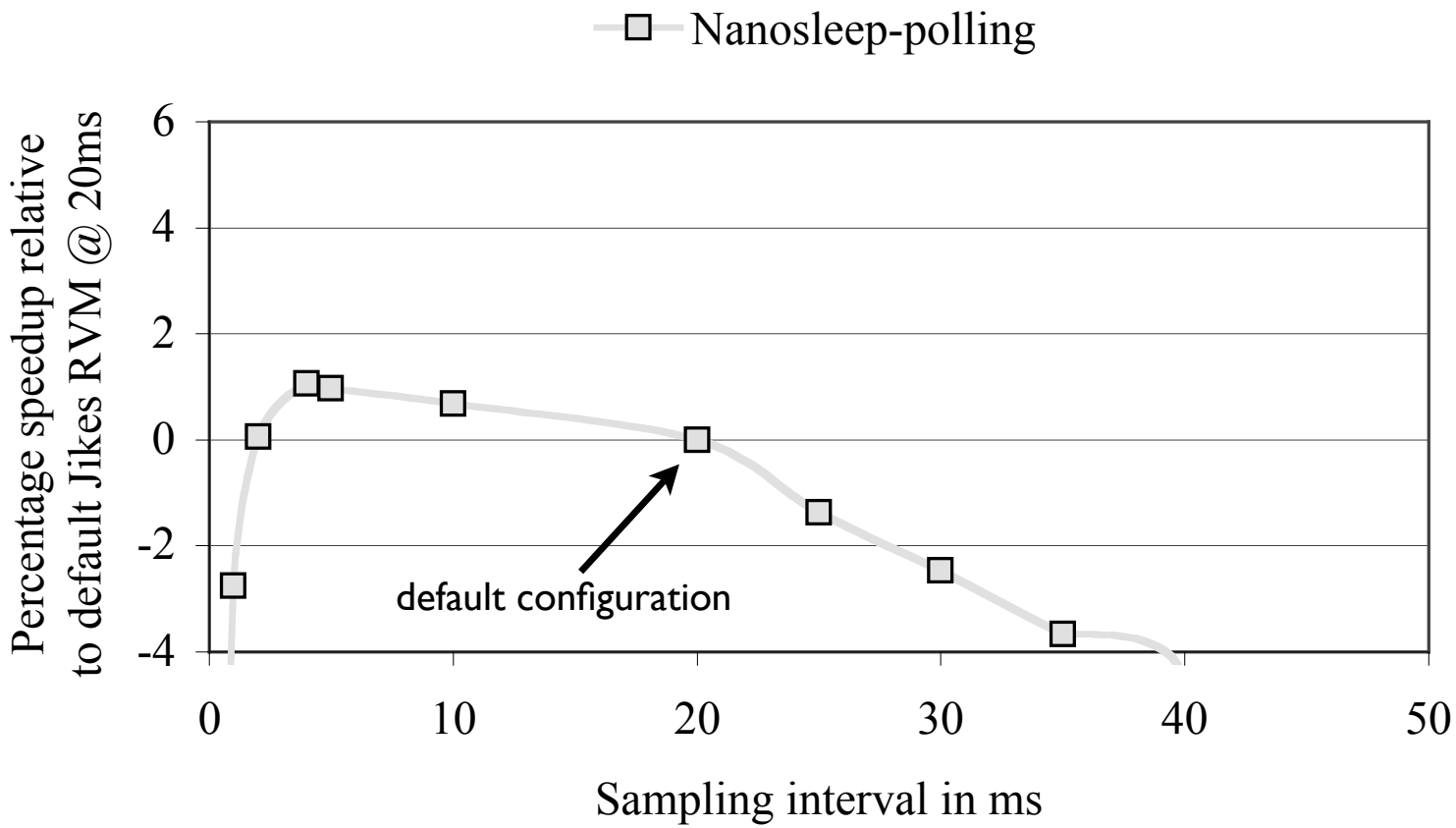
Data analysis

- 11 runs, removed first run, averaged remaining 10 runs
- For validating speedup we used a one-sided student t-test with a 95% confidence level

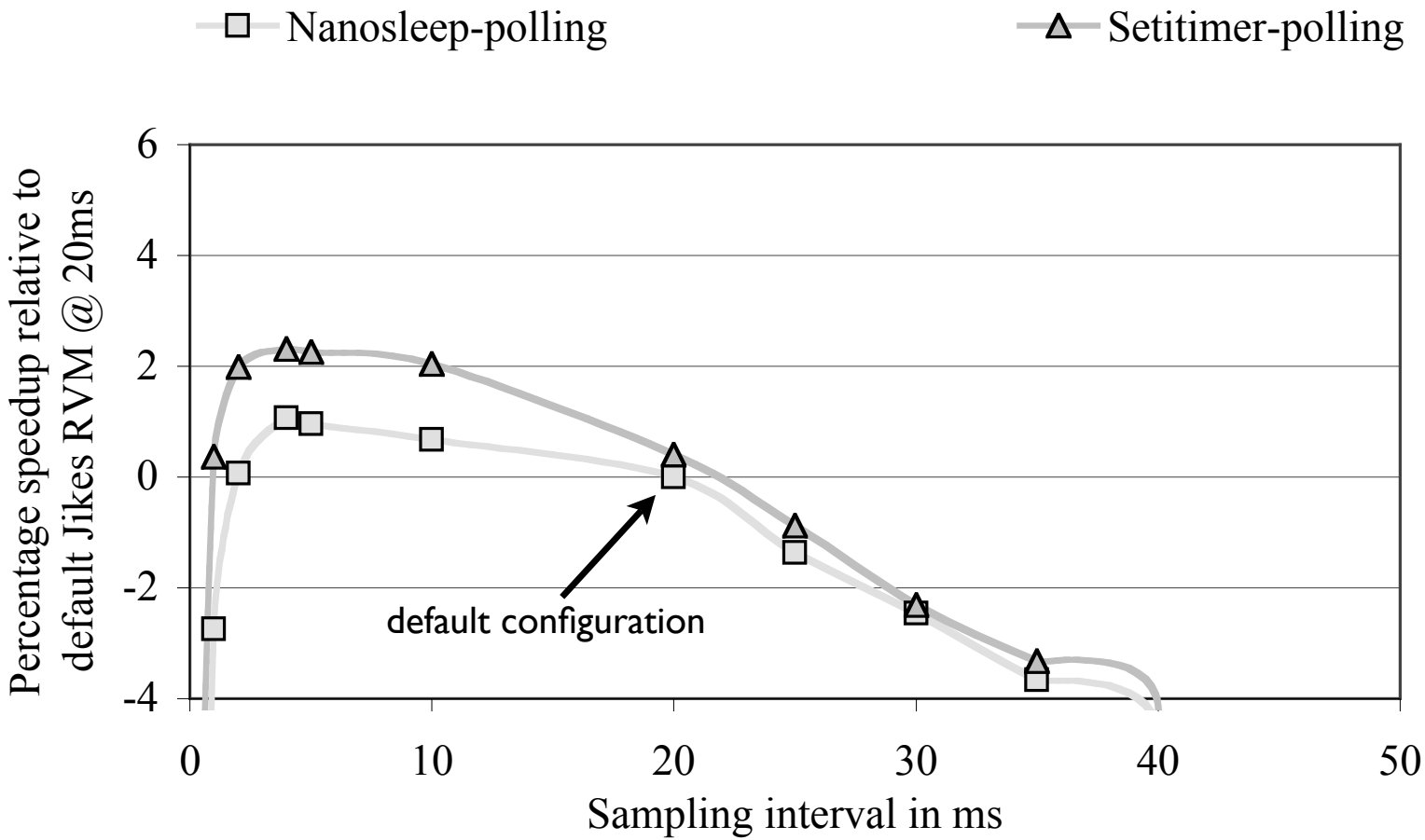
Average percentage speedup



Average percentage speedup



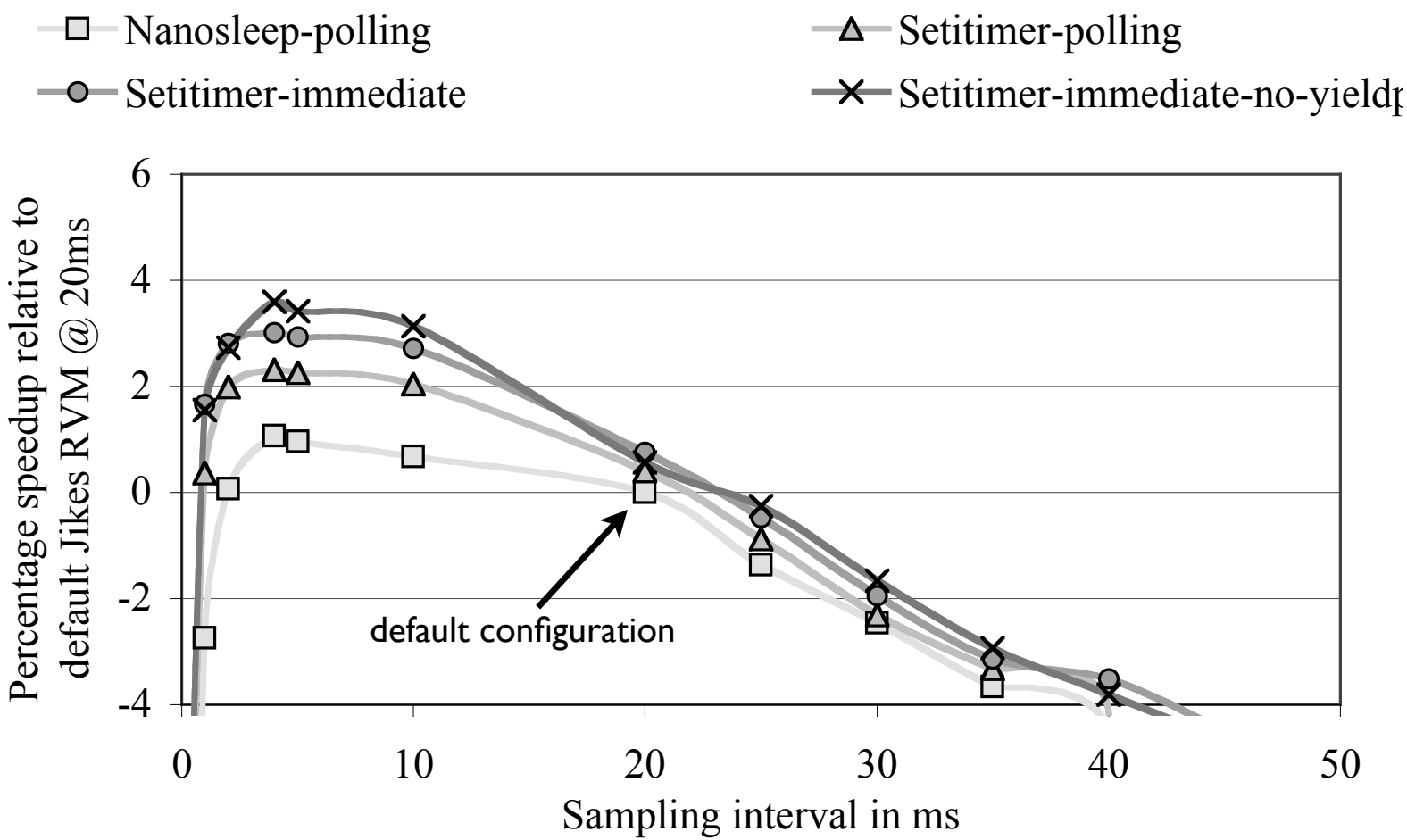
Average percentage speedup



We implemented a "setitimer-immediate" approach in Jikes RVM

- Removed polling points code
- Can sample all methods

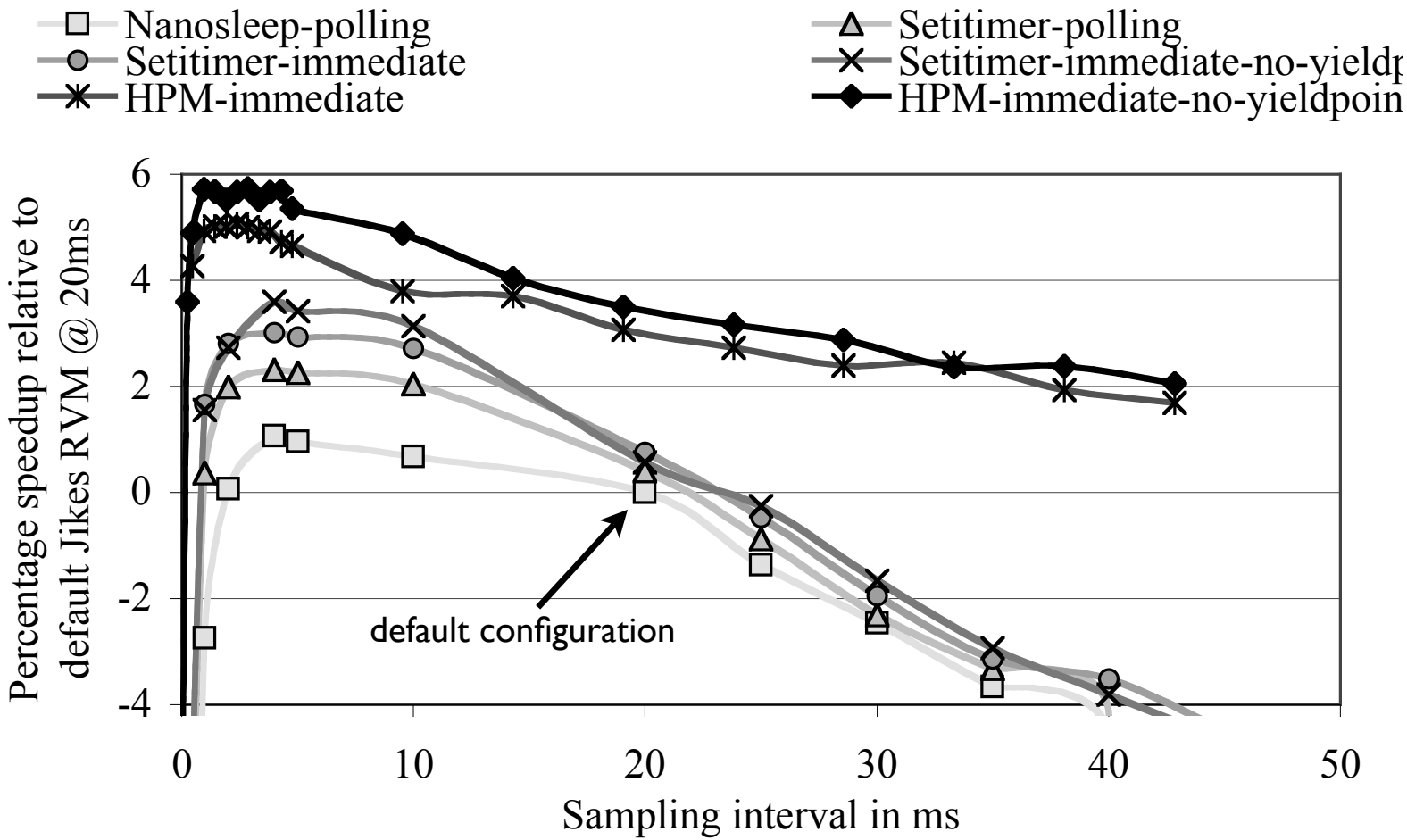
Average percentage speedup



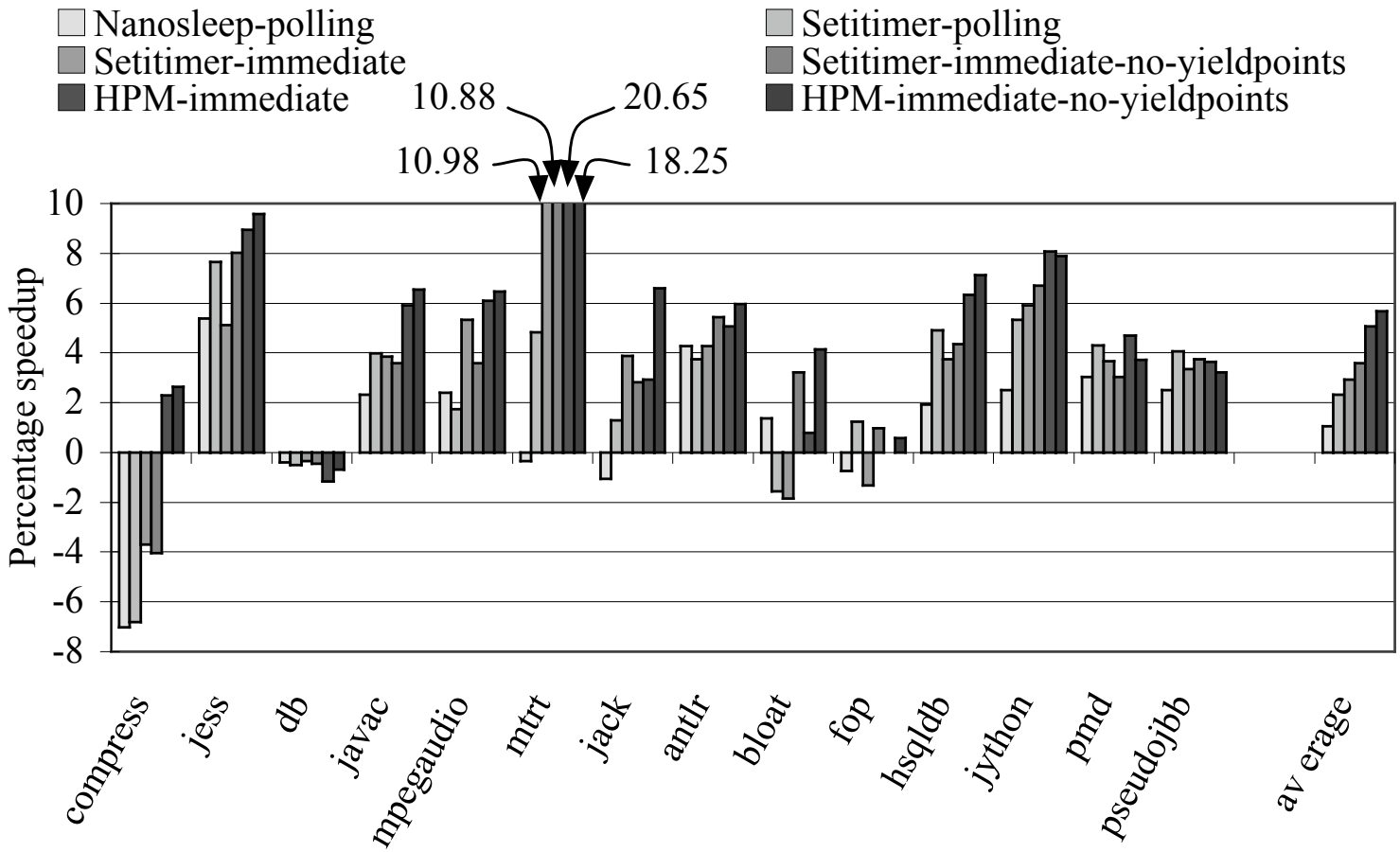
We implemented a "HPM-immediate" approach in Jikes RVM

- Removed polling points from code
- Can sample all methods
- No OS limitations
- No delay between expiration of the timer and scheduling of the thread
- Fixed timer tick intervals become relatively less frequent as processors get faster

Average percentage speedup



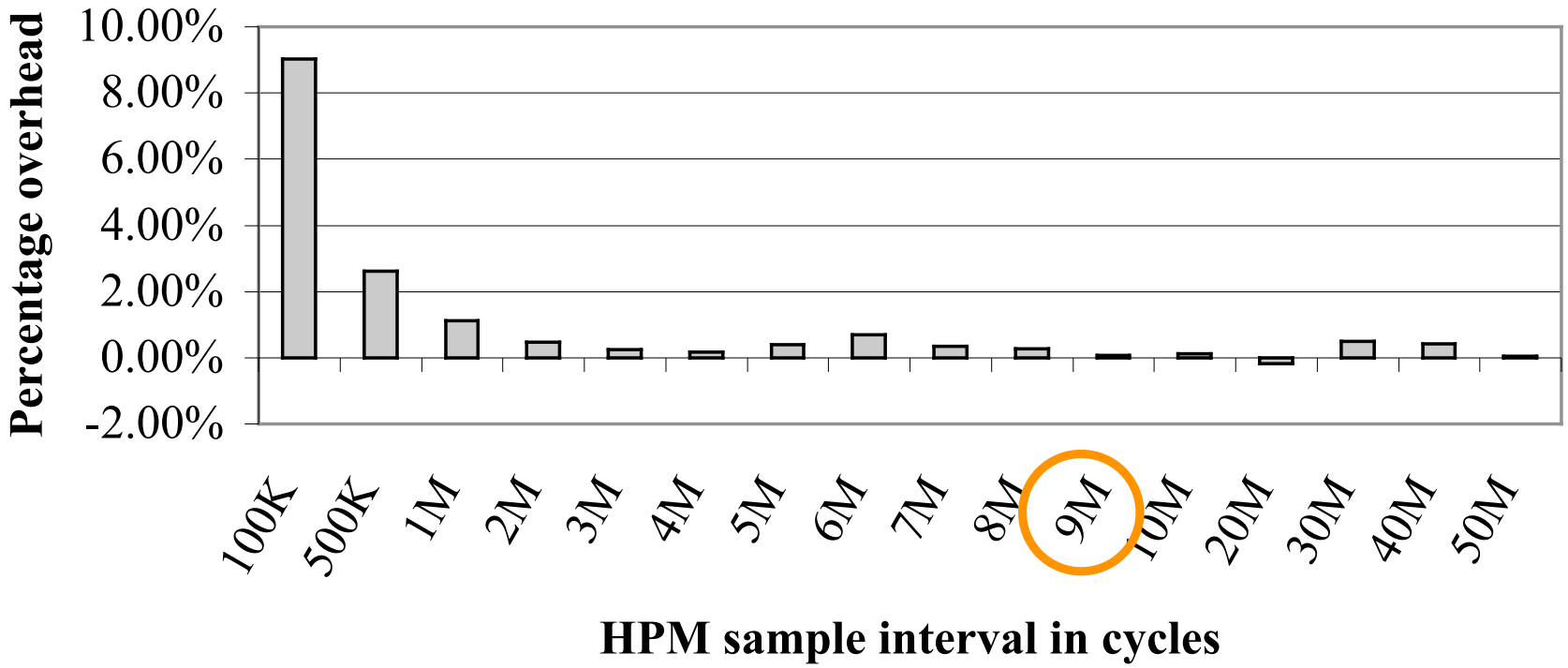
Average percentage speedup



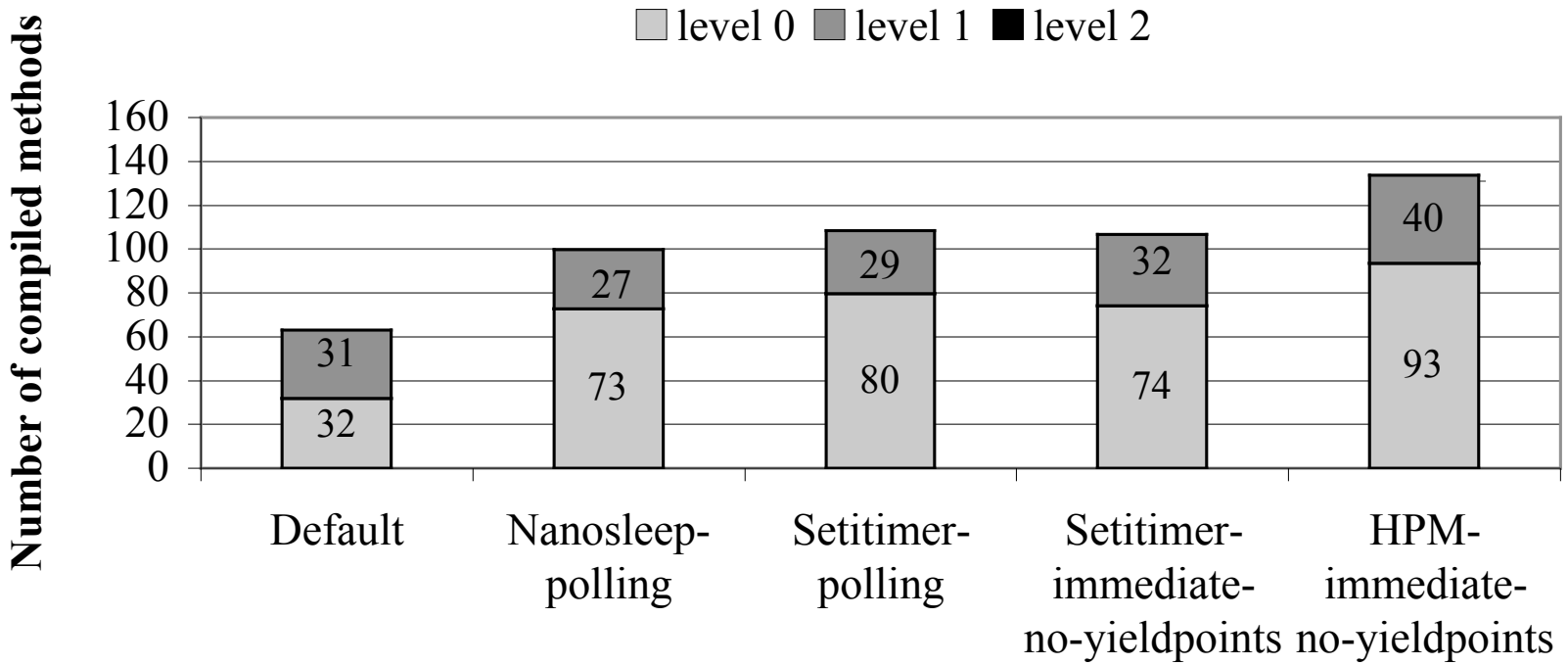
Average speedup of 5.7% over default Jikes RVM

- Immediate sampling: 3.0%
- HPM triggering: 2.1%
- Removing polling points: 0.6%

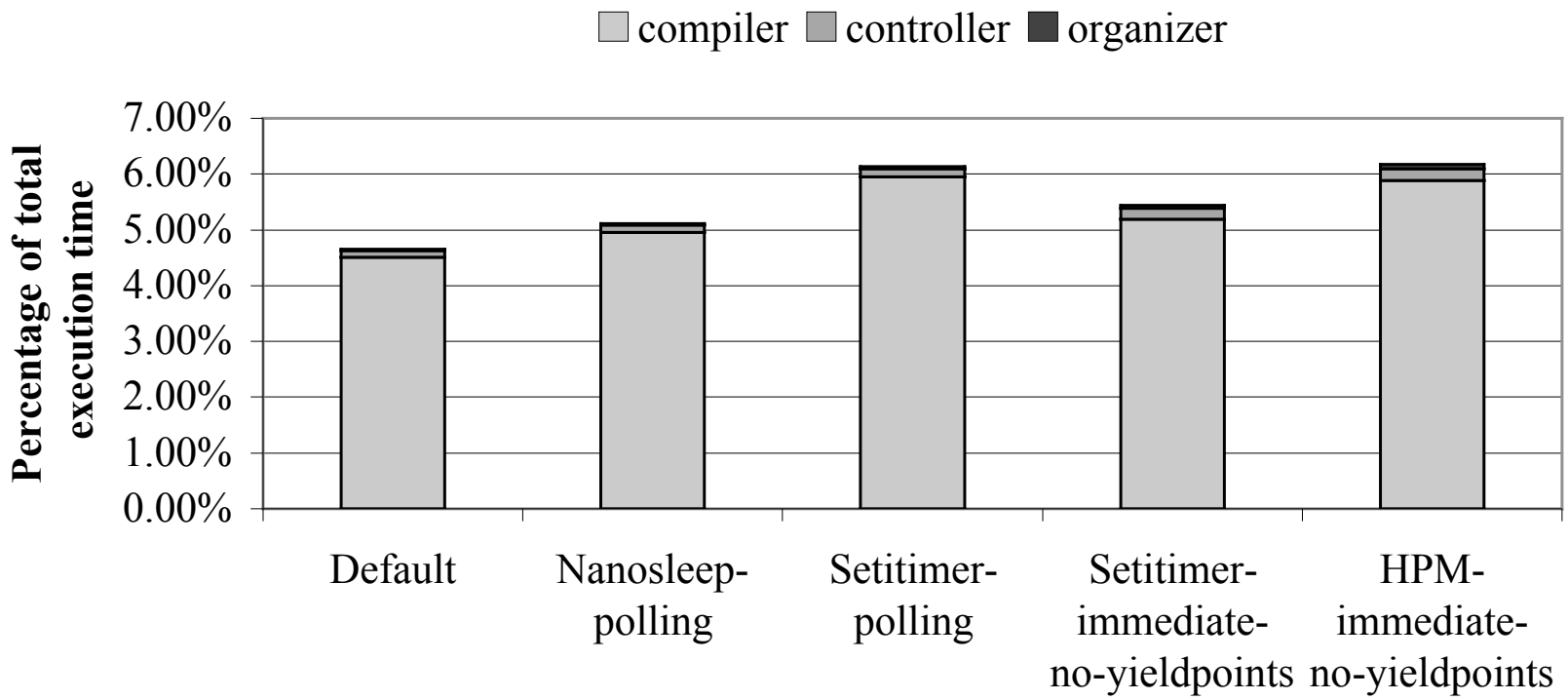
Producing HPM samples doesn't add much overhead



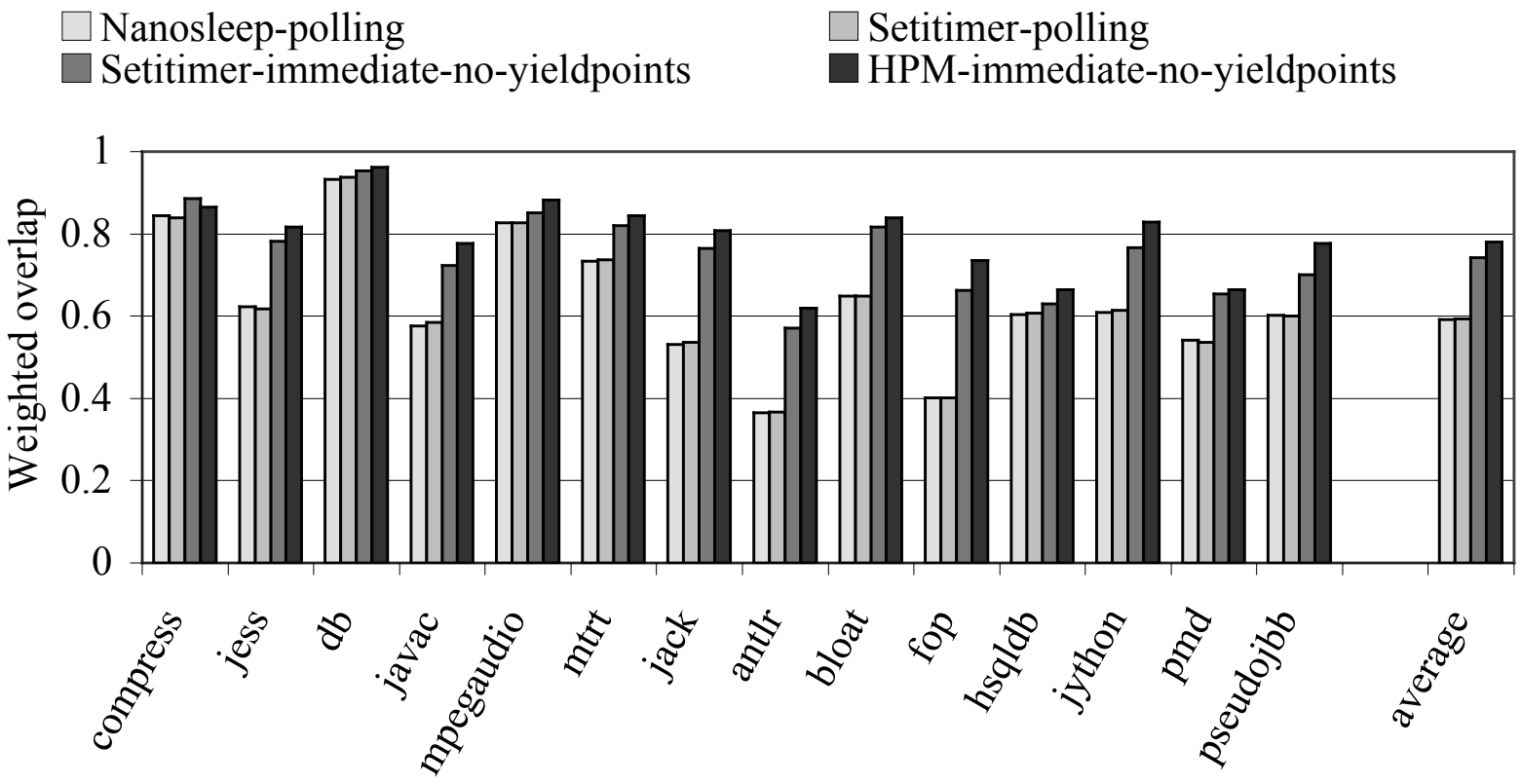
HPM-Immediate optimizes twice as many methods



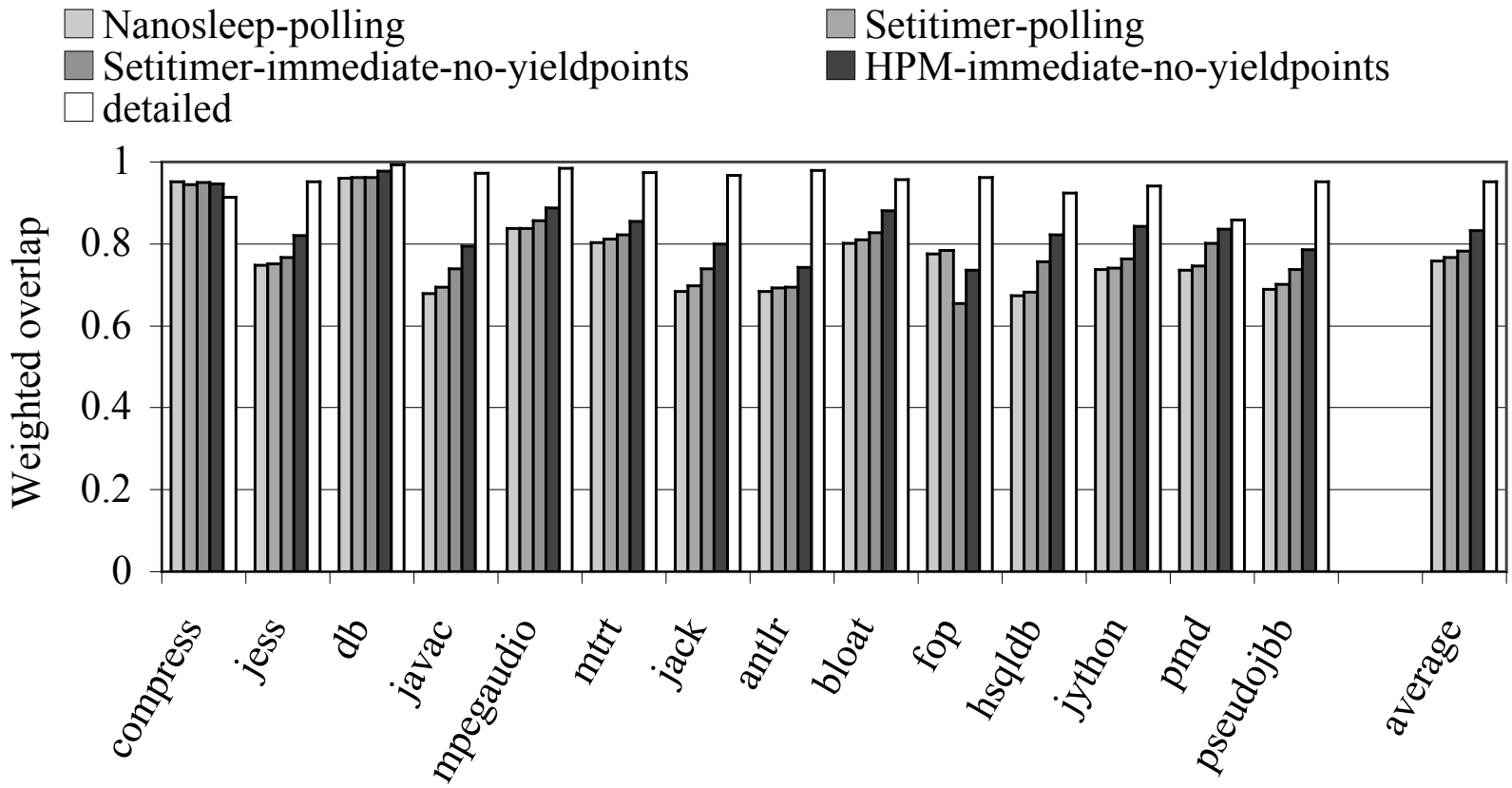
Consuming HMP-samples doesn't add much overhead either



HPM-Immediate is more accurate



HPM-Immediate is more stable



Conclusions

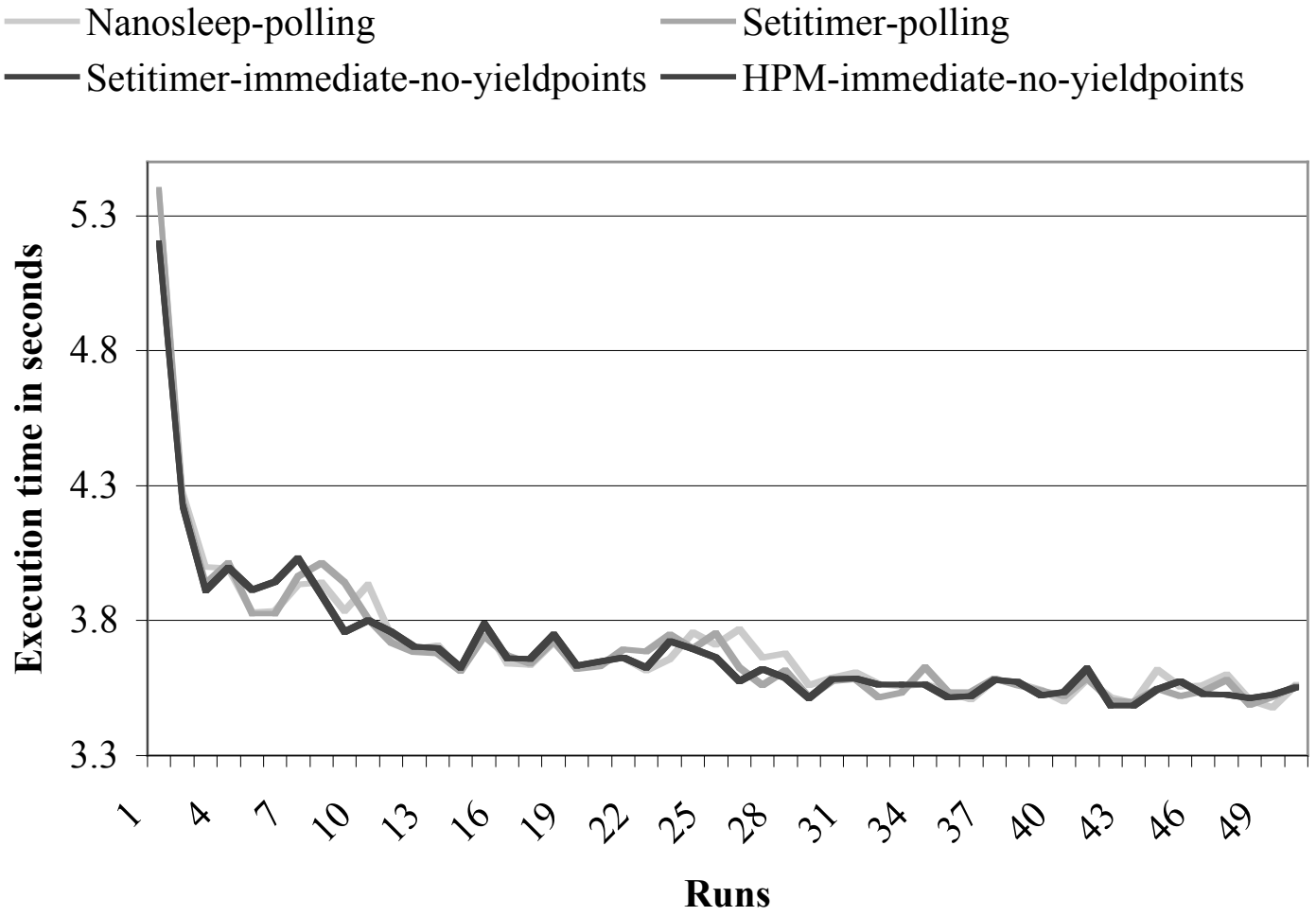
- Empirically evaluated the design space of several sample-based profilers.
- Described the design and implementation of HPM-sampling approach.
- Empirically evaluated the HPM-sampling in Jikes RVM, demonstrating that it improves performance by 5.7% on average, and up to 18.3%.
- Simple idea but clear win. Need for "black box" HPM functionality.

Future work

- Can we use non-cycle count events (i.e. cache miss count events)?
- Can we use it for other parts of the optimization system (i.e. method inlining)?

Thanks!

No real change for steady-state performance



Related work

- Lu et al.: for path profiling
- Adl-Tabatabai et al.: prefetching
- Lipasti et al.: speculative optimization
- Schneider et al.: locality improvements
- Merten et al.: branch behavior
- ...