TUHH
Technische Universität Hamburg

Leibniz Universität Hannover

MELF: Multivariant Executables for a Heterogeneous World

USENIX ATC'23

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2023-07-10

Motivation

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Tell me why!

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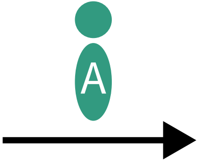

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Turn it off!

B

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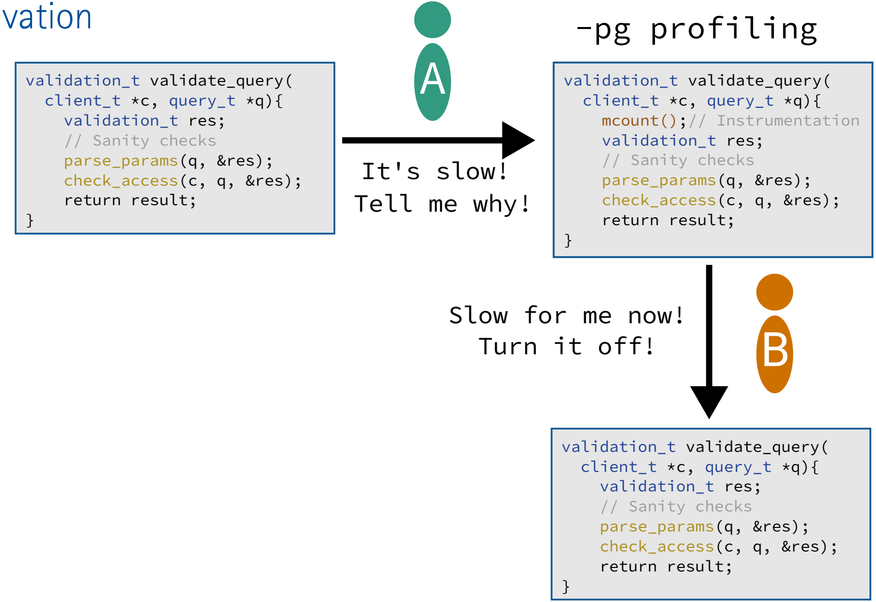

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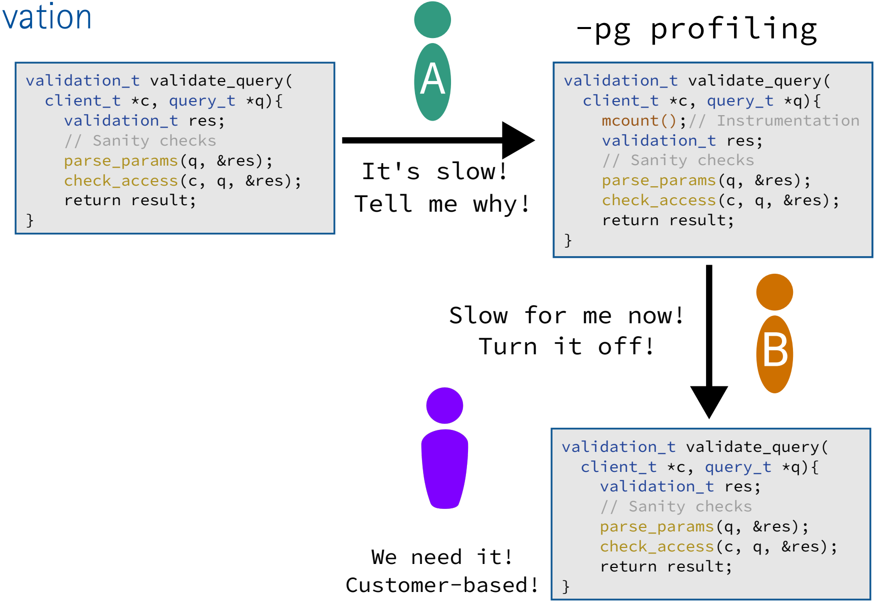

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We need it!
Customer-based!

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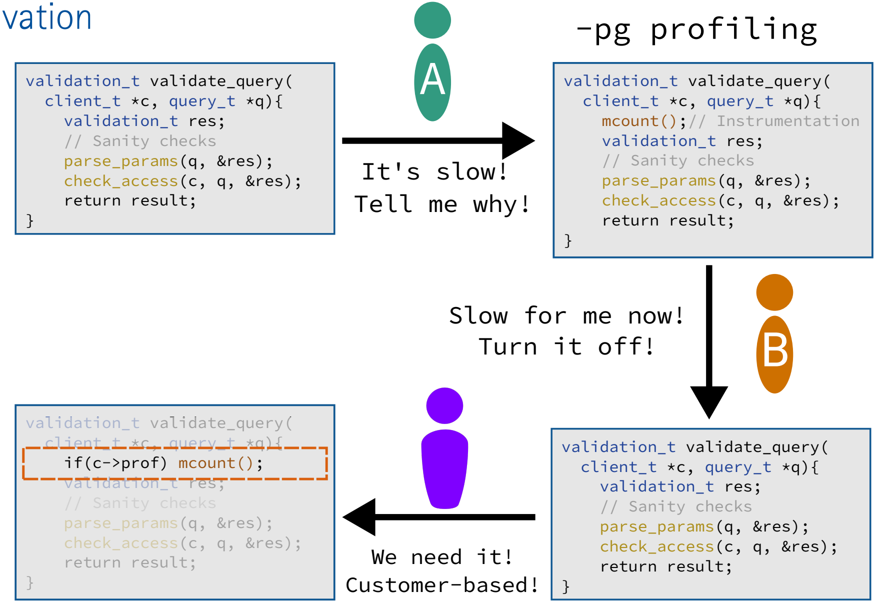

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Checks and Condition Propagation

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Checks and Condition Propagation

Multivariant ELF

Multivariant ELFs

- **Static:** Multivariant Binary Format
  - Multiple compile-time variants of program
  - Function granularity
- **Dynamic:** Overlay Manager
  - Concurrent usage of multiple variants
  - Kernel extension for synchronized address spaces
- **Case-Studies**
  - Performance isoliation of profiling (memcached)
  - Dynamically selectable assertions (sqlite)
  - Context-specific address sanitizer (mariadb)
  - Heterogeneous ISA-aware thread pool

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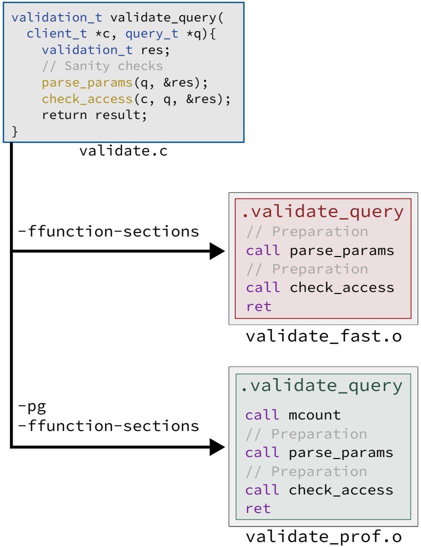

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validate.c

```
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call parse_params
// Preparation
call check_access
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```

validate_fast.o

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.validate_query

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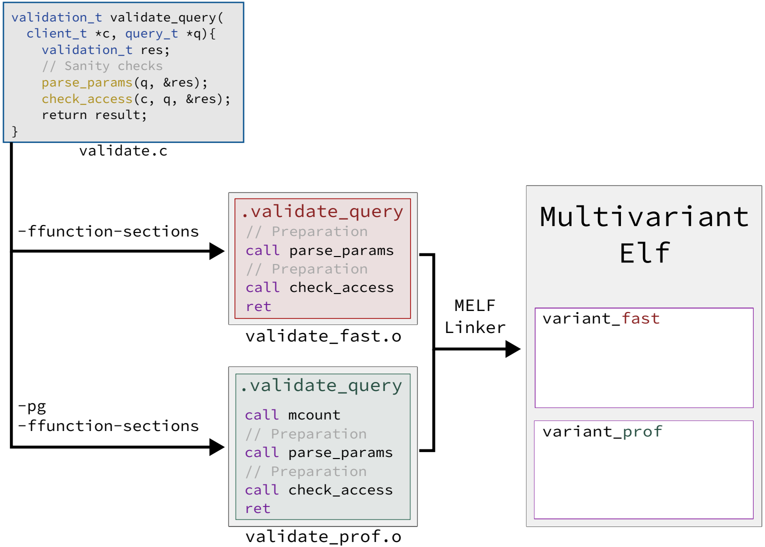

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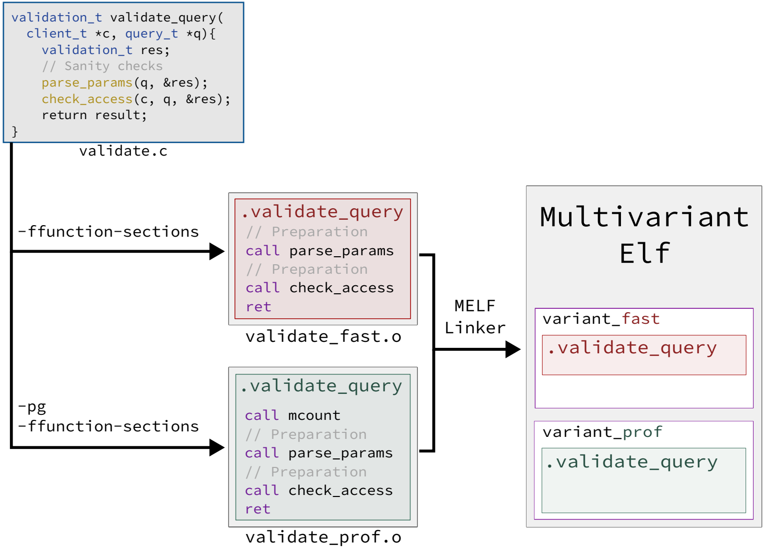

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MELF
Linker

Multivariant
Elf

variant_fast

.validate_query

variant_prof

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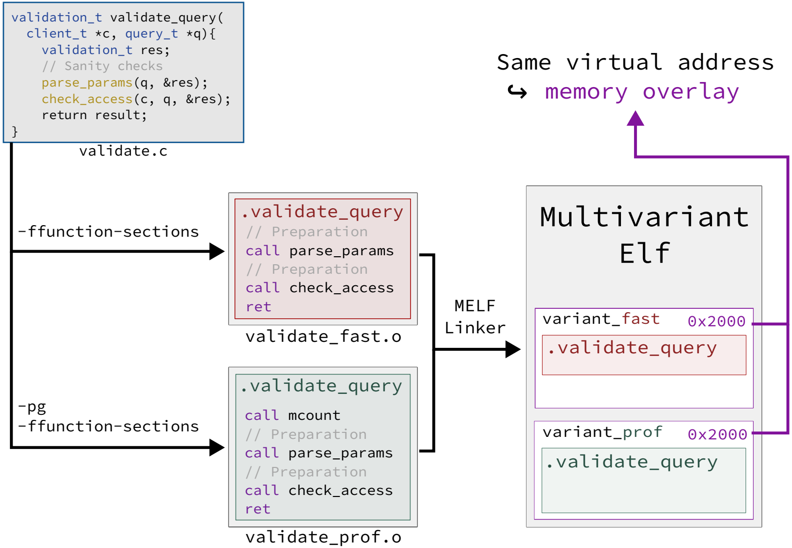

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Same virtual address
↪ memory overlay

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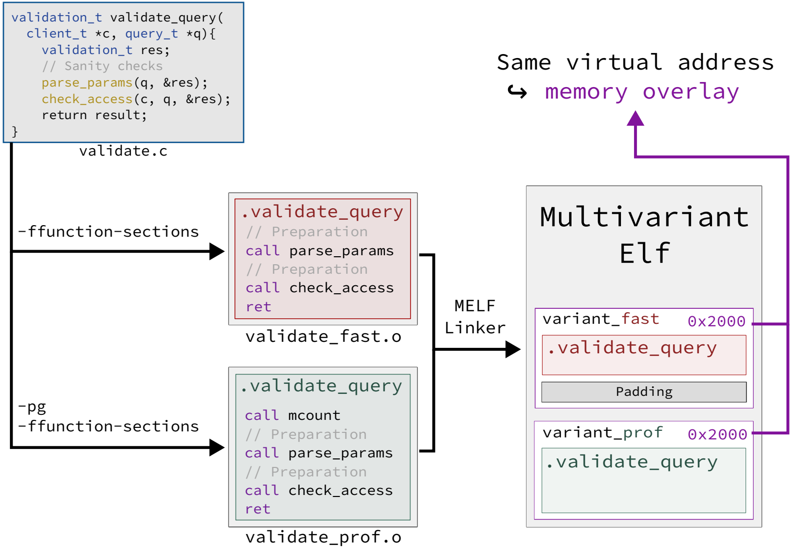

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MELF Linker

Multivariant Elf

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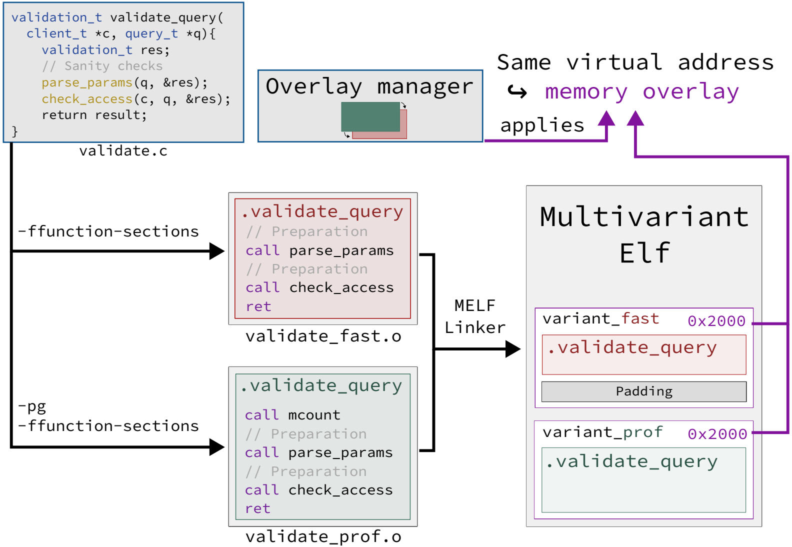

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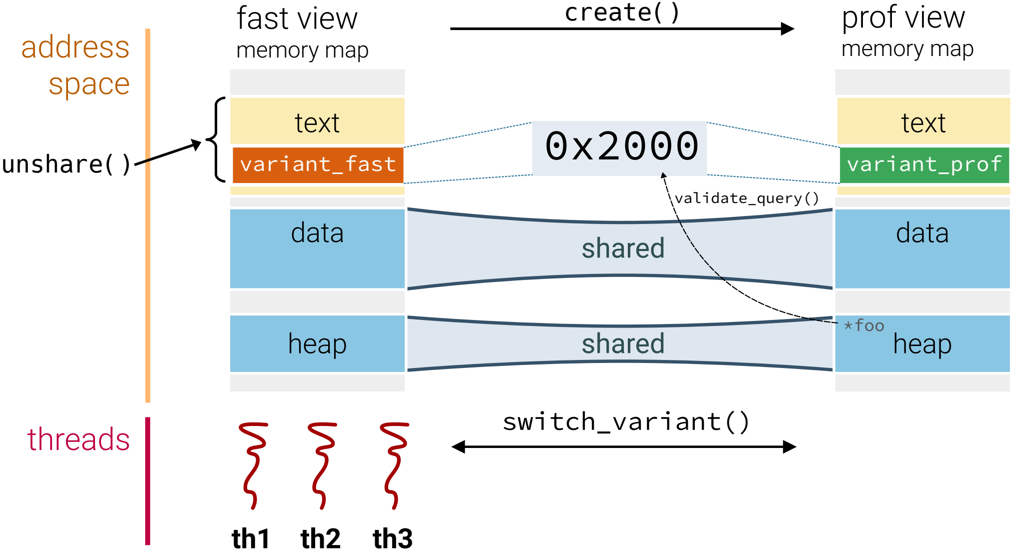
Synchronized Address Space Views

Rommel et al. 2020



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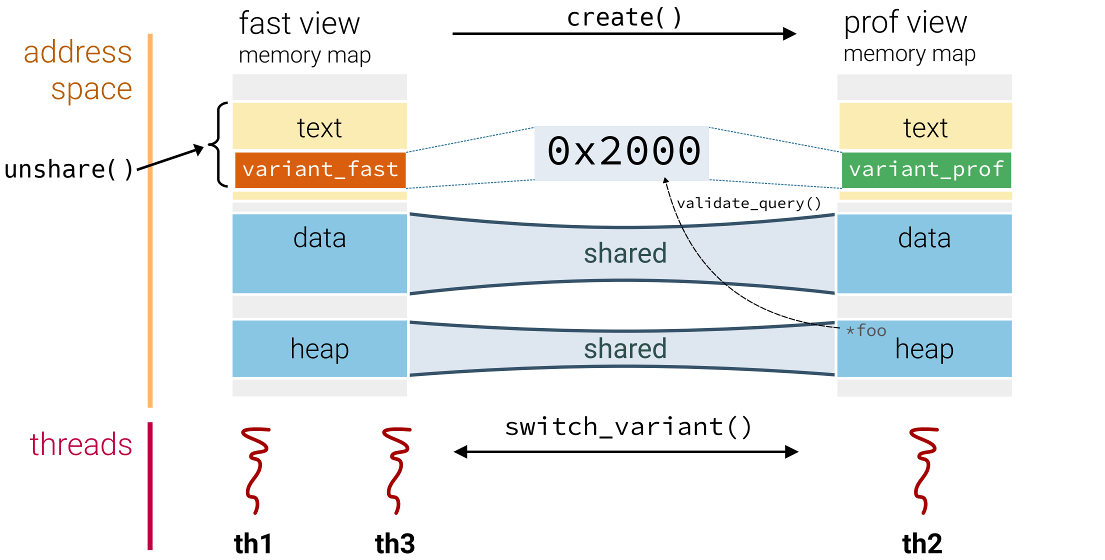

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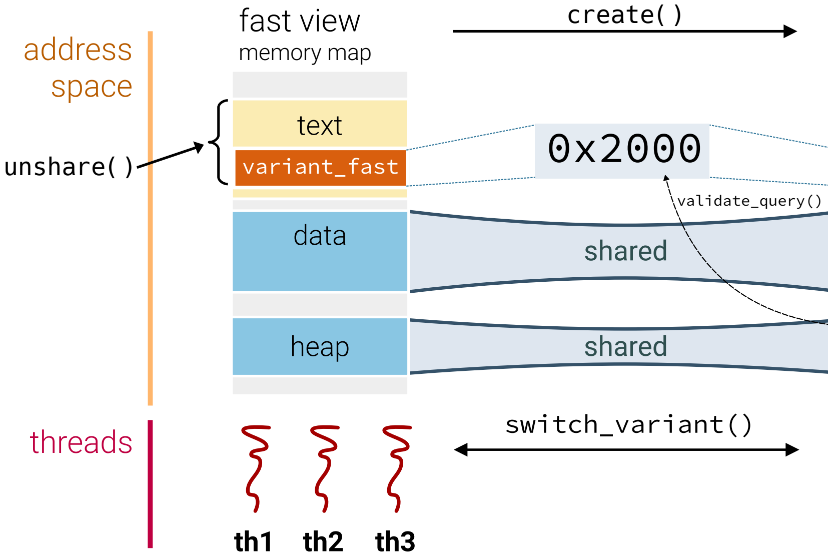
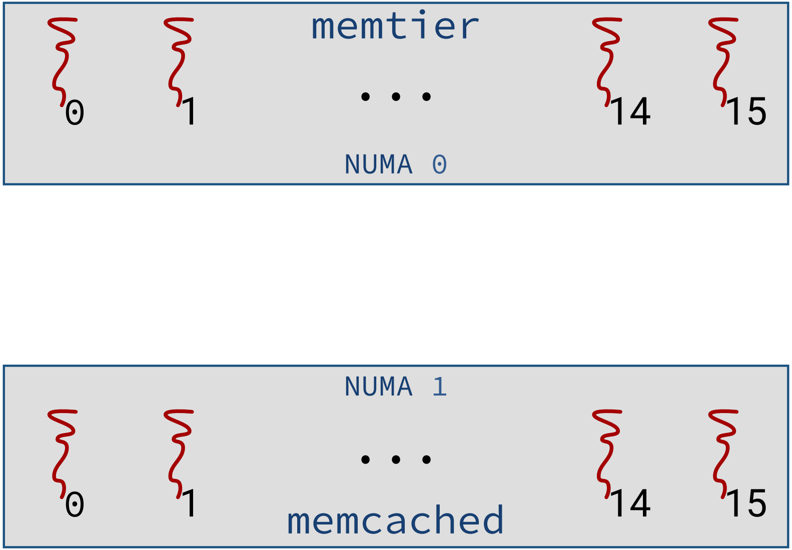


Case-Study: Performance isolation of profiling



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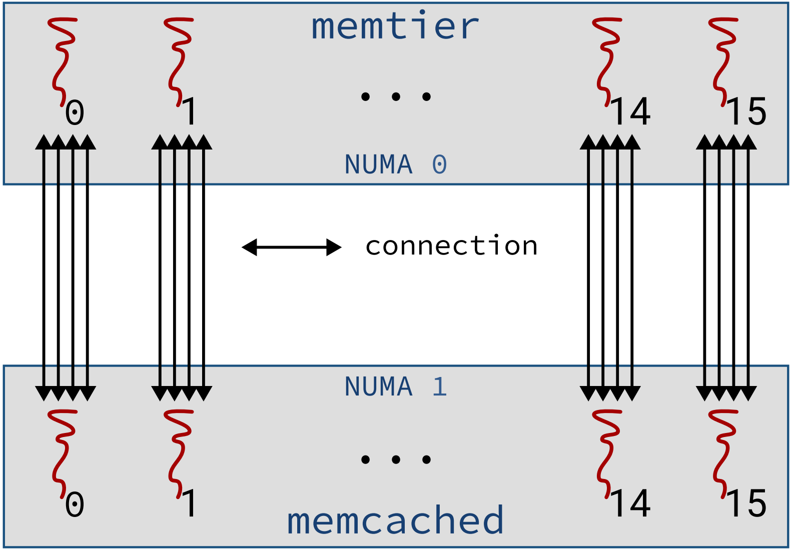

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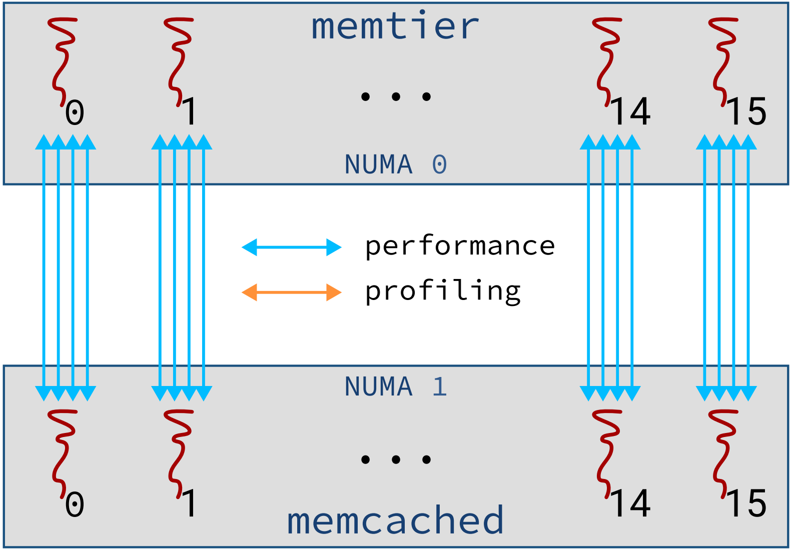

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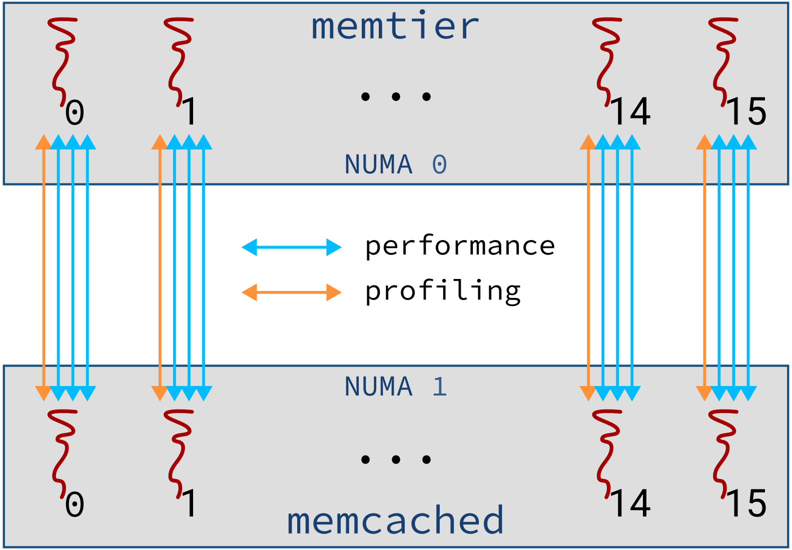

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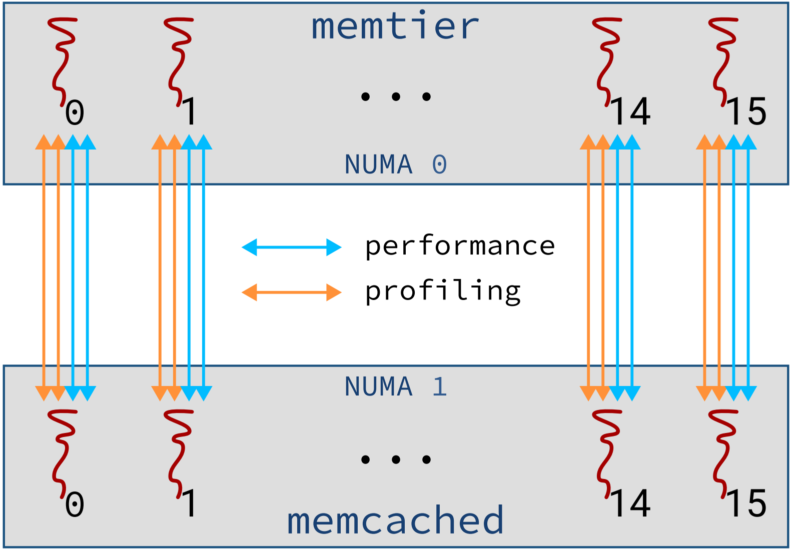

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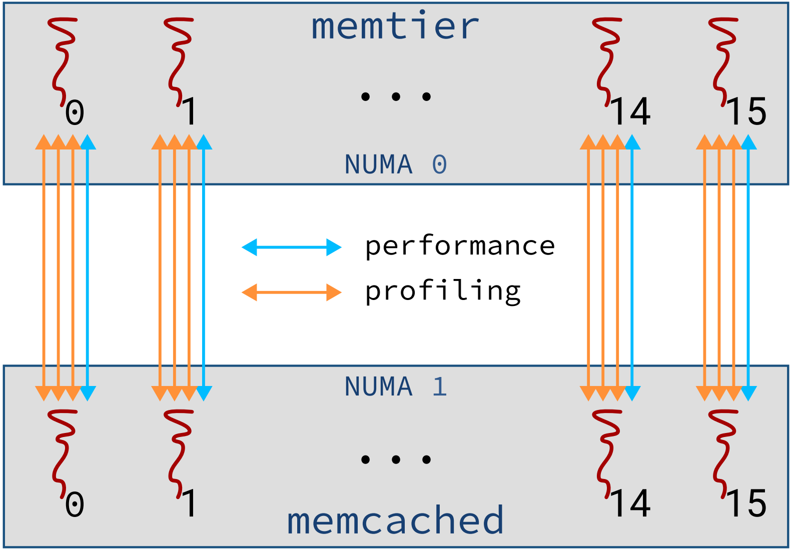

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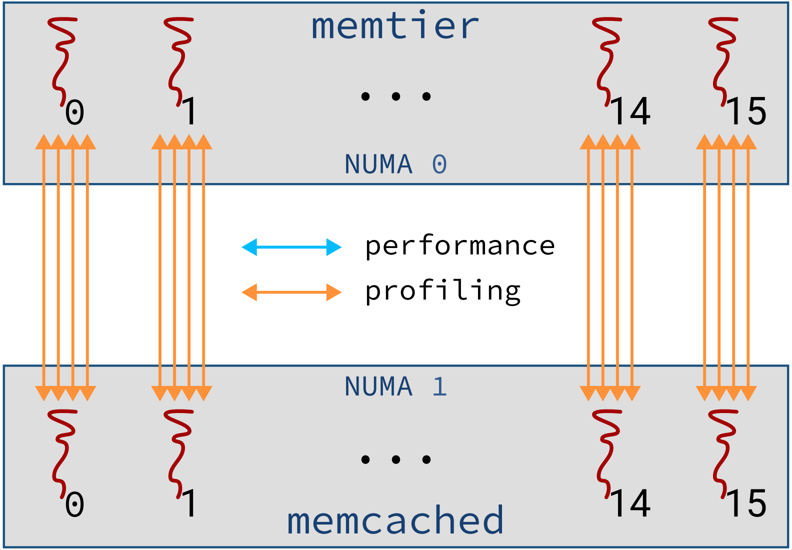
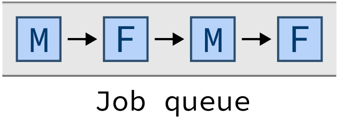


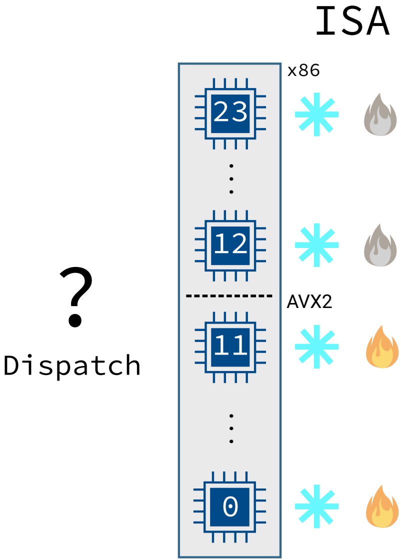
Case-Study: Performance isolation of profiling results

- Latency impact of profiling connections on performance connections
  - 0% profiled connections →0.11% higher mean latency
  - 75% profiled connections →5.94% higher mean latency
- Without MELF: Always activating profiling →175% higher mean latency!

Case-Study: Heterogeneous ISA-aware thread pool

	F	M
✱	57.9ms	58.3ms
🔥	57.9ms	38ms





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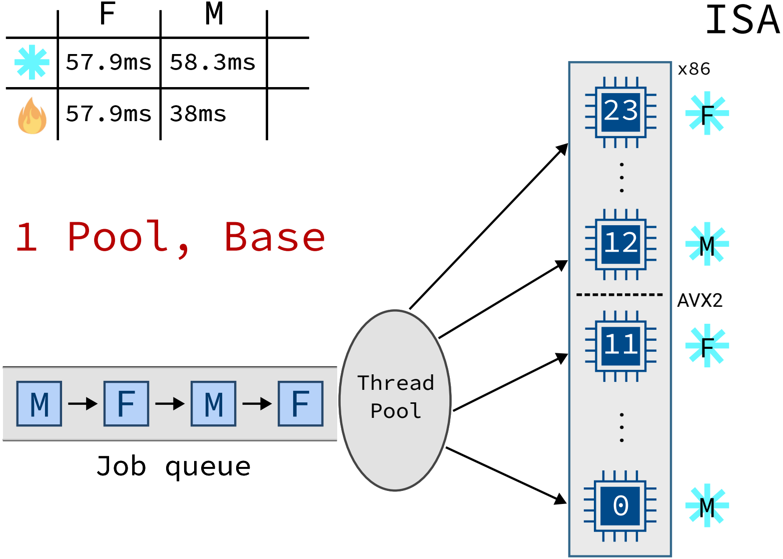
1 Pool, Base



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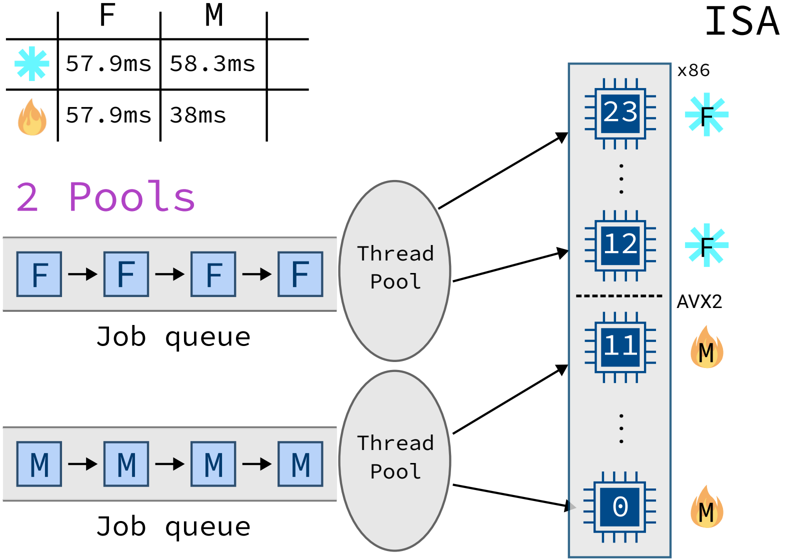
2 Pools



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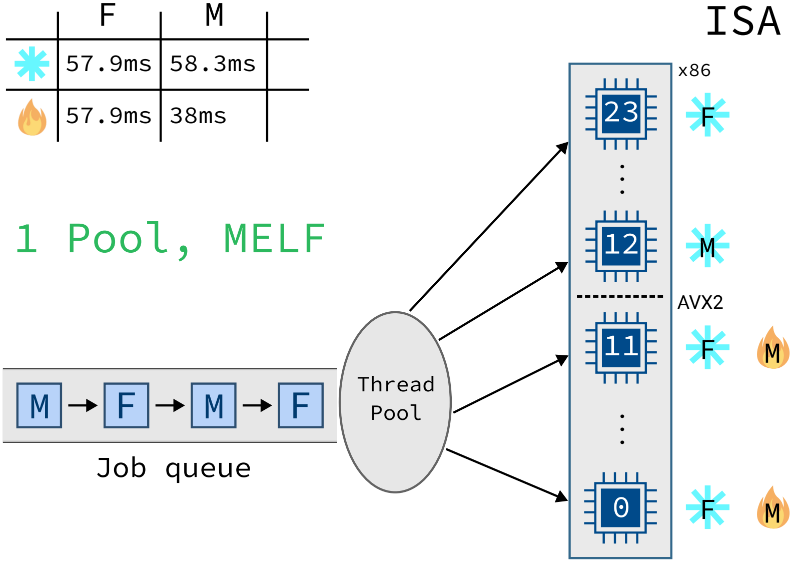

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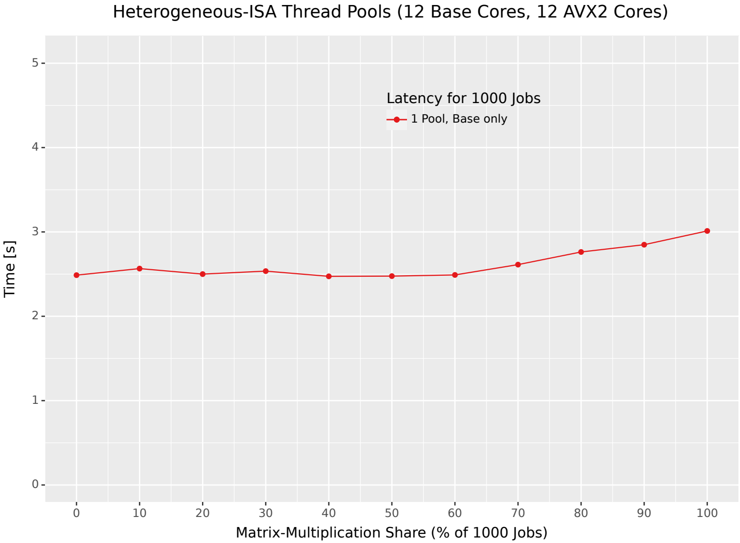

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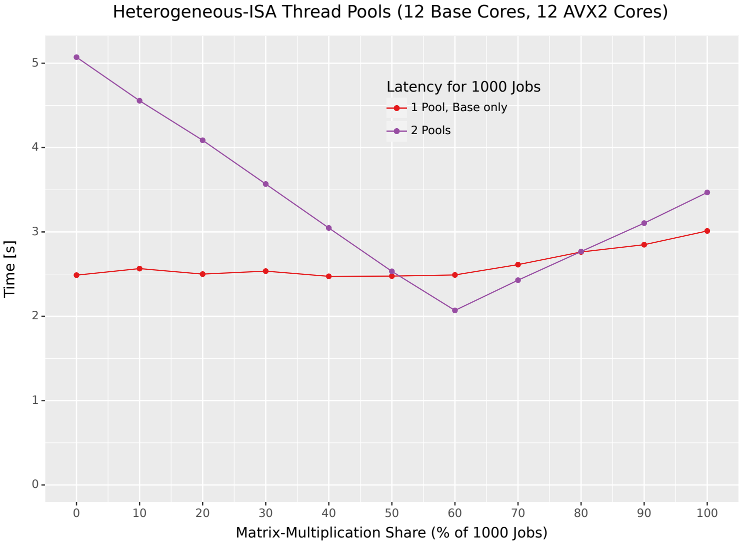
Heterogeneous-ISA Thread Pools (12 Base Cores, 12 AVX2 Cores)

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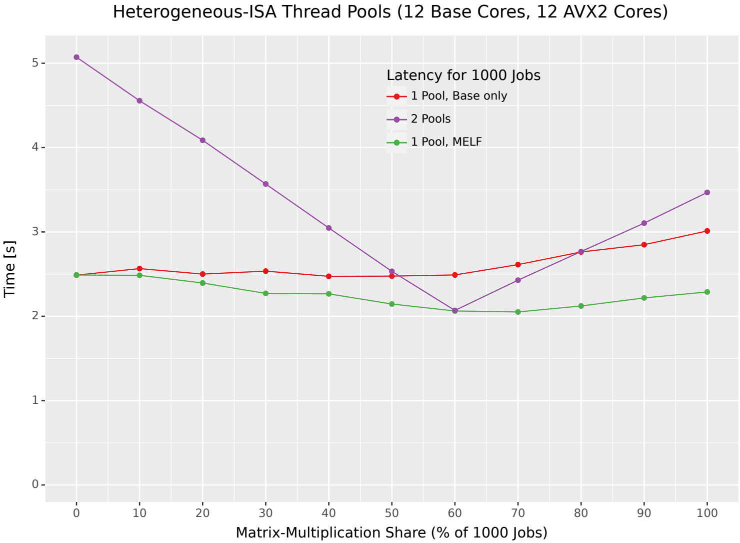

Conclusion

- MELF: Dynamic exchange of compile-time variants on a per-function level via memory overlaying
- Thread-local adaptation via address space views
- Performance isoliation of profiling (memcached)
- Heterogeneous ISA-aware thread pool
- Dynamically selectable assertions (sqlite)
- Context-specific address sanitizer (mariadb)

Varability mechanism for a heterogeneous world

ARTIFACT EVALUATED
usenix ASSOCIATION
AVAILABLE

ARTIFACT EVALUATED
usenix ASSOCIATION
FUNCTIONAL

ARTIFACT EVALUATED
usenix ASSOCIATION
REPRODUCED

toellner@sra.uni-hannover.de

Dominik Töllner et al. Multivariant Executables for a Heterogeneous World – Conclusion 10 – 10