Language-Centric Performance Analysis of OpenMP Programs with Aftermath

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Joint work with:
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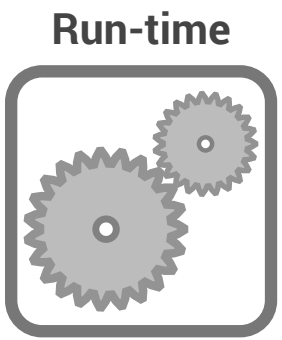
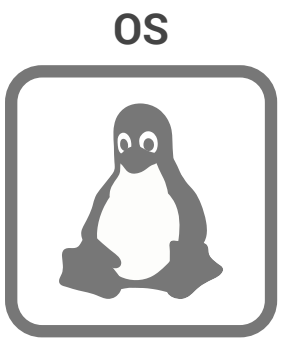
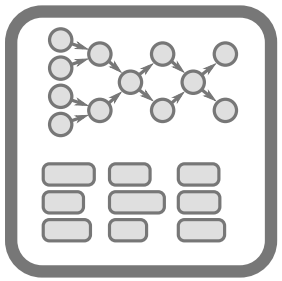
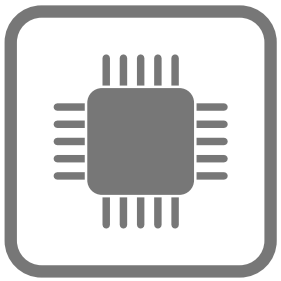
IWOMP 2016

Analysis of OpenMP Programs









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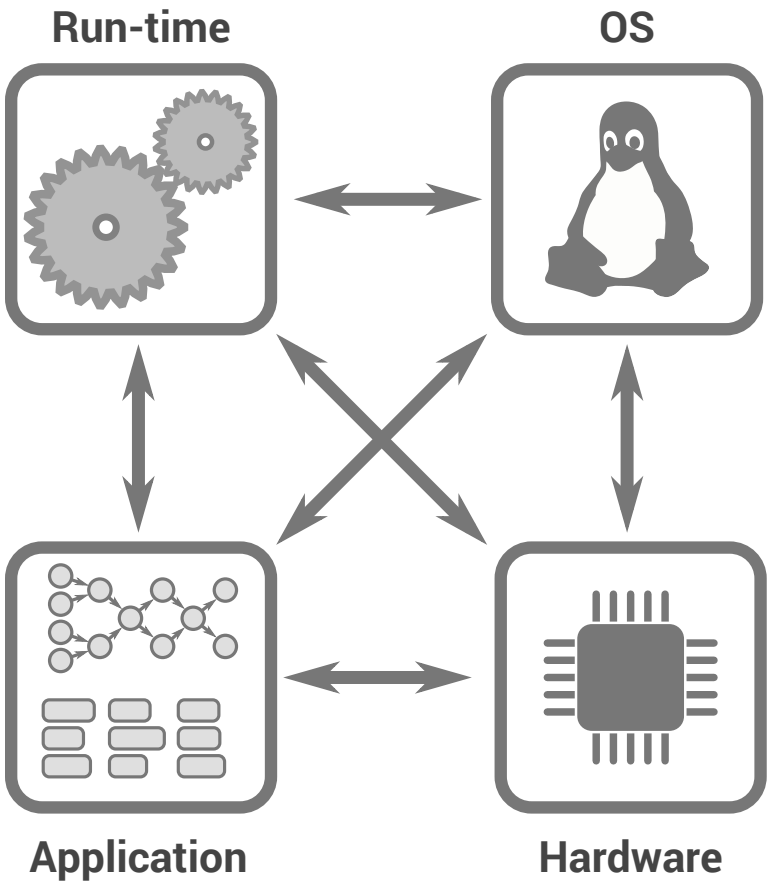

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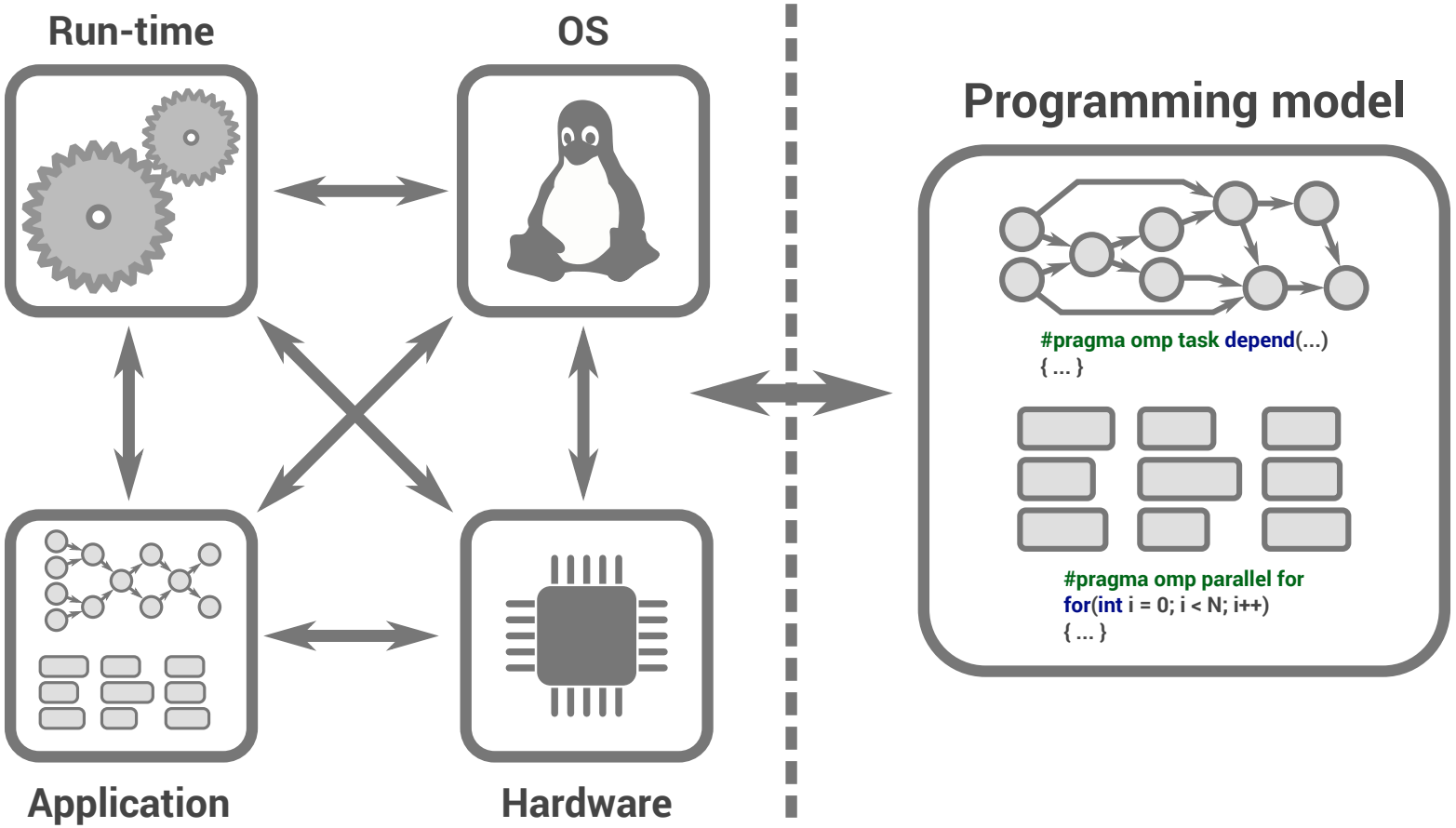

New Tools for Performance Analysis

Frequent topics for performance analysis:

- Amount of parallelism and load balacing
- Duration of execution phases
- Synchronization overhead (e.g., barriers)
- Choice of an appropriate loop schedule
- Data distribution on NUMA systems
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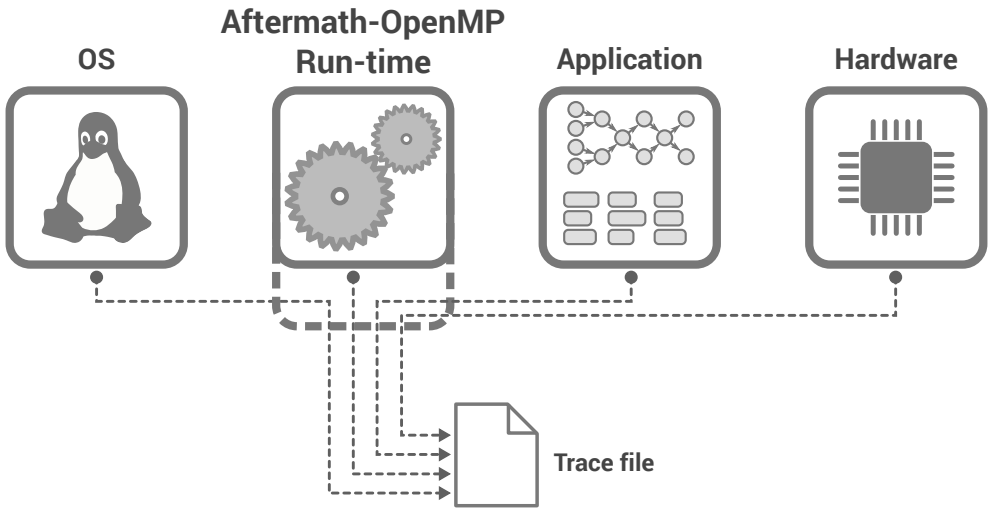
Our tools: Aftermath & Aftermath-OpenMP

- Aftermath: Graphical tool for performance analysis
- Aftermath-OpenMP: Instrumented LLVM/clang run-time

Outline

1. Overview of Trace-based Analysis
2. Overview of Aftermath’s GUI
3. Demo
4. Overhead of Tracing
5. Summary & Conclusion

Trace-based Analysis with Aftermath



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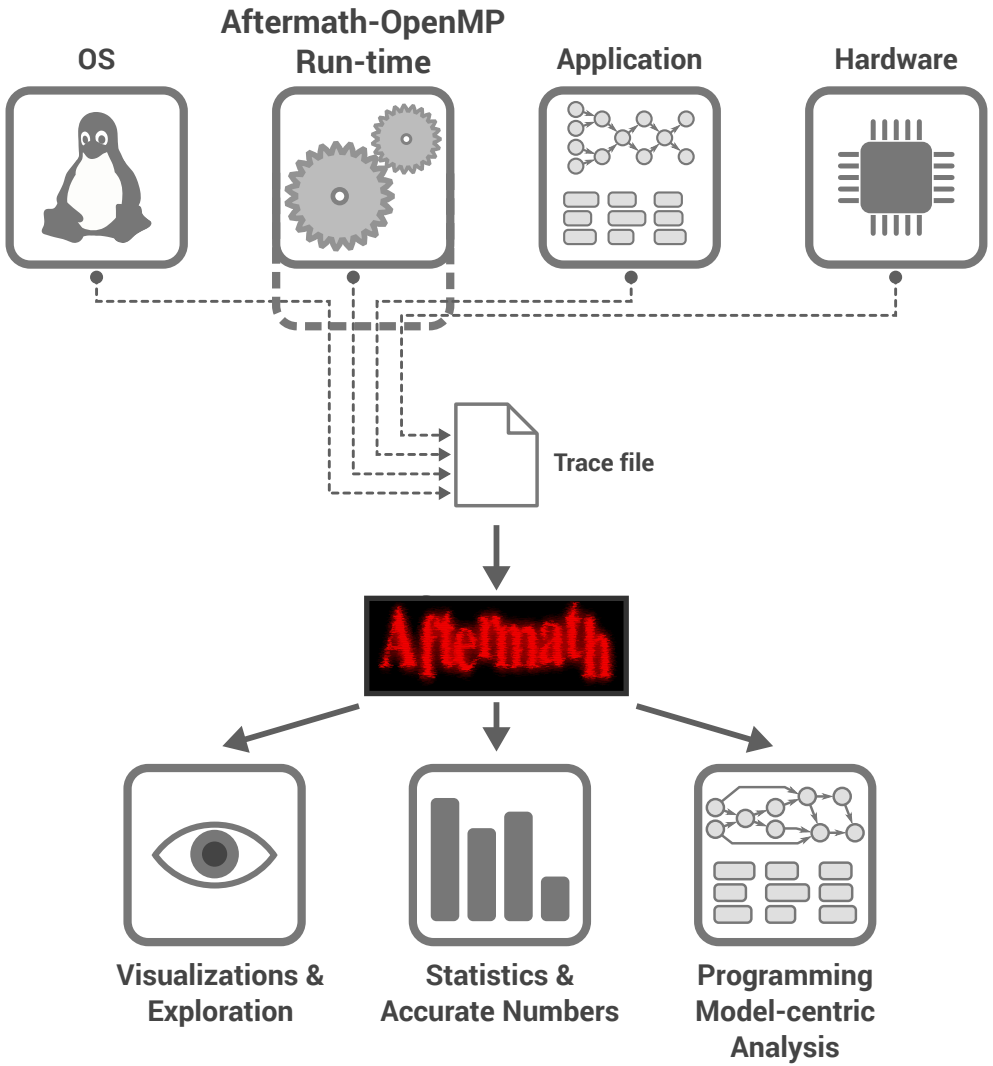

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for(int i = 0; i < 100; i++)
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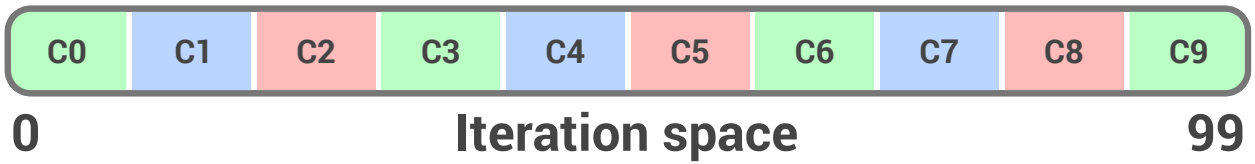

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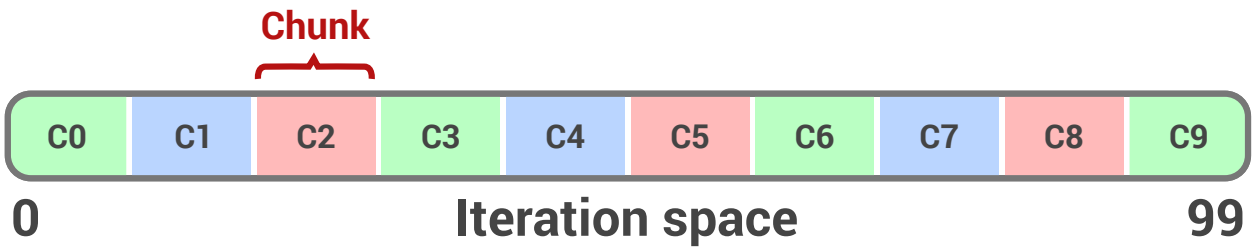

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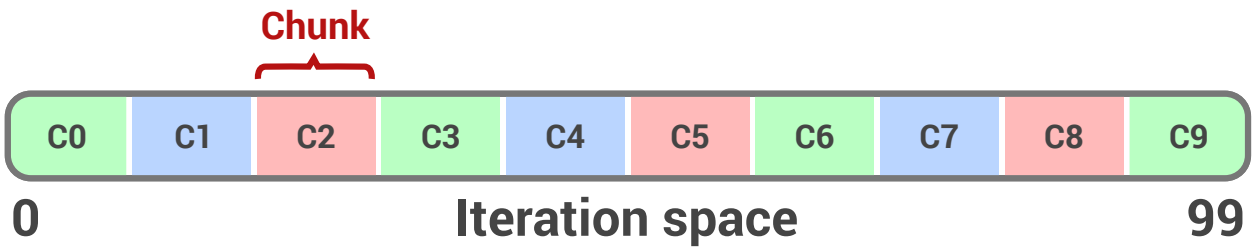

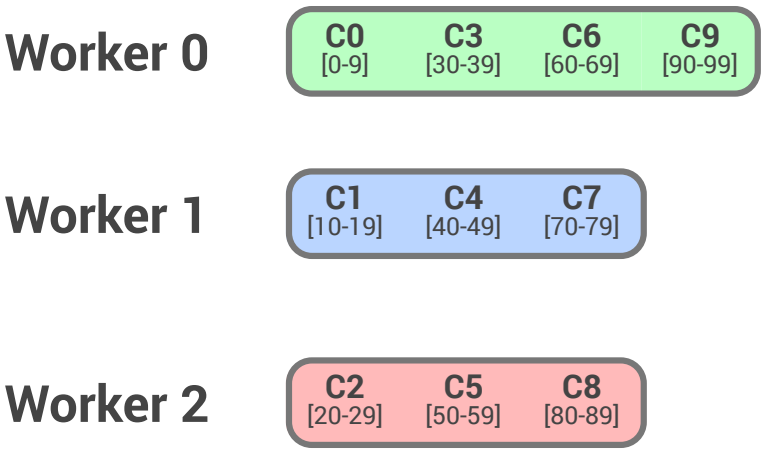

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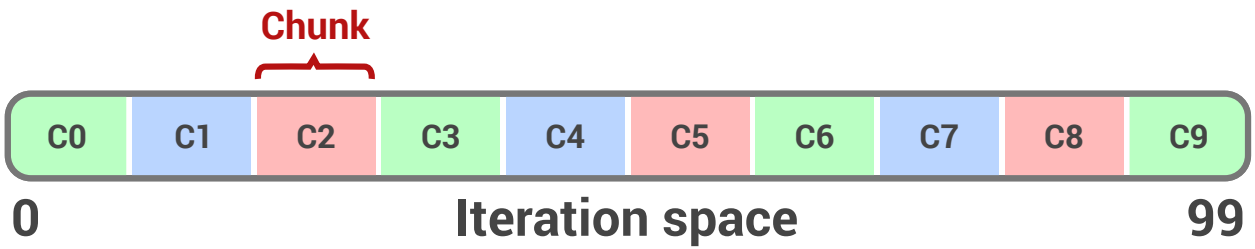

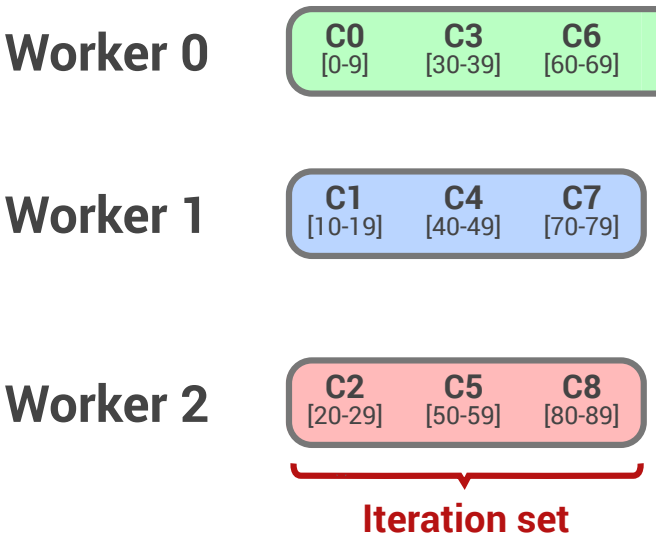

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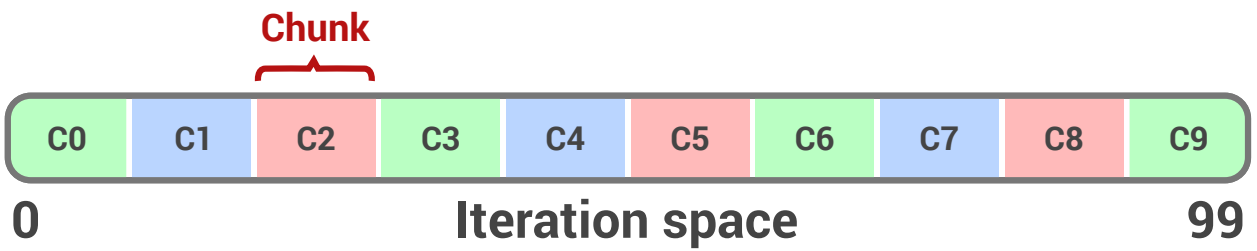

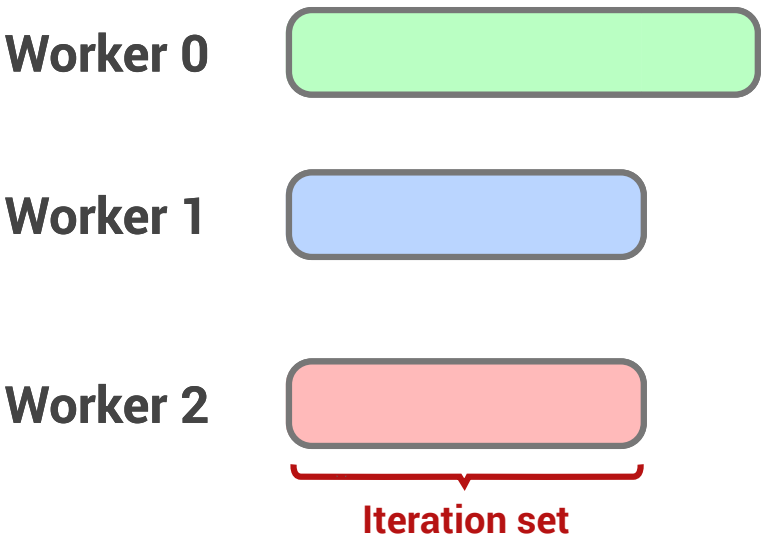

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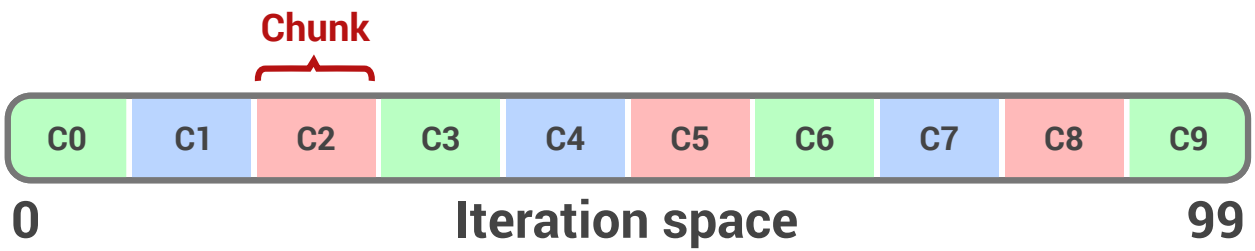

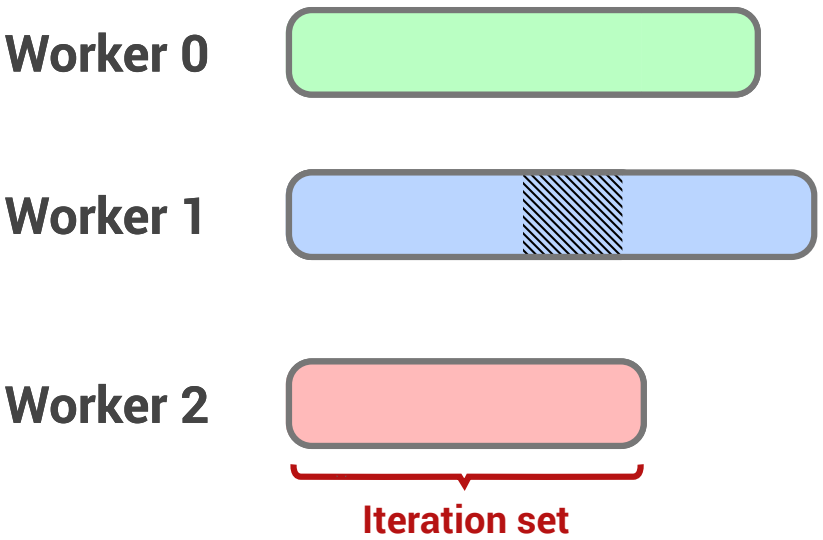

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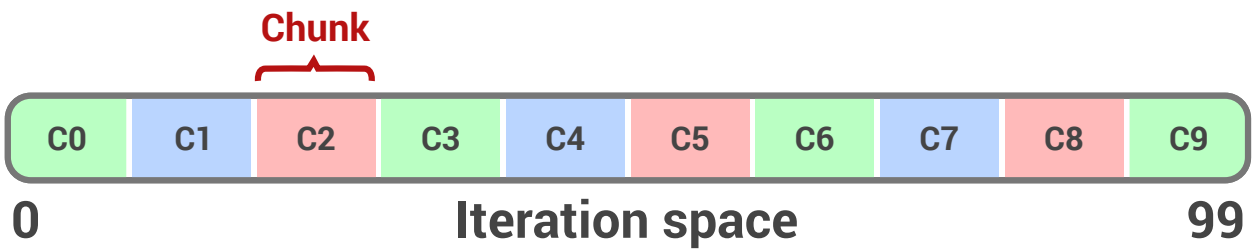

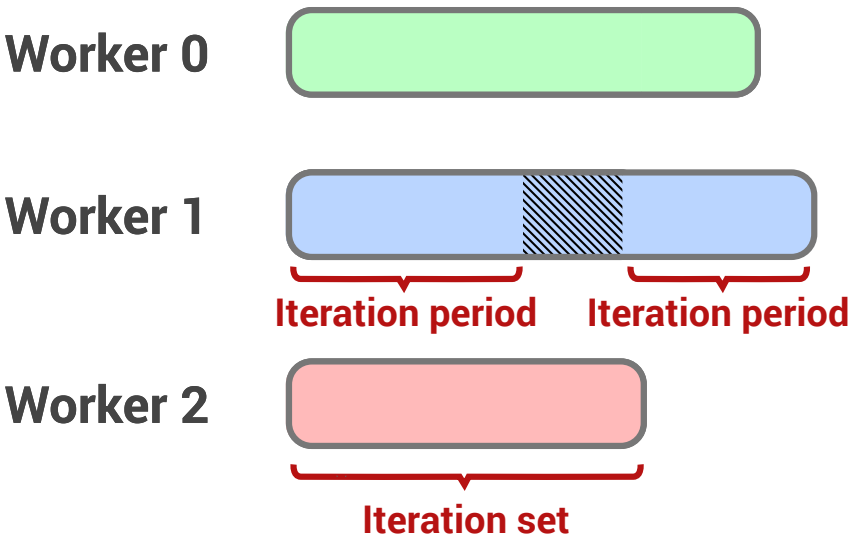

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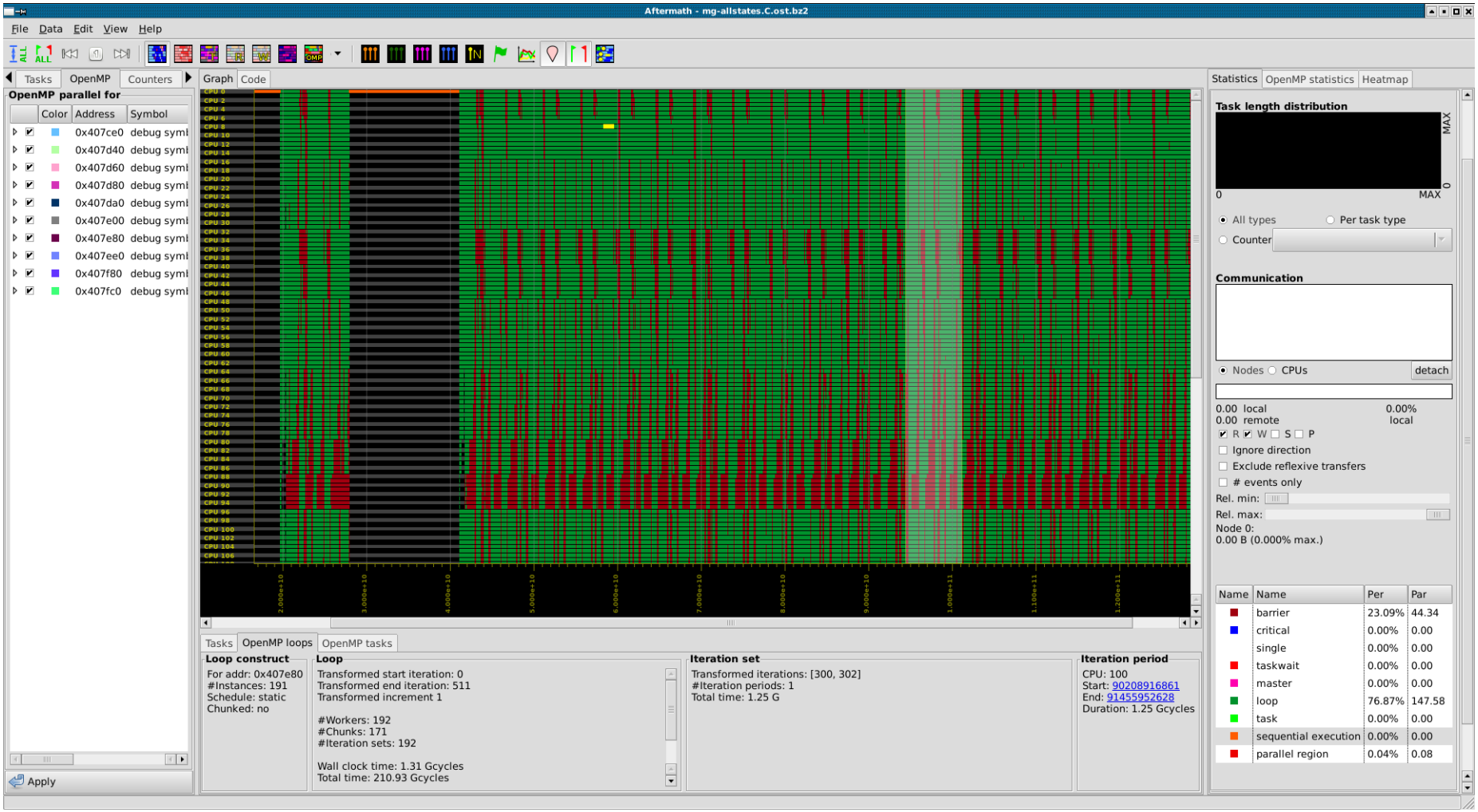

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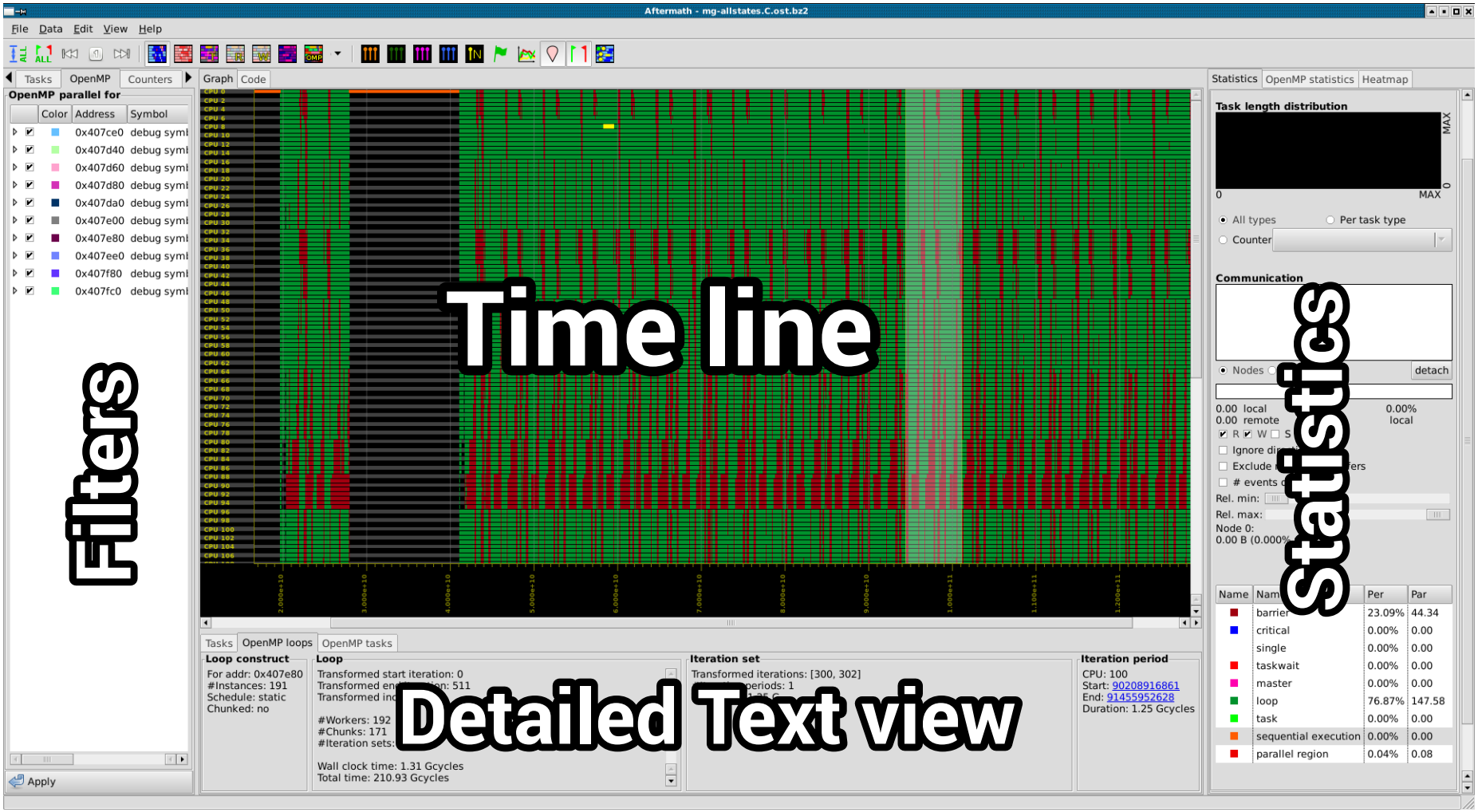

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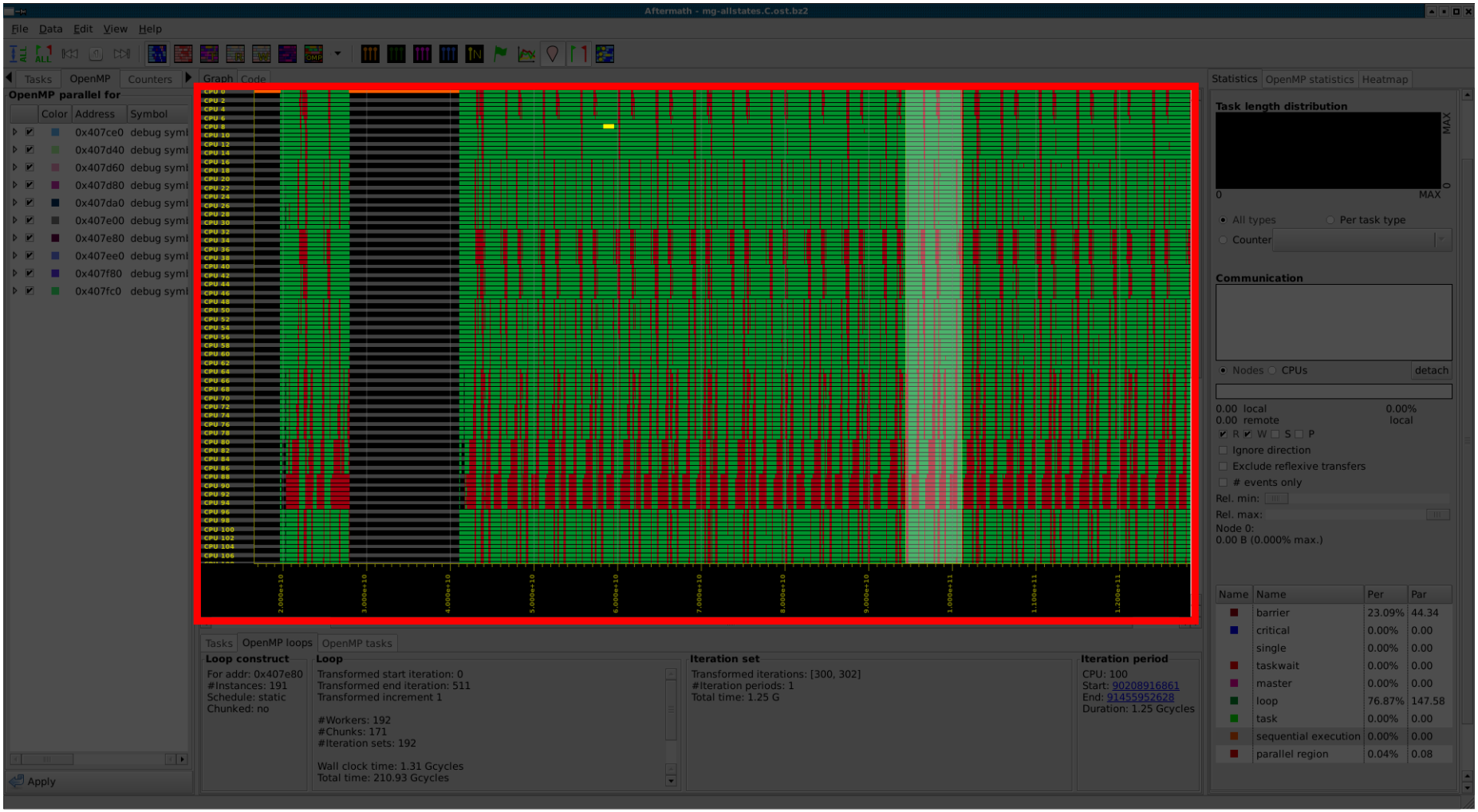

Time line

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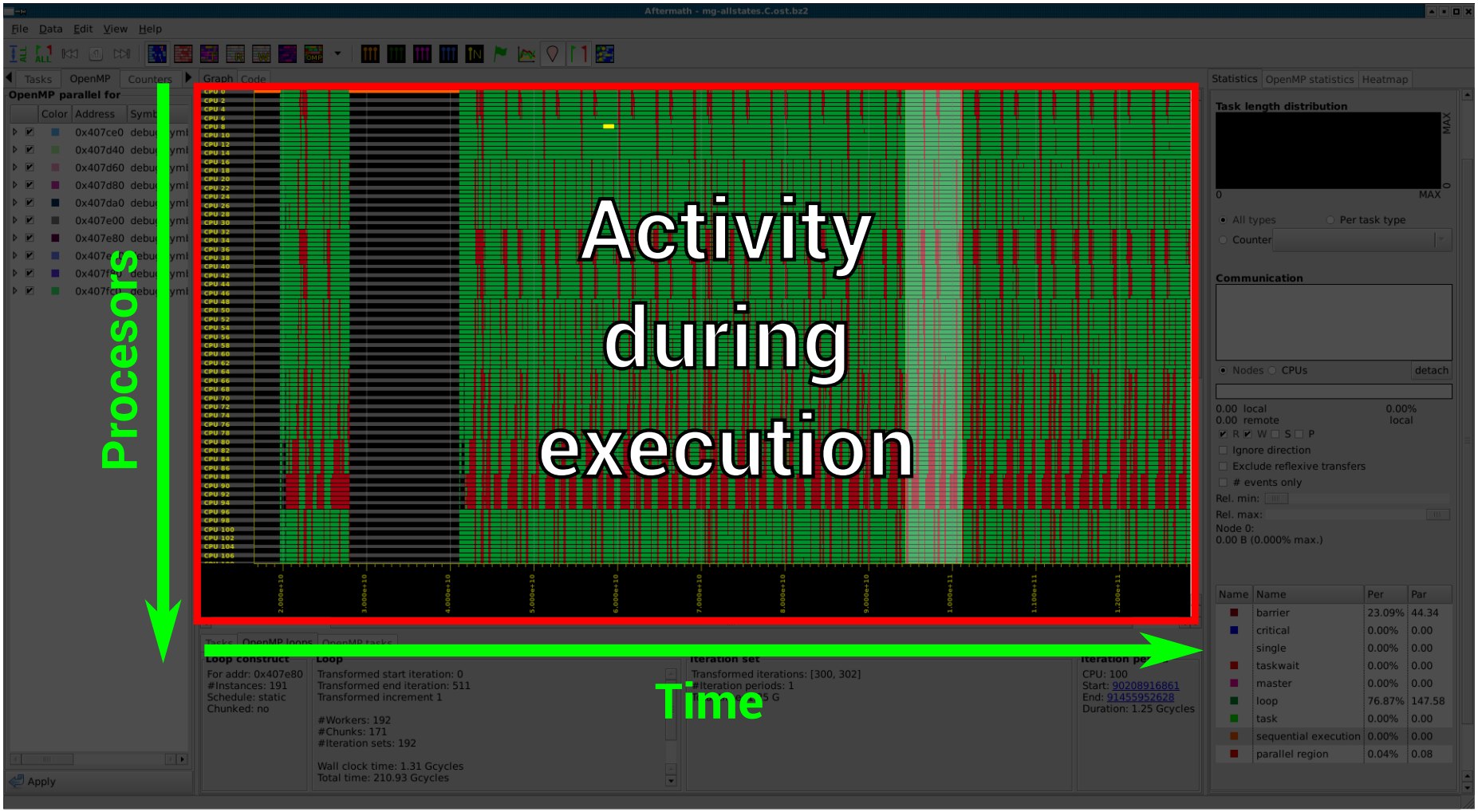

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Time line: Run-time states

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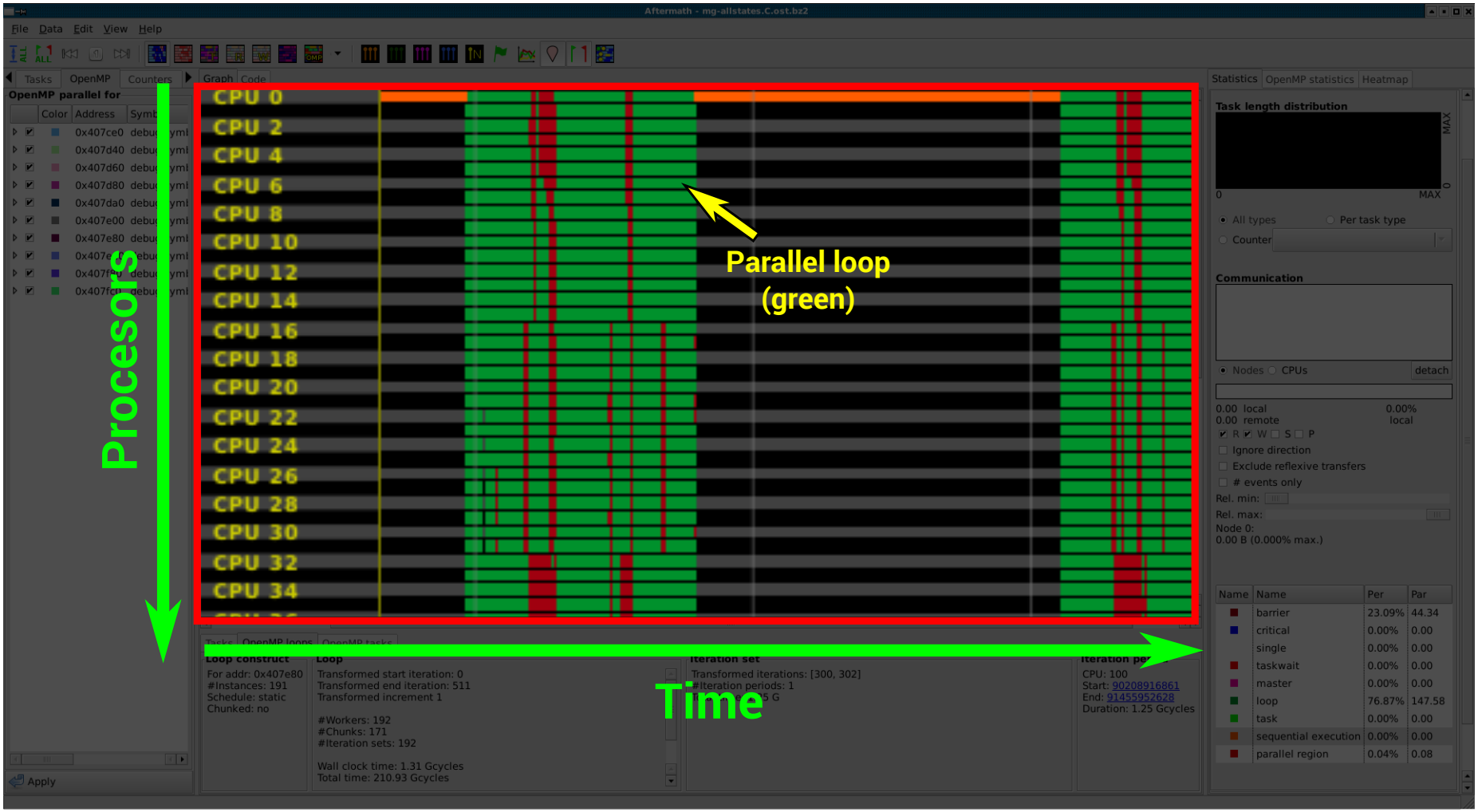

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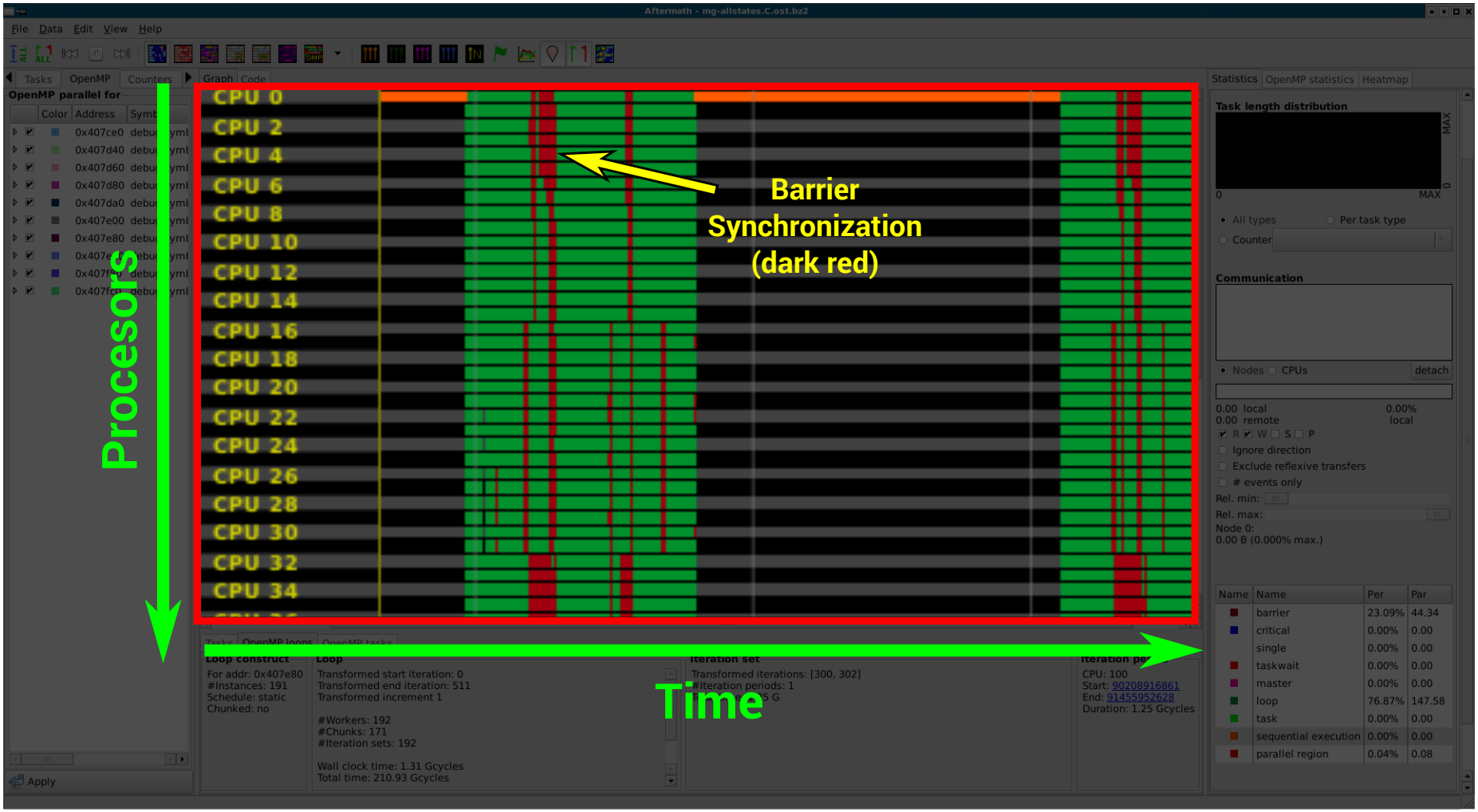

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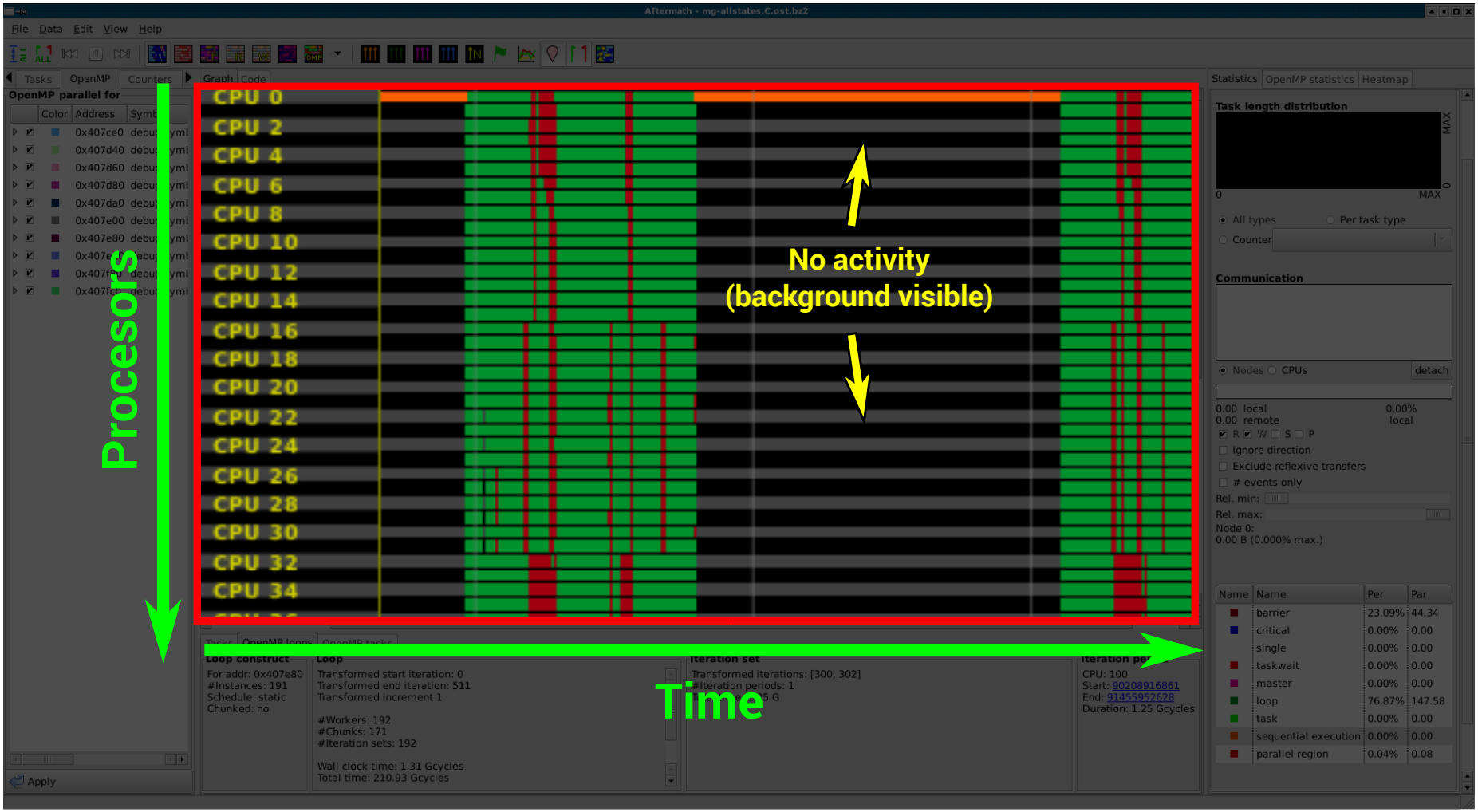

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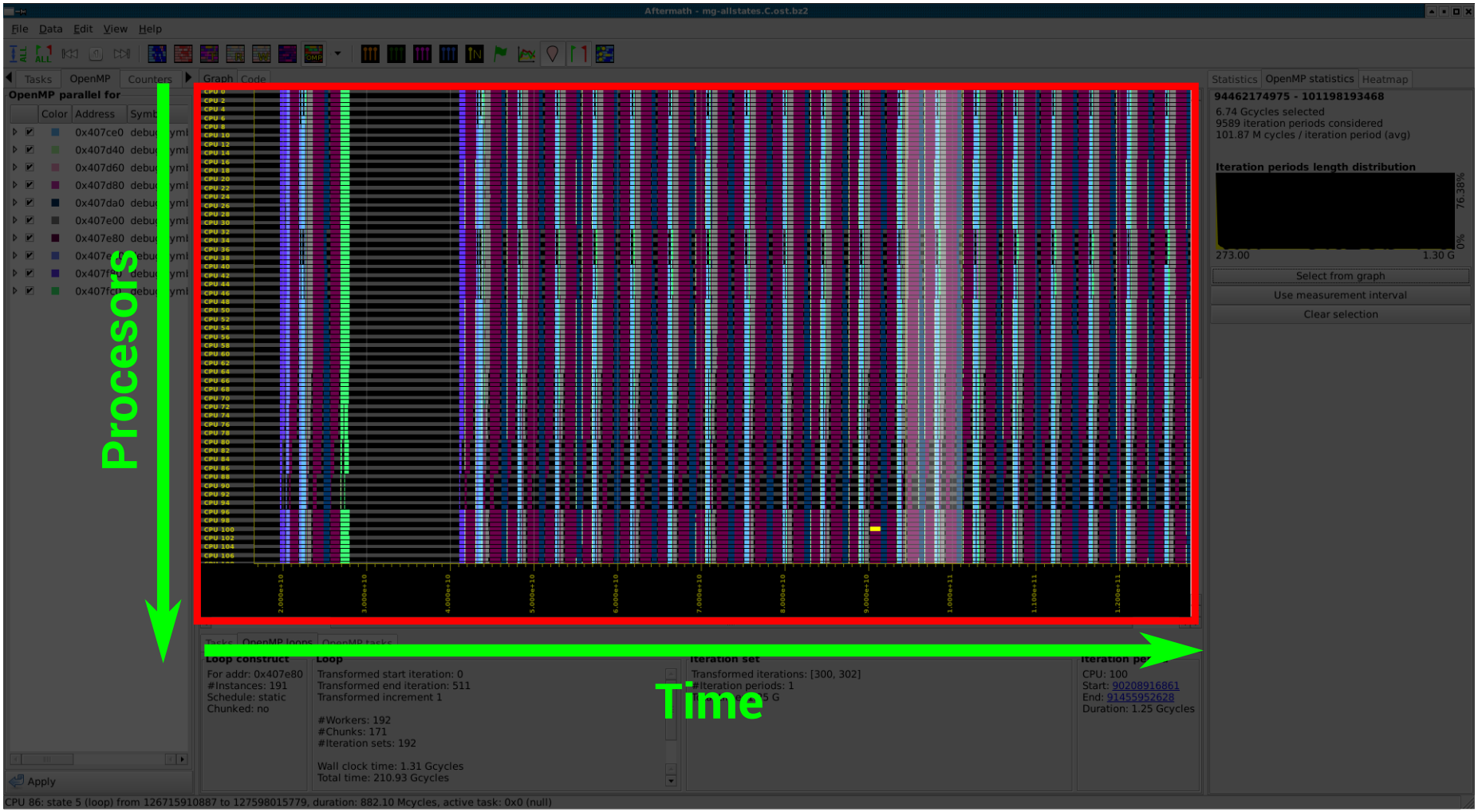

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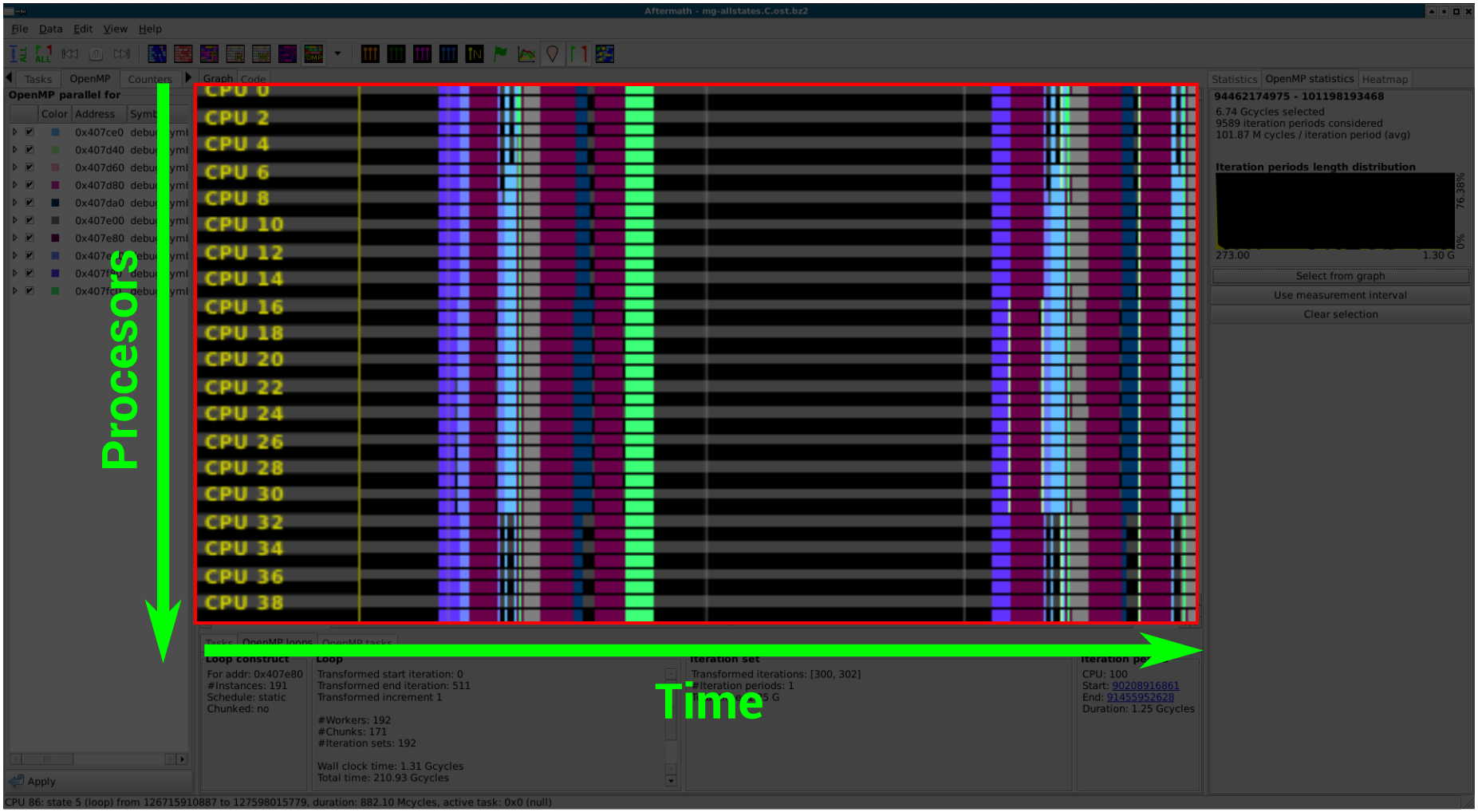

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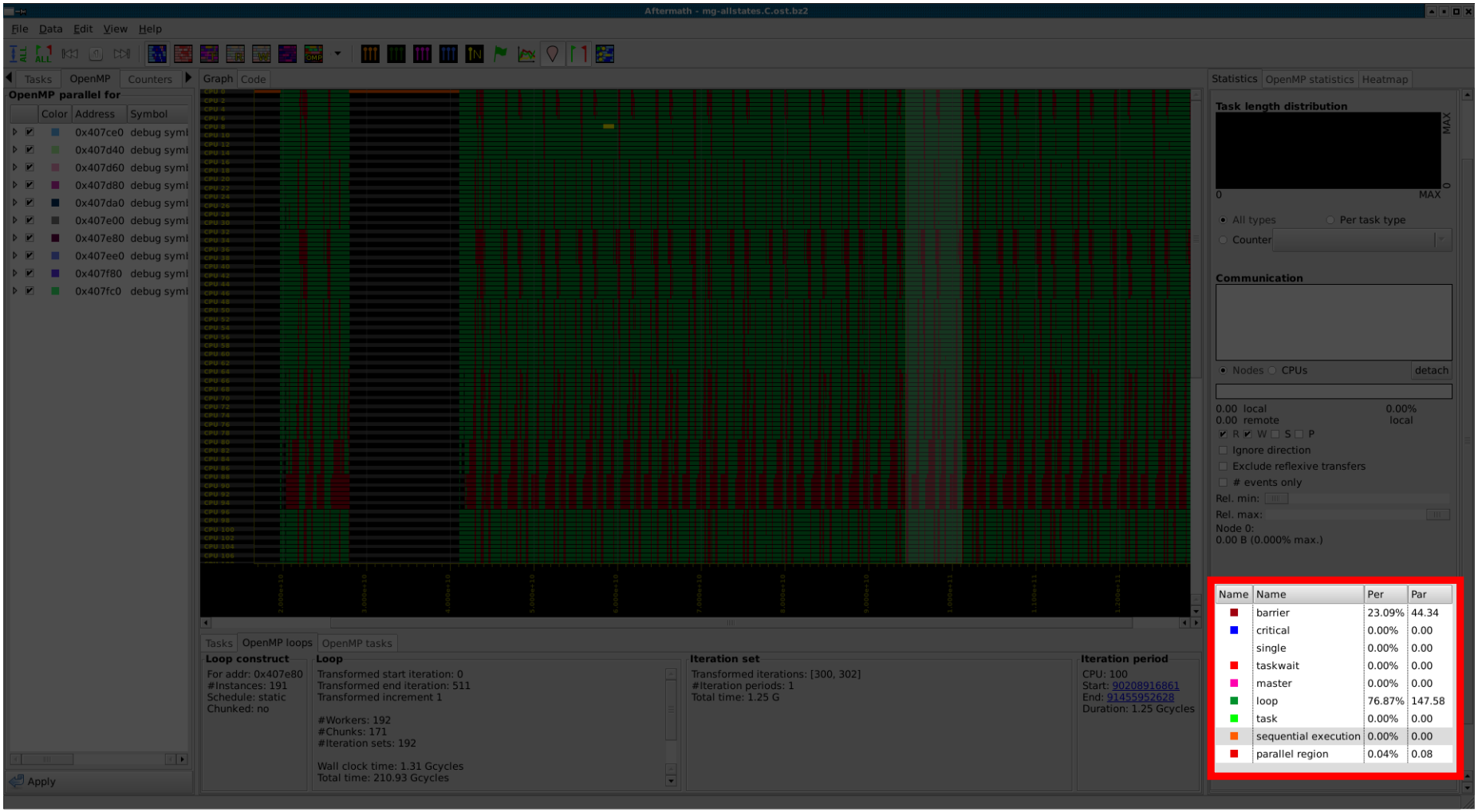

State statistics

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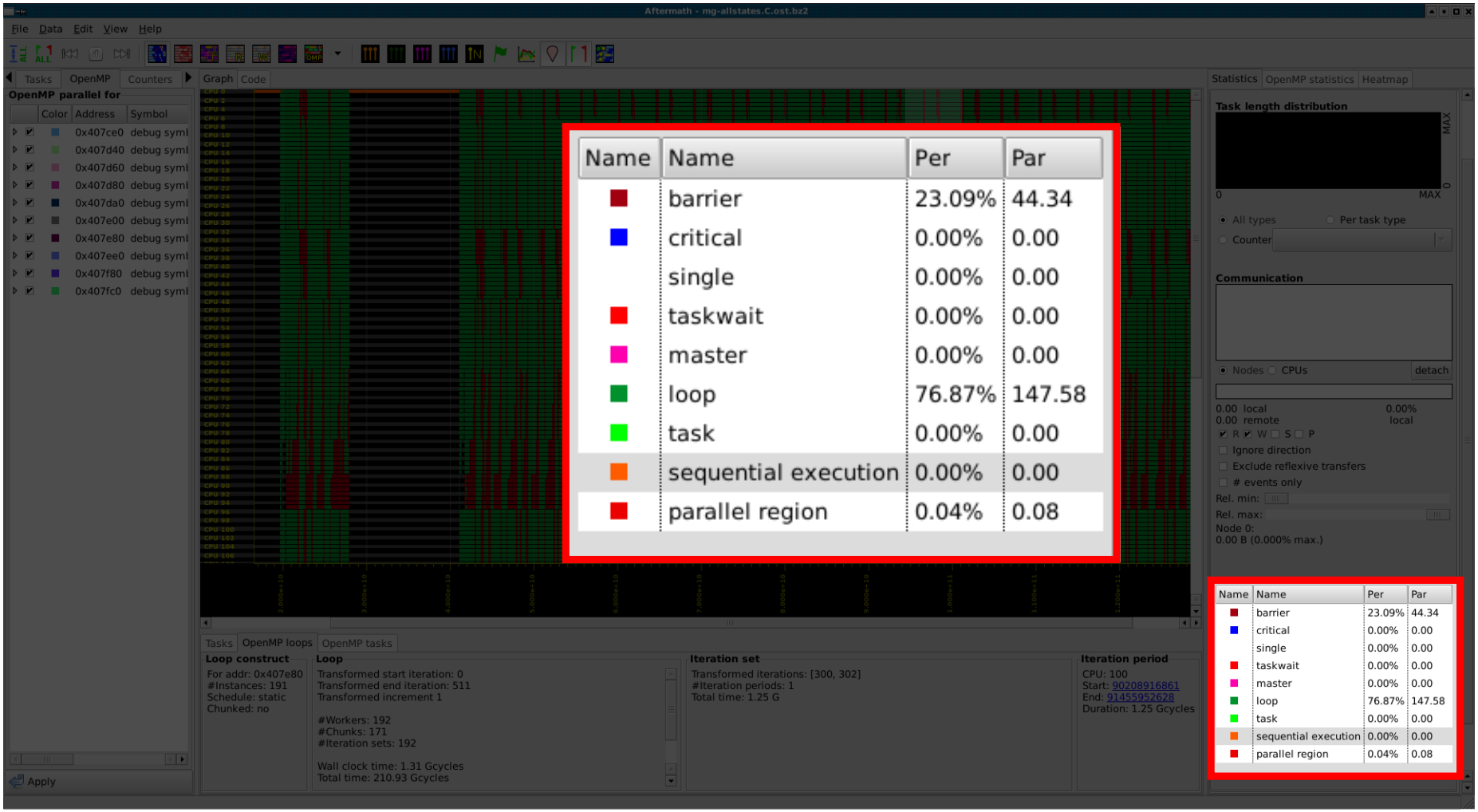

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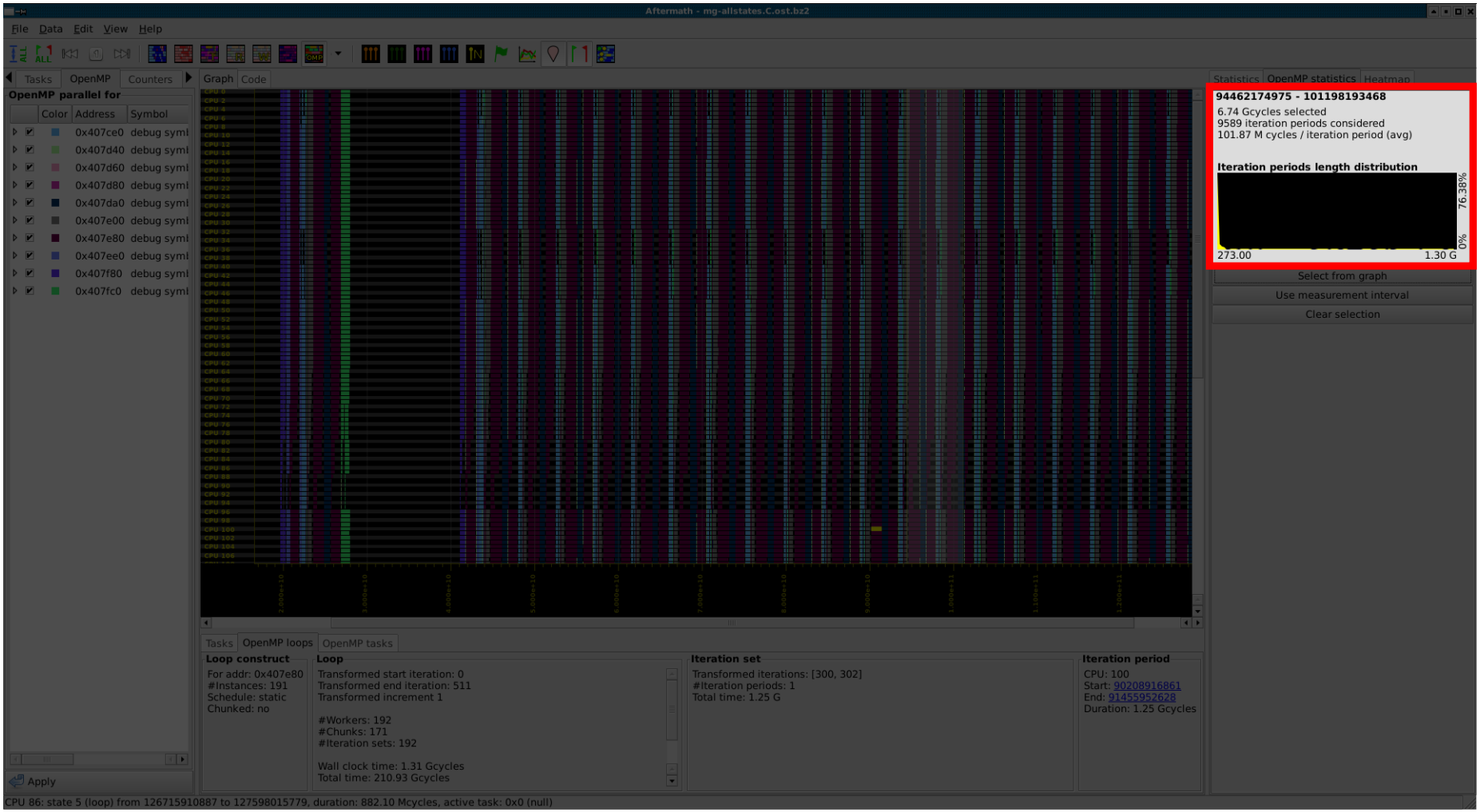

Histogram showing duration of iteration periods

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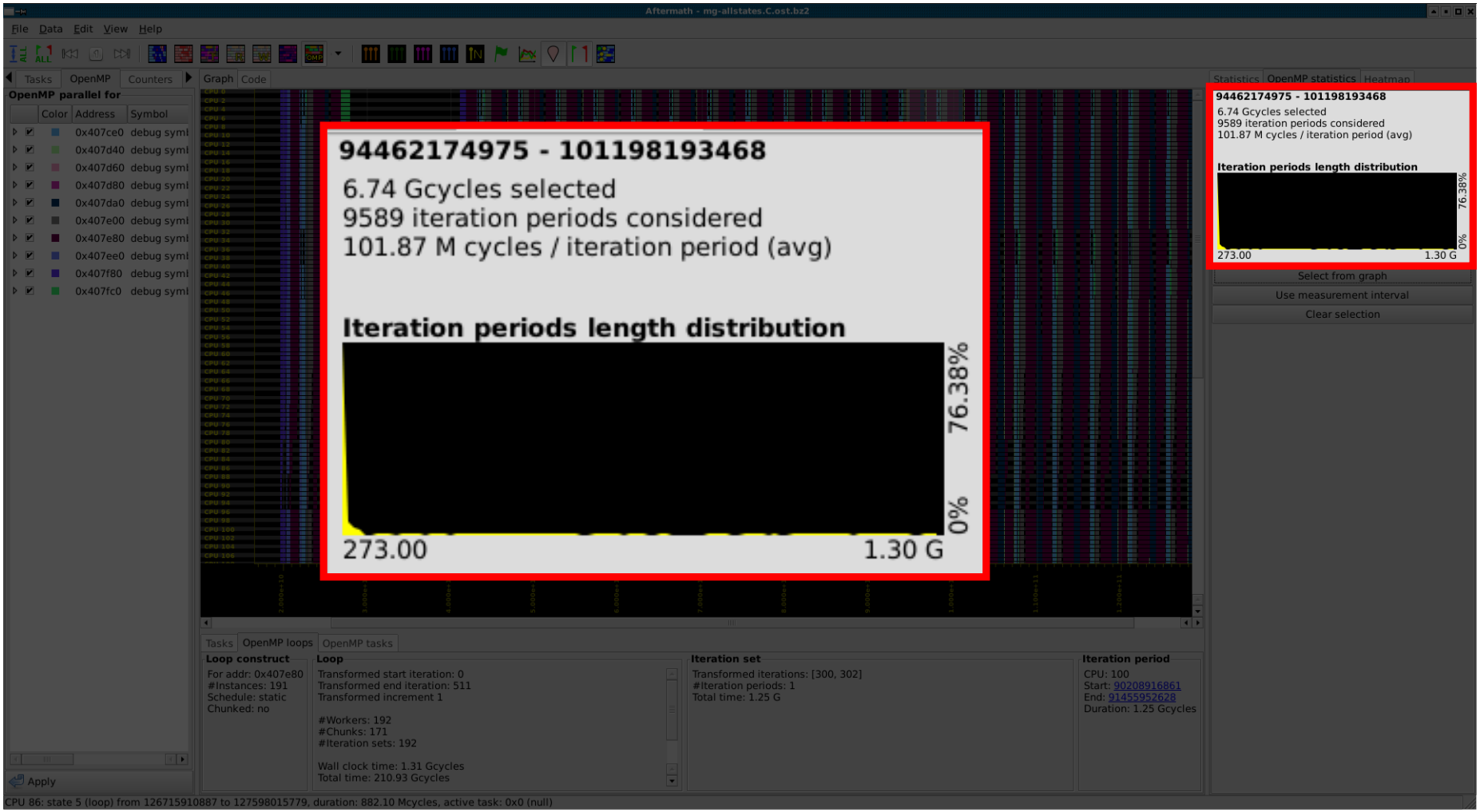

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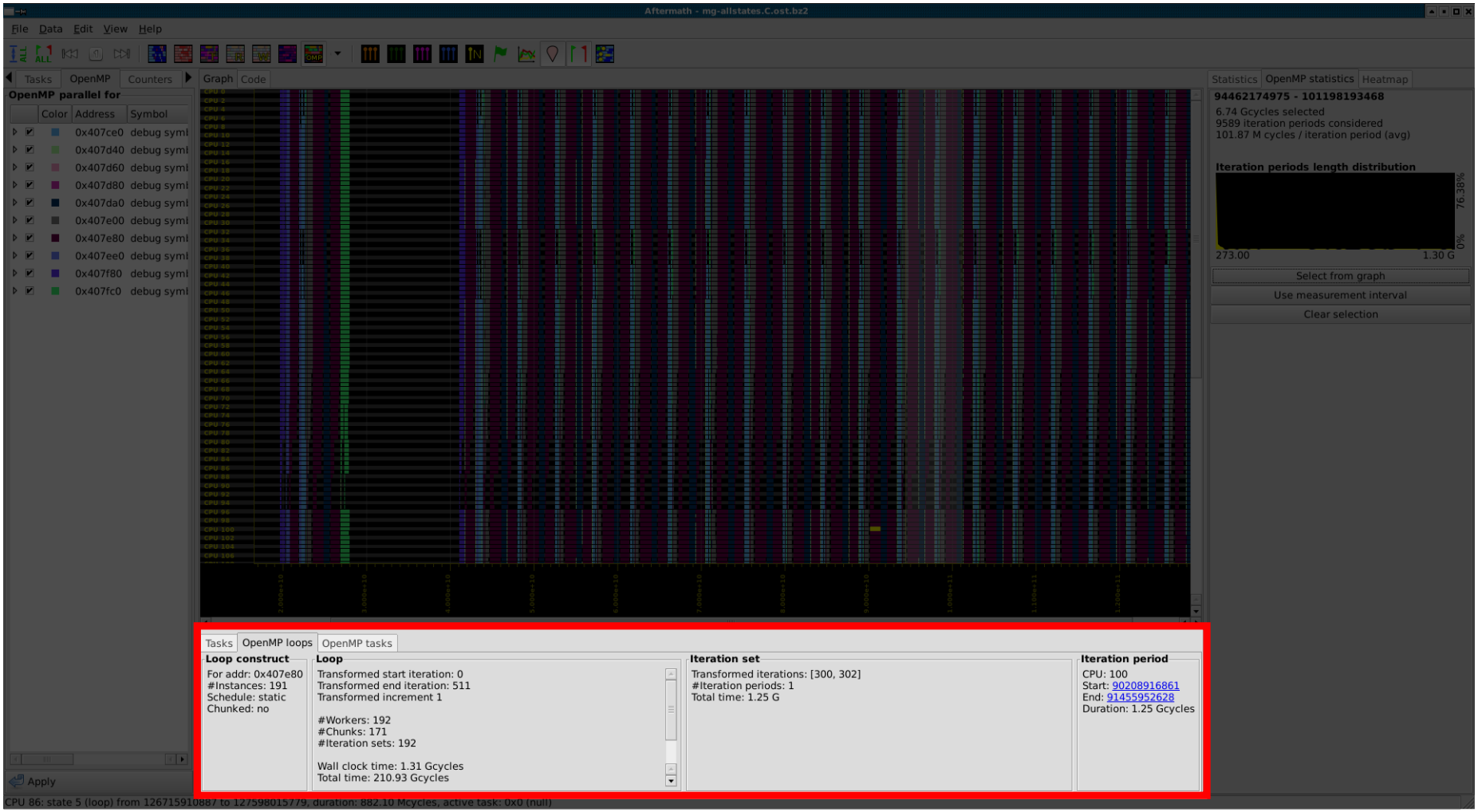

Detailed text view for parallel loops

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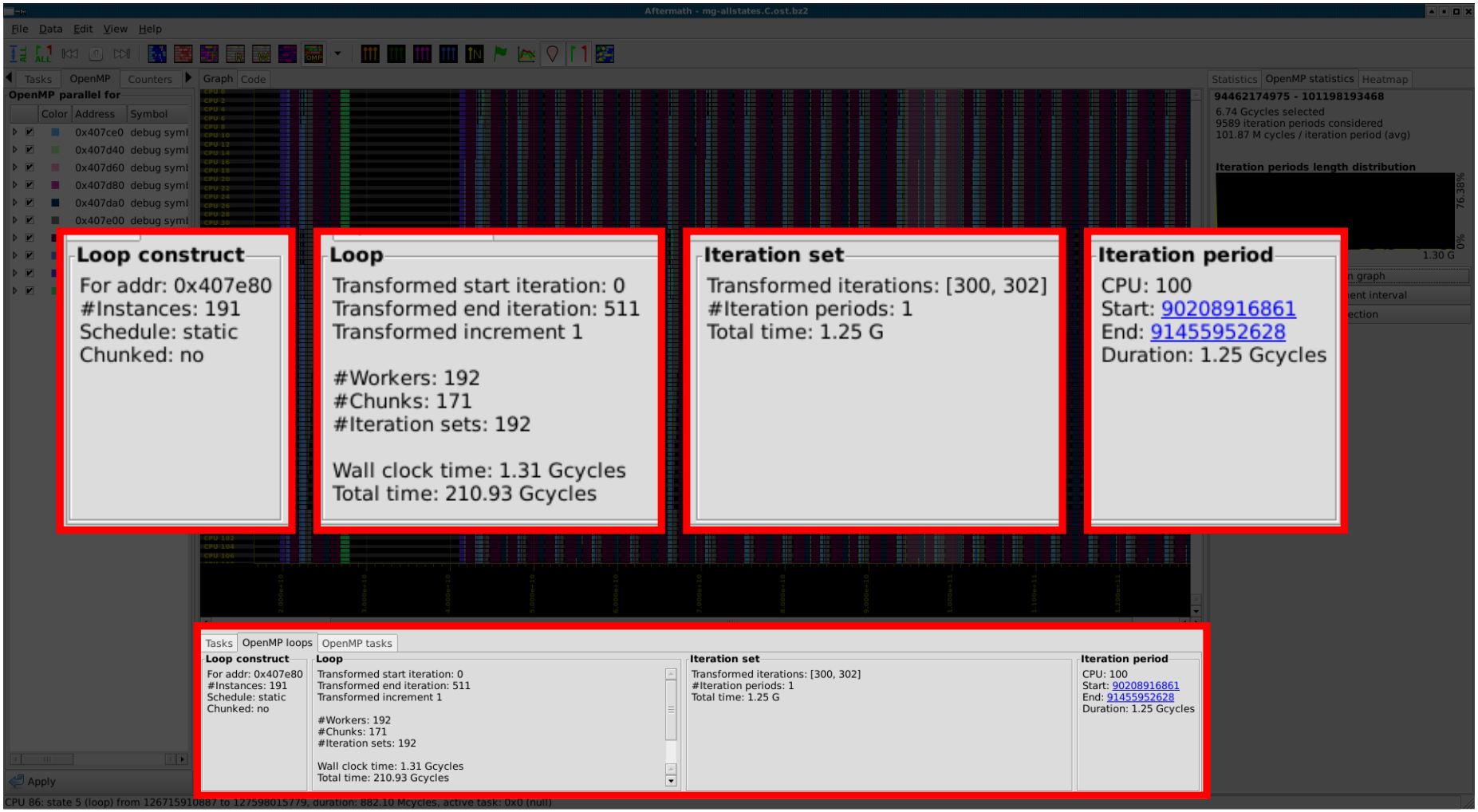

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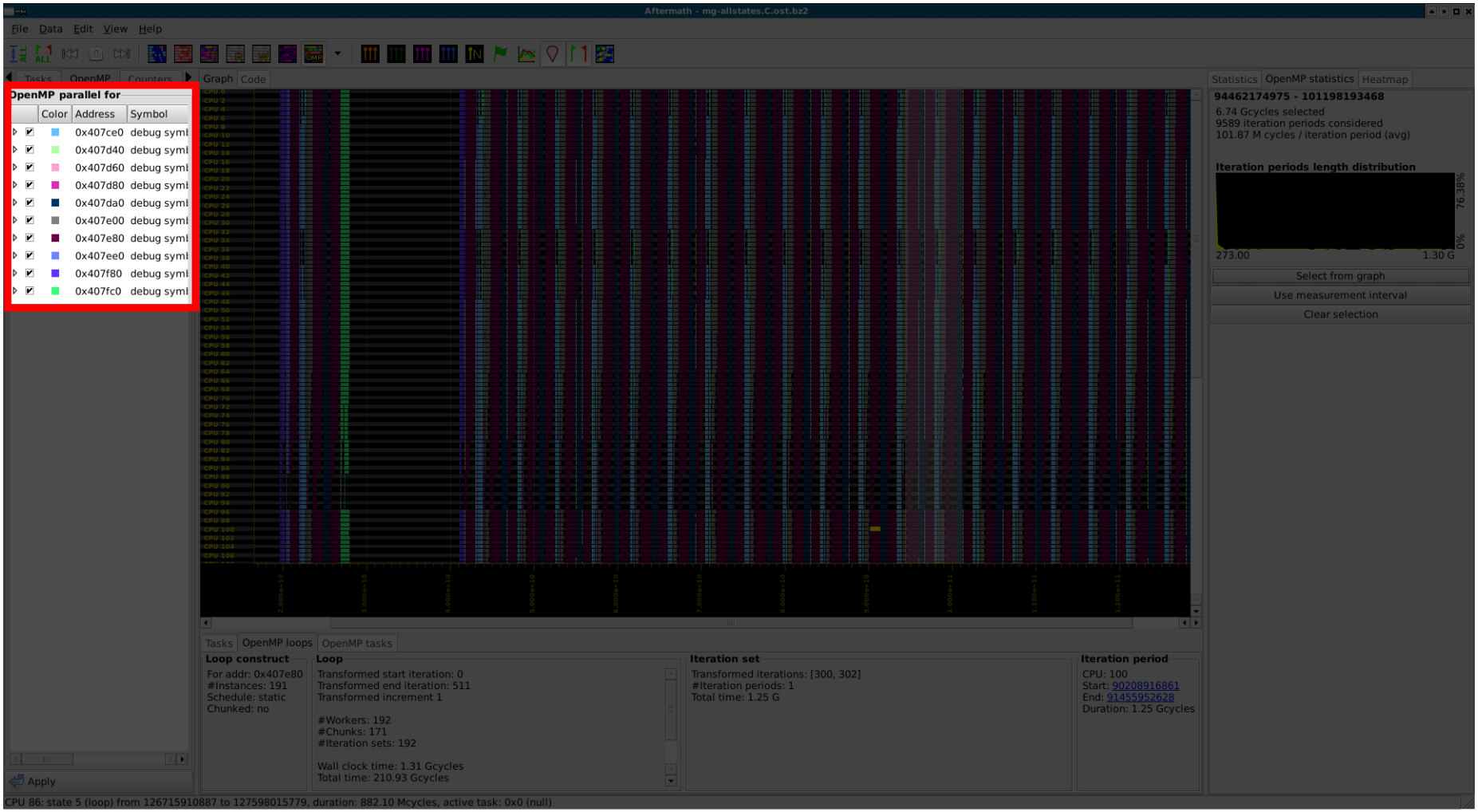

Filter for loop constructs

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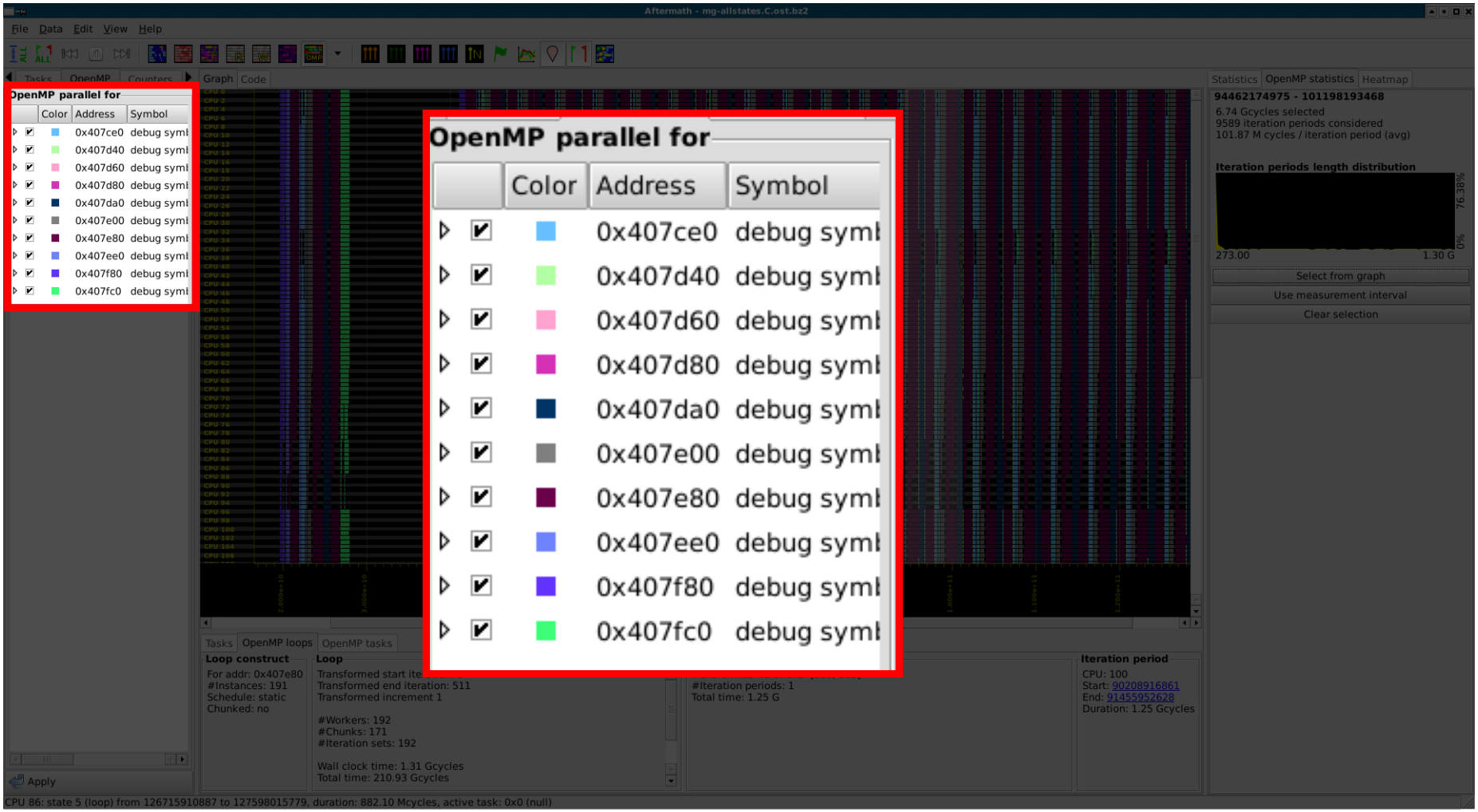

Filter for loop constructs

Demo: NPB's MG benchmark

Benchmark: NPB MG

- NPB 2.3 C implementation from the Omni Compiler Project
- C input class (512×512 elements)

Test platform

- SGI UV 2000 (Xeon E5-4640)
- 192 cores (Hyperthreading disabled)
- 24 NUMA nodes, 756 GiB RAM
- LLVM/clang 3.8.0
- Aftermath-OpenMP for trace generation

DEMO

Demo: Summary

Execution phases

- Parallel initializations + Main Computation
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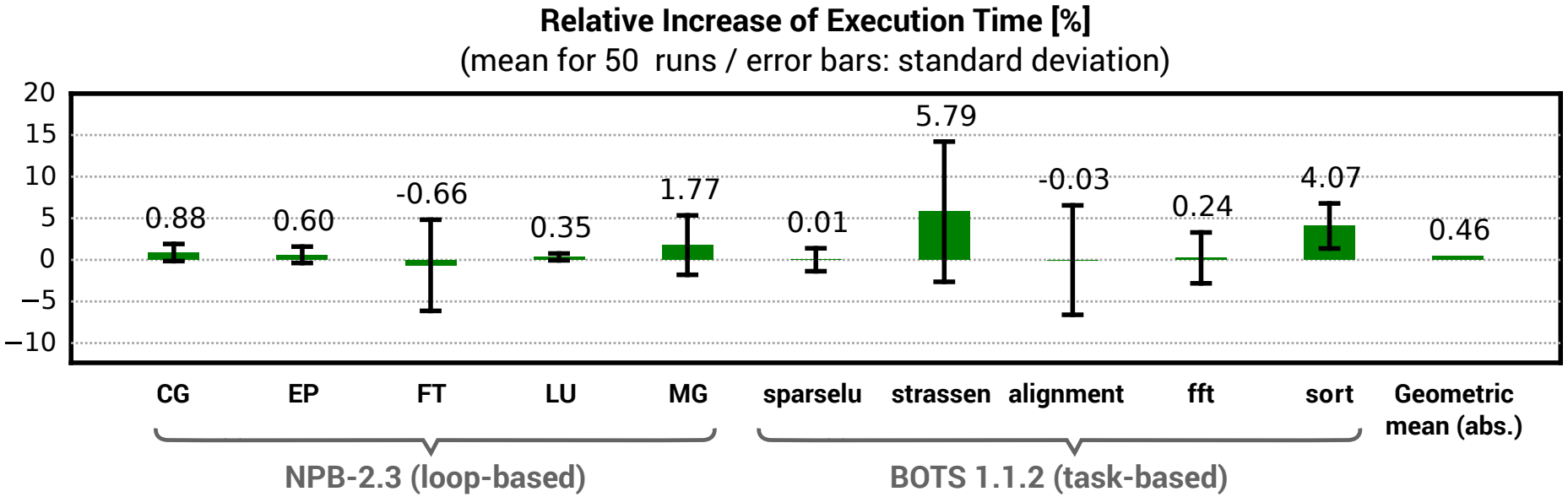
Solution

- Change allocation scheme: one big allocation
- Reduce number of workers: #iters = $n \times$ #workers
- Result: 35$\times$ speedup

Overhead of Tracing



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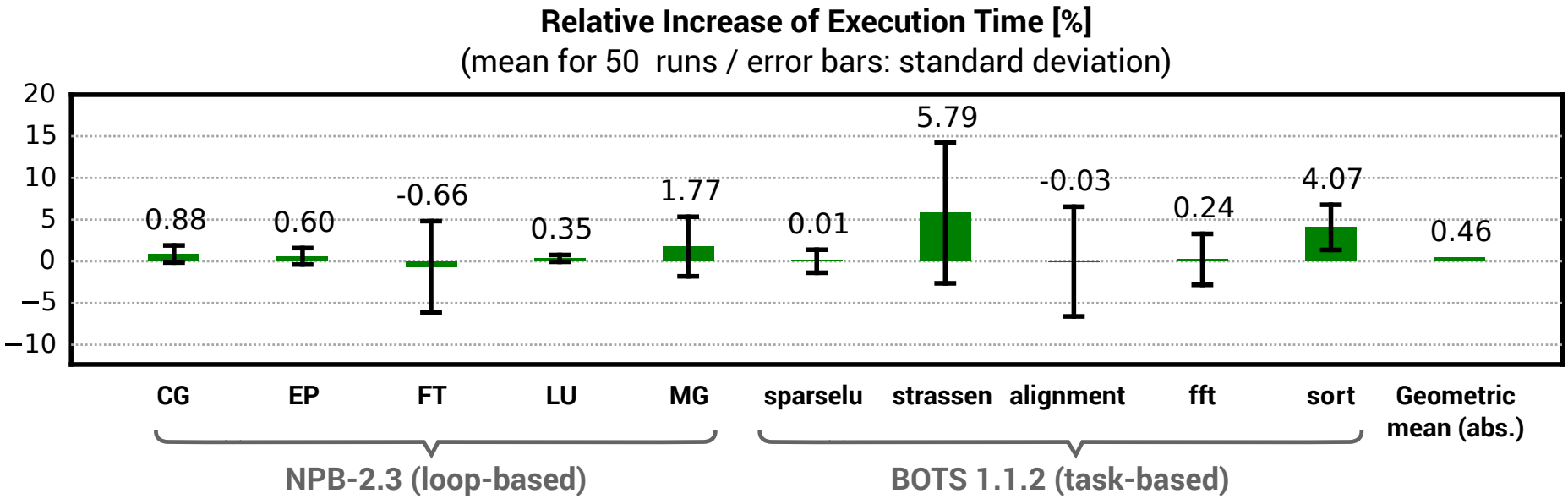

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Missing benchmarks

- Outlier: *floorplan* (+380% execution time; very small tasks)
- Segfaults (*BT*, *nqueens*, *uts*) / Excessive Execution time (*IS*) / Verification Failure (*health*)

Using Aftermath & Aftermath-OpenMP

Drop-in replacement for libomp with wrapper script:

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Source code and tutorial:

`http://www.openstream.info/aftermath`

Virtual Machine
(Aftermath + Aftermath-OpenMP + sample traces + documentation):

`http://www.openstream.info/vm`

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- Dependent tasks
- Automate recurring analyses

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On-line resources

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