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cfaed CENTER FOR ADVANCING ELECTRONICS DRESDEN

Ohua as STM alternative for shared state applications

Master Midway Defense

Felix Wittwer

29. January 2020

TECHNISCHE UNIVERSITÄT DRESDEN

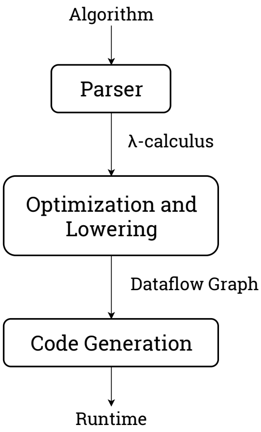
DRESDEN concept

DFG

WR WISSENSCHAFTSRAT

Ohua[1]

Framework for implicit parallel programming:



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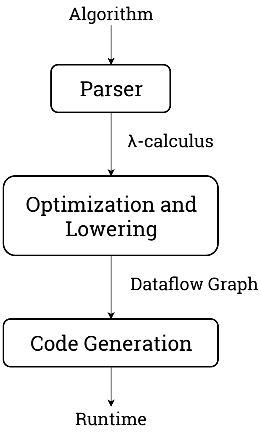

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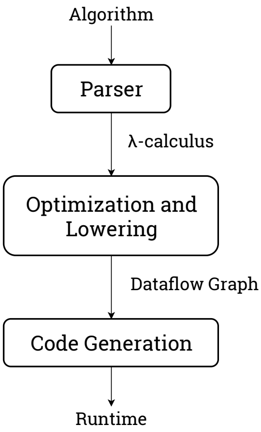

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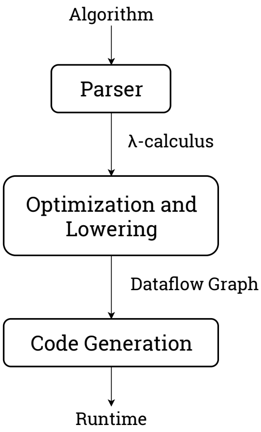

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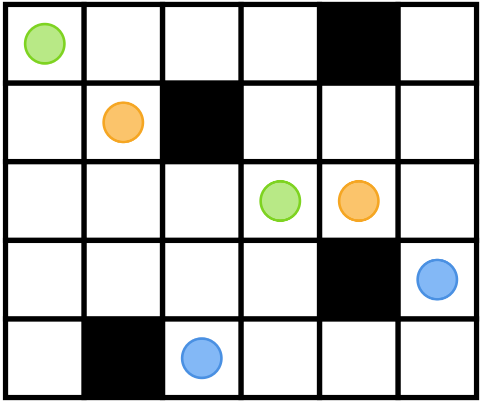
Throwback: Labyrinth Benchmark

Given: 3D maze, pairs of points



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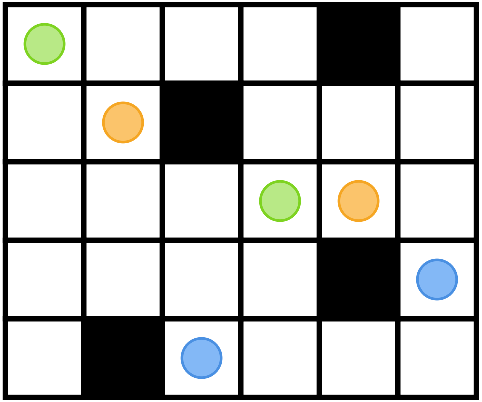

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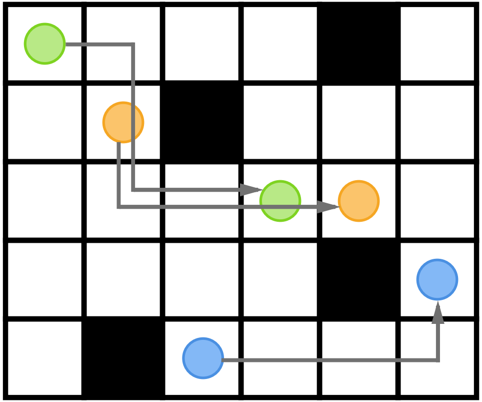

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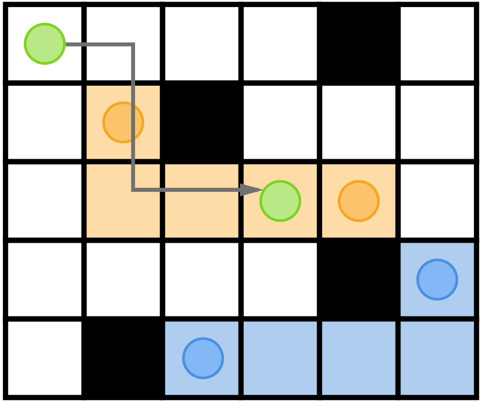

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Throwback: Labyrinth Benchmark

Given: 3D maze, pairs of points

Goal: Map a path between each pair of points

Implementation:

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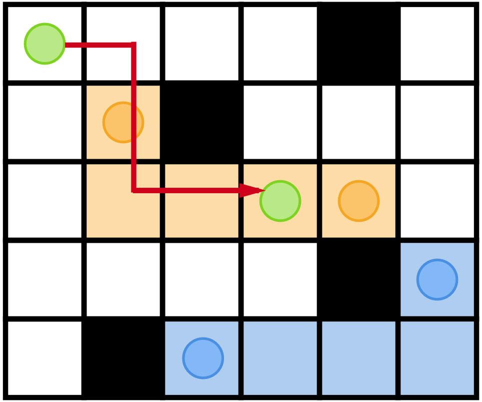
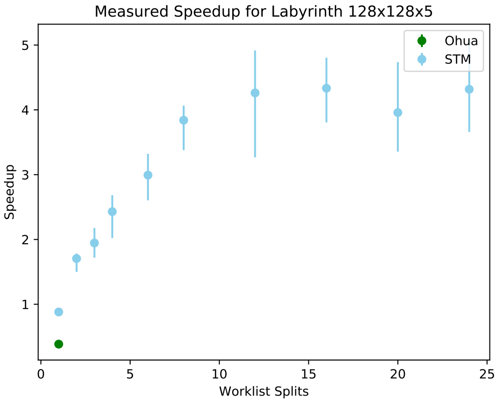
  $\rightarrow$ retry if path crosses other paths



Throwback: Early Results



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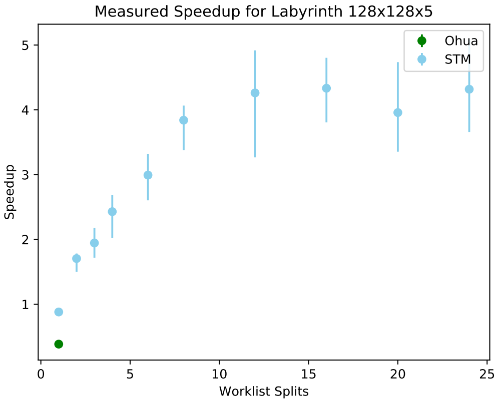

- Ohua: one measuring point
- Speedup < 0.5
- parallelizable problem that would be solved with locks
- Ohua's aim: offer lock-free alternative

Improving the Benchmark Performance

Previousy envisioned steps:

1. add a simple scheduler to the runtime to improve measurability

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Goal: Finding generalized dataflow transformations

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Goal: Finding generalized dataflow transformations
$\rightarrow$ develop proof of concept implementations

Transformation 1: Worklist Splits

```
fn fill(maze: Maze, to_map: Vec<(Point, Point)>) -> Maze {

    let paths = for pair in to_map {
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    let (remap_paths, new_maze) = update_maze(maze, paths);

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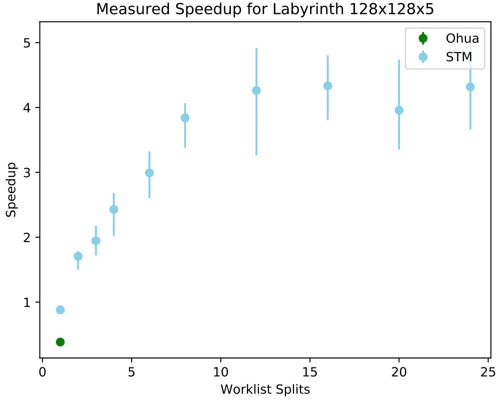

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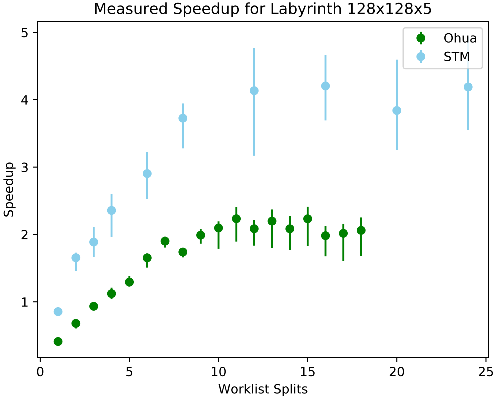

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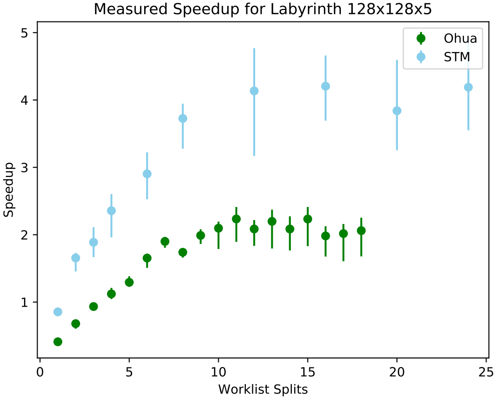
Transformation 1: Worklist Splits

- Granular parallelism control



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- Granular parallelism control
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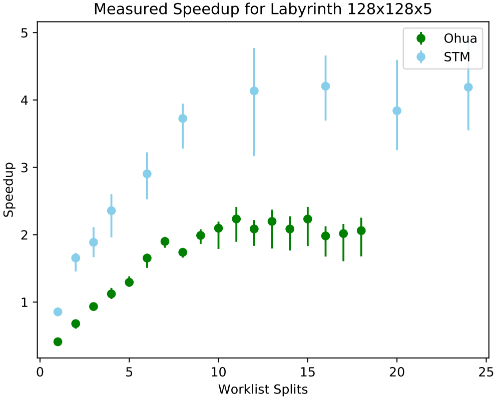

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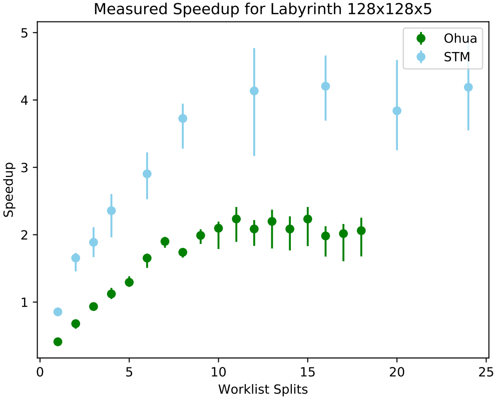
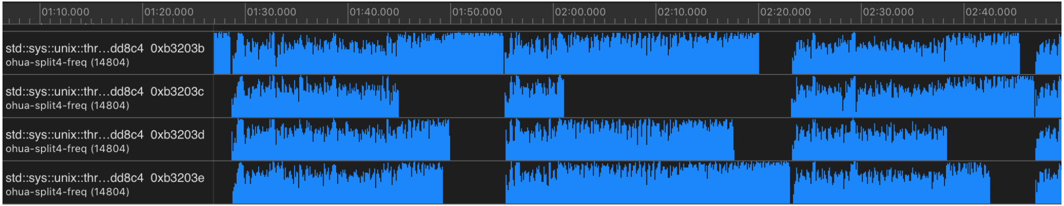
Reason: Straggler Problem

- Synchronization points force all threads to wait



Straggler Problem with Splitting

Instruments trace for 4-split implementation:



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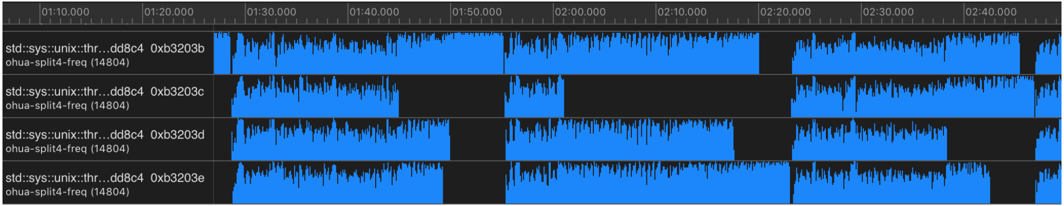

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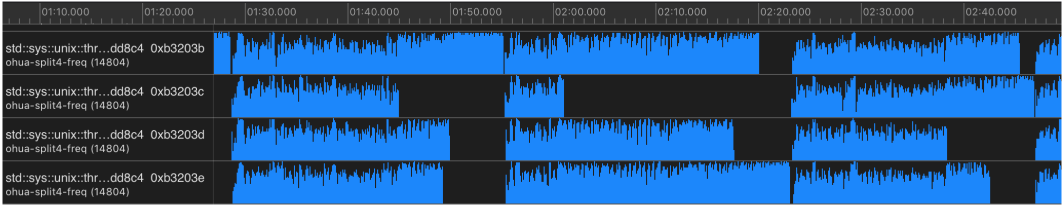

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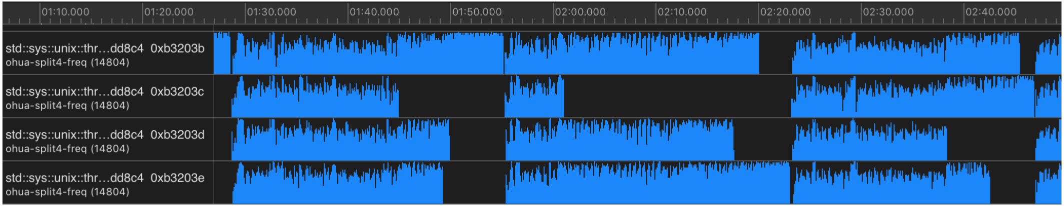

- Worklists don’t take equally long to process
- All threads are forced to wait at barrier
  - each recomputation affects execution time twice
  - uses more processing time and causes slack time for other cores

Transformation 2: Update Frequency

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fn fill(maze: Maze, to_map: Vec<(Point, Point)>) -> Maze {

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```
fn fill(maze: Maze, to_map: Vec<(Point, Point)>) -> Maze {
    let (points, still_to_map) = take_n(to_map, frequency);
    let (tm0, tm1) = splitup(points);
    let part0 = for pair in tm0 {
        find_path(maze, pair)
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    let paths = join(part0, part1);

    let (remap_paths, new_maze) = update_maze(maze, paths);
    let to_remap = join(remap_paths, still_to_map);

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Transformation 3: Improve Resource Utilization

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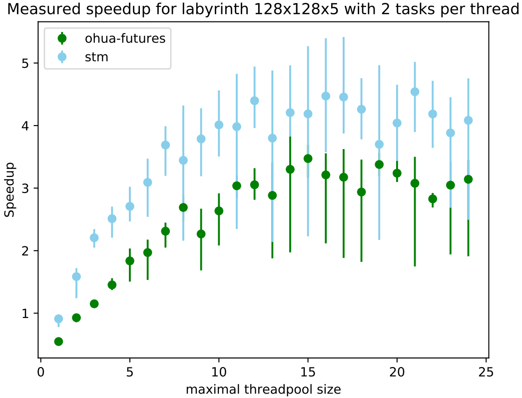
  - when thread is done it can steal work from other threads

Result: Significant Performance Improvements



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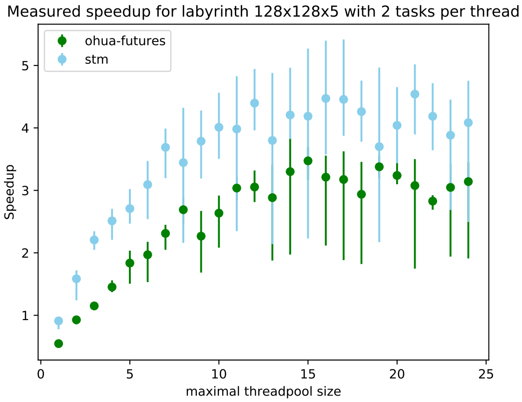

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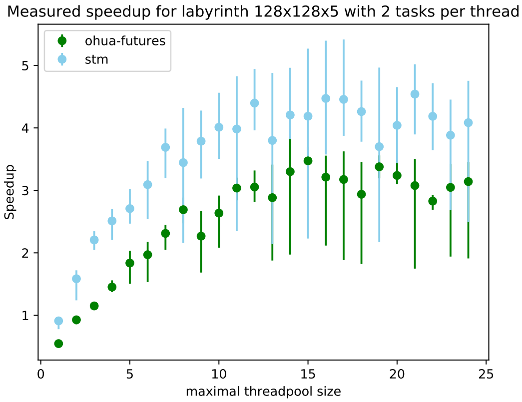

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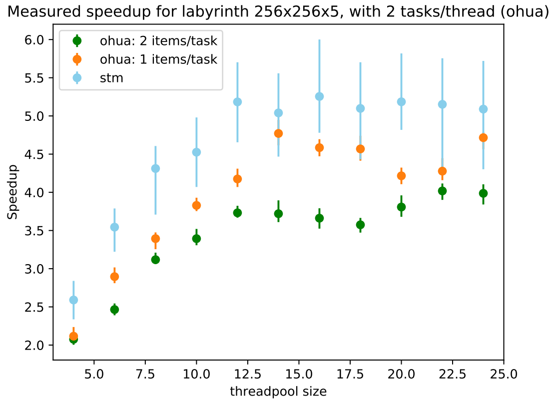

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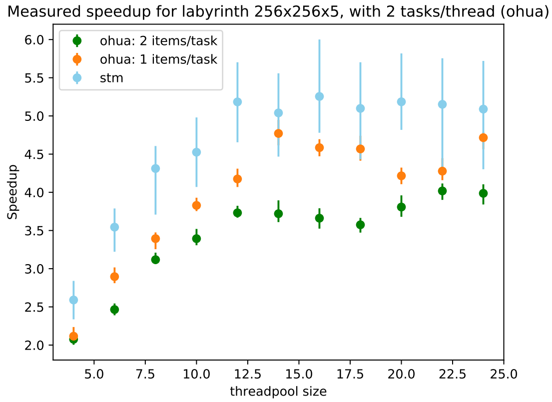

- Proof of concept: Ohua almost on par with `stm`
- Advantage: deterministic execution model
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  - also reflected by execution times

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Transformations: Overview

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General-purpose transformations applied:

1. Data parallelism for stateless loop computations
   - improve execution times
2. Batch write accesses to shared state
   - state updates take effect earlier
3. Use work-stealing algorithm
   - lessens effect of the straggler problem

Other benchmarks

- According to Minh et al.[2] applications for `stm` are manifold

[2] Minh, Chi Cao, et al. "STAMP: Stanford transactional applications for multi-processing." 2008 IEEE International Symposium on Workload Characterization. IEEE, 2008.

Other benchmarks

- According to Minh et al.[2] applications for `stm` are manifold
- Each has own behavioral patterns
  $\rightarrow$ test transformations on representative application range

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Benchmark 2: Intruder

- Simulates intrusion detection system

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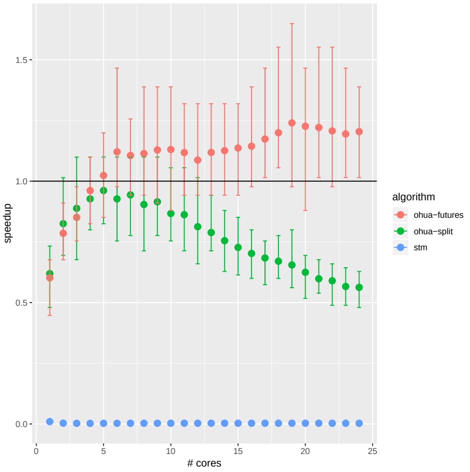

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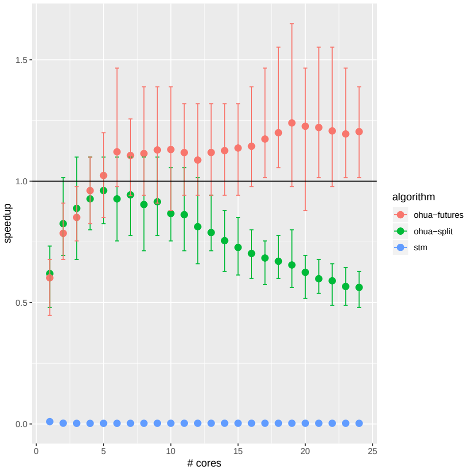

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Benchmark 2: Intruder

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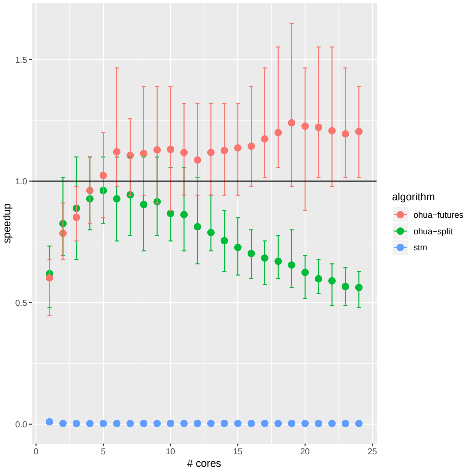
- Ohua: Speedups of up to 1.25
- No contention due to its execution model



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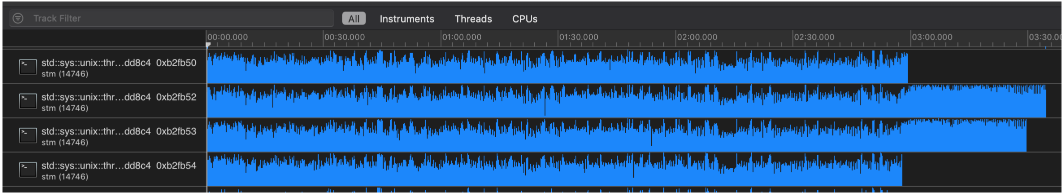
2. Implement compiler optimizations
   - add dataflow transformations to the Ohua compiler
3. Verify results
   - using previously examined benchmarks

Thank you for your attention.

Backup

Backup: Straggler Problem in STM



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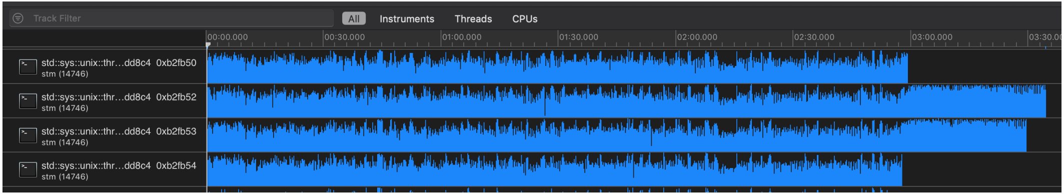

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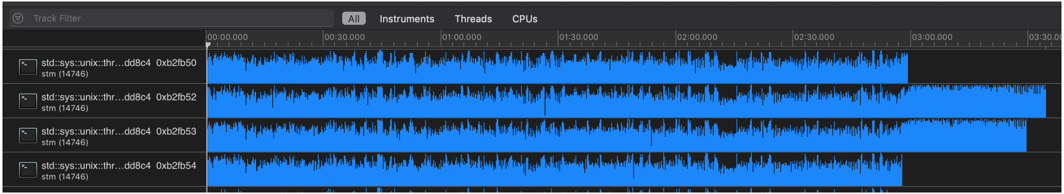

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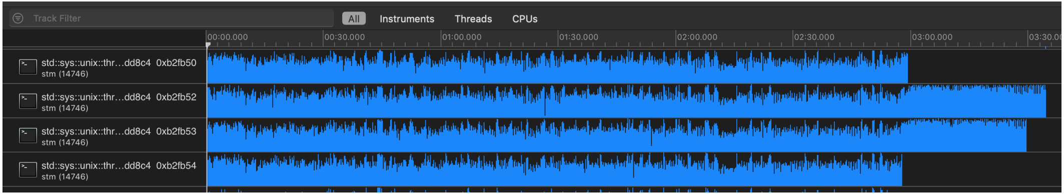

- STM interleaves reads and writes on shared data
- trade-off: no synchronization barriers but
  - non-deterministic execution model
  - more recomputations due to state invalidation

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Backup: Benchmark Classification

Classification of STAMP[2] suite benchmarks:

application	tx length	r/w set	tx time	contention
labyrinth	long	large	high	high
bayes	long	large	high	high
yada	long	large	high	medium
vacation	medium	medium	high	low/medium
genome	medium	medium	high	low
intruder	short	medium	medium	high
kmeans	short	small	low	low
ssca2	short	small	low	low

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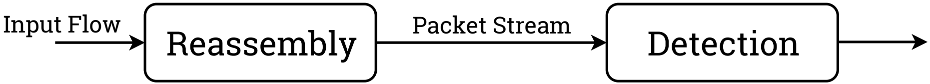

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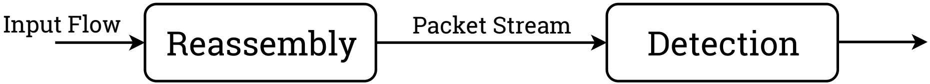

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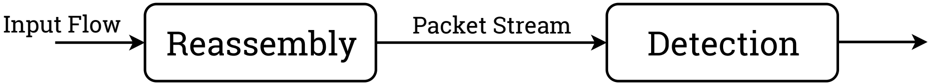

- Reconstructed packets stored in shared hash map
- Parallel write accesses in STM provoke recomputations