Ohua as STM alternative for shared state applications

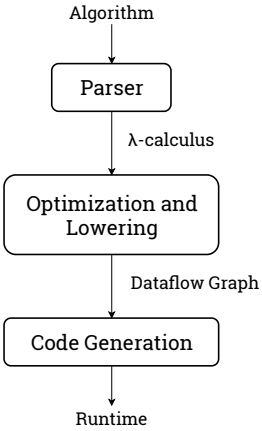
Master Midway Defense

Felix Wittwer

29. January 2020

Ohua[1]

Framework for implicit parallel programming:



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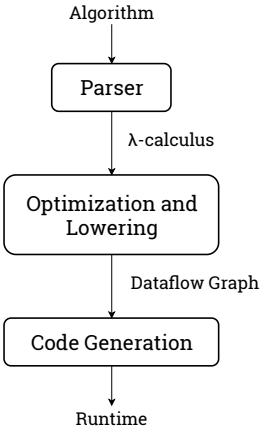

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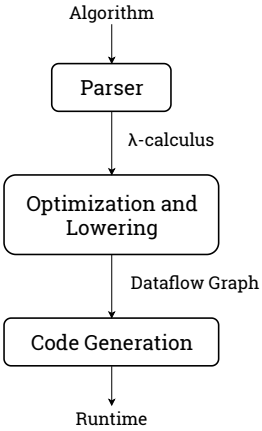

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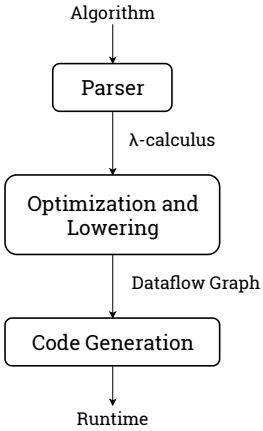

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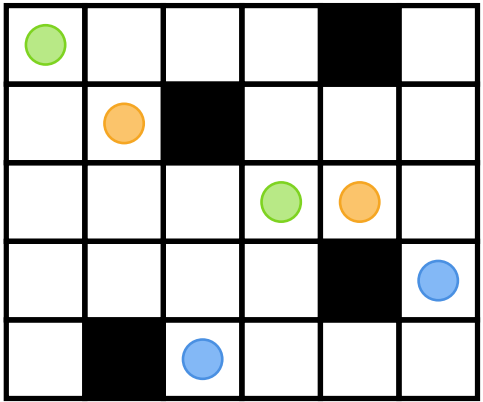
Throwback: Labyrinth Benchmark

Given: 3D maze, pairs of points



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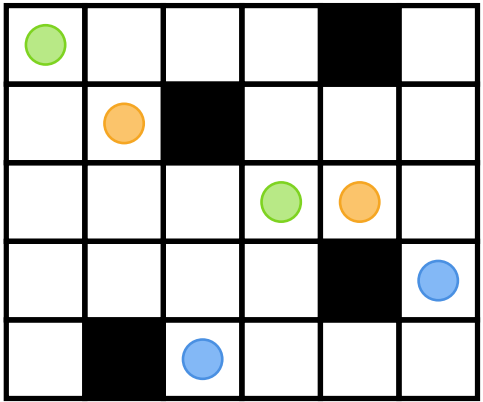

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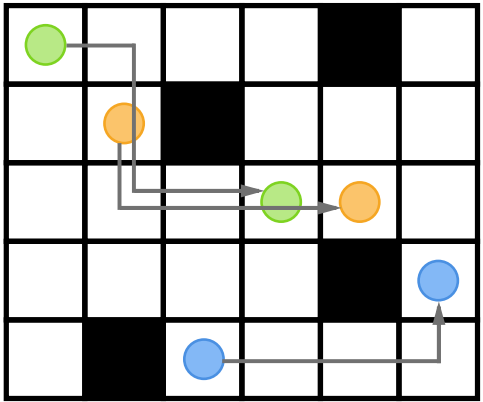

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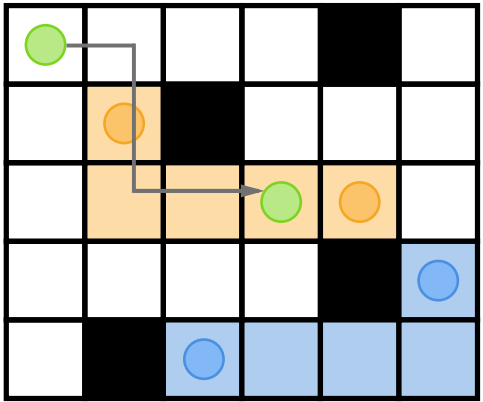

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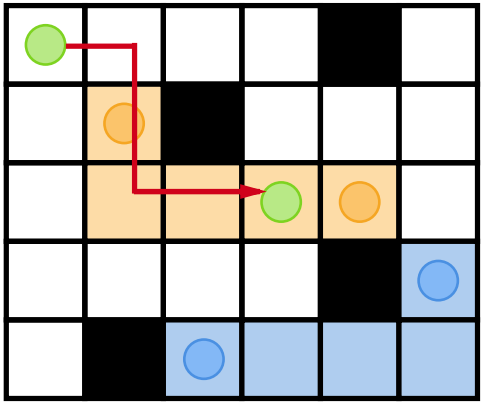
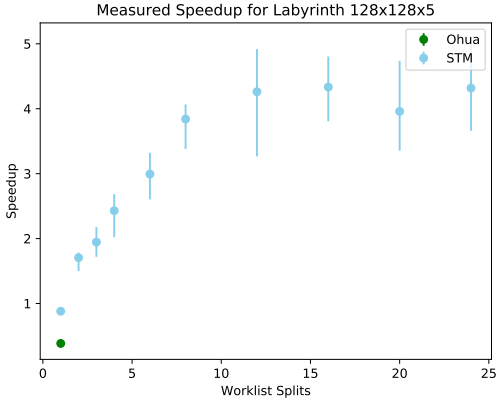


Throwback: Early Results



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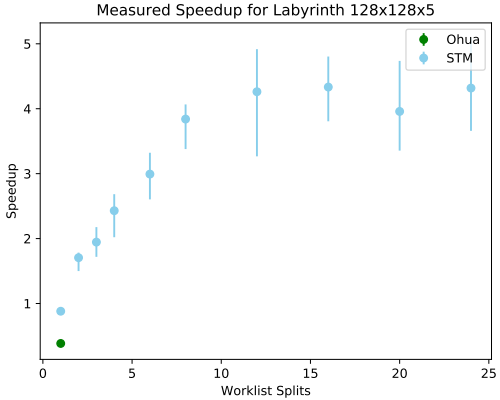

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- parallelizable problem that would be solved with locks
- Ohua's aim: offer lock-free alternative

Improving the Benchmark Performance

Previousy envisioned steps:

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Goal: Finding generalized dataflow transformations
→ 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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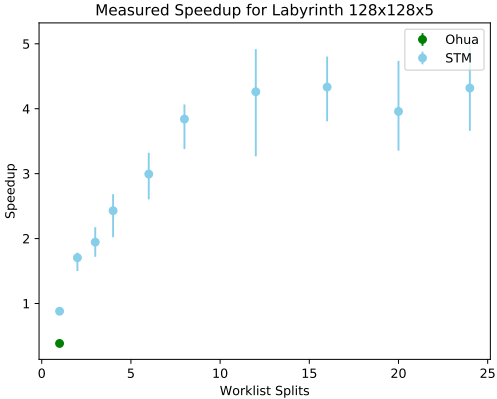

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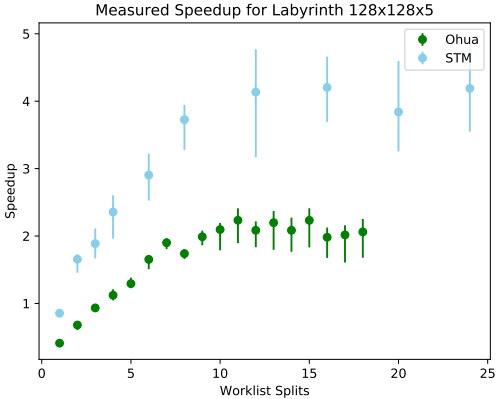
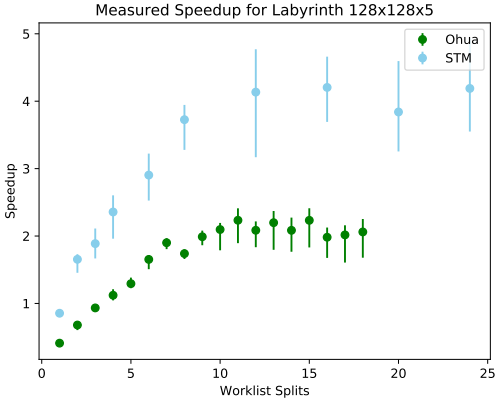


Transformation 1: Worklist Splits

- Granular parallelism control



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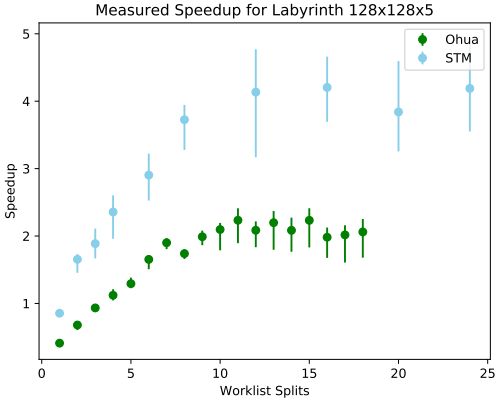

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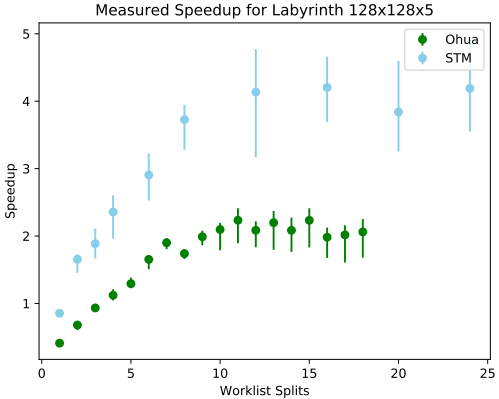
Reason: Straggler Problem

- Synchronization points force all threads to wait



Straggler Problem with Splitting

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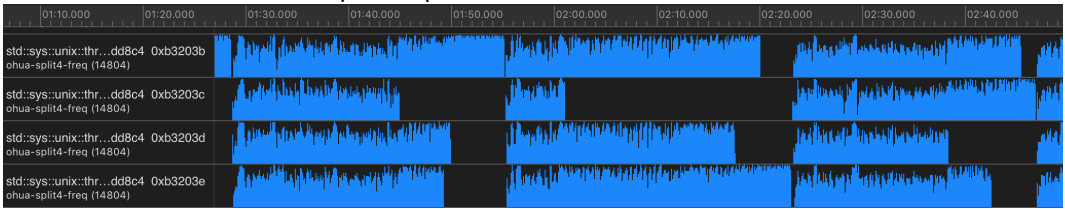

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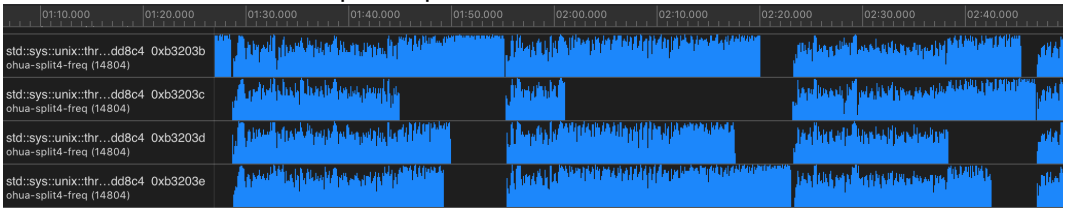

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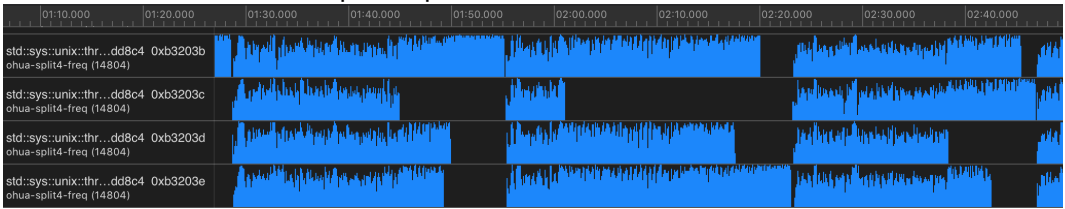

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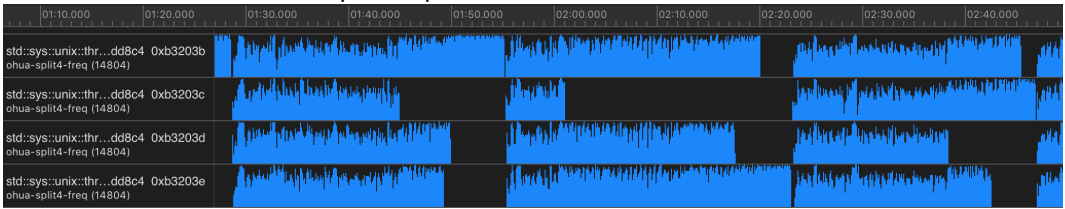

- Worklists don’t take equally long to process
- All threads are forced to wait at barrier
  - each recomputation affects execution time twice
  - uses more processing time and causes slack time for other cores

Transformation 2: Update Frequency

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

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    let to_remap = join(remap_paths, still_to_map);

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

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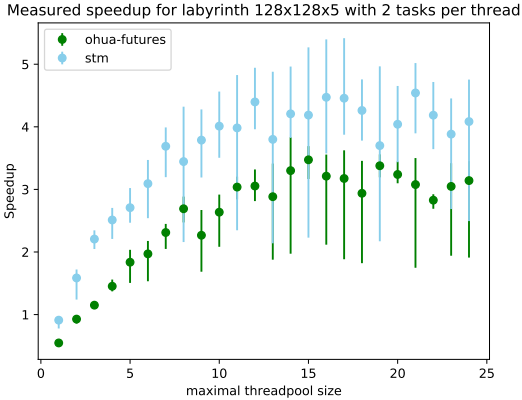

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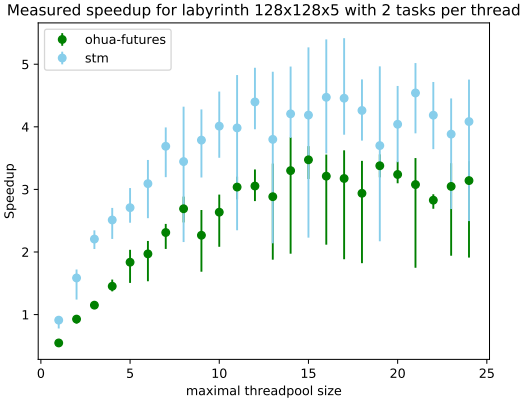

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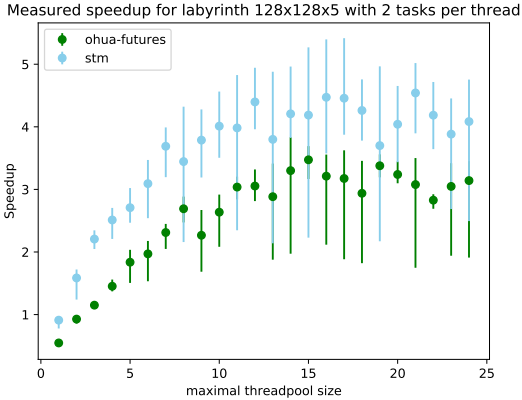

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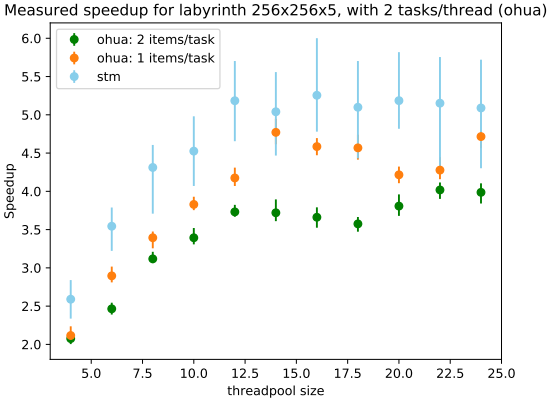

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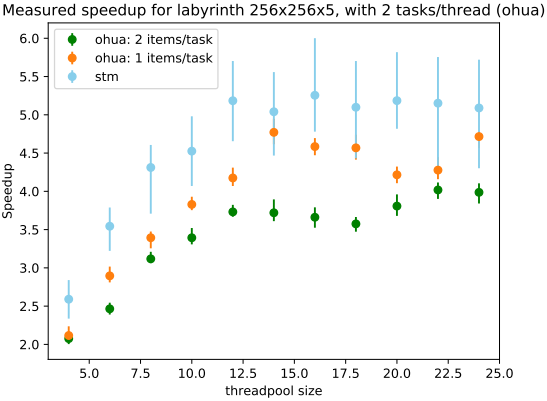

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  - also reflected by execution times

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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.

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- Each has own behavioral patterns
  $\rightarrow$ test transformations on representative application range

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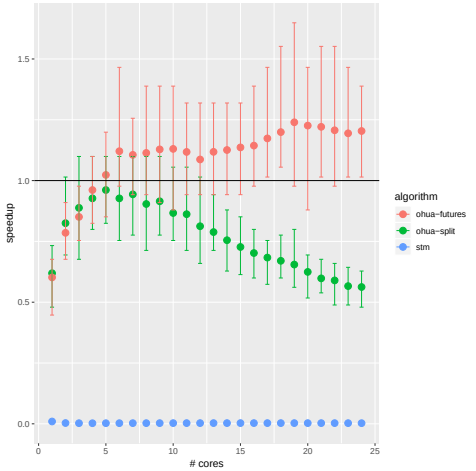

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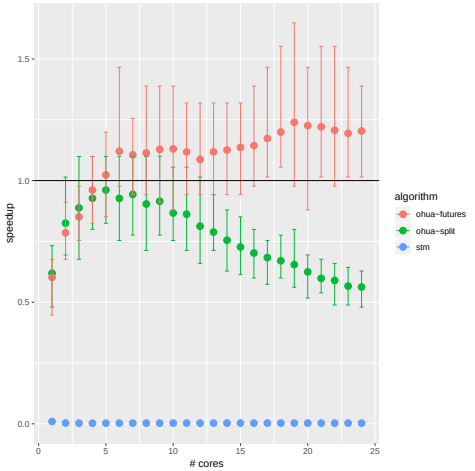

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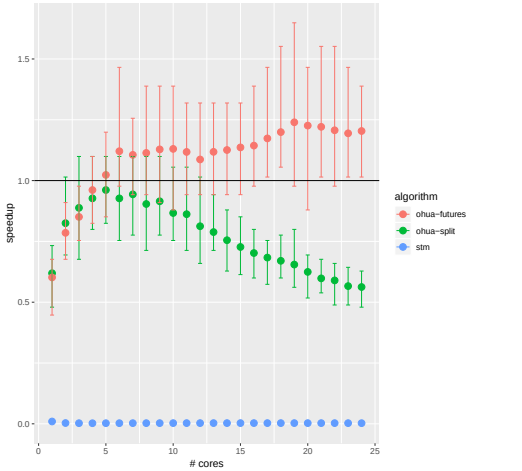
- No contention due to its execution model



Next Steps

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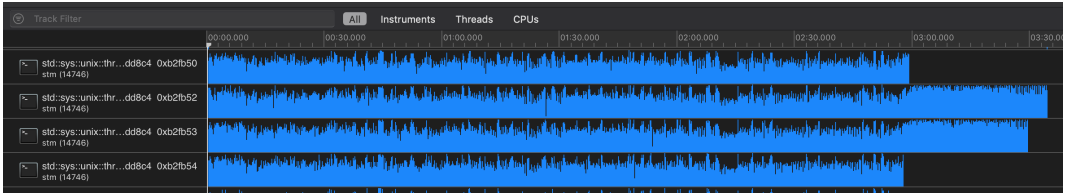
   - add dataflow transformations to the Ohua compiler
3. Verify results
   - using previously examined benchmarks

Thank you for your attention.

Backup

Backup: Straggler Problem in STM



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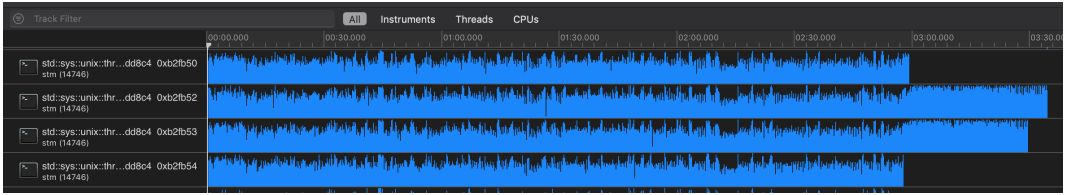

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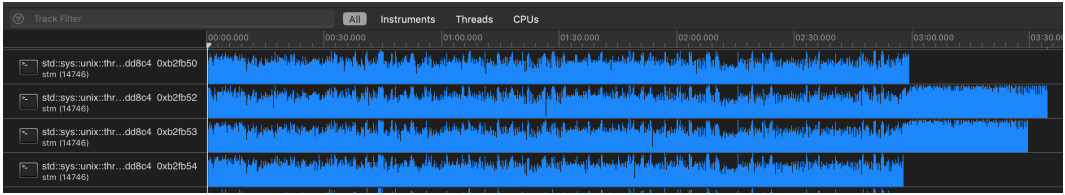

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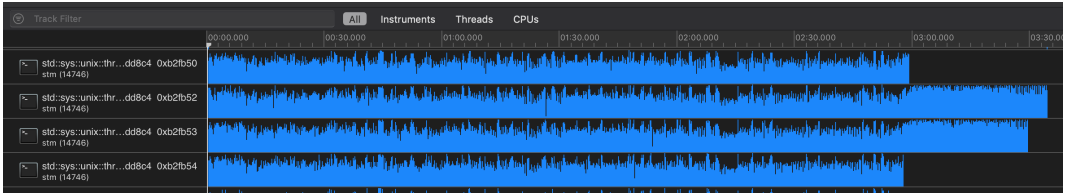


- STM interleaves reads and writes on shared data
- trade-off: no synchronization barriers but
  - non-deterministic execution model
  - more recomputations due to state invalidation

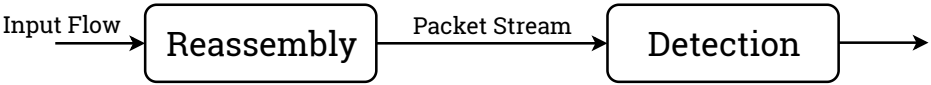
Backup: Benchmark Classification

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

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

Backup: Intruder Benchmark



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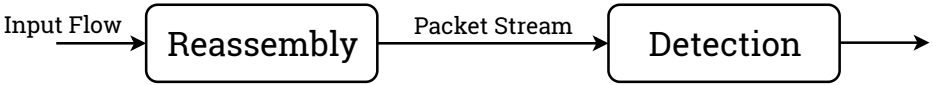
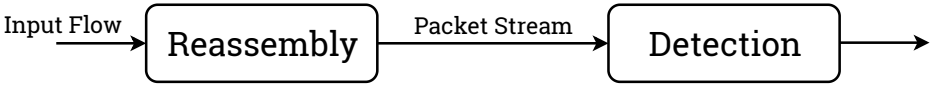


- Reconstructed packets stored in shared hash map

Backup: Intruder Benchmark



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