Australian National University

Faster Work–Stealing With Return Barriers

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The New Era of Computing

- Commodity processors with parallel execution abilities
- A fundamental turn toward concurrency in software

The Challenge

- Modern hardware requires s/w parallelism
- Software parallelism difficult to identify, expose
  - Hard coded optimizations may get you there…
- Hard to realize potential of modern processors

Goal: performance ***and*** productivity

Options ?

- Language based features to expose parallelism
  - Dynamic task parallelism
  - Work–stealing scheduler
- A runtime to hide the hardware complexities

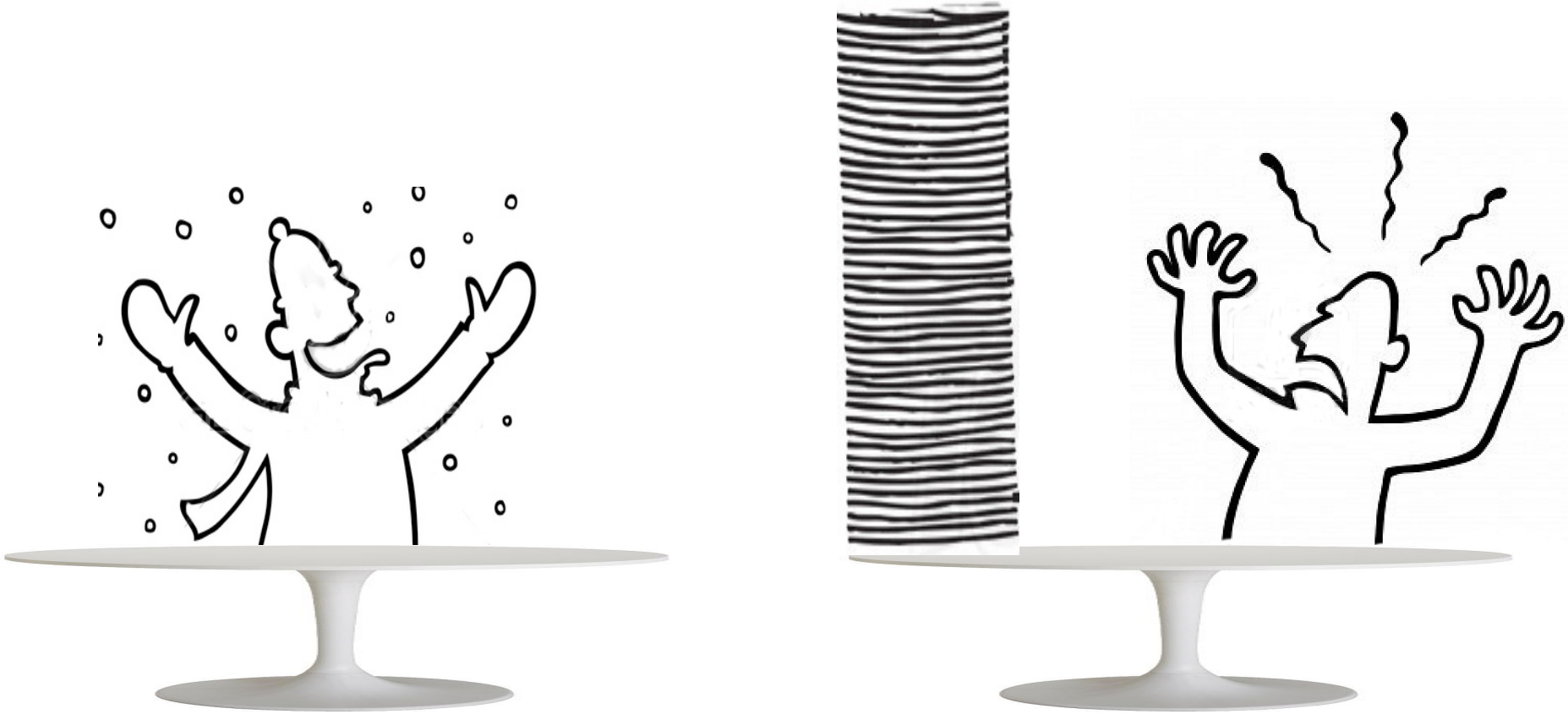
Contributions

- ✔ In-depth analysis
  - Of overheads associated with stealing tasks
- ✔ A new design
  - Simple extension to JVM re-using old idea
- ✔ Detailed performance study
  - Using standard work-stealing benchmarks
- ✔ Results
  - That show we can significantly reduce the tasks stealing overhead

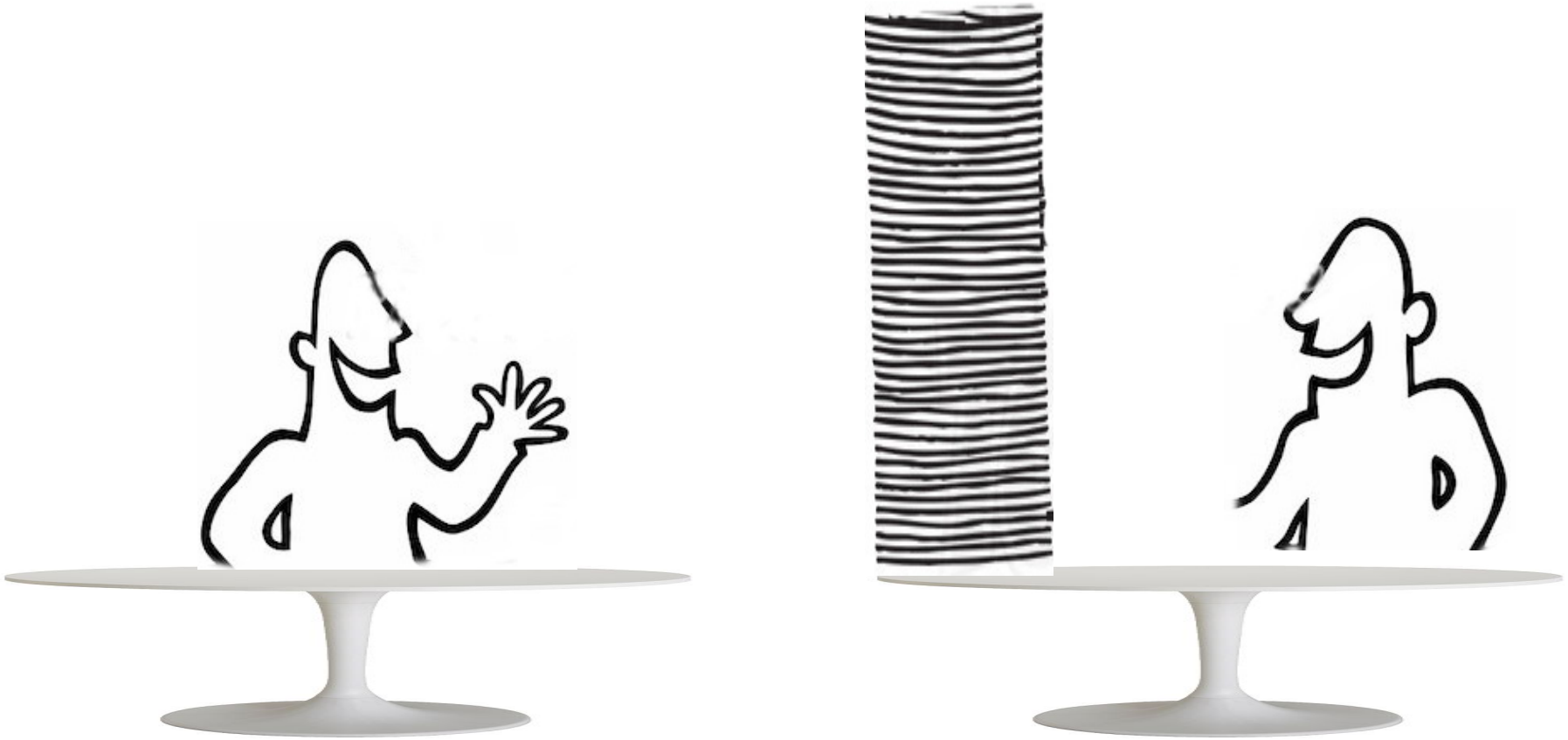
Understanding Work–Stealing

Work–Stealing

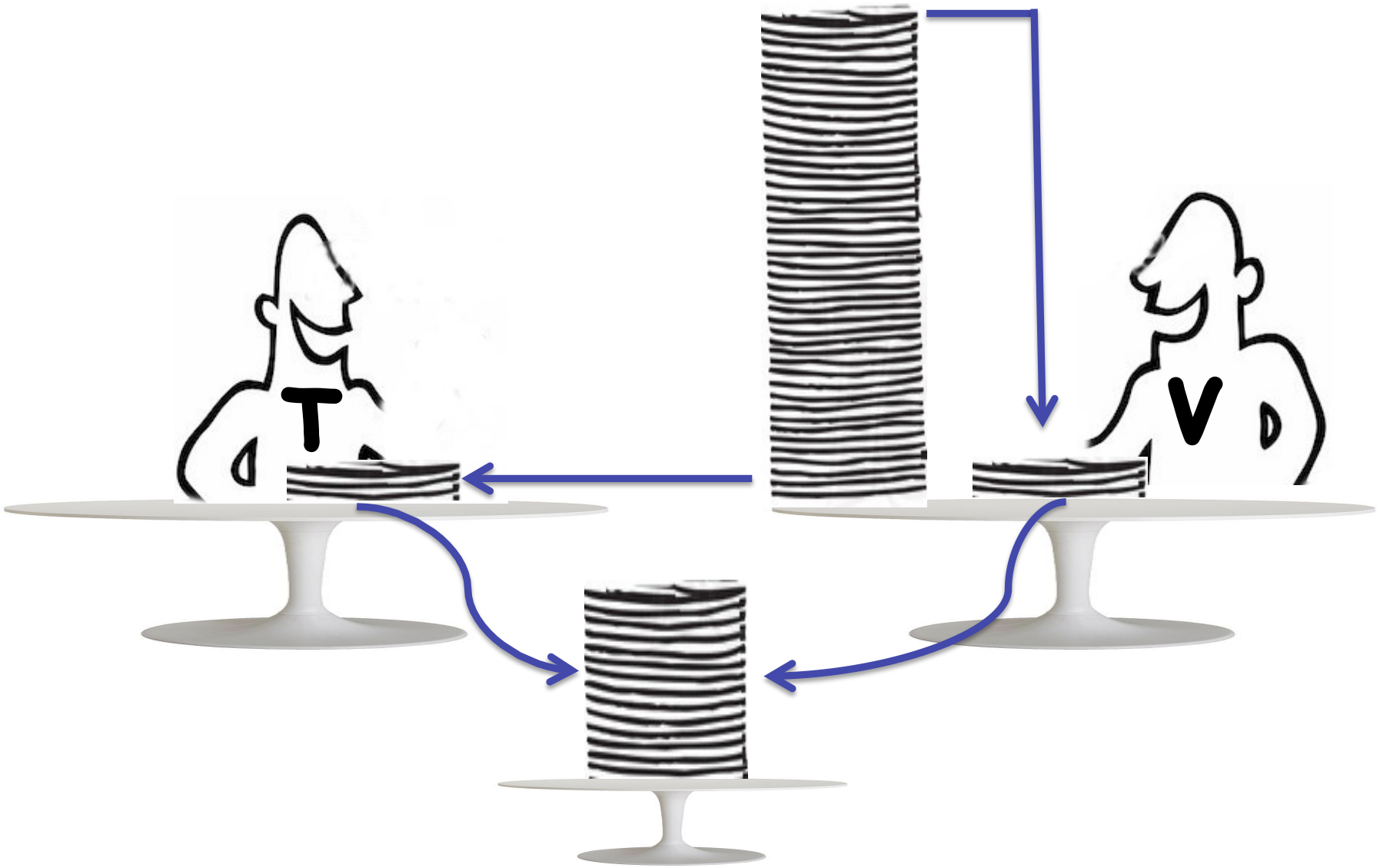
Work–Stealing



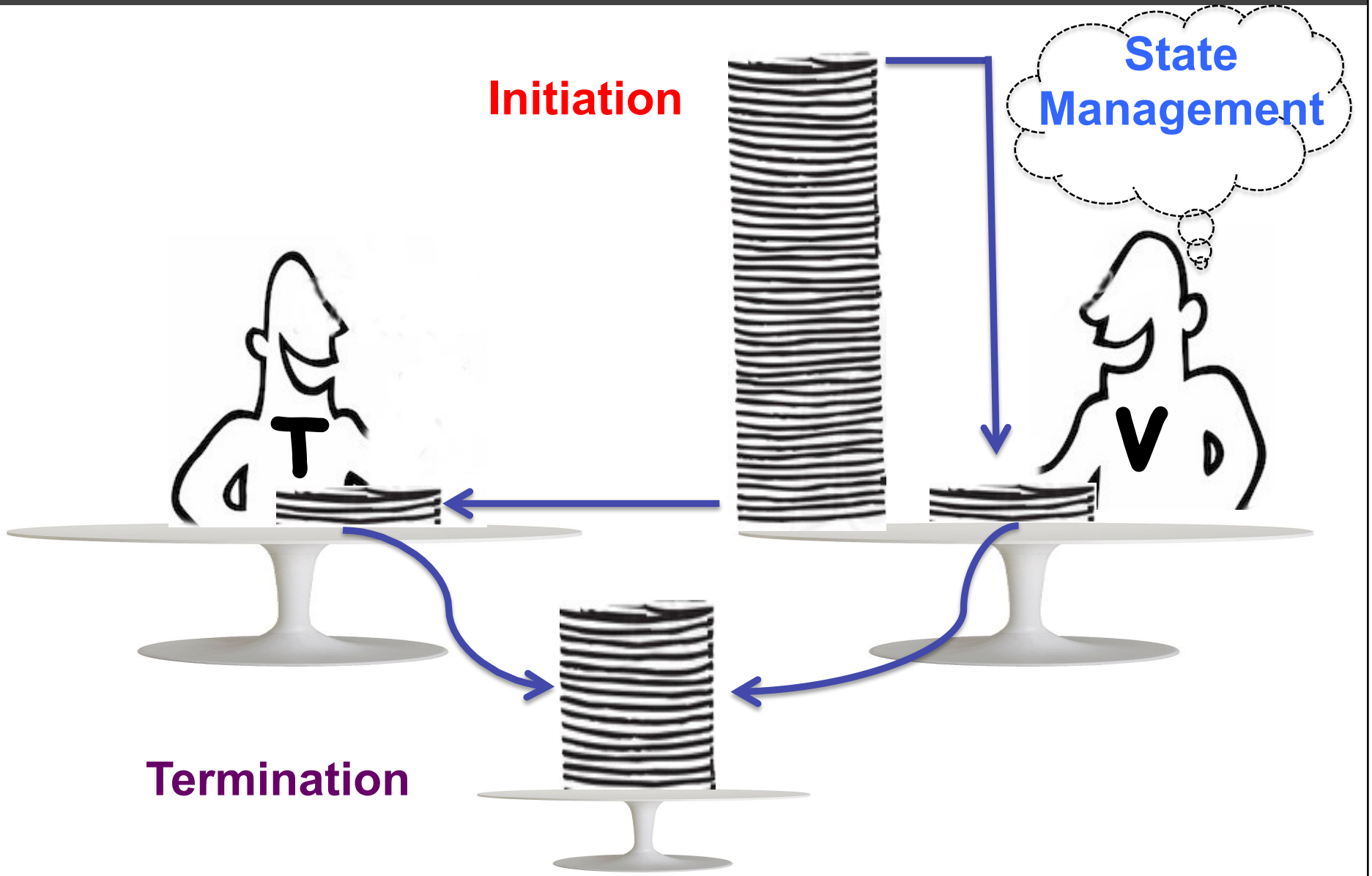
Work–Stealing



Work–Stealing



Work–Stealing



Our Prior Work

Our Prior Work

Work-Stealing Without The Baggage *

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Abstract

Work-stealing is a promising approach for effectively exploiting software parallelism on parallel hardware. A programmer who uses work-stealing explicitly identifies potential parallelism and the runtime then schedules work, keeping otherwise idle hardware busy while relieving overloaded hardware of its burden. Prior work has demonstrated that work-stealing is very effective in practice. However, work-stealing comes with a substantial overhead: as much as 2× to 12× slowdown over orthodox sequential code.

In this paper we identify the key sources of overhead in work-stealing schedulers and present two significant re-

1. Introduction

Today and in the foreseeable future, performance will be delivered principally in terms of increased hardware parallelism. This fact is an apparently unavoidable consequence of wire delay and the breakdown of Dennard scaling, which together have put a stop to hardware delivering ever faster sequential performance. Unfortunately, software parallelism is often difficult to identify and expose, which means it is often hard to realize the performance potential of modern processors. Work-stealing [3, 9, 12, 18] is a framework for allowing programmers to explicitly expose *potential* parallelism. A work-stealing scheduler within the underlying lan-

OOPSLA 2012

Eliminating Sequential Overheads

- Sequential overheads
  - Initiation
  - State management
  - Code restructuring

Fork–Join: 200%

X10: 400%

- Exploit existing JVM mechanisms
  - **Initiation**: Execution stack for steal initiation
  - **State management**: Extract state from stack & registers
  - **Code restructuring**: Try–catch blocks for control flow
- Eliminated most sequential overheads **12%**

Motivating Analysis

Methodology

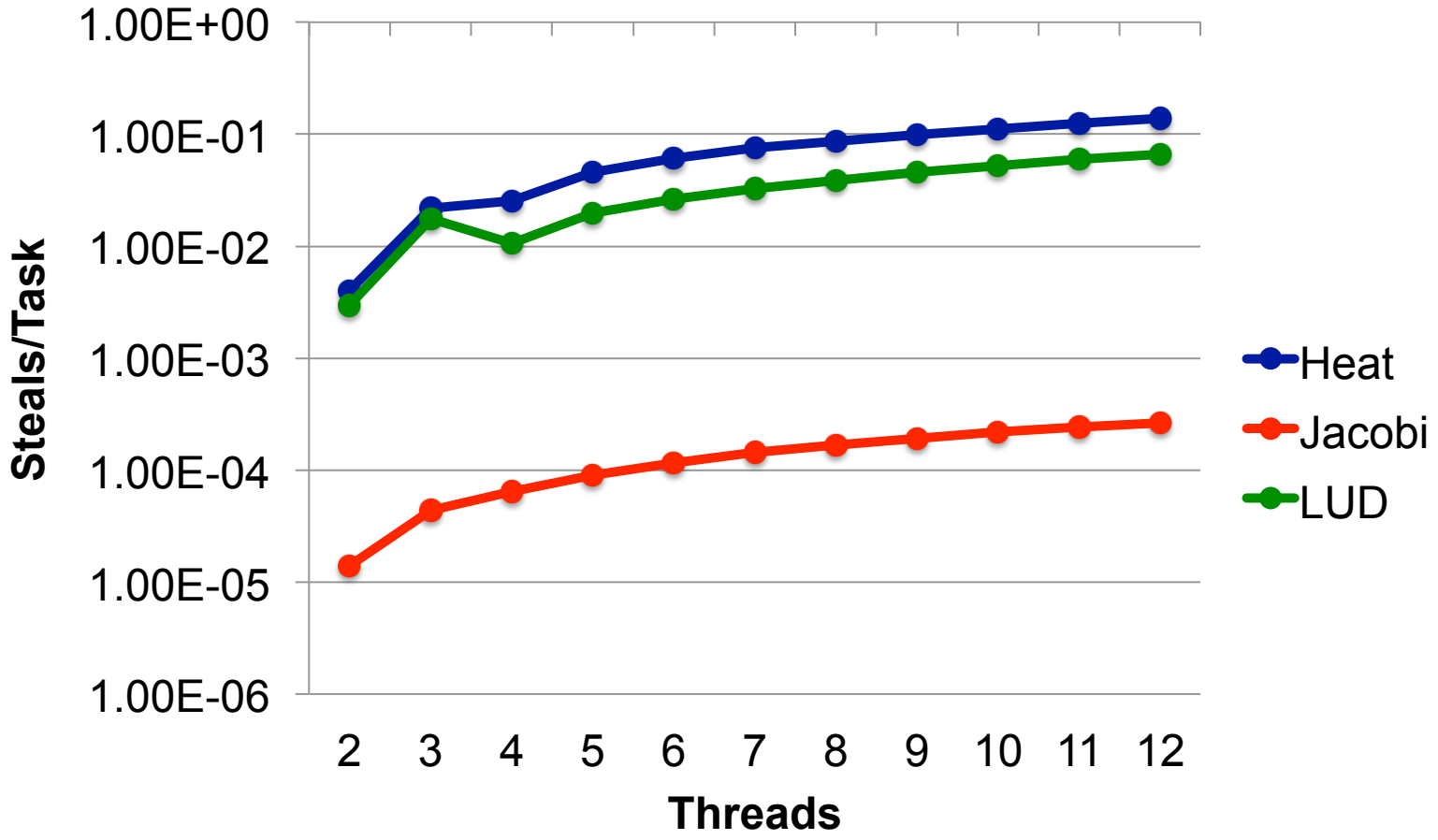
- Benchmarks
  - Jacobi
  - LU Decomposition
  - Heat Diffusion
- High steal ratio

- Hardware Platform
  - 2 Intel Xeon E7530
    - 6 cores each

- Software Platform
  - Jikes RVM (3.1.2)

Motivating Analysis

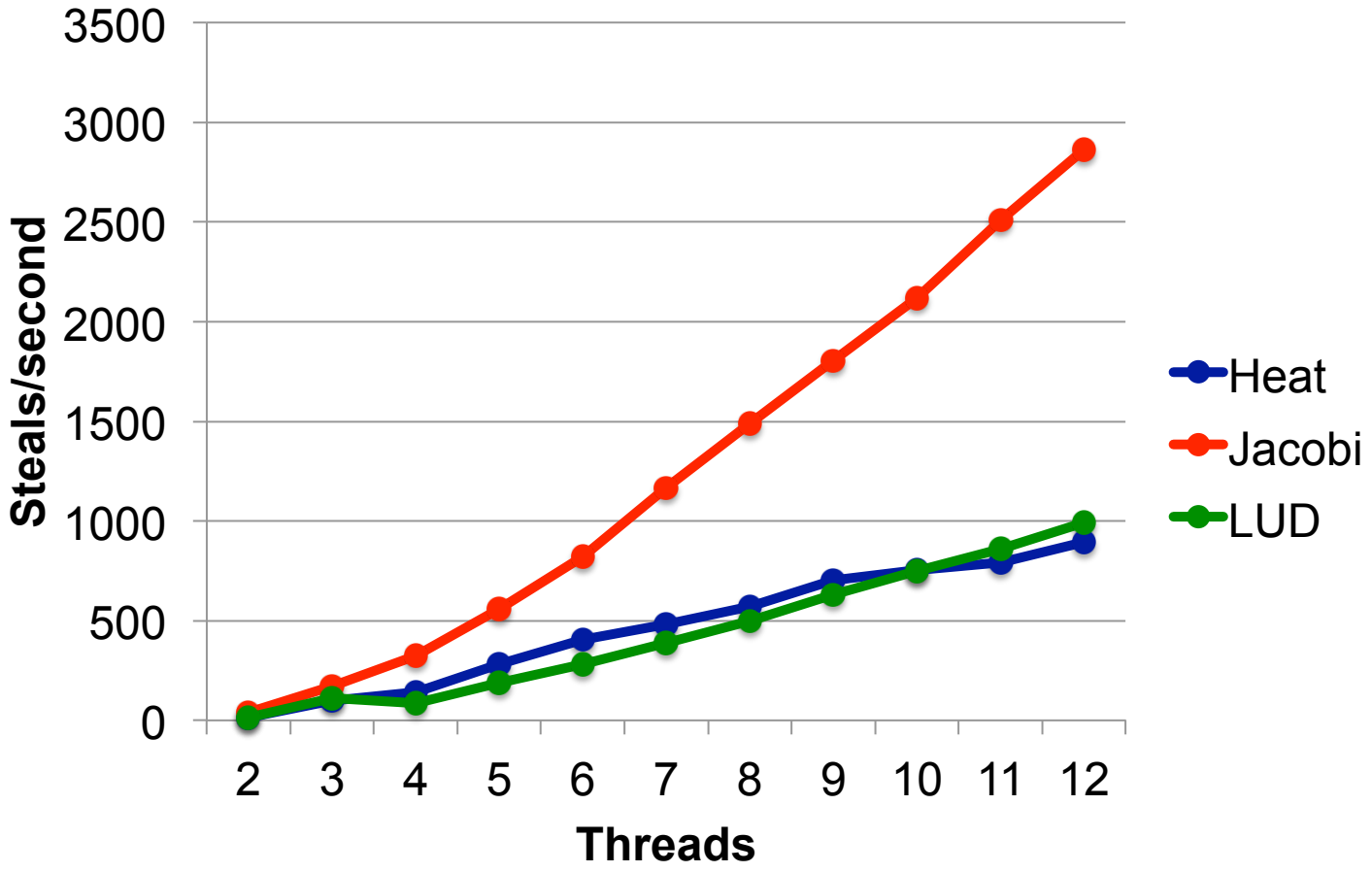
Steals:Task Ratio



Measured using JavaWS (Try–Catch)

Motivating Analysis

Steal Rate



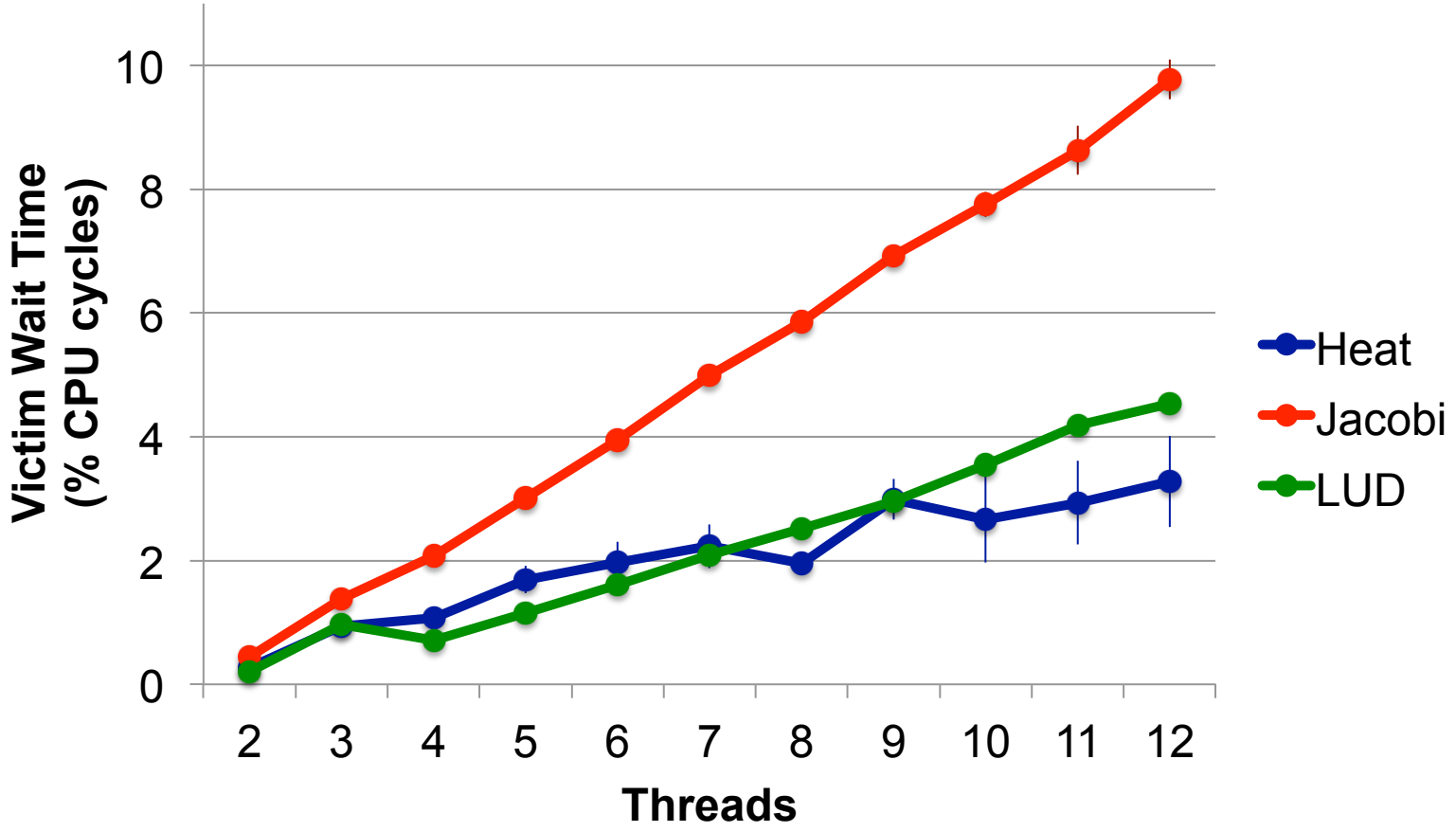
Measured using JavaWS (Try–Catch)

Insight

- Steal ratio and steal rate not correlated

Motivating Analysis

Steal Overhead



Measured using JavaWS (Try–Catch)

Insights

- Steal ratio and steal rate not correlated
- Higher steal *rate* correlates to high steal overhead

Our Approach

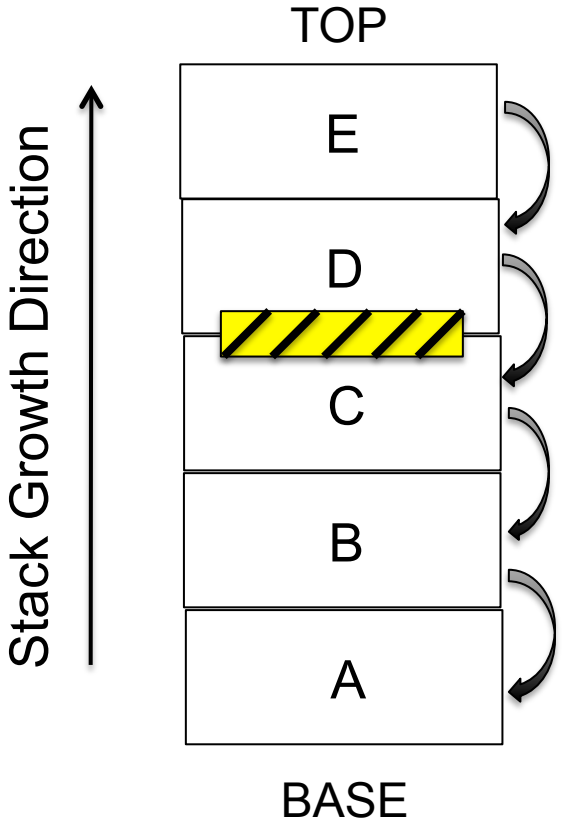
Reducing Stealing Overhead

- Two pronged attack
  - Reduce the cost of each steal
    - Return barriers
  - Reduce total number of steal events
    - Steal more than one continuation at a time

Implementation

Return Barrier

- Allows runtime to intercept a common event
- Hijack a return and bridge to some other method
- Register and stack state preserved



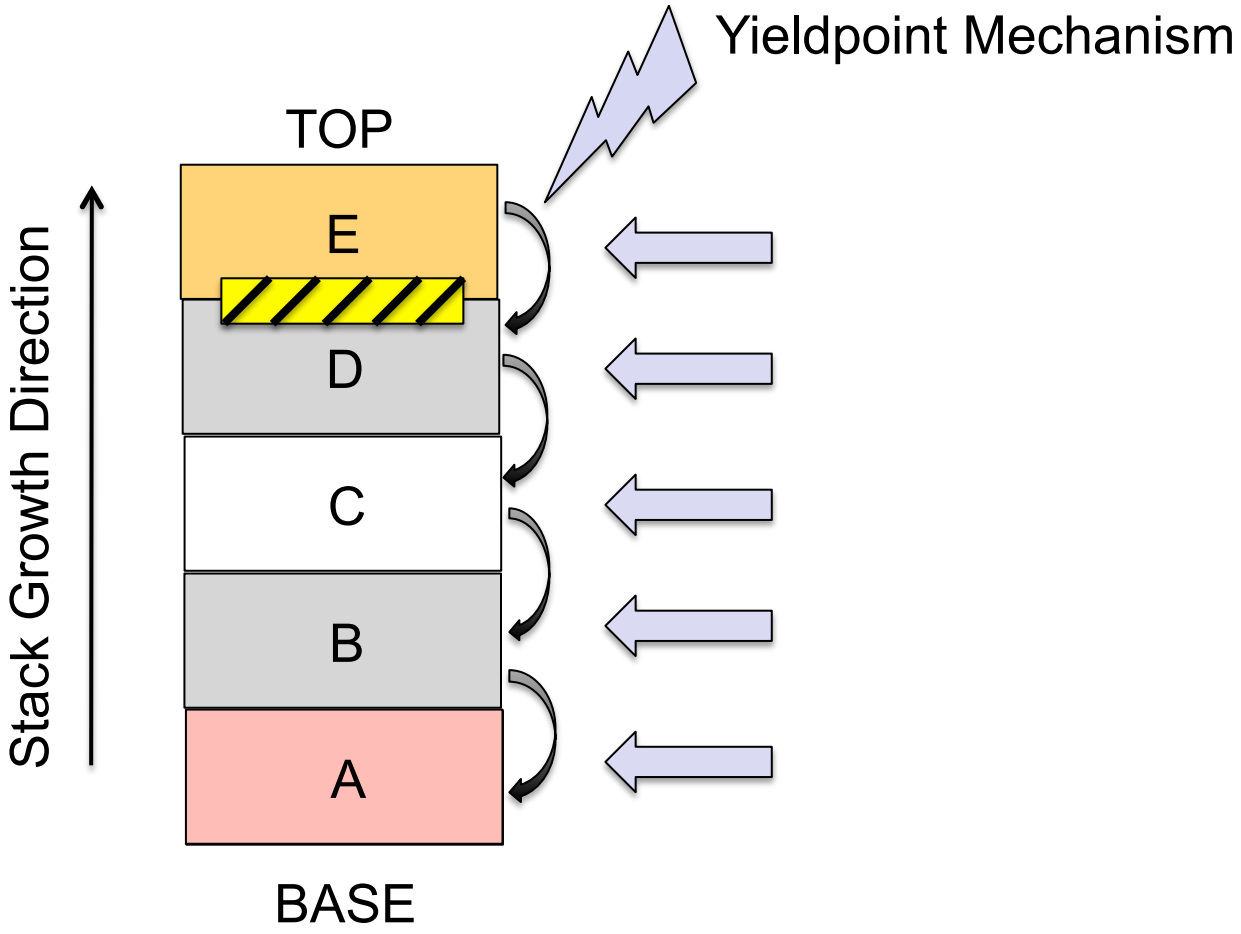
Frame D

Frame Pointer	Return Address
Frame C	trampoline method Method C

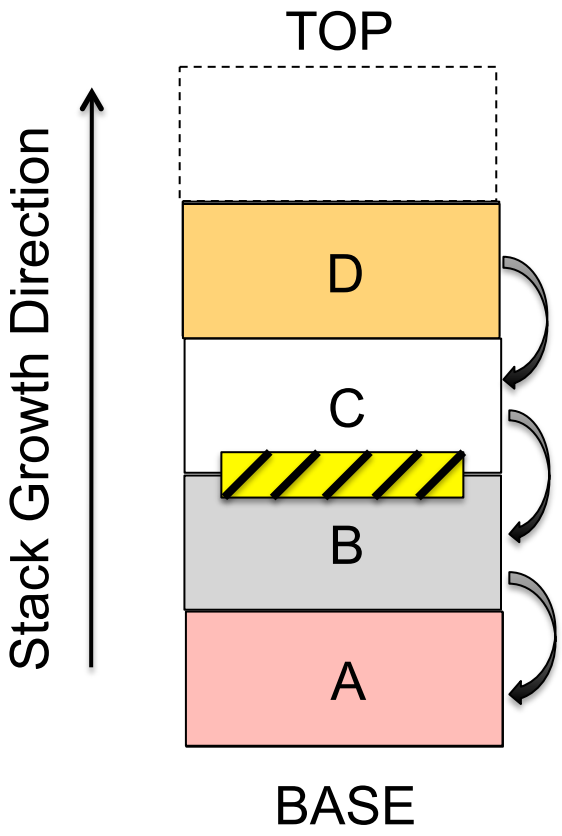
trampoline method

Hijacked Frame Pointer	Hijacked Return Address
Frame C	Method C

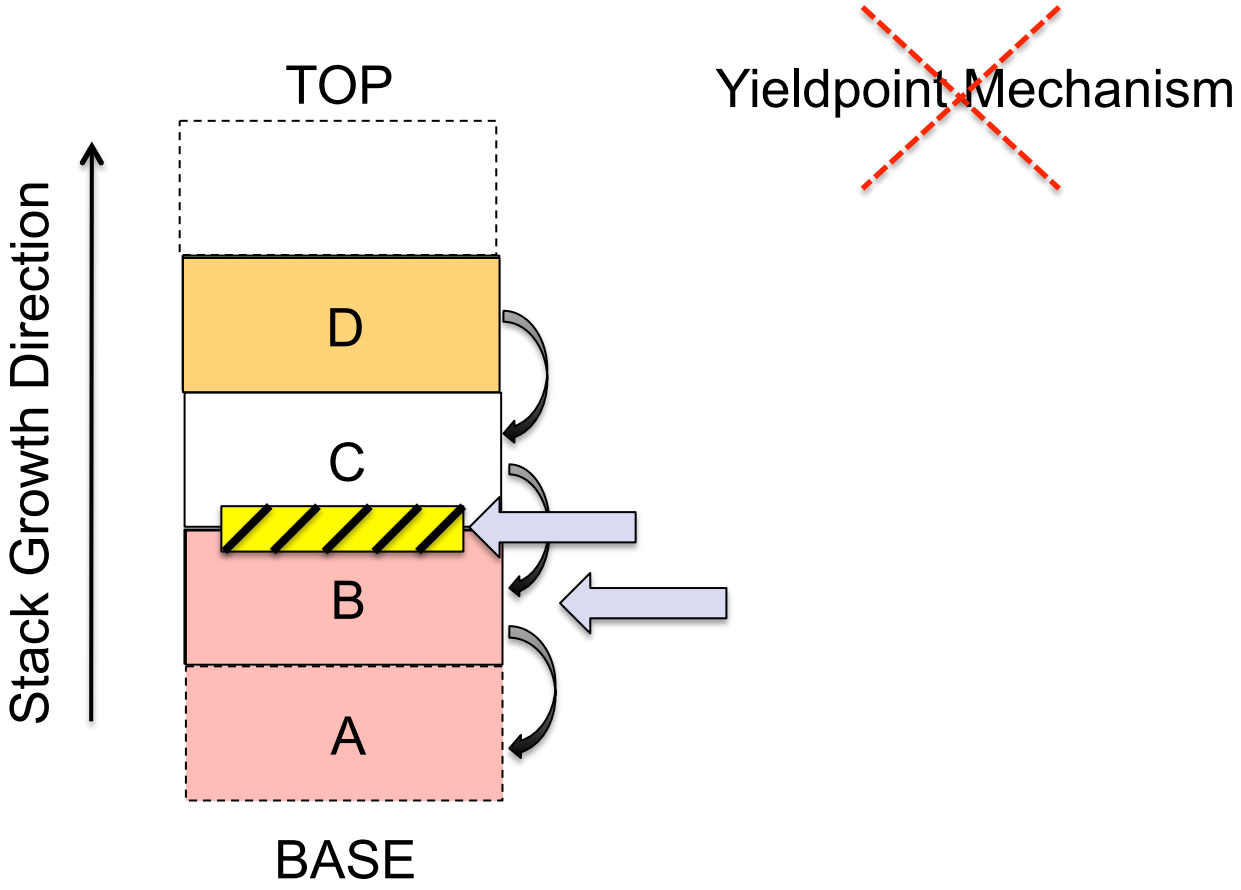
Thief Installs Return Barrier



Victim Moves The Return Barrier

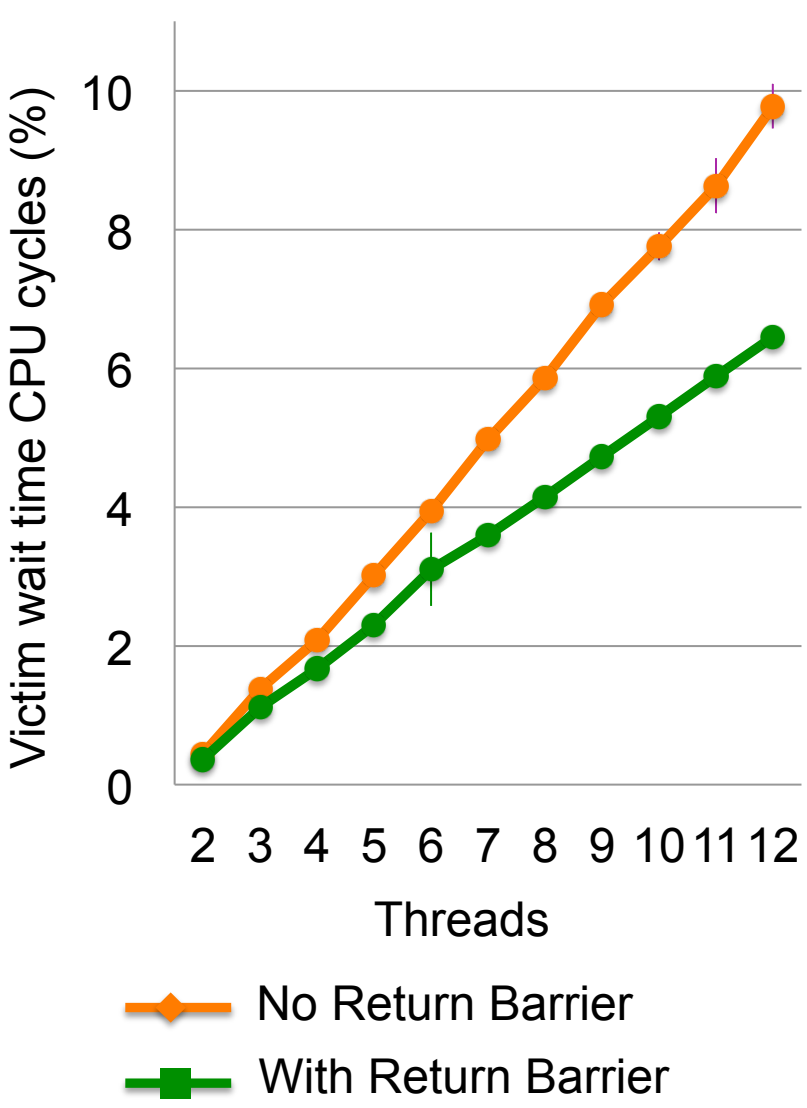


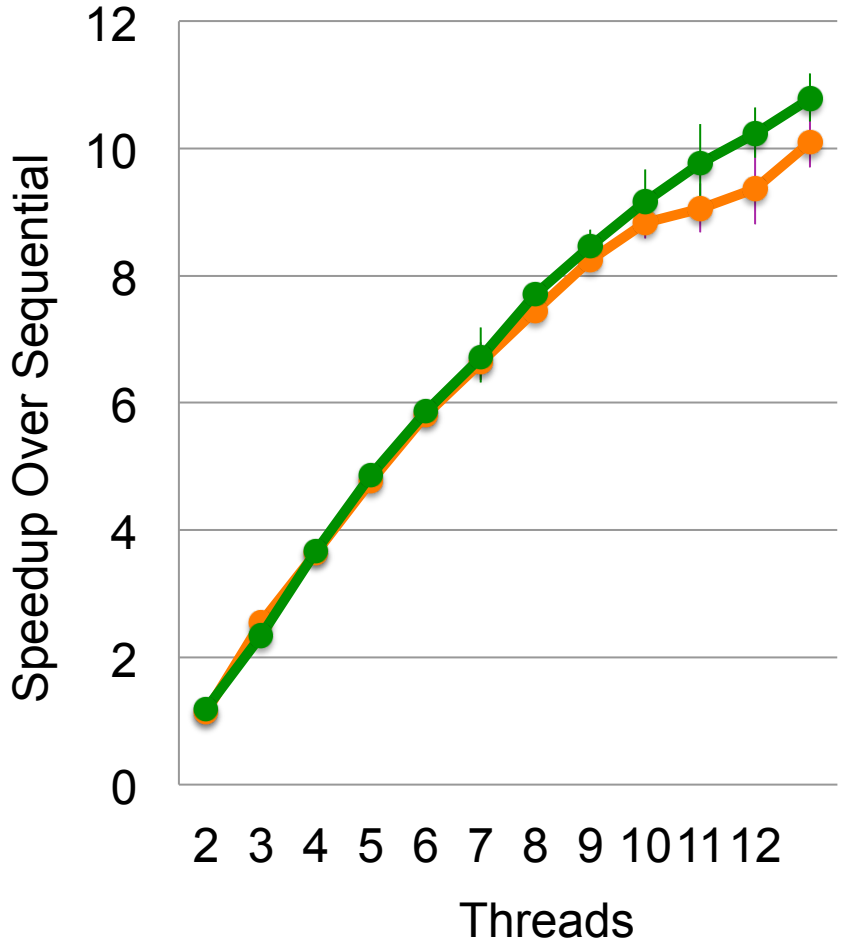
Robbing A Victim With Return Barrier



Performance Evaluation

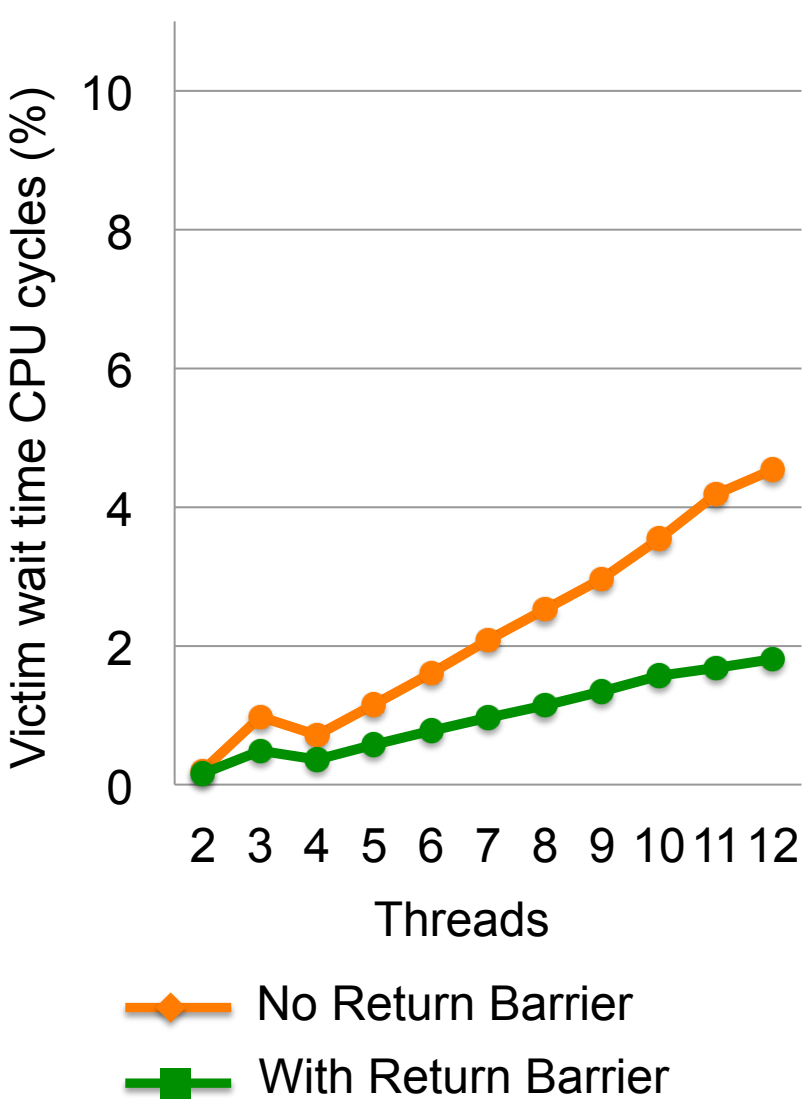
Evaluation

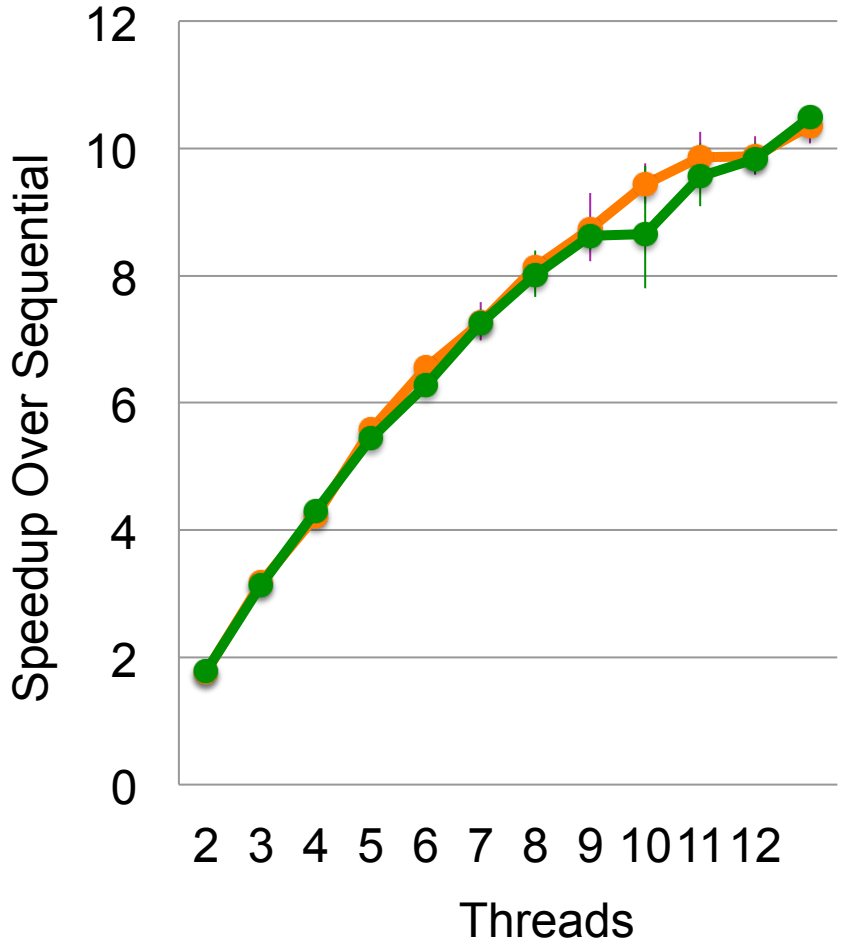




Jacobi

Evaluation





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Summary

- Steal overhead dominated by steal rate
- Two pronged attack
  - Reduce the cost of each steal
    - Return barriers
  - Reduce total number of steals
    - Steal more than one
- No change in speedup

Future Work

- Steal overhead dominated by steal rate
- Two pronged attack
  - Reduce the cost of each steal
    - Return barriers
  - Reduce total number of steals
    - Steal more than one
- No change in speedup ?
- Merge both the techniques