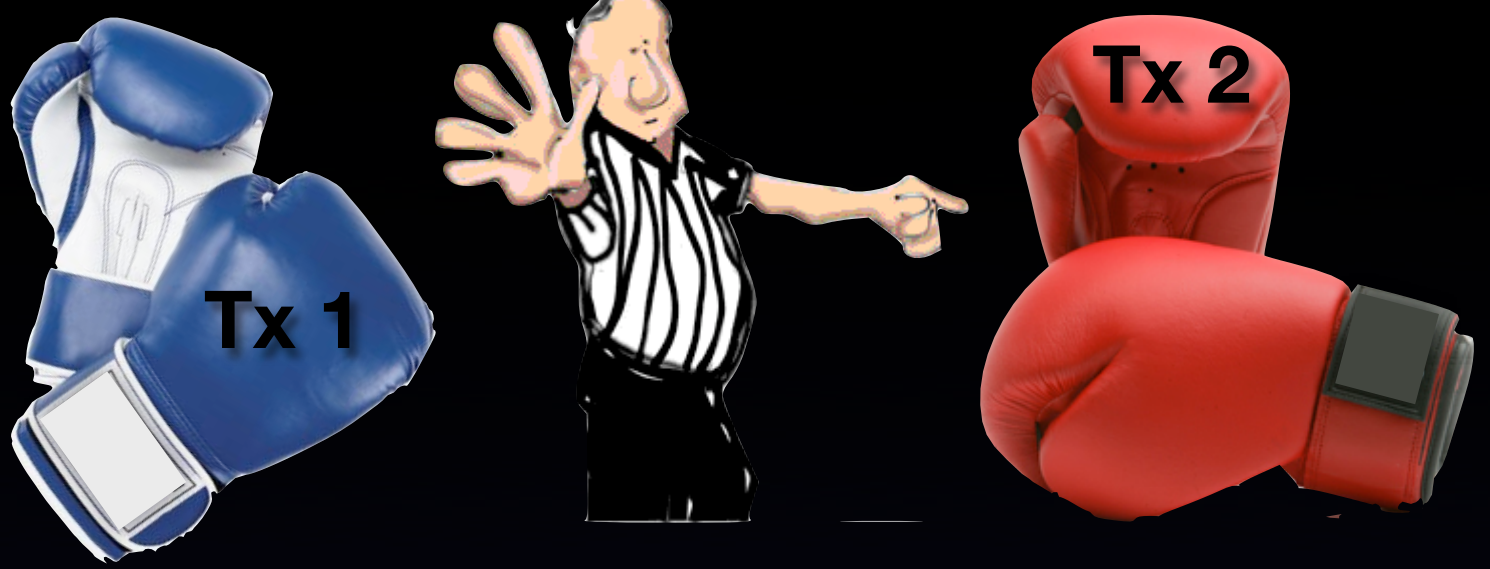

Refereeing Conflicts in Hardware Transactional Memory

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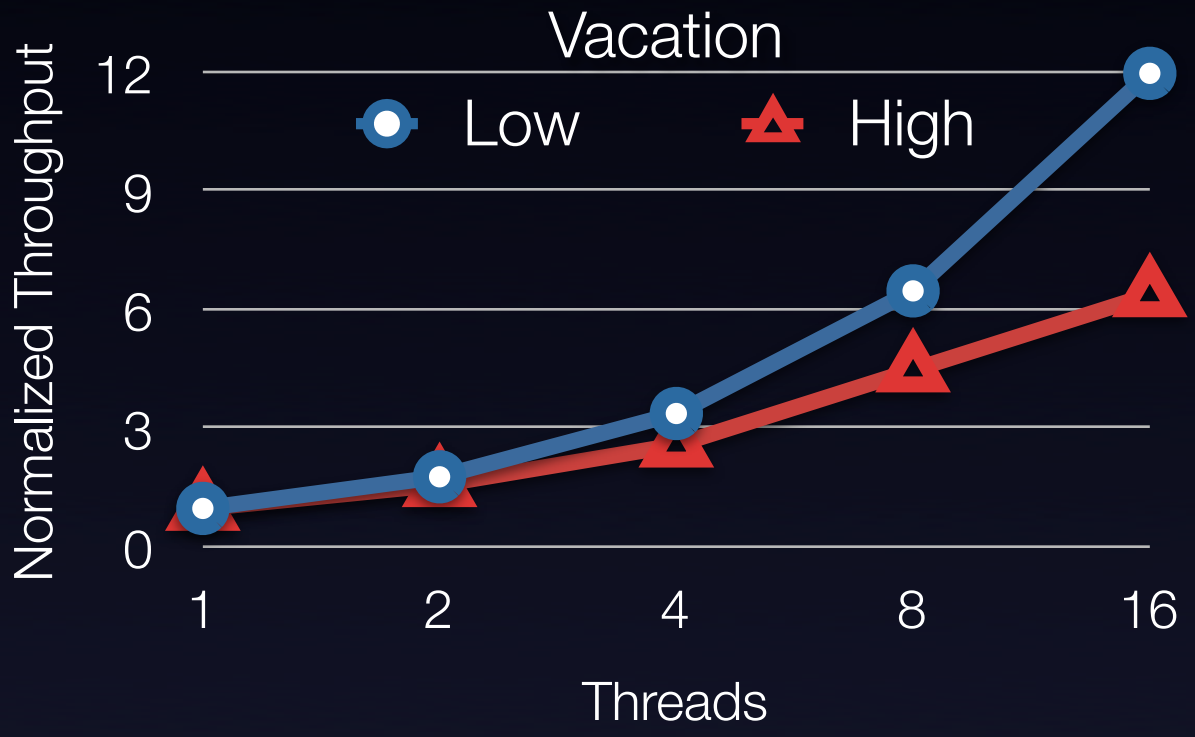
Conflicts affect performance

Conflict: concurrent accesses to the same location from two different transactions where at least one is a write

- In the absence of conflicts, Hardware TM provides
  - low latency and high scalability
- With conflicts, performance can degrade significantly



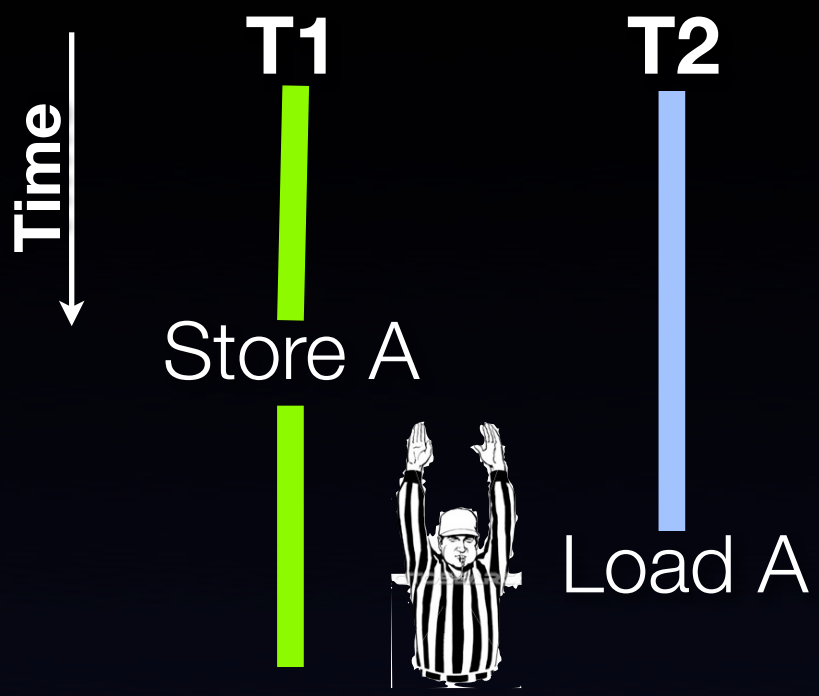
Conflicts can be common

Application	txs w/ conflicts
Bayes	85%
Delaunay	85%
Intruder	90%
Kmeans	15%
Vacation	73%
STMBench7	68%

- We anticipate that as TM becomes popular
  - large and long transactions will become common
  - new intricate sharing patterns will introduce conflicts

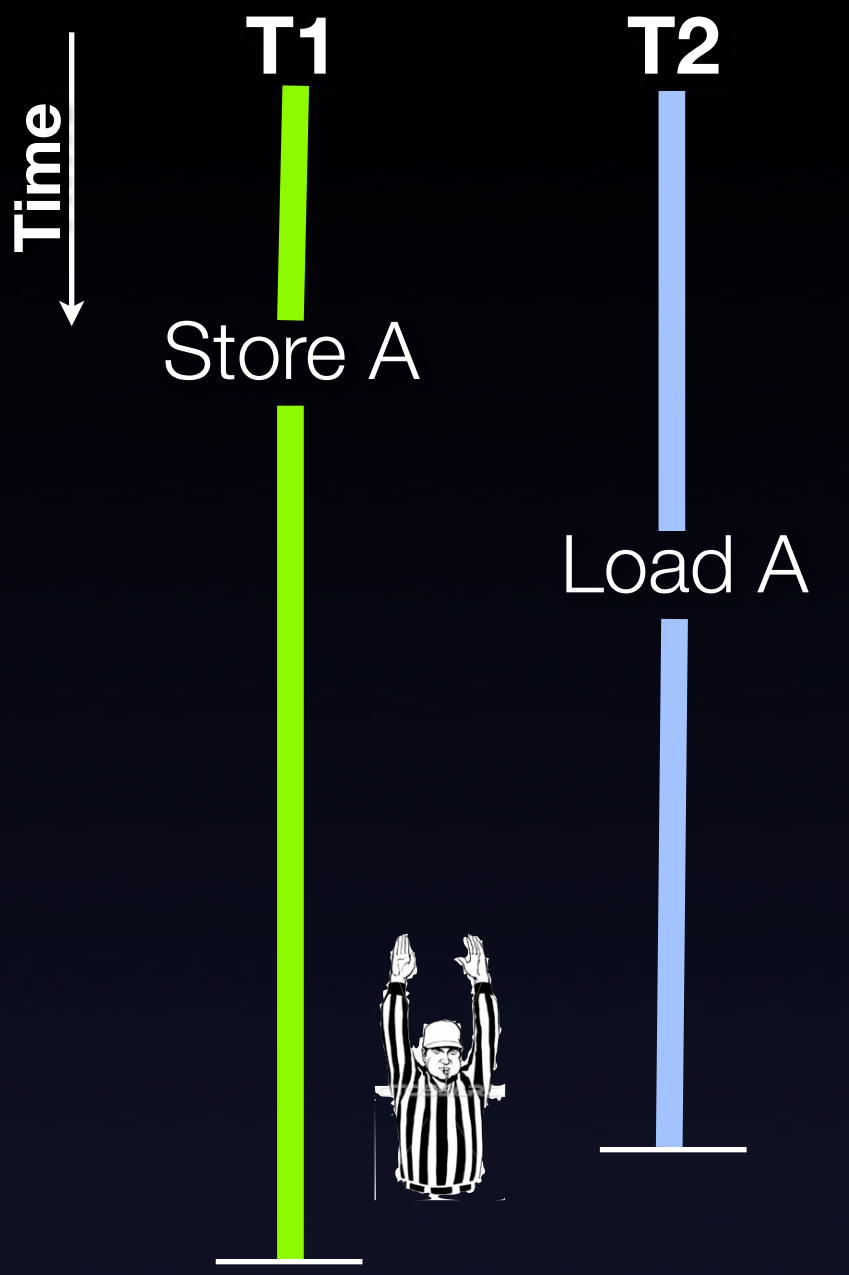
Conflict Management Primer

Conflict Management Primer



- Conflict Type
  - what type of accesses ?
  - read-write, write-read, write-write
- Conflict Detection
  - when to resolve ?
  - Eager (at access), Lazy (at commit)

Conflict Management Primer



- Conflict Type
  - what type of accesses ?
  - read-write, write-read, write-write
- Conflict Detection
  - when to resolve ?
  - Eager (at access), Lazy (at commit)
- Contention Management
  - How to choose loser ?
  - priority, timestamp, etc.
- Action
  - What action to take ?
  - stall, abort self, abort other etc.

Our Contributions

- Comprehensive study of policy in HTMs
  - conflict detection and conflict management interplay
  - quantify effect on application performance
- Is Lazy better than Eager ?
  - can we do better ?
- How does the contention manager help ?
  - is it important ?

Experimental Platform

- FlexTM [ISCA'08]
  - allows conflict detection to be controlled in software
  - permits pluggable software contention managers
- TM Hardware: 16 core CMP, Private L1s, Shared L2
  - signatures for conflict detection
  - private L1s for speculative buffering
    - overflow handled by hardware controller
  - transaction commit protocol
    - allows parallel transaction commits
    - no centralized arbiter

Workloads

- TM Workloads
  - STAMP (Stanford)
  - STMBench7 database (EPFL)
  - Web-cache and Graph stress tests (U.Rochester)
- TM Policies
  - Conflict detection: Lazy, Eager, and Mixed
  - Contention Management: w/ and w/o stalling, timestamps, access sets, aborts

Is Lazy better than Eager ?

Can we do better ? : Mixed

Is the contention manager important ?

Conflict Detection

- Eager (manages conflict at access time)

Goal: If transactions can't commit together, save work

  - to progress, transactions abort enemies
  - transactions can stall and try to elide the conflict

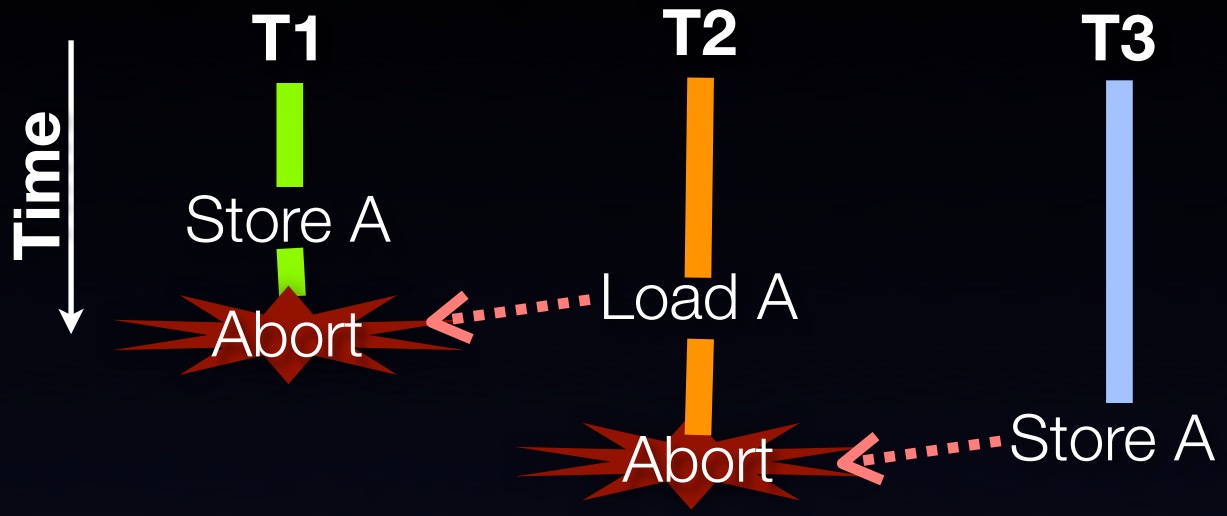
- Lazy (manages conflict at commit)

Goal: postpone detection hoping conflict disappears

  - to commit, writers abort enemies
  - writers can stall to elide reader conflicts

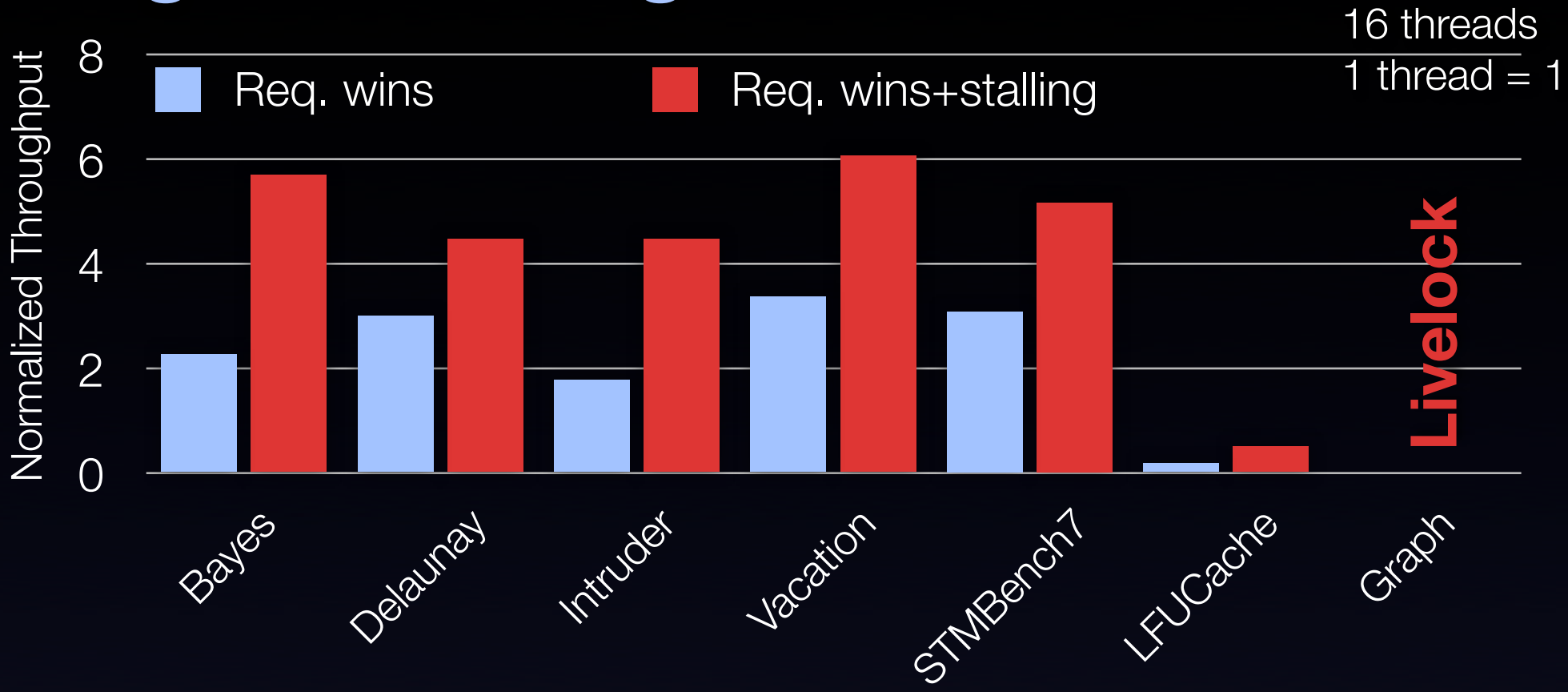
Eager's Performance Limitations

- Futile aborts waste work and hinder progress
  - stalling access may help avoid the conflict



- Inability to overlap conflicting transactions

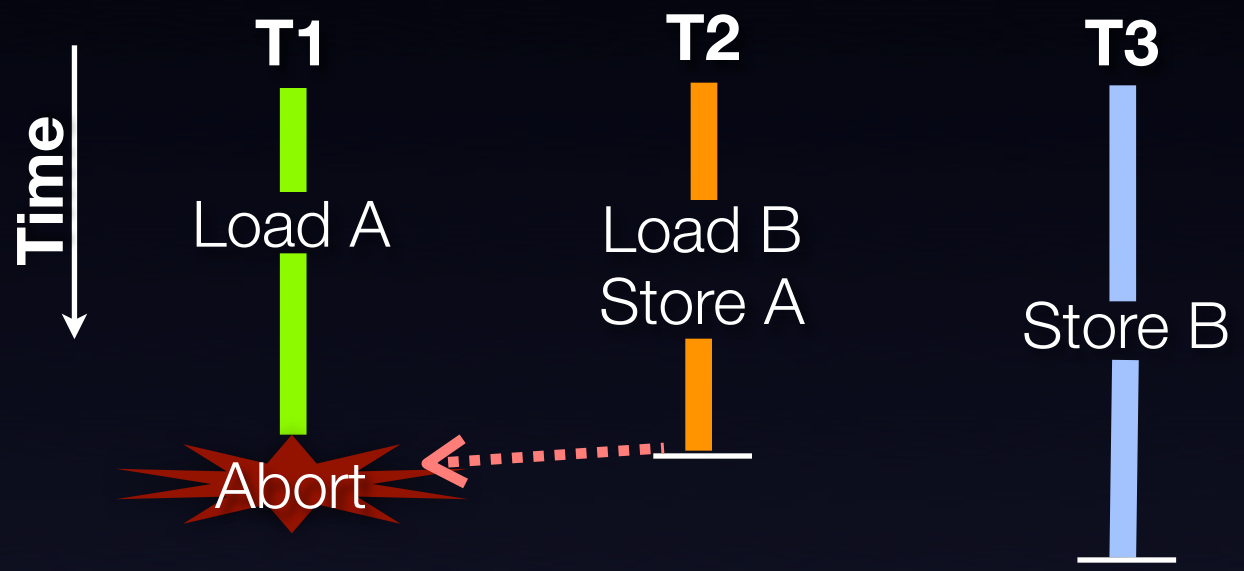
Eager w/ Stalling



- Can reduce occurrence of futile aborts (livelock ?)
  - reduces wasted work due to aborts
- Is it good enough ?
  - cannot exploit concurrency in application

Lazy's Benefits (1/2)
Small Contention Window

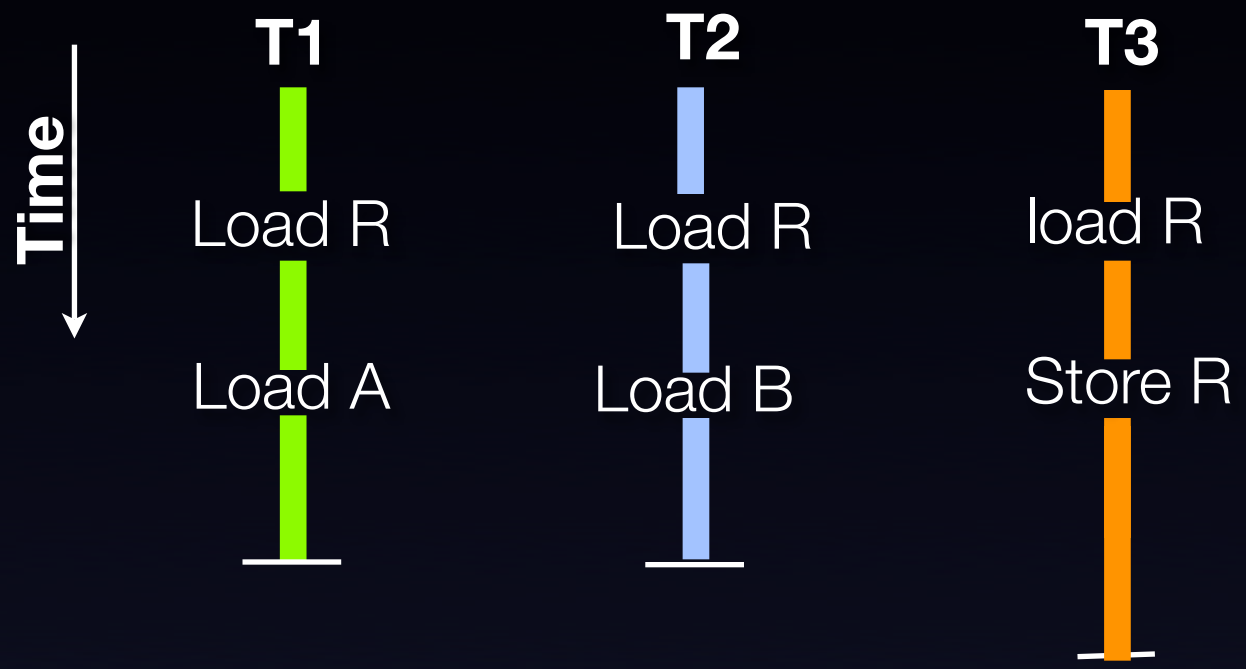
- Conflicts checked only at commit
  - reduces likelihood of conflict winner being aborted
  - can reduce the occurrence of futile aborts
  - prioritizing the commiter avoids livelock in practice



Also observed in Software TMs by Spear et al. [PPOPP'09]

Lazy's Benefits (2/2): More commits

- Even transactions with overlapping accesses
  - can execute concurrently
  - can commit concurrently



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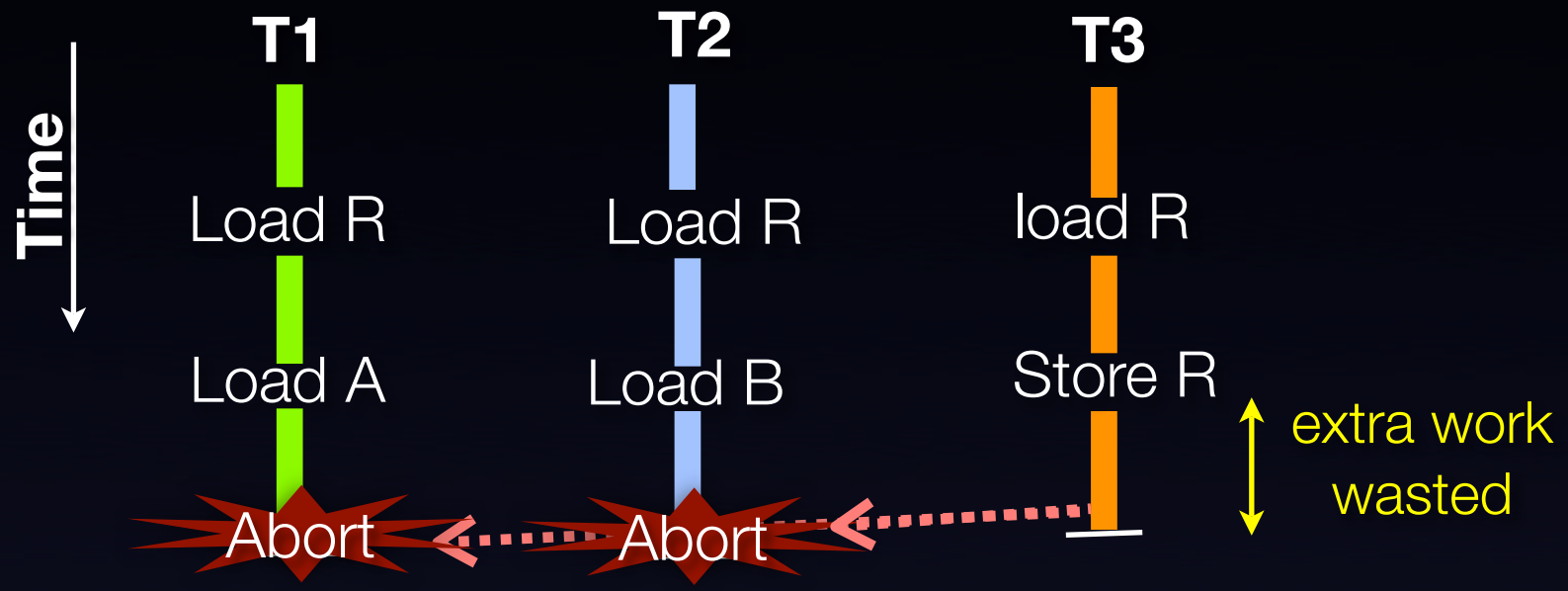
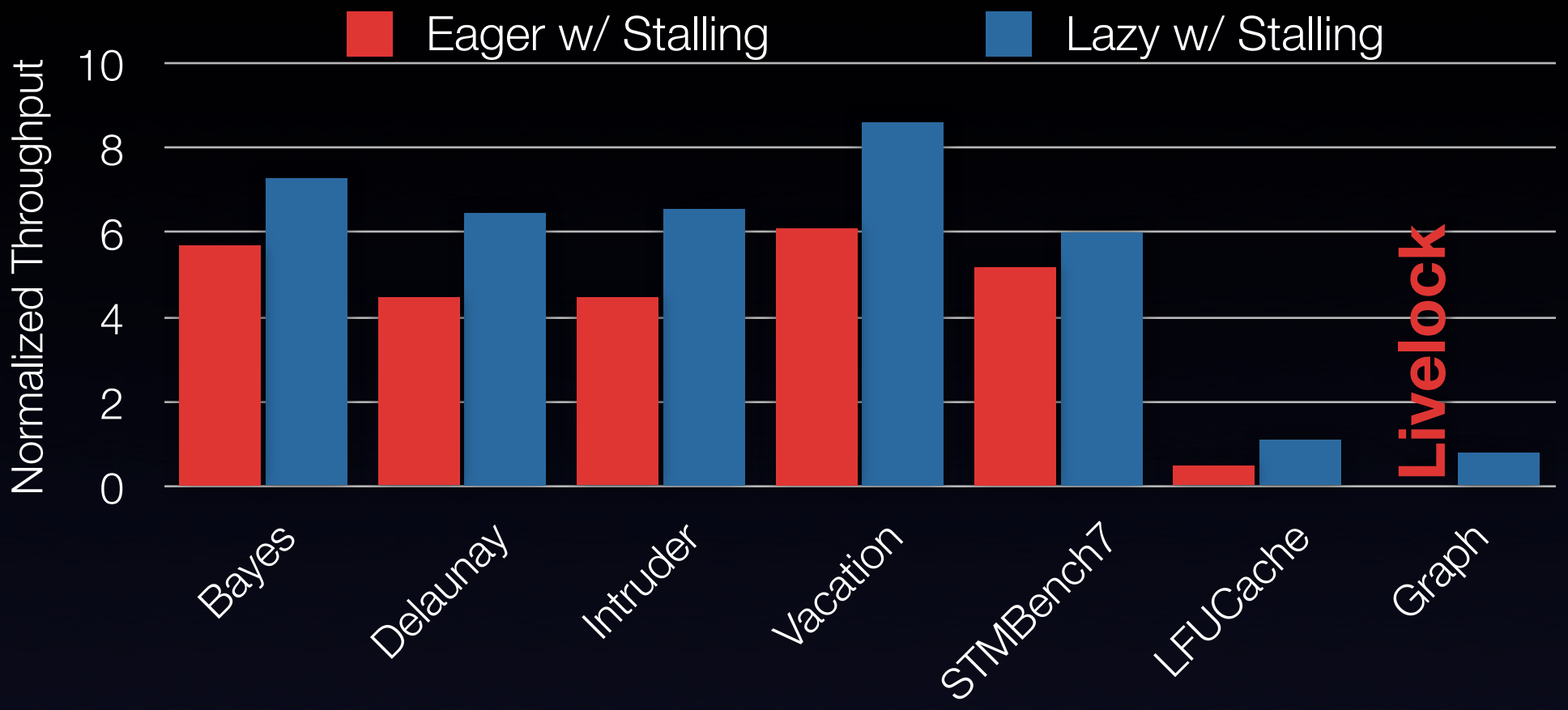


- Caveat: Can waste more work than Eager
  - postponing conflict detection was futile (T2 commits first)
  - may be solved by stalling commit

Lazy performs better than Eager



- Lazy improves performance over Eager (Avg. 40% , Max. 2x)
- Ensures progress in non-scalable workloads
- Lazy may lose performance due to wasted work (STMBench7)
  - postponing dueling read-write conflicts is futile

Is Lazy better than Eager ?

Can we do better ? : Mixed

Is the contention manager important ?

Mixed Conflict Detection

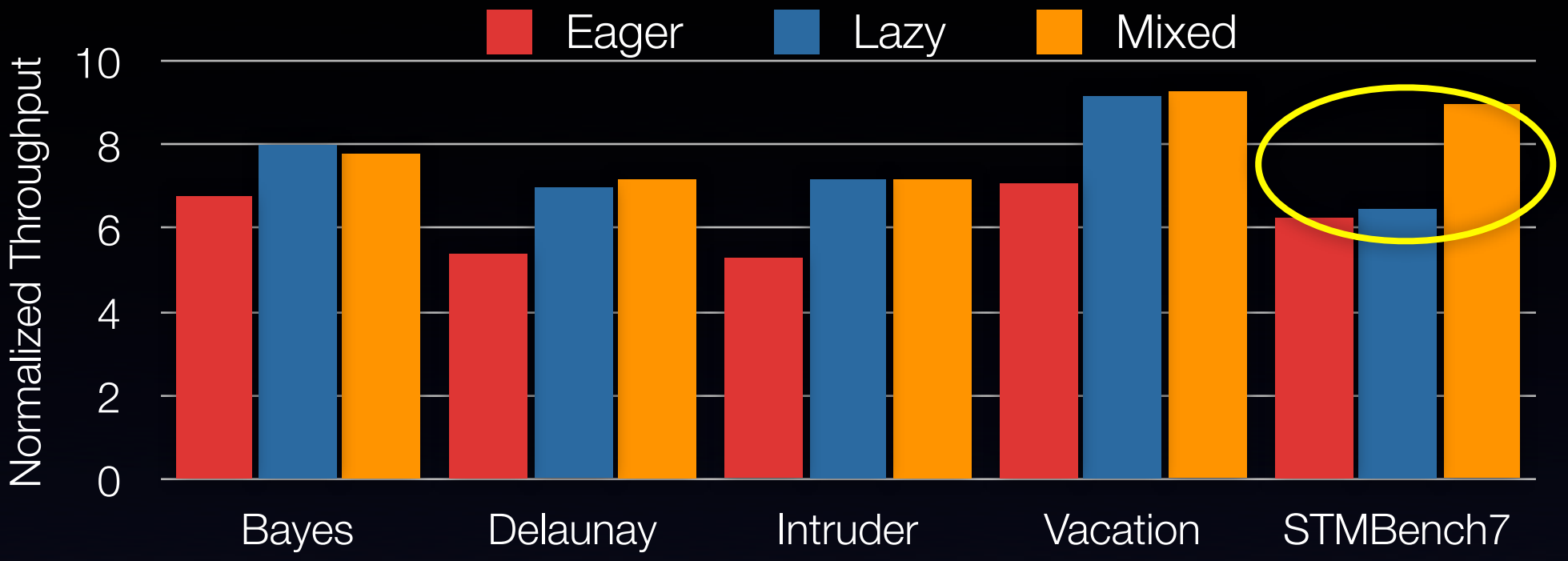
Tunes detection based on conflict type

- Detects Write-Write conflicts eagerly
  - may save wasted work, if winner commits
- Detects Read-Write and Write-Read conflicts lazily
  - allows useful concurrency

Added Benefit: complexity-effective implementation

- needs to support only single-writer and/or multiple-readers
- at most two versions of data, speculative and non-speculative

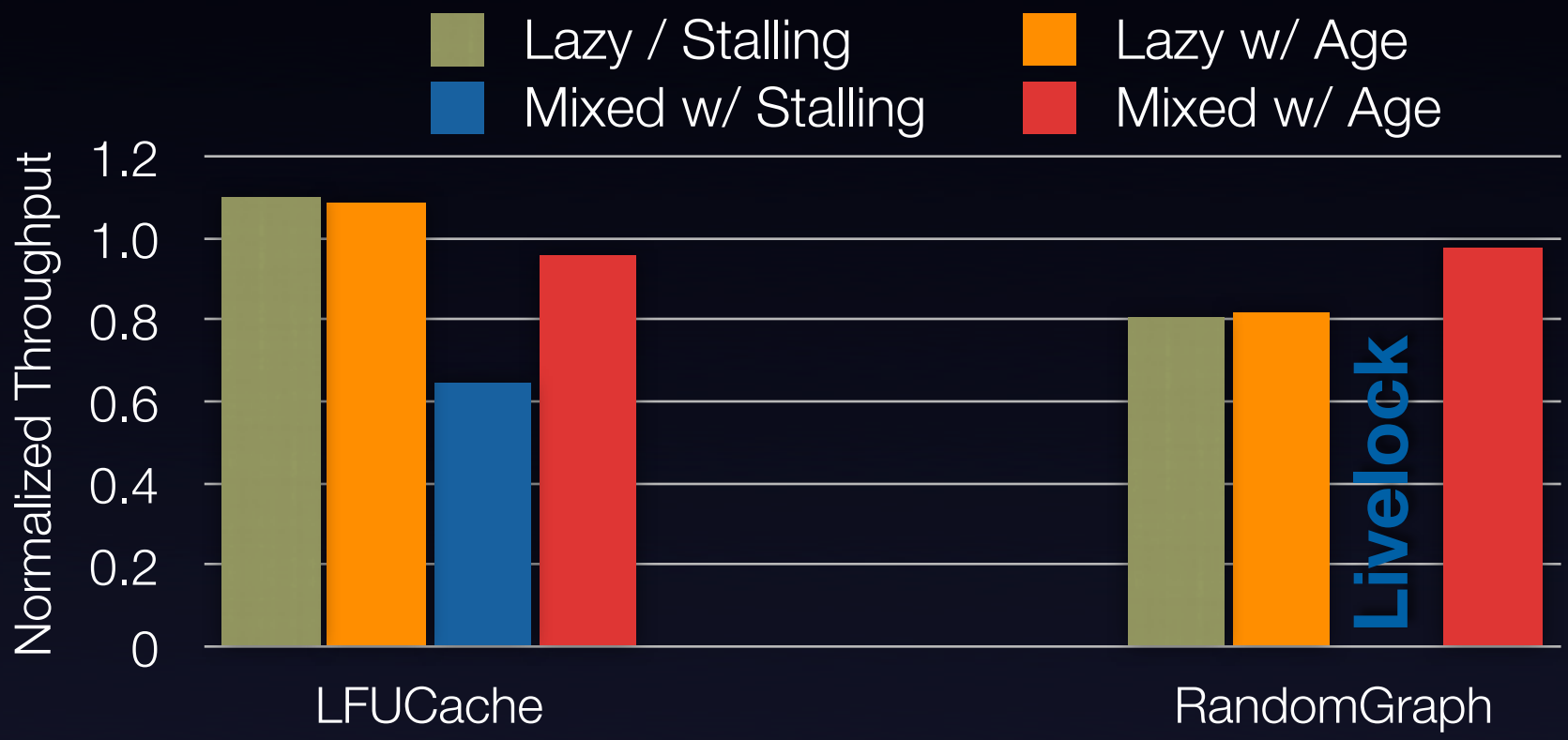
Mixed



- Mixed improves performance by ~40% in STMBench7
  - saves wasted work on conflicts between long and short writers
  - exploits reader-writer concurrency like Lazy

Mixed's Problem

- Mixed can suffer from weaker progress conditions than Lazy
  - inherited from Eager write-write detection
  - can be solved with appropriate contention managers



Is Lazy better than Eager ?

Can we do better ? : Mixed

Is the contention manager important ?

Contention Management

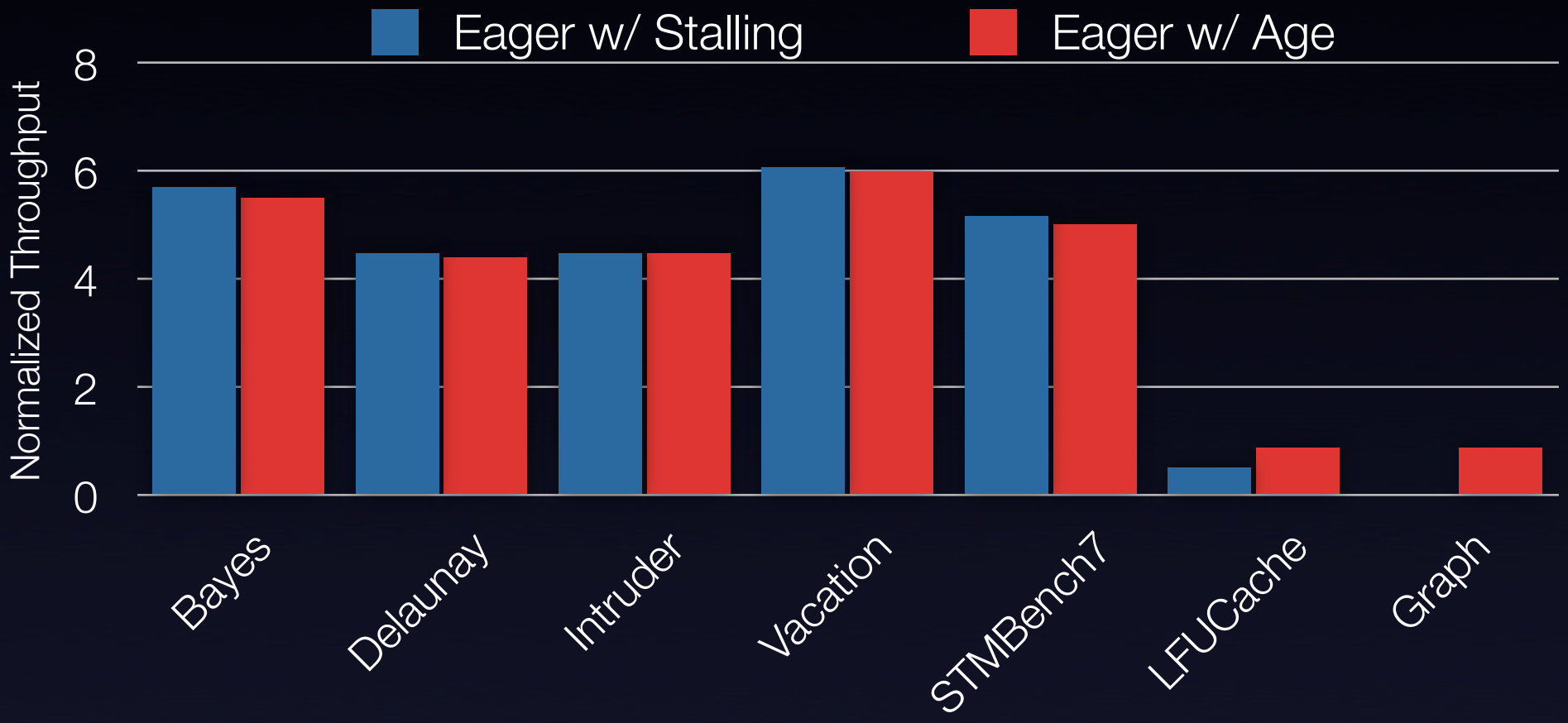
- Is a priority scheme that chooses winner in a conflict
  - can help progress by prioritizing starving transactions
  - simplified in Hardware TMs since transactions are visible
- Priority arbitration (our implementation)
  - always stall before making a decision
  - higher priority transaction always make's progress
  - lower priority transaction can stall or abort itself
  - priority changed on various dynamic events, hardware performance counters to reduce overheads

Priority Schemes

- Age (similar to Greedy [Guerraroui, PODC'05])
  - global timestamp acquired by transaction at begin, retained on aborts, discarded on commits
  - ensures progress of the oldest transaction
- Aborts
  - local abort counter
  - tries to ensure progress of starving transaction
  - theoretically, transaction could always get beaten
- Size (similar to Polka [Scherer, PODC'05])
  - local read set counter, retained on aborts (like Karma)
  - prioritizes transactions which have made progress

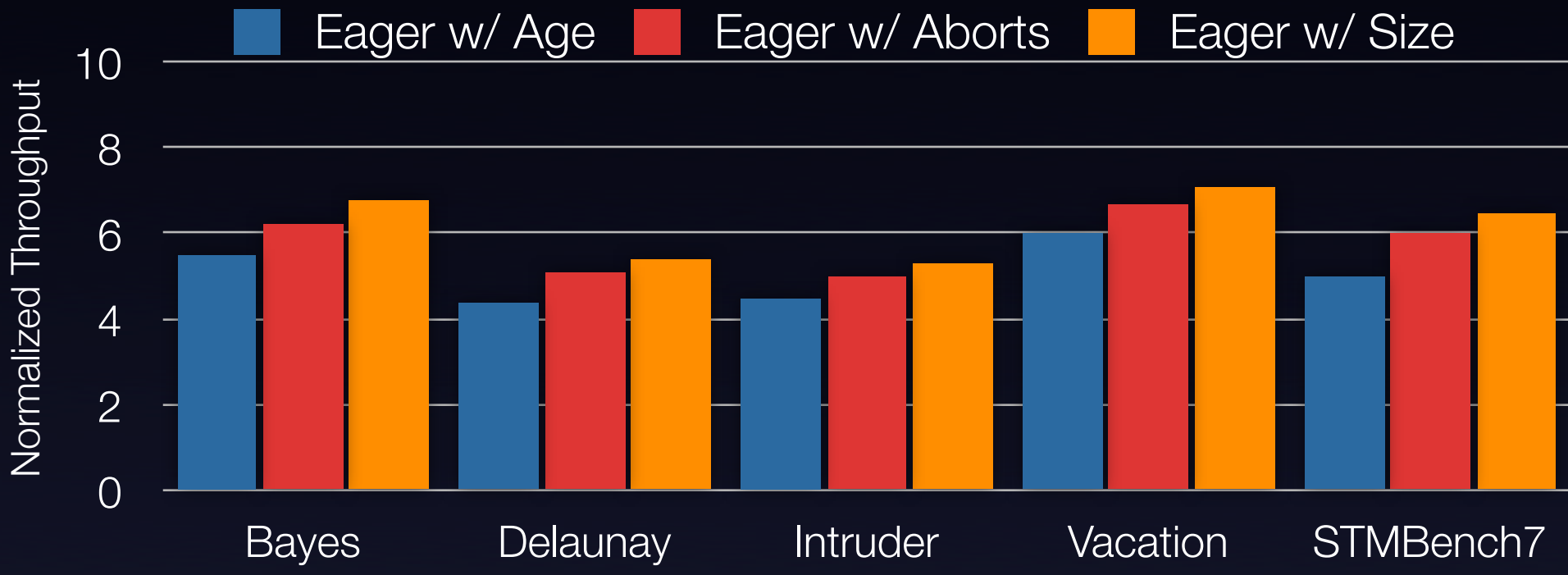
Centralized Priority (Age)

- Implemented in software
- Timestamp suffers from scalability issues
- Hinders concurrency in Eager by convoying readers behind a writer (performance drops ~10%)



Distributed Priority (Size and Aborts)

- Cheaper to implement, no centralized mechanisms
- Weaker progress guarantees
  - no provable starvation or livelock freedom
- Size is highest performing manager
  - maximizes parallelism ensuring reader sharers make progress
  - ensures writers don't starve in practice



Summary

Policy important in HTMs, tradeoffs similar to STMs

- Lazy performs better than Eager (Avg. 40% increase)
  - narrows contention window and ensures progress
  - exploits reader-writer parallelism to attain more throughput
- Mixed is a good tradeoff between desire to exploit concurrency and implementation complexity
- Contention manager
  - less important in Lazy
  - can help with progress in Eager and Mixed

Summary

Look at paper for details on
1) conflict patterns in our TM workloads
2) implementation tradeoff discussion

Acknowledgments
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http://www.cs.rochester.edu/research/synchronization