Tackling The Challenges of Big Data
Big Data Systems

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Tackling The Challenges of Big Data
Big Data Systems
Multicore Scalability
Introduction

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Goal: Scalability

- **With n cores, do n times as much work**
- **One way to think about multi-core performance**
- **Limit to scalability: serial sections**

- **Parallel time: P**
- **Serial time: S**

Sharing vs. Partitioning

- **One approach to multi-core systems: partitioning**
- **Advantage: avoids sharing between partitions**
- **Disadvantage: may be hard to choose a partitioning**
- **Disadvantage: may require load-balancing**

Outline

- **Hardware: cache coherence**
- **Cache coherence and scalability**
  - Example: implementing a lock
  - Avoiding performance collapse
- **Improving scalability by avoiding locks**
  - Example: lock-free reads in a stack
  - Generalizing lock-free reads with RCU

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Tackling The Challenges of Big Data

Module: Big Data Systems

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Module: Big Data Systems

Topic: Multicore Scalability

Cache coherence

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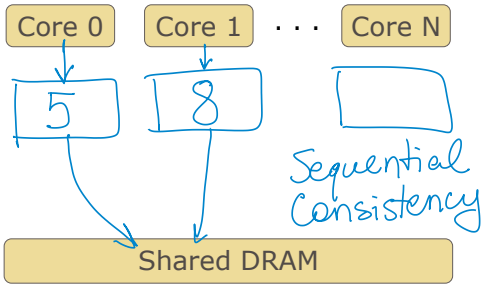
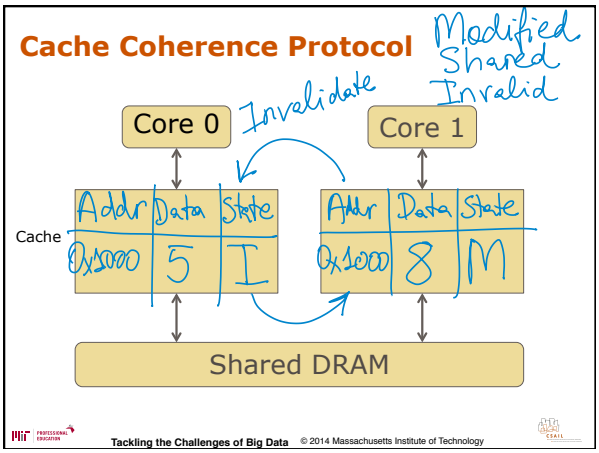
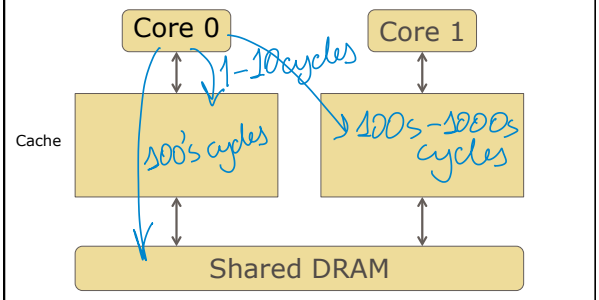
Multi-Core Hardware



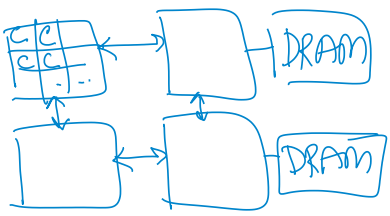
Cache Coherence Protocol



Performance With Cache Coherence



Multi-core hardware in practice



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Cache coherence

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Implementing a lock

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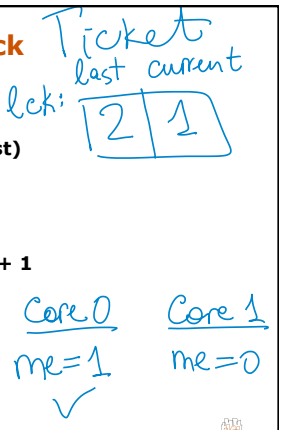
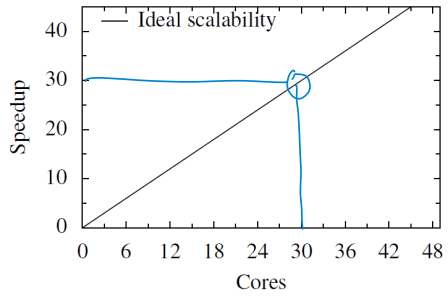
Implementing A Lock

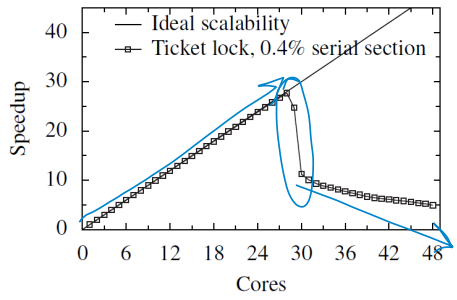
- **acquire(lck):**
  me = atomic_inc(&lck.last)
  while lck.current != me:
  pass /* spin */
- **release(lck):**
  lck.current = lck.current + 1



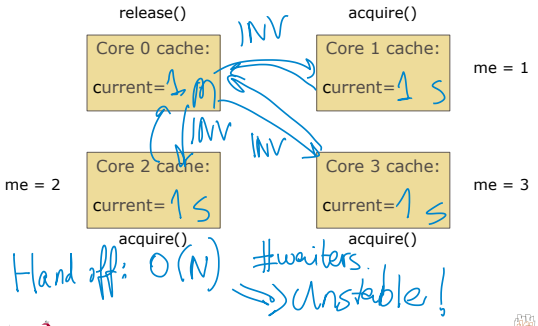
Performance Of Ticket Locks



Performance Of Ticket Locks



Why Do Ticket Locks Collapse?



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Implementing a lock

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Non-collapsing locks

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Avoiding Lock Collapse

- **What's the ideal performance for a contended lock?**
  - Constant hand-off time: no collapse
  - Total performance at best remains flat: still have a serial section, so no scalability

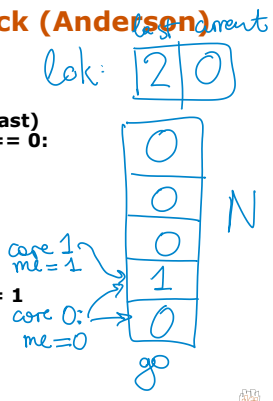
Non-Collapsing Lock (Anderson)

- **acquire(lck):**

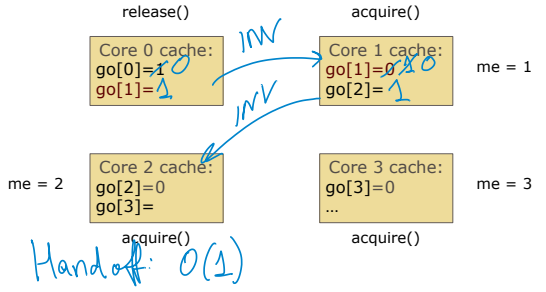
```
me = atomic_inc(&lck.last)
while lck.go[me % N] == 0:
  pass  /* spin */
lck.current = me
```

- **release(lck):**

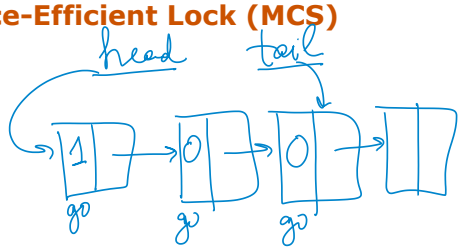
```
me = lck.current
lck.go[me % N] = 0
lck.go[(me + 1) % N] = 1
```



Non-Collapsing Lock: Cache Coherence



Space-Efficient Lock (MCS)



Non-Collapsing Locks

- **Helps avoid collapse under contention**
- **Does not improve scalability: serial section remains**
- **To improve scalability, eliminate contention**
  - Fine-grained locks
  - Avoid locks altogether

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Non-collapsing locks

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Lock-free synchronization

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Example Data Structure: Stack

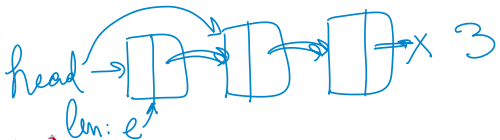
- length():

```
e = head
while e != NULL:
  i = i + 1
  e = e.next

return i
```

- pop():

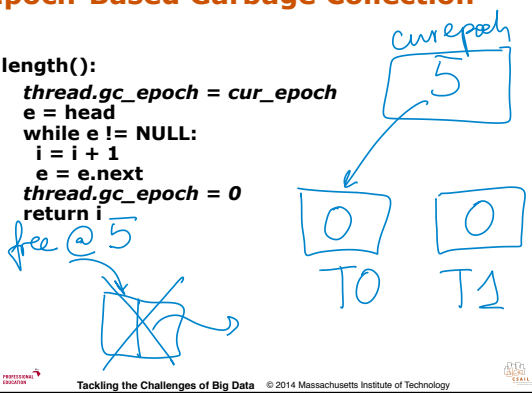
```
e = head
head = e.next
free(e)
```



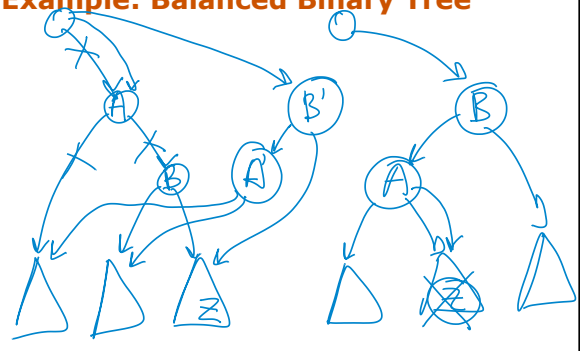
Epoch-Based Garbage Collection

- length():

```
thread.gc_epoch = cur_epoch
e = head
while e != NULL:
  i = i + 1
  e = e.next
thread.gc_epoch = 0
return i
```



Example: Balanced Binary Tree



RCU Enables Scalable Readers

- **Three rules:**
  - Lock-free readers
  - Single pointer update in writers (update a copy)
  - Delayed free
- **Readers do not modify any shared cache lines**
- **Concurrent readers can execute in private caches**
  - No cache-coherence traffic!
- **Good scalability for read-heavy workloads**

Conclusion: Multicore Scalability

- **Cache-coherence protocols in hardware**
- **Lock can collapse due to sharing one cache line**
- **Multiple cache lines help avoid collapse due to a lock**
- **RCU: powerful technique for read-heavy workloads**

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