Driving Extreme Concurrency with Intel® Transactional Synchronization Extensions
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Concurrency Challenge
Concurrency Challenge

• More and more cores are added into a single system
• more cores = better performance?
  - multi-threaded code is difficult to write and difficult to test
  - Even multi-threaded enterprise applications do not *automatically* run faster on multi-core servers

If software not optimized, more cores lead to worse performance
Difficulty of Software Development

- Identify concurrency (algorithmic, manual...)
- Manage concurrency (locks, ...)

Correctness ↔ Performance

Hard to Write Fast and Correct Multi-Threaded Code
**Need for Synchronization**

Sophia wants $50 from $A$
- $A == $100$, $A$ set to $50$

Peter wants $60 from $A$
- $A == $100$, $A$ set to $40$

**A should be -10**

Sophia wants $50 from $A$
- Sophia locks table
- $A == $100$, $A$ set to $50$

Peter wants $60 from $A$
- Peter waits till lock release
- $A == $50$, Insufficient funds

*Peter and Sophia saw $A == $100$. Locks prevent such data races*
Lock Granularity Optimization

Coarse grain locking (lock per table)

Sophia withdraws $20 from A
• Sophia locks table
Peter wants $30 from B
• Waits for Sophia to free table

Fine grain locking (lock per element)

Sophia withdraws $20 from A
• Sophia locks A
Peter wants $30 from B
• Peter locks B

Such Tuning is Time Consuming and Error Prone
Complexity of Fine Grain Locking

Sophia transfers $20 from A to B
  • Sophia locks A and locks B
Performs transfer
  • Sophia unlocks A and unlocks B

Sophia transfers $20 from A to B
  • Locks A
Peter transfers $50 from B to A
  • Locks B
  • Cannot lock A

Expensive and Difficult to Debug Millions of Lines of Code
Opportunity with TSX
What We Really Want...

Developer uses coarse grain lock
Hardware elides the lock to expose concurrency in program
• Sophia and Peter don’t wait
• Hardware automatically detects real data conflicts

Lock Elision: Fine Grain Behavior at Coarse Grain Effort
TSX Benefit: High Concurrency

- **Exposes Concurrency & Eliminates Unnecessary Communication**

  - Lock transfer latencies
  - Serialized execution

  - Concurrent execution
  - No lock transfer latencies

  - Reducing lock instruction latencies insufficient
Fine-grain locking is not silver bullet
- A real-world application with fine grain lock on a 8-socket machine: significant performance regression was fixed with lock affinity

For large machines, lock affinity more important than lock granularity

Removes Ping-Pong effect on locks in large machines
Let The CPU Handle the Locks

Hardware does the work of figuring out concurrency
   • Fine grain performance at coarse grain effort

**Intel® TSX ‡ : Instruction set extensions for IA**
   • Transactionally execute lock-protected critical sections
   • Execute without acquiring lock → expose hidden concurrency
   • Hardware manages transactional updates – All or None

**Intel® Architecture Instruction Set Extensions Programming Reference**
   • https://software.intel.com/sites/default/files/m/9/2/3/41604

‡ Intel® Transactional Synchronization Extensions (Intel® TSX), available on next generation Intel® microarchitecture (Haswell)
Summary
Intel® TSX Summary

• Improve existing synchronization and software scalability
• Reduce time-to-market for multi-threaded software
• Think about how Intel TSX can help your customers and other novel usages
Thank You