DMP

Deterministic Shared Memory Multiprocessing

University of Washington

ASPLOS 2009

Joe Devietti, Brandon Lucia, Luis Ceze, Mark Oskin

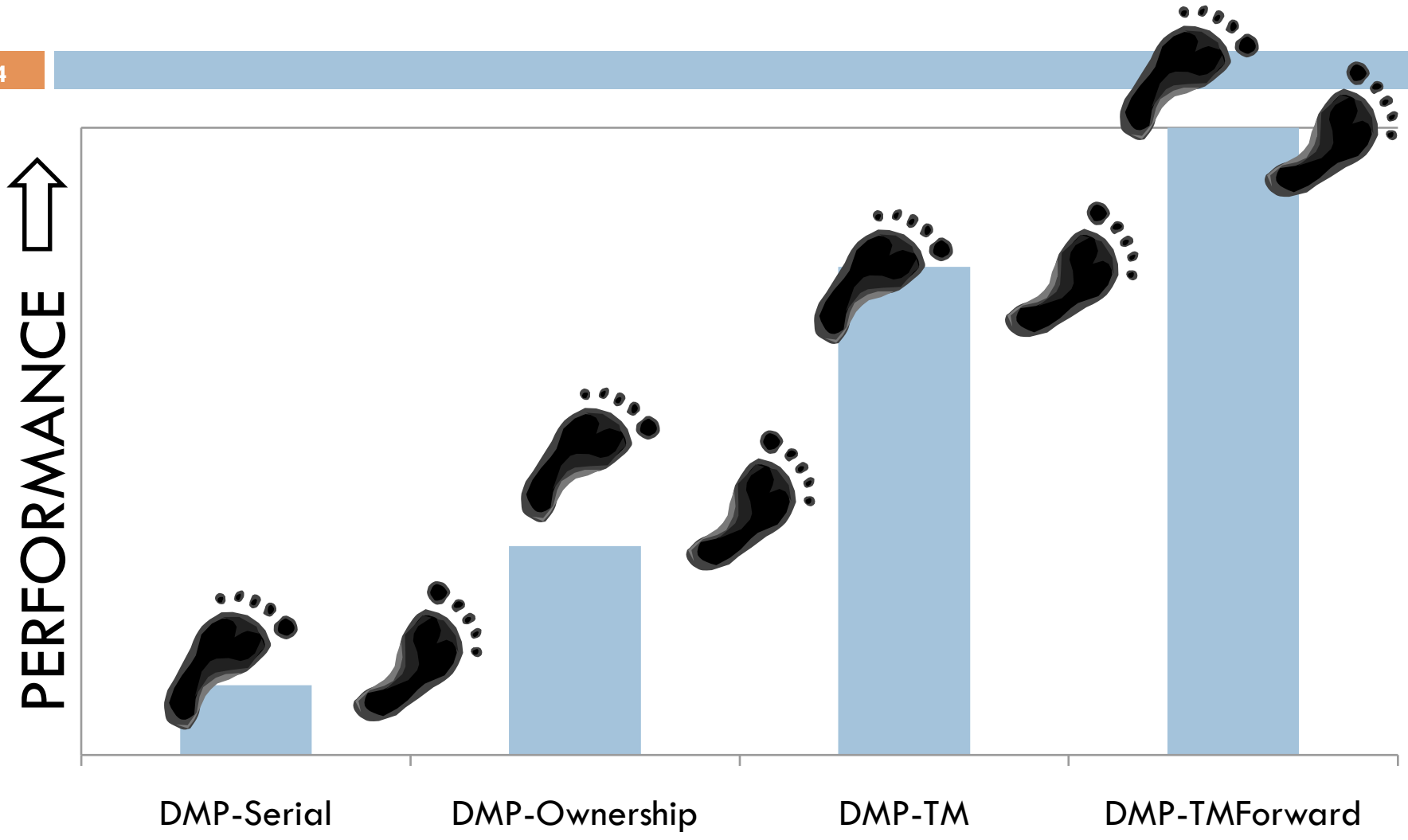
DMP Guarantees

- DMP provides execution-level determinism for arbitrary programs
- Compared to language-level determinism, programmer has no control over which deterministic program he gets
- DMP is a hardware proposal
  - Tom Bergan's CoreDet presentation tomorrow shows compiler version

The DMP Approach

- We only care about communicating instructions
- Deterministic serialization → same communication
  - …but what about performance?
- Recover parallelism from non-communicating insns

Talk Outline



DMP-Serial Example

Can we do better?

- Communicating insns cause cache line state transitions
- Break each quantum into communication-free **parallel prefix** and communicating **serial suffix**

DMP-Ownership

- Need to know when communication happens, to transition from parallel to serial mode
  - Leverage existing cache coherence protocol
  - When a line changes state, communication is (potentially) happening!
  - The **Memory Ownership Table (MOT)** tracks information about ownership
- State of MOT must evolve deterministically
  - Only allow updates during serial suffix

DMP-Ownership Example

DMP-TM: Recovering Parallelism with Speculation

- DMP-Ownership conservatively assumes that all cache line state transitions are communication
  - …but many transitions are not
- Use TM support to speculate that a quantum is not involved in communication
  - If communication happens, rollback + re-execute
  - **Commit quanta in-order** (need DT to commit)

DMP-TM Example

DMP-TM-Forward: Speculative Value Forwarding

- DMP-TM eliminates WAW and WAR dependencies
  - but cannot speculate past true (RAW) dependences
- Idea: speculatively forward values to "future" quanta
  - ordered transactions make it easy to decide *when* and *where* to forward
  - rollback if a quantum's speculatively read data is updated before the quantum commits

DMP-TM-Forward Example

Rollbacks in DMP-TM-Forward

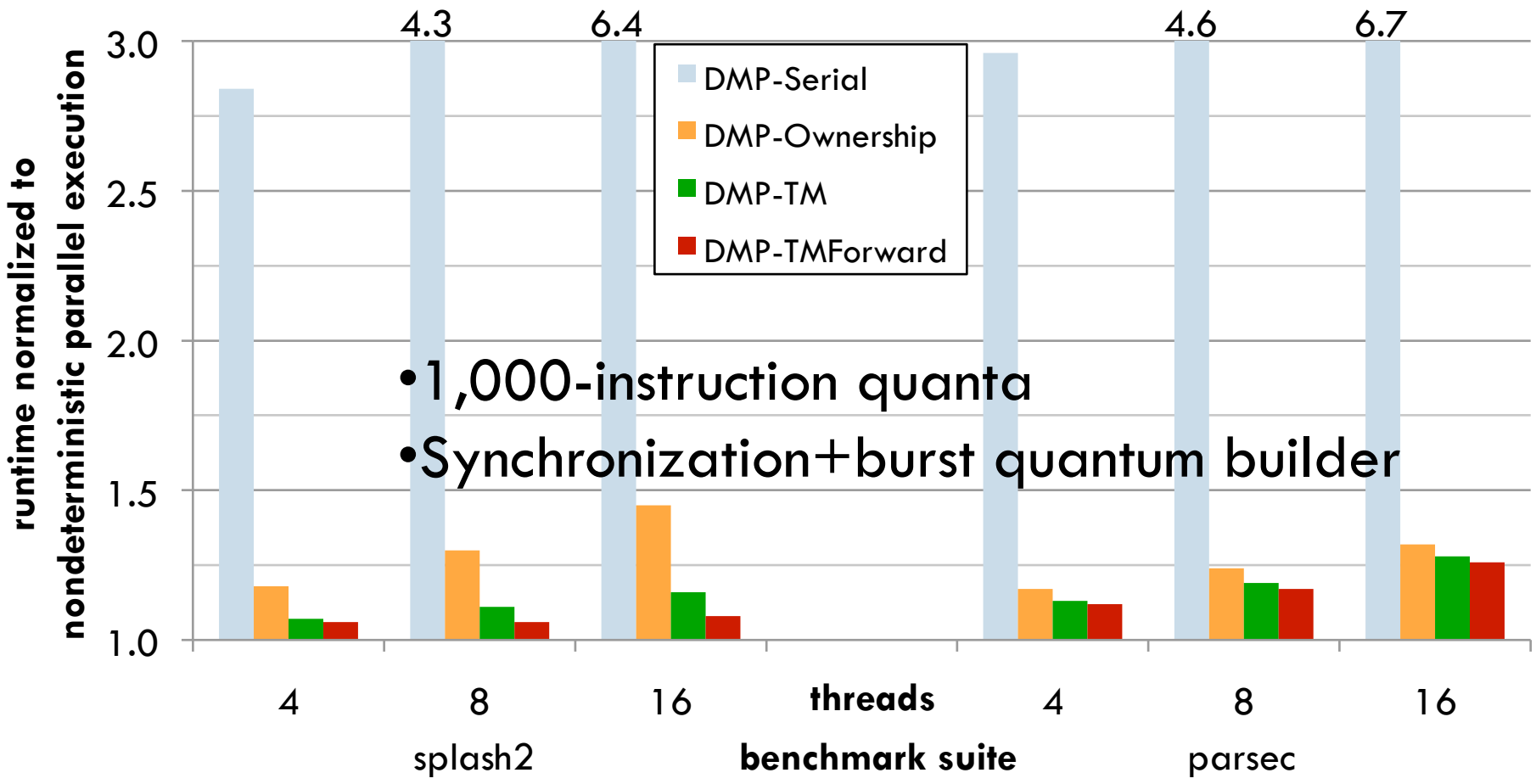
Better Quantum Building

- Any deterministic policy will work
- We want quanta that are free of communication
  - no communication → no serialization, no rollbacks

Experimental Methodology

- PIN-based simulator
  - Models serialization, quantum building, address conflicts and transaction rollbacks
  - Assumes constant IPC with free commits
- SPLASH2 and PARSEC benchmark suites

Results


4.3
6.4
4.6
6.7
3.0
2.5
2.0
1.5
1.0
runtime normalized to nondeterministic parallel execution
DMP-Serial
DMP-Ownership
DMP-TM
DMP-TMForward
•1,000-instruction quanta
•Synchronization+burst quantum builder
4
8
16
threads
4
8
16
splash2
benchmark suite
parsec

Conclusions

- DMP is a new multiprocessor architecture that provides execution-level determinism for arbitrary programs
  - Leverages existing architectural techniques
  - Performance very close to nondeterministic execution
- **Determinism is a worthwhile and achievable goal**

Also in the paper…

- Support for debugging
  - Adding instrumentation without affecting communication
- Making execution deterministic across machines
- Dealing with nondeterminism from I/O and the OS