

An approach for debugging large-scale parallel applications

Một giải pháp kiểm tra lỗi ứng dụng kích thước lớn

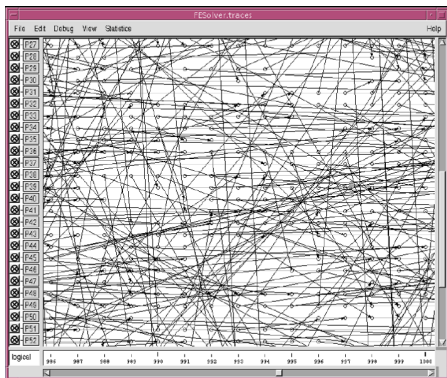
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Outline

- 1 Background Information
- 2 Detection Algorithm
- 3 Experimental Results and Analysis
- 4 Further Discussions
- 5 Conclusion

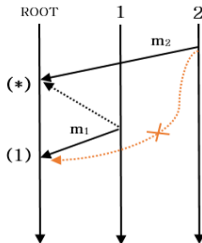
Parallel Applications



Requirements

- Message Passing
- Large-scale
- Long-running

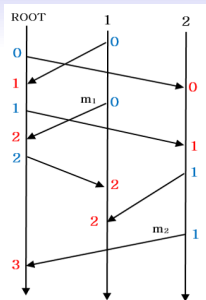
Abnormal Behaviors



(a)

- Non-deterministic → **not receivable** blocking receiving events
- Abnormal behavior detection makes applications **more reliable**

Receivable Clock

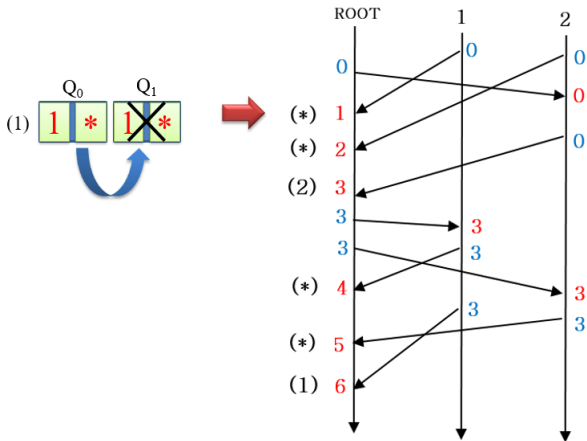


Lemma

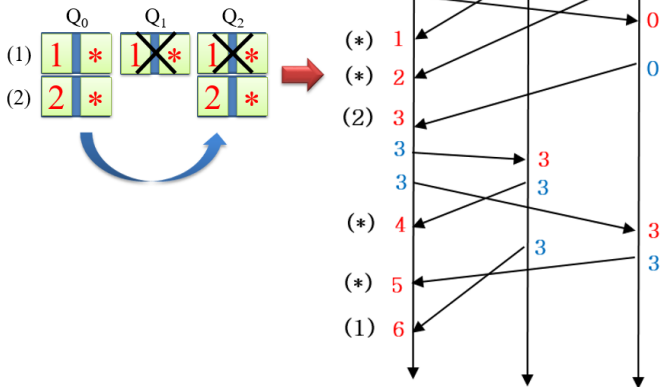
Receiving event a on process p_a has RC v_a . Sending event b on process p_b piggybacks RC v_b on outgoing message m . The one and only one requirement for message m receivable at a is $v_a > v_b$.

$$a \xrightarrow{R} b \Leftrightarrow v_a > v_b$$

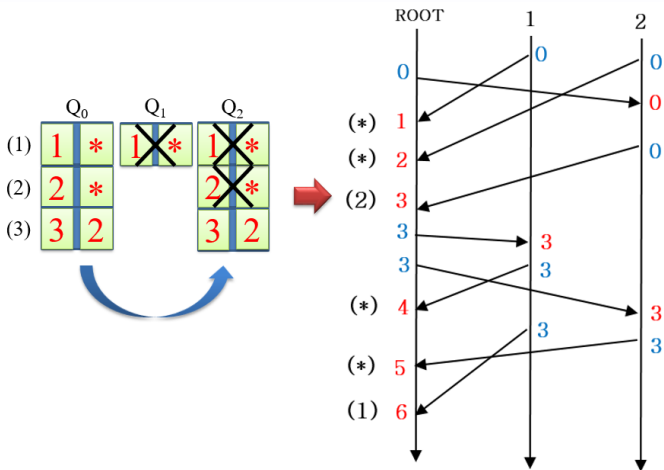
Detection Algorithm



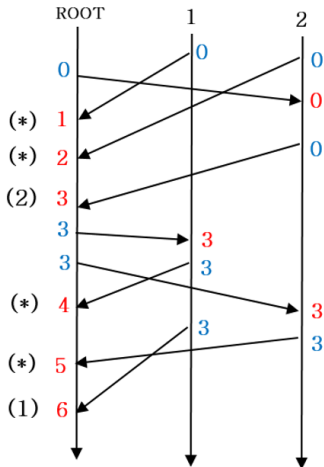
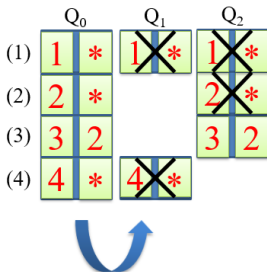
Detection Algorithm



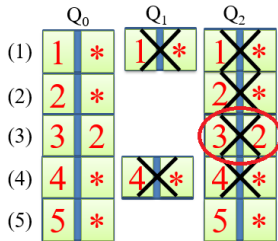
Detection Algorithm



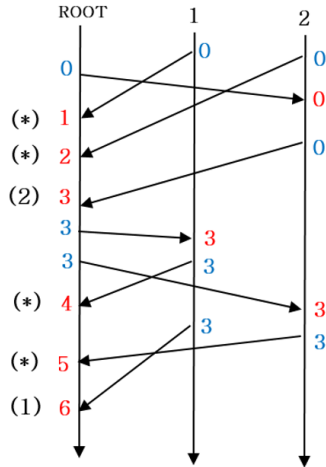
Detection Algorithm



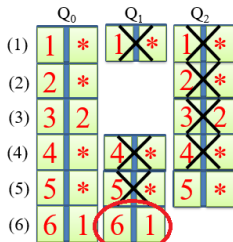
Detection Algorithm



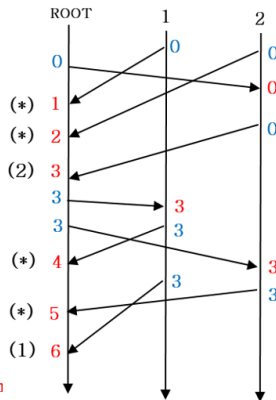
Deadlock Detection



Detection Algorithm

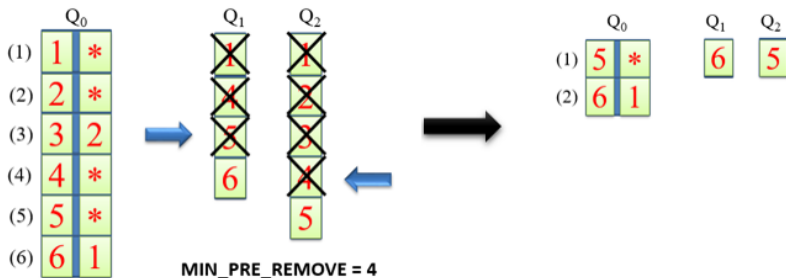


Another Deadlock Detection



Memory Overhead Reduction

Events Storage Optimization: Routinely remove abundant receiving events in the queue of root process.



Experimental Setup

The experiments are conducted in 2 compute nodes:

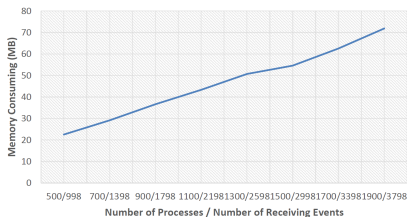
- Intel(R) Xeon(R) CPU E5-2680 v3 @ 2.50GHz
- 24 core
- 128 GB memory

Running 2 MPI benchmarks:

- Lattice QDC
- IOR

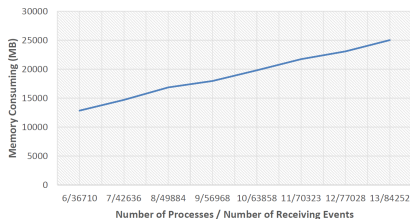
Memory Utilization

IOR: Memory Utilization



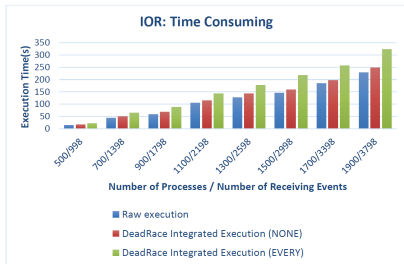
IOR ($N_p/N_e \sim 0.5$)

Lattice QCD: Memory Utilization

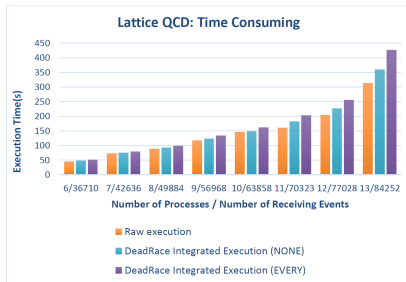


Lattice QCD ($N_p/N_e \sim 1/6000$)

Time Consuming

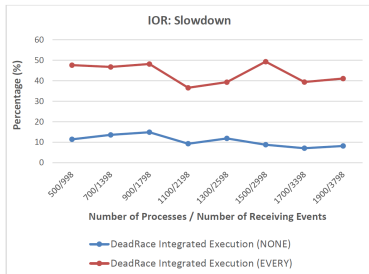


IOR ($N_p/N_e \sim 0.5$)

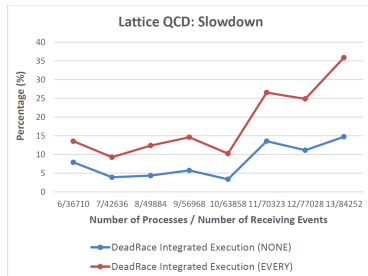


Lattice QCD ($N_p/N_e \sim 1/6000$)

Slowdown

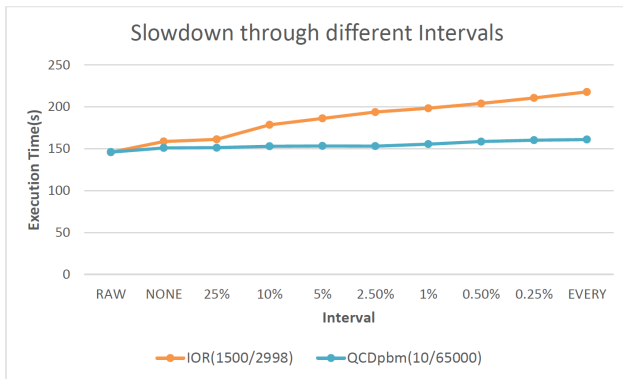


IOR ($N_p/N_e \sim 0.5$)



Lattice QCD ($N_p/N_e \sim 1/6000$)

Memory Overhead Reduction



Conclusion

- Abnormal behaviors are **worth addressing and detecting** in effort of make large-scale parallel applications **more reliable**
- **Artificially replay another executions on-the-fly** brings potential approach for further researching
- Ongoing researches: **collective communication, not master/slave models**