Brief Announcement: Non-blocking Monitor Executions for Increased Parallelism *

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Motivation and Approach: Monitors are a prevalent programming technique for thread synchronization in shared-memory parallel programs. The current design of monitors uses the *wait/notification* mechanism that blocks threads from executing without exclusive access to critical sections. We explore the idea of allowing non-blocking executions of monitor methods to improve the collective worker thread throughput and cache-locality in multi-threaded programs.

Our proposed framework, called *ActiveMonitor*, uses the concept of *futures* [1,2] to provide non-blocking monitors by creating: (i) an *executor* for every monitor object (similar to remote-core-locking [3]), and (ii) *tasks* — equivalent to monitor methods — that are submitted to the executors. Our framework handles these steps automatically. The framework allows the programmer to use the keyword 'nonblocking' in signatures of monitor methods to make their execution non-blocking. Non-blocking methods return a *future* reference, which can be used to retrieve the result of method invocation. We re-interpret linearizability in this context, and enforce two rules to guarantee correctness: **(a)** all the tasks submitted to one monitor executor are processed in FIFO order. **(b)** tasks corresponding to a worker thread's invocations of methods on different monitors are processed in program order (of the worker thread). See [4] for details.

Evaluation: We present the performance evaluation of our approach for two monitor-based problems in Java. In our benchmark, worker threads collectively perform 512000 operations in total on shared data protected by monitors. We vary the number of workers from 2 to 24 on a 24-way machine, and measure the time required for all the workers to complete their operations.

1. Bounded-Buffer Problem: Every producer's put invocation is non-blocking, and every consumer's take is blocking. Items are plain objects. We also compare runtimes of Java's ArrayBlockingQueue based implementation (denoted by ABQ). We collect runtimes by varying: (a) number of workers for a fixed buffer-size (=4). (b) buffer-size for fixed number of producers/consumers (=16 each). (c) limit on non-blocking tasks allowed for fixed buffer-size (=4), and 16 producers and consumers each. Fig. 1 shows the results of these three experiments. Across all results, we use these legends for implementation techniques: LK: Java Reentrant locks, AS: *AutoSynch* [5], AM: *ActiveMonitor* (this paper).

2. Sorted Linked-List Problem: Worker threads insert or remove, with equal

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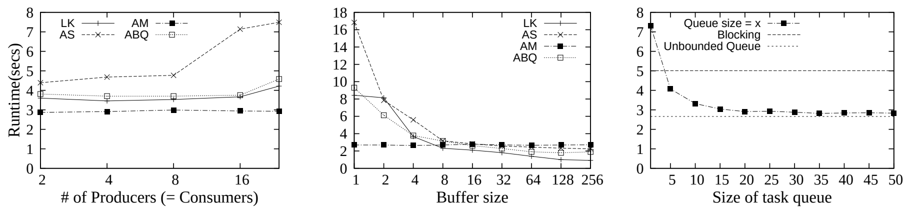
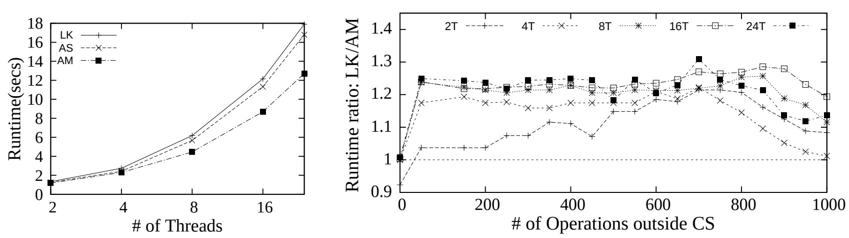


(a) Buffer-size = 4 (b) Varying buffer-size (c) Varying tasks-queue size

Fig. 1: Runtimes (mean values across 25 runs) for bounded-buffer

probability, random integer values on a pre-populated linked-list of integers that is sorted in non-decreasing order. Both insert and remove operations are non-blocking. Each worker thread also performs some local operations outside the critical section (CS) between successive updates to the list. We collect the runtimes by varying: (a) number of workers, keeping local operations outside CS/worker fixed at 250. (b) number of workers as well as number of local operations outside CS. The results of these two experiments are shown in Fig. 2.

See [4] for extended evaluation on other monitor problems, details of CPU and memory consumption, and comparison with other implementation techniques.



(a) Varying # of workers (b) Varying # of workers, and ops outside CS

Fig. 2: Results (mean values across 25 runs) for sorted linked-list

References

1. R. H. Halstead, "Multilisp: A language for concurrent symbolic computation," *ACM Trans. Program. Lang. Syst.*, vol. 7, no. 4, pp. 501–538, Oct. 1985.
2. A. Kogan and M. Herlihy, "The future(s) of shared data structures," in *PODC*, 2014.
3. J.-P. Lozi *et al.*, "Remote core locking: Migrating critical-section execution to improve the performance of multithreaded applications," in *USENIX Annual Technical Conference*, 2012, pp. 65–76.
4. http://arxiv.org/abs/1408.0818.
5. W.-L. Hung and V. K. Garg, "AutoSynch: An Automatic-signal Monitor Based on Predicate Tagging," in *PLDI*, 2013, pp. 253–262.