

CHALMERS | GÖTEBORG UNIVERSITY

Reactive Concurrent Data Structures and Algorithms for Synchronization

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Abstract

Parallelism plays a significant role in high-performance computing systems, from large clusters of computers to chip-multithreading (CMT) processors. Performance of the parallel systems comes not only from concurrently running more processing hardware but also from utilizing the hardware efficiently. The hardware utilization is strongly influenced by how processors/processes are synchronized in the system to maximize parallelism. Synchronization between concurrent processes usually relies on shared data structures. The data structures that enhance parallelism by allowing processes to access them concurrently are known as *concurrent data structures*. The thesis aims at developing efficient concurrent data structures and algorithms for synchronization in asynchronous shared-memory multiprocessors.

Generally speaking, simple data structures perform well in the absence of contention but perform poorly in high-contention situations. Contrarily, sophisticated data structures that can scale and perform well in the presence of high contention usually suffer unnecessary high latency when there is no contention. Efficient concurrent data structures should be able to adapt their algorithmic complexity to varying contention. This has motivated us to develop fundamental concurrent data structures like trees, multi-word compare-and-swap and locks into reactive ones that timely adapt their size or algorithmic behavior to the contention level in execution environments. While the contention is varying rapidly, the reactive data structures must keep the cost of reaction below its benefit, avoiding unnecessary reaction due to the contention oscillation. This is quite challenging since the information of how the contention will vary in the future is usually not available in multiprogramming multiprocessor environments. To deal with the uncertainty, we have successfully synthesized non-blocking synchronization techniques and advanced on-line algorithmic techniques, in the context of reactive concurrent data structures. On the other hand, we have developed a new optimal on-line algorithm for one-way trading with time-varying exchange-rate bounds. The algorithm extends the set of practical problems that can be transformed to the one-way trading so as to find an optimal solution. In this thesis, the new algorithm demonstrates its applicability by solving the freshness problem in the context of concurrent data structures.