Chapter 51
Cost Evaluation of Synchronization Algorithms for Multicore Architectures

Masoud Hemmatpour
Politecnico di Torino, Italy

Renato Ferrero
Politecnico di Torino, Italy

Filippo Gandino
Politecnico di Torino, Italy

Bartolomeo Montrucchio
Politecnico di Torino, Italy

Maurizio Rebaudengo
Politecnico di Torino, Italy

ABSTRACT

In a multicore environment, a major focus is represented by the synchronization among threads and processes. Since synchronization mechanisms strongly affect the performance of multithread algorithms, the selection of an effective synchronization approach is critical for multicore environments. In this chapter, the cost of the main existing synchronization techniques is estimated. The current investigation covers both hardware and software solutions. A comparative analysis highlights benefits and drawbacks of the considered approaches. The results are intended to represent a useful aid for researchers and practitioners interested in optimization of parallel algorithms.

INTRODUCTION

One of the major issues in modern computer architecture is multicore design. Programmers have been urged to design innovative algorithms by exploiting multicore facilities. Synchronization, i.e., the technique adopted for coordinating threads or processes to have appropriate execution order, is one of the

DOI: 10.4018/978-1-5225-7598-6.ch051

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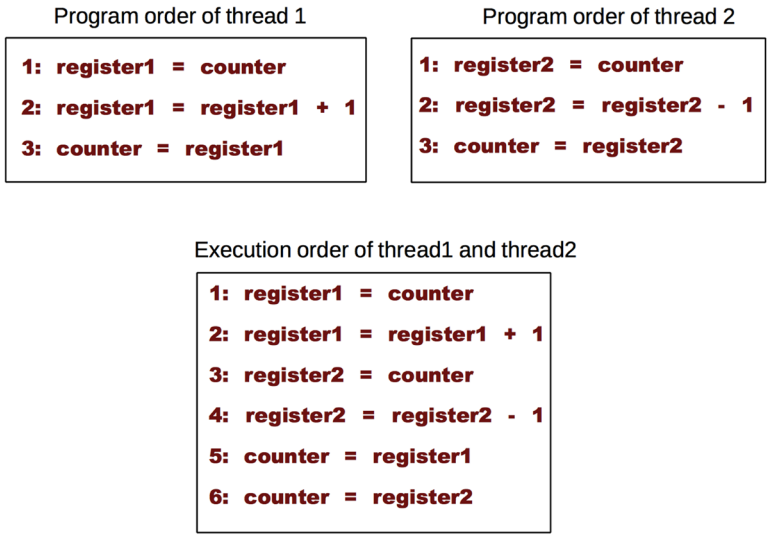
main issues in programming on a multicore processor. In the literature, many synchronization techniques based on hardware and software have been proposed (Petrović, 2014; Yoo, 2013; McKenney, 1998). Modern computers provide special hardware instructions that allow to test and modify the content of a word atomically (e.g., the *cmpxchg* instruction of Intel) which can be used for synchronization of threads (Valois, 1995; Gao, 2007). Software techniques can synchronize threads without any dependency on hardware instructions (McKenney, 1998; Mellor-Crummey, 1991). One important aspect of a synchronization algorithm is its performance, which is evaluated in terms of overhead. In this study, the term cost is used to address an overhead of synchronization algorithm. The state-of-the-art approaches strive to increase the performance by reducing the cost of the synchronization. To the best of the authors knowledge a study to analyze the possible costs of synchronization mechanisms is absent. So, this chapter investigates the costs in the main steps of a synchronization mechanism. Moreover, since memory access is one of the most important costs in synchronization mechanisms, a discrete time Markov chain model of memory access cost is presented to evaluate the memory access overhead.

The remainder of this chapter is organized as follows. The primitives of the main synchronization algorithms are described in Section 2. Then, a theoretical evaluation of each cost and experimental results are presented in Section 3. Finally, some conclusions are described in Section 4.

BACKGROUND

When threads are working simultaneously on a shared object, their synchronization should be managed properly, otherwise the instructions of different threads interleave on the shared object in a wrong way. For example, Figure 1 shows the program order of two threads that are working on the shared object counter (Silberschatz, 2006). Since one thread is incrementing the counter and another one is decrementing it, at the end, the counter is expected to have the initial value. However, as Figure 1 illustrates, there is a possible execution order of instructions that leads to an incorrect result.

Figure 1. Incorrect execution of the instructions order



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