Synchronization Algorithms for Multi-Dimensional Cellular Arrays

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Abstract: Synchronization of large-scale networks is an important and fundamental computing primitive in parallel and distributed systems. We study a synchronization problem that gives a finite-state protocol for synchronizing cellular automata. The synchronization in cellular automata has been known as firing squad synchronization problem since its development, in which it was originally proposed by J. Myhill in the book edited by Moore [1964] to synchronize all/some parts of self-reproducing cellular automata. The problem has been studied extensively for more than fifty years [1-2]. It is defined as follows: Given a one-dimensional array of n identical cellular automata, including a *general* at one end that is activated at time $t = 0$, we want to design the automata such that, *at some future time*, all the cells will *simultaneously* and, *for the first time*, enter a special *firing* state. The problem has been referred to as achieving a *macro-synchronization* in *micro-synchronization* system and *realizing a global synchronization using only local information exchange*.

In this paper, we present a survey on recent developments in designing optimum- and non-optimum-time synchronization algorithms and their implementations for one- and two-dimensional cellular arrays. Several simple, state-efficient mapping schemes are proposed for embedding one-dimensional firing squad synchronization algorithms onto two-dimensional arrays. First we introduce three types of firing squad synchronization algorithms for one-dimensional arrays: an optimum-time firing squad synchronization algorithm with a general at one end of the array, its generalized version where the general can be positioned at an arbitrary cell of the array, and a delayed version which can delay the synchronization time for some steps. Then, it can be seen that these three algorithms for one-dimensional arrays will be efficiently employed, together with several mapping schemes, for designing optimum- and non-optimum-time synchronization algorithms for two-dimensional arrays.

References

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