Service and Metastability Performance of Arbiters
PhD Thesis written by Lindsay Kleeman 1986
University of Newcastle, Australia

ABSTRACT

The thesis reports the results of a study of issues related to the performance of arbiters. Arbiters are digital circuits which are inherently susceptible to metastable behaviour because of the asynchronous nature of their inputs. The thesis examines a number of fundamental issues concerning metastability in digital circuits and establishes their relevance to the performance of arbiters and synchronisers. Furthermore, the thesis presents new models and new analytical tools for evaluating the service and utilisation performance of arbiters.

The question of the unavoidability of metastability is examined in the thesis and previous results are extended to enable direct application to circuits with realistic waveforms. It is also shown in the thesis that redundancy and masking techniques are ineffectual in improving the performance of synchronisers with respect to metastability.

A general model for analysing the metastable performance of digital systems, called the aperture model, is developed in the thesis. One application of the aperture model is to the evaluation of the performance of various schemes designed for improving the metastable performance of synchronisers. The development of the aperture model is an important step towards the analysis of the rate of occurrence of failure due to metastability in arbiters.

The thesis identifies a new class of arbiters referred to as batched arbiters. This batching mechanism can be combined with primary service disciplines, such as fixed priority and round robin to generate new service disciplines. Models are developed for these arbiters which include many practical circuit parameters not previously considered. The modelling has been carried out for both asynchronous and clocked arbiters.

New analytical tools for the analysis of the service and utilisation performance of arbiters are developed in the thesis. The techniques are based on imbedded Markov chains. Arbitrary service time distributions can be handled by the analysis techniques developed, and the performance under light and heavy request loadings is derived. The analysis techniques are applied to both asynchronous and clocked arbiters, and a variety of service disciplines.
The aperture model for metastability of digital circuits is combined with the analysis techniques for the arbiter models adopted to derive the metastable failure rate performance of various arbiters. Furthermore, the impact of certain internal arbiter functions, such as the request resetting mechanism in clocked arbiters is evaluated.