Asynchronous Programming in the Abstract Behavioural Specification Language

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Summary

The mainstream object-oriented languages use multi-threading as the model of concurrency and parallelism. However, reasoning about the correctness of multi-threaded programs is notoriously difficult. Also due to the complexity of balancing work evenly across cores, the thread model is of little benefit for efficient processor use or horizontal scalability. On the other hand, chip manufacturers are rapidly moving towards so-called manycore chips with thousands of independent processors on the same silicon real estate. Current programming languages can only leverage the potential power by inserting code with low level concurrency constructs, sacrificing clarity. Alternatively, a programming language can integrate a thread of execution with a stable notion of identity, e.g., in active objects.

Abstract Behavioural Specification (ABS) is a language for designing *executable* models of parallel and distributed object-oriented systems based on active objects, and is defined in terms of a formal operational semantics which enables a variety of static and dynamic analysis techniques for the ABS models.

The overall goal of this thesis is to extend the asynchronous programming model and the corresponding analysis techniques in ABS. Based on the different results, the thesis is structured as follows: Part I gives a preliminary overview of the ABS. In part II, we apply an extension of ABS with a restricted notion of shared memory to provide a parallel and distributed model of *preferential attachment* which is used to simulate large-scale social networks with certain mathematical properties. In Part III, we formally extend ABS to enhance both asynchronous programming by data streaming between processes, and parallelism by multi-threading within an actor. Finally in part IV, a new technique based on predicate abstraction is introduced to analyze the ABS models for the absence of deadlock within an actor.