

ABSTRACT

Modern day embedded systems are heterogeneous. The heterogeneity arises due to the fact that such systems typically comprise multiple sub-systems which have widely varying functionalities. For example, there may be sensors activated by environmental variations in pressure or temperature, there may be mechanical moving parts like gears which are actuated by electronic signals generated by control units; the signal generation by control units may also depend on GPS data gathered by satellite links, etc. Formal techniques for system synthesis and validation require appropriate Models of Computations (MoCs) for specifying such sub-systems. Consequently, the overall system specification becomes a mix of specifications involving multiple such MoCs. Methods for formal analysis of such heterogeneous specifications are still at their infancy although some simulation frameworks have been proposed till date.

The present work tries to provide some insight in this regard by advocating a generalized meta-model of computation as an all-encompassing specification method which can also be used in formal analysis as demonstrated here. Such a well known meta-model which may capture multiple MoCs and their interactions compositionally is the tagged signal model (TSM). The model has been used for providing sound execution semantics to heterogeneous system simulation tools like Ptolemy (Eker et al., 2003). However, the scope of formal analysis techniques like performance evaluation and correctness verification of TSM based system specification has not been explored till date.

Using TSM as an underlying MoC, we propose a methodology for performance evaluation of schedules for job-shops modeled using tag machines. Comparison of the method with existing ones reveals that the proposed method has no dependence on schedule length in terms of modeling efficiency and it shares the same order of complexity with existing approaches. The proposed method, however, is shown to bear promise of applicability to performance evaluation of systems specified using other models of computation (MoCs) and heterogeneous system models having such multiple constituent models.

For correctness verification of TSM based system models, we provide a representation of tagged systems using the semantics of Kleene algebra. We further illustrate mechanisms for both behavioural verification through equivalence checking and property verification of heterogeneous embedded systems based on this algebraic representation.

Keywords: Heterogeneous Embedded Systems, Tagged Signal Model, Asymptotic Performance Evaluation, Job-shop Scheduling, Petri Nets, Heaps of Pieces, Formal Verification, Actor Theory, Kleene Algebra.