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Static Analysis of Run-time Modes in Kahn Process Networks

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Kahn Process Networks (KPNs) are used for modeling streaming-oriented applications with changing behavior. To meet the performance and energy constraints of embedded devices, such applications must be mapped to parallel architectures in an optimal way. Finding an optimal mapping to the constrained architecture presumes that the behavior of the KPN is statically known. Considering the run-time behavior of streaming-oriented applications, we can identify run-time modes in which the system offers a certain behavior. In this book, we present a static analysis that identifies such run-time modes at compile-time.

To that end, we use abstract interpretation based on polyhedral abstraction and an automata-based representation of KPNs to consider the expected run-time behavior. We have developed a state partitioning algorithm to separate control-oriented parts from transformative parts. The automata states are partitioned according to the run-time behavior. We identify modes and their hierarchies for individual processes by using our graph reduction algorithm to transform state partitioned automata to mode automata. To obtain the overall network behavior, we have developed a composition algorithm for asynchronously communicating mode automata. We abstract from unnecessary considerations of interleaving states by choosing one representative execution. The result is a mode automaton describing the whole network behavior.

To evaluate our method, we have implemented a prototype of our analysis. For an arbitrary KPN, our implementation statically analyzes its run-time modes and their corresponding behaviors. We have evaluated typical case studies, e. g., a reconfigurable Finite Impulse Response filter, which demonstrate the practicability of our approach. Optimizing backends that map KPNs to parallel architectures can be guided by these analysis results.