Abstract

The growing demand for mapping diverse embedded applications on to shared processors has brought focus on control-scheduling co-design approaches. In the co-design context, to cope with multiple design trade-offs between control and platform parameters, non-uniform execution of controllers has become a promising alternative to the traditional periodic executions. This thesis primarily focuses on such non-uniform pattern guided execution of the controllers and proposes a bouquet of new formalisms and frameworks for efficiently addressing various aspects of this control-scheduling co-design problem. The primary contributions of this thesis are as follows:

- The thesis develops an adaptive scheduling framework for a set of control loops by introducing the notion of loop execution patterns. A structured synthesis mechanism is proposed for generating such loop execution patterns under different input disturbance scenarios. The proposed synthesis methodology employs stable adaptive switching between loop execution patterns for improved quality of control and resource utilization while guaranteeing the schedulability of the loops.

- The thesis presents a unique framework for post-processing a static schedule of a set of control loops such that combined control performance can be improved further. The proposed method instruments each loop to switch between multiple controllers by co-operatively sharing their execution slots.

- The thesis provides a fault tolerant framework for synthesizing the specifications of a set of loop execution patterns, that are robust enough to guarantee the desired control performance under platform non-idealities. The synthesis process is developed leveraging the concept of bounded model checking for generating such robust specifications.

- The thesis develops a co-design framework to synthesize a co-schedulable combination of loop execution patterns for a set of control loops over a shared wireless multi-hop control network, along with their associated routing solution, such that overall control performance gets optimized. The proposed framework is also shown to be useful for evaluating fault tolerance of a resource-constrained shared network subject to communication link failures.

Keywords: *Embedded Control Systems, Software-based Controller, Loop Executions, Scheduling, Control Performance, Stability.*