



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : Sanjit Kumar Roy
Roll Number : 136101002
Programme of Study : Ph.D.
Thesis Title:
Task and Message Co-scheduling Strategies in Real-time Cyber-Physical Systems
Name of Thesis Supervisor(s) : Dr. Arnab Sarkar & Dr. Chandan Karfa
Thesis Submitted to the Department/ Center : CSE
Date of completion of Thesis Viva-Voce Exam : 15/09/2022
Key words for description of Thesis Work : Real-time Systems, Cyber-Physical Systems, Scheduling

SHORT ABSTRACT

Cyber-Physical Systems (CPSs), like those in the automotive and avionic do mains, smart grids, nuclear plants, etc., often consist of multiple control sub systems running on distributed processing platforms. Most of these control systems are modeled as real-time independent tasks or Precedence-constrained Task Graph (PTG), depending on the nature of interactions between their functional components. These tasks typically read their input parameters via sensors. The sensed inputs are then transmitted as messages over communication channels to processing elements where corresponding control outputs are computed. The outputs in turn, are communicated to actuators as messages through communication channels. This dissertation presents several novel real-time task-message coscheduling strategies for safety-critical CPSs, consisting of various types of task and execution platform scenarios.

The entire thesis work is composed of multiple contributions categorized into four phases, each of which is targeted towards a distinct task/platform scenario. The first phase delves with the design of co-scheduling strategies for independent periodic real-time tasks, with associated input and output messages, on a bus-based homogeneous multiprocessor system. Although most scheduling approaches have traditionally been oriented towards homogeneous multiprocessors, continuous demands for higher performance and reliability along with better thermal and power efficiencies, have created an increasing trend towards distributed heterogeneous processor platforms. In the second phase, we have considered the problem of scheduling real-time systems modeled as PTGs on fully-connected heterogeneous systems. The tasks considered in both the first and second phases, may have multiple implementations designated as service-levels/quality-levels, with higher service-levels producing more accurate results and contributing to higher rewards/Quality of Service (QoS) for the system. In the third phase, we extend the problem of scheduling PTGs on fully-connected platforms, to CPS systems where the processors are connected through a limited number of bus based shared communication channels. While the third phase considers the problem of scheduling a single PTG, the final phase solves the problem of scheduling multiple independent periodic real-time PTGs. The works proposed in the third and fourth phases, endeavour towards the maximization of slack within the generated schedule, which can then be used to minimize energy dissipation in the system. The thesis proposes both optimal and heuristic solution approaches for all its phases. Practical applicability and efficacy of the presented schemes have been extensively evaluated through simulation-based experiments as well as real-world benchmarks.

Sanjit Kumar Roy
16/09/2022