The Feasibility Analysis of Mixed-Criticality Systems

Saravanan Ramanathan, Xiaozhe Gu, Arvind Easwaran

Nanyang Technological University, Singapore

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Outline

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1. Motivation
2. Open Problem
3. Possible Solution
4. Design Methodology

Motivation

2007	• Vestal introduced MC system
2012	• EDF-VD: Speed-up optimal single-core algorithm
2015	• MC-Fluid/MCF: Speed-up optimal multi-core algorithm
2016	• No optimal MC algorithm • No known tight feasibility bound

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The open problem

What is a tight feasibility bound for Mixed-Criticality (MC) task systems?

Outline

Possible Solution

Mixed-Criticality System:

- Single-core / Multi-core scheduling
- Dual-criticality / Multi-Criticality system
- Periodic / Sporadic task model
- Implicit / Constrained deadline

Possible Solution

Mixed-Criticality System:

- Single-core / ~~Multi-core~~ scheduling
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Mixed-Criticality Task Model

Task Model: Implicit-deadline dual-criticality (namely LO and HI) periodic task system is being considered.

$\tau_i = (T_i, \chi_i, C_i^L, C_i^H, D_i)$

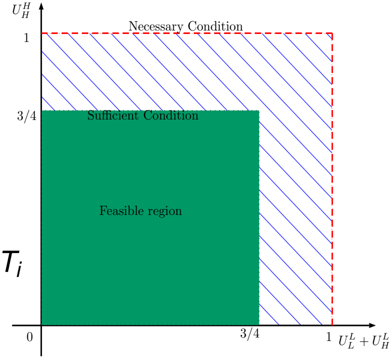
- $T_i \in \mathbb{R}^+$ is the period,
- $\chi_i \in \{LO, HI\}$ is the criticality level,
- C_i^L and C_i^H are the LO- and HI-criticality Worst-Case Execution Time (WCET) values respectively; we assume $C_i^L \leq C_i^H$ and,
- $D_i = T_i$ is the relative deadline.

MC Feasibility Analysis

System-level utilizations are defined as

- $U_L^L \stackrel{\text{def}}{=} \sum_{\tau_i \in \tau_L} u_i^L$,
- $U_H^L \stackrel{\text{def}}{=} \sum_{\tau_i \in \tau_H} u_i^L$ and
- $U_H^H \stackrel{\text{def}}{=} \sum_{\tau_i \in \tau_H} u_i^H$

where, $u_i^L = C_i^L / T_i$ and $u_i^H = C_i^H / T_i$



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Design Methodology

Challenge: Determining the worst-case mode switch pattern

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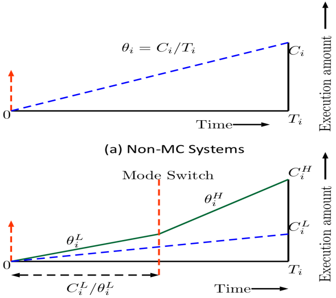
Solution: Fluid model

- Execution rate (θ_i) determines the mode switch instant (C_i^L/θ_i^L)
- Non-MC systems: Most fluid algorithms are optimal



(a) Non-MC Systems

(b) MC Systems

Design Methodology

Design of optimal scheduling algorithm involves

1. In LO mode: Schedule LO-criticality tasks as late as possible
2. In LO mode: Schedule HI-criticality tasks with their virtual deadline (C_i^L/θ_i^L)
3. In HI mode: Optimal scheduling of HI-criticality tasks inclusive of carry-over demand of HI-criticality tasks.

Design Methodology

HI-mode schedulability: In the absence of LO-tasks, fluid scheduling can optimally schedule HI-tasks in HI-mode.

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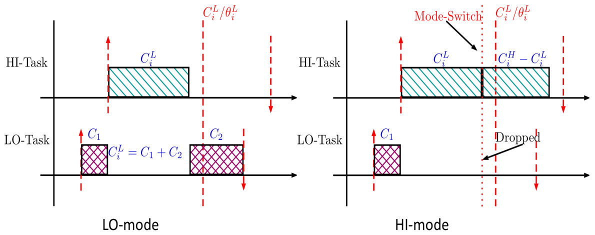
LO-mode schedulability:

1. Use DP-Fair to schedule HI-tasks in LO mode
   - Virtual deadline (C_i^L/θ_i^L) and actual deadline (T_i)
2. Schedule LO-tasks as late as possible



Thank you..!

Questions..?

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