Semiclairvoyance in Mixed Criticality Scheduling

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Mixed (dual) Criticality Jobs Model

- We have n jobs $\mathcal{J} = \{J_1, J_2, \dots, J_n\}$.
- Each job is characterized as $J_i = \{\chi_i, a_i, [c_i^L, c_i^H], d_i\}$
  - $\chi_i \in \{\text{LO}, \text{HI}\}$ is the criticality of the job
  - a_i is the arrival time
  - $[c_i^L, c_i^H]$ denote the LO-crit and HI-crit estimates of WCET
  - d_i is the deadline

Runtime Behavior

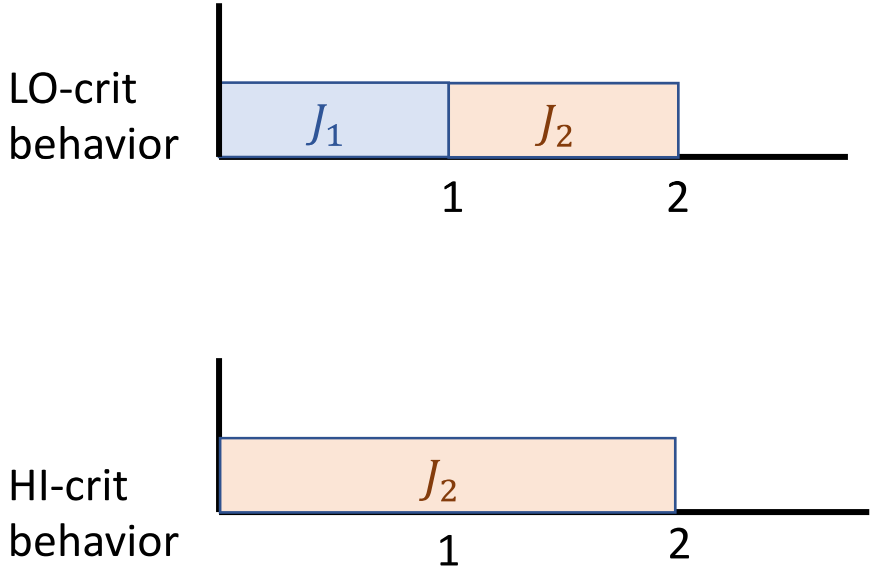
- Job i executes for e_i time.
  - If $e_i \leq c_i^L$ for all i --- low-criticality behavior
  - If $c_i^L < e_i \leq c_i^H$ for any i --- high-criticality behavior

- Correctness Condition
  - In any low-criticality behavior, all jobs must meet their deadlines
  - In any high-criticality behavior, all high-criticality jobs meet their deadlines (low-criticality jobs need not execute)

Offline (Clairvoyant) Scheduling

- Execution time e_i's are known in advance.
  - schedule all jobs using EDF if $e_i \leq c_i^L$ for all i (LC behavior)
  - schedule only high-crit jobs using EDF if $c_i^L < e_i$ for any i (HC behavior)
- Used to gauge feasibility and to prove speedup bounds.

Job	χ_i	a_i	c_i^L	c_i^H	d_i
J_1	LO	0	1	1	1
J_2	HI	0	1	2	2

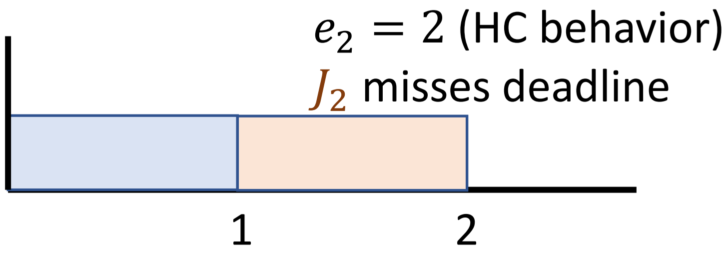


Online Scheduling of MC jobs

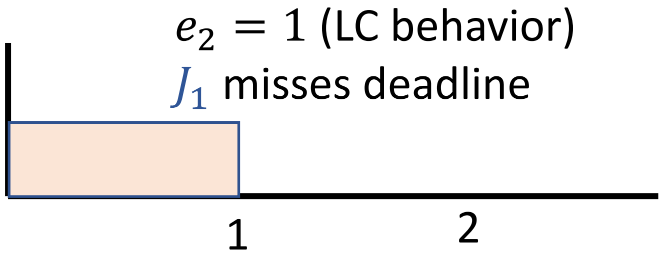
- Actual execution time e_i is revealed online.
- The scheduler must assume low criticality behavior until $e_i > c_i^L$ for some job --- *mode switch* to high-criticality behavior.

Job	χ_i	a_i	c_i^L	c_i^H	d_i
J_1	LO	0	1	1	1
J_2	HI	0	1	2	2

Case 1: start J_1



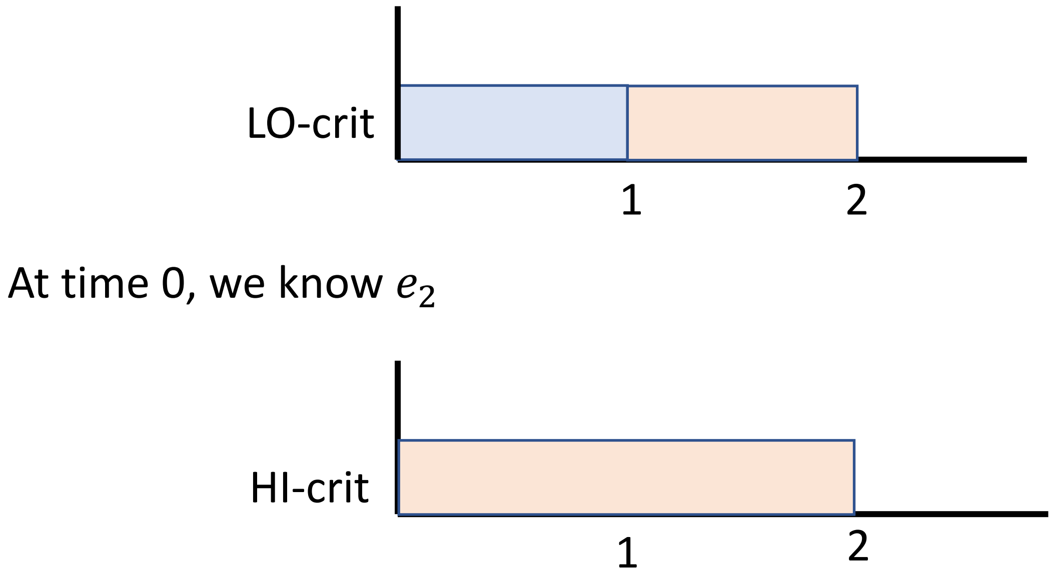
Case 1: start J_2



This paper: Semi-Clairvoyant Scheduling

- We know whether $e_i \leq c_i^L$ when the job arrives at time a_i.
- Applications in scenarios where the running time depends on input which might be known at invocation.
- Can schedule our job set

Job	χ_i	a_i	c_i^L	c_i^H	d_i
J_1	LO	0	1	1	1
J_2	HI	0	1	2	2



Semi-Clairvoyance is not Clairvoyance

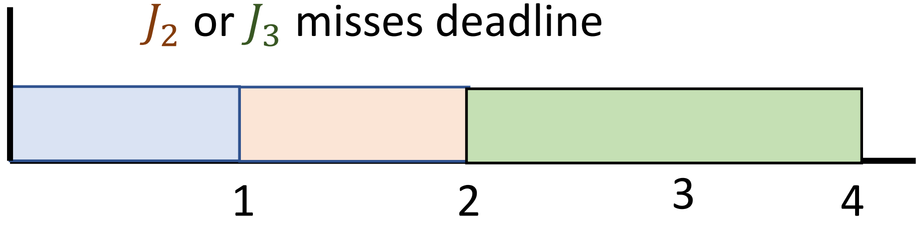
There are feasible job sets semi-clairvoyant schedulers can not schedule.

Job	χ_i	a_i	c_i^L	c_i^H	d_i
J_1	LO	0	1	1	1
J_2	HI	0	1	1	2
J_3	HI	1	1	2	3

Case 1: start J_1

$e_3 = 2$ (HC behavior)

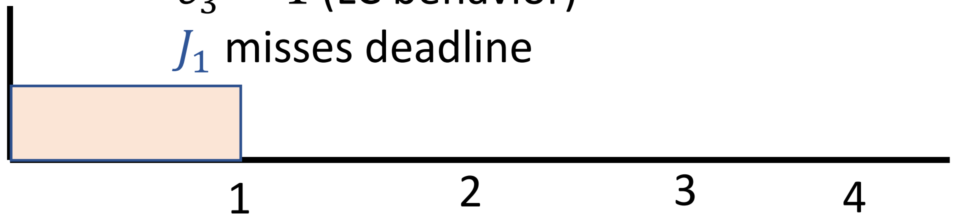
J_2 or J_3 misses deadline



Case 2: start J_2

$e_3 = 1$ (LC behavior)

J_1 misses deadline



This paper: Theoretical Analysis of Semi-Clairvoyance for Dual-Criticality Tasks

- Speedup lower bound of 3/2 for semi-clairvoyance.
- Provide an optimal algorithm based on LP.
- Show that this algorithm has speedup of 3/2.
- For semi-clairvoyant tasks, a fluid algorithm is optimal.

	Non Clairvoyant	Semi Clairvoyant
Online Scheduling Complexity	NP-Hard	Polynomial Time
Speedup bound (Jobs)	1.618 (tight)	1.5 (tight)
Speedup bound (Tasks)	4/3 (tight)	1

Future Work

- Burns and Davis have since provided an analysis of fixed priority scheduling of tasks in this model.
- More Future Work?
  - More than 2 criticality levels?
  - Multiprocessor or parallel tasks?
  - For tasks, the speedup bound of 1 is for a fluid scheduler. Is there a more practical scheduler with the same bound?