Markov Decision Process for Mixed Criticality Probabilistic Real-Time System

Jasdeep Singh, Zhishan Guo, Luca Santinelli, Guillaume Infantes, David Doose, Julien Brunel

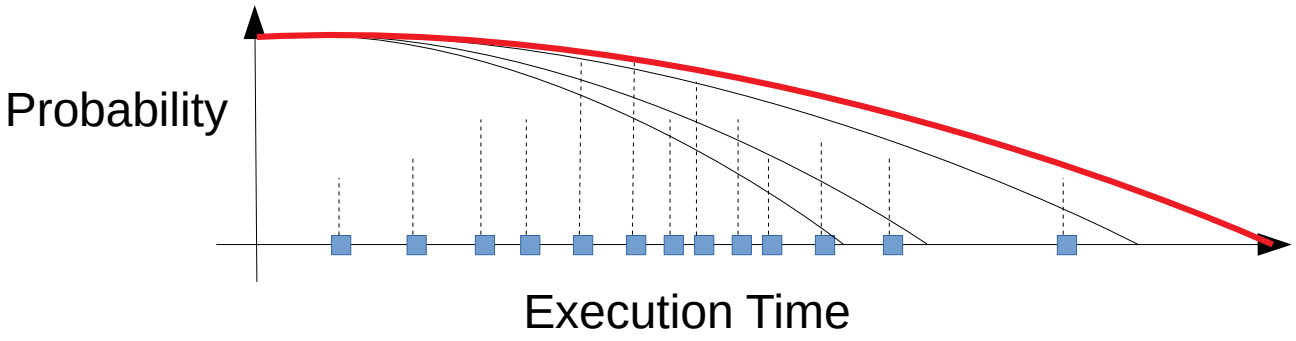
ONERA

THE FRENCH AEROSPACE LAB

retour sur innovation

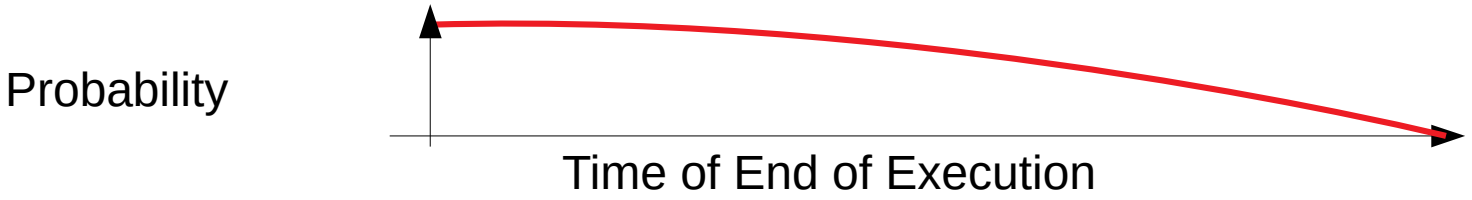
Probabilistic Real-Time System

- pRTS: A real-time system with at least one property is probabilistically defined
- pWCET: Probabilistic Worst Case Response Time



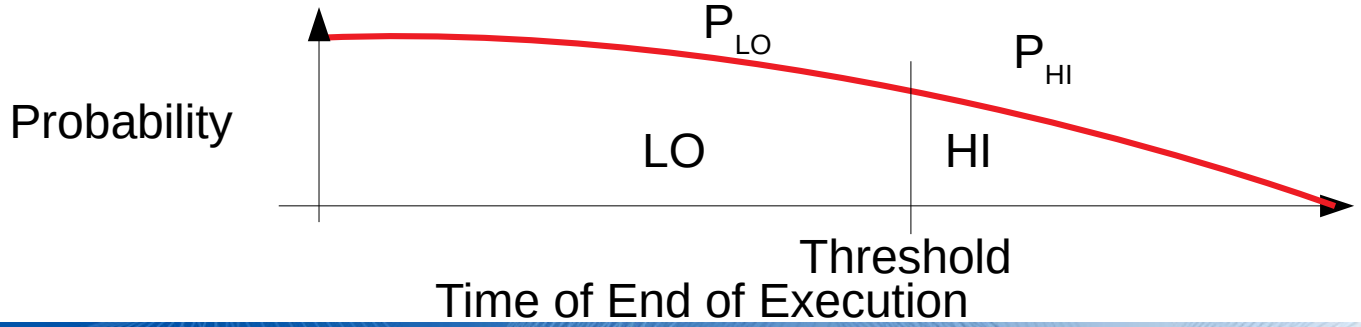
Given System

- pRTS:
  - HI and LO Tasks with pWCET, periods and deadlines
  - Scheduling policy, preemptive, jobs aborted at deadline
- Schedulability Analysis (done seperately):
  - Probabilistic Worst Case Response Time (pWCRT) for each job in the hyperperiod



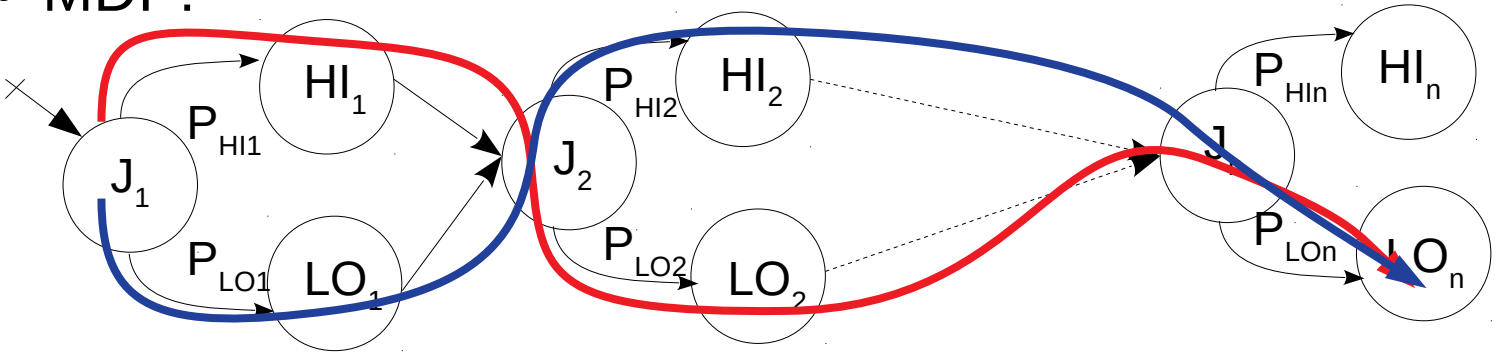
Mixed Criticality and Probability

- pRTS has two modes: HI and LO (can be easily extended to multiple modes)
- System criticality defined using job criticality modes
- Job has pWCRT with threshold for criticality



System Criticality Definition

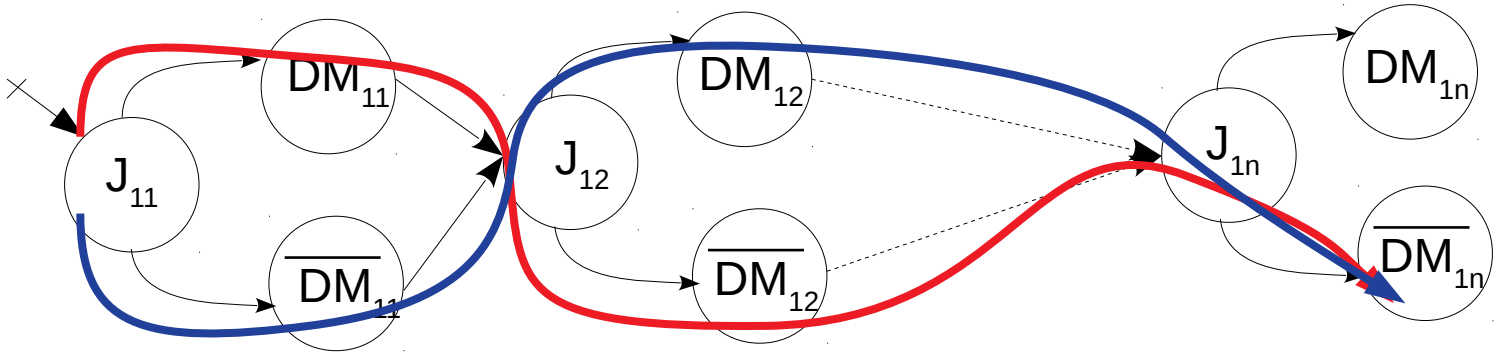
- (k,n): System is in HI criticality mode if at least k out of n HI jobs are in HI mode
  - (1,n) and (n,n) are extreme cases
- MDP:



- Using the (k,n) definition, path through the MDP
- Summation of Path Probability: Probability that pRTS enters HI mode , Pr(S->HI)

Task Probability of Deadline Miss

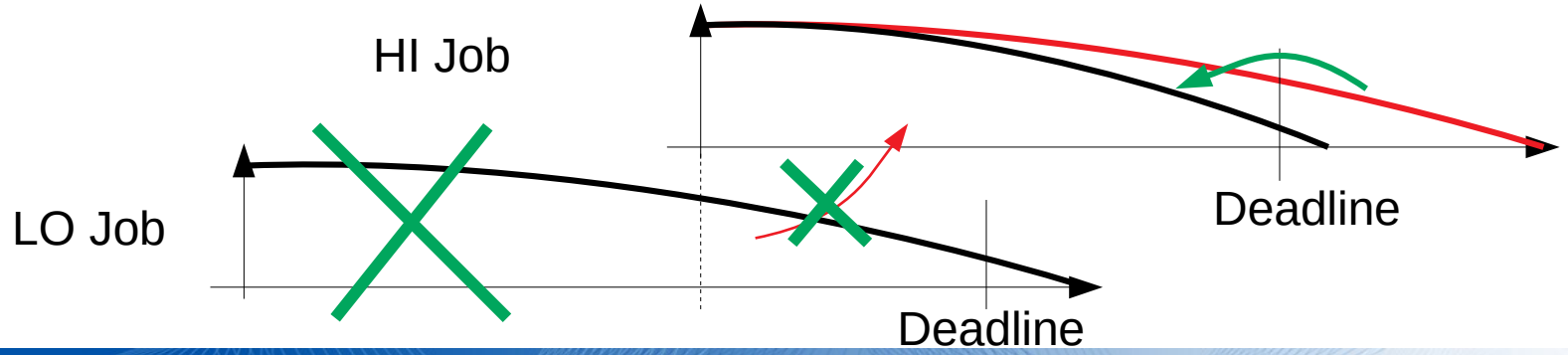
- Task misses a deadline if at least one job misses a deadline



- Using definition, path through the MDP
- We obtain: Probability of deadline miss of a task
- Used to quantify that of HI tasks

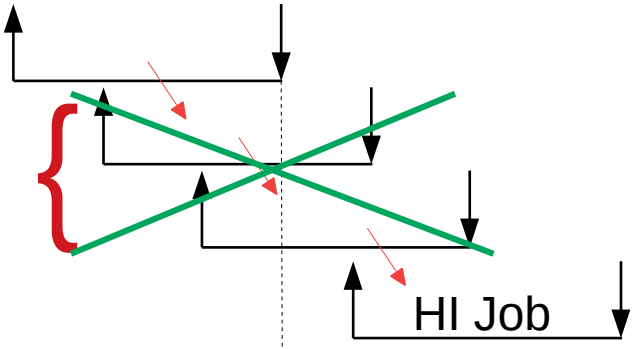
Dropping of LO-criticality jobs

- Imposed Requirement: The probability that a pRTS enters HI criticality mode should not exceed $\mathrm{P}_{\max}$
- Method proposed performs selective dropping of LO jobs
  - There exists backlog to the HI jobs, from higher priority
  - HI jobs contribute to Pr(S → HI)
  - Dropping LO jobs reduces the backlog



Method of dropping LO jobs

- Probabilistic backlog always exists to the jobs in pRTS
- Backlog passing forms a chain



Ensures an Improvement
Because backlog=0

- Aim is to cut this chain of backlog
  - Complex to ensure the best point
- Drop overlapping jobs

Open Problems for Discussion

- On the use of pWCRT
- Using said method to reduce the probability $P(S \rightarrow HI)$
- Sequential thinking of the approach
  - Dropping LO jobs to reduce probability of entering HI mode will require them to be dropped always
- Probabilistic models provided a global picture but difficult to obtain deterministic answers

THANK YOU

Jasdeep Singh, Zhishan Guo, Luca Santinelli, Guillaume Infantes, David Doose, Julien Brunel

ONERA

THE FRENCH AEROSPACE LAB

retour sur innovation