Non Preemptive Scheduling of Periodic Mixed Criticality Real-Time Systems

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Outline

- Real-time systems
- Probabilistic Real-time systems
- Mixed criticality systems
- Graph and Tree model
- Schedule

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- Worst Case Evaluation

Real-Time applications

- System of tasks to be executed on processors with resources
- Require real-world timing guarantees
- Done through scheduling: Arrange task execution in time
- Scheduling uses task WCET
- Real execution time is **Rarely** equal to WCET

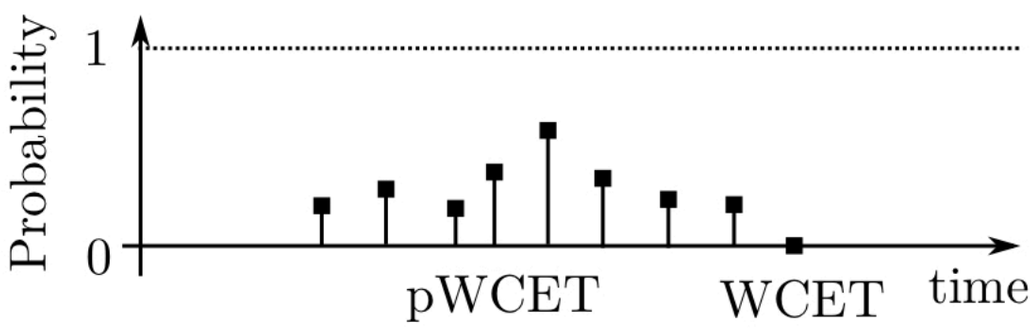
Probabilistic R/T systems

- Practically, execution time is rarely equal to WCET

- Instead of WCET => pWCET (probabilistic worst case execution time)

- pWCET: worst case probability distribution of various possible execution times

- pWCET is assumed given



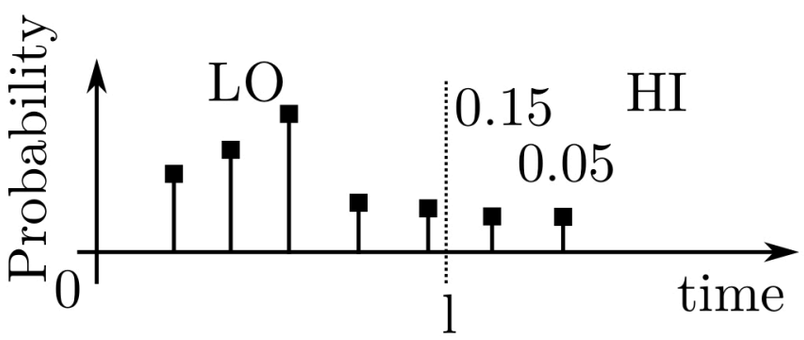
Probabilistic quantification of pessimism in WCET !

Mixed Criticality Systems

- MC Systems: Tasks with different criticalities
- Each criticality corresponds to system criticality
- Task takes more time than ‘expected’=> system HI mode
- Lower and Upper WCET
- System HI mode => All LO tasks are dropped; schedulability of HI ensured
- Model represents clear line between processor demands

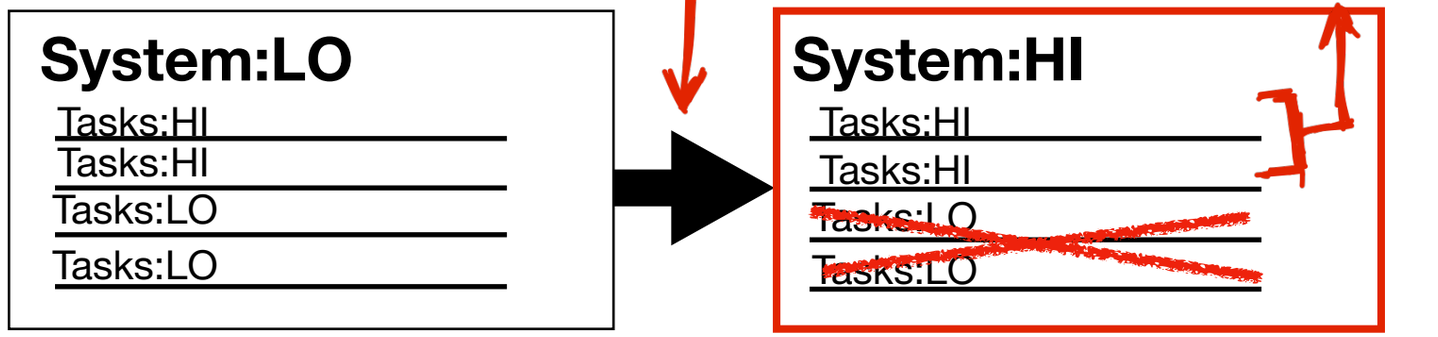
Deterministic adjustment of pessimism in WCET !

MC from PWCET



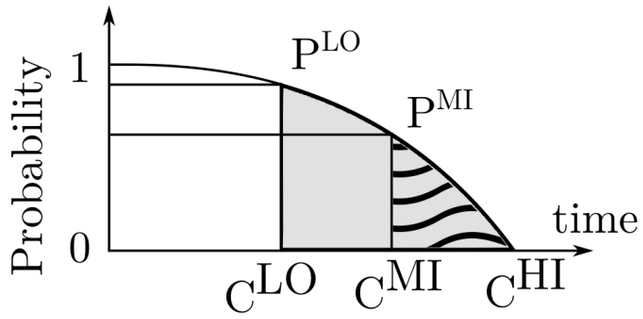
If one HI task takes longer than “usual”

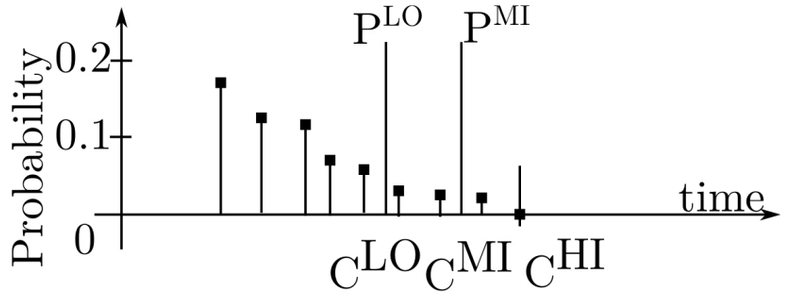
More time to execute

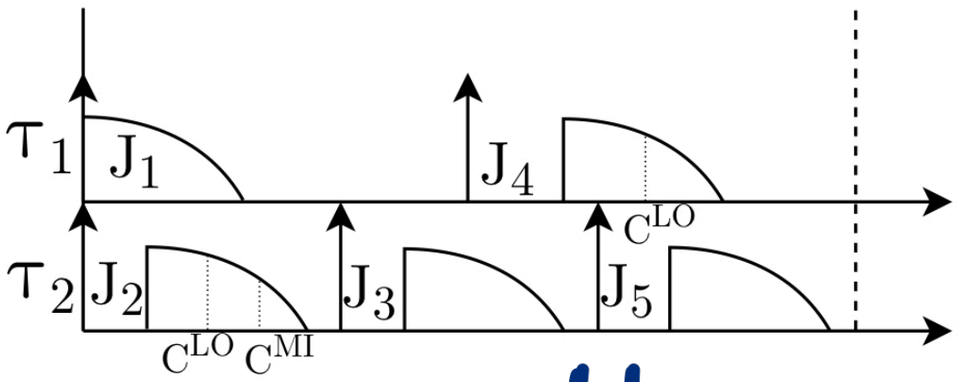


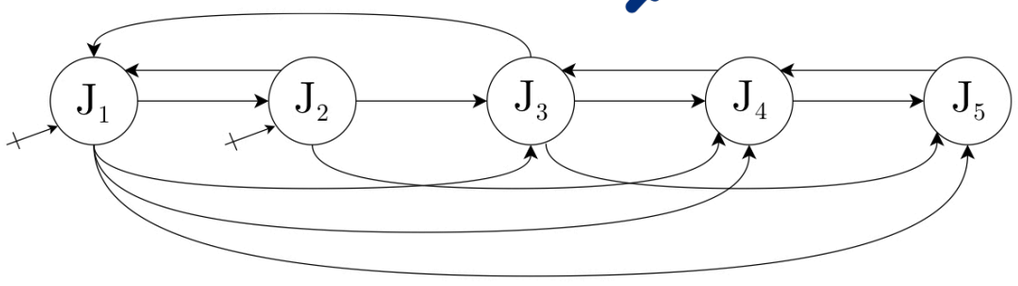
Graph and Tree Model

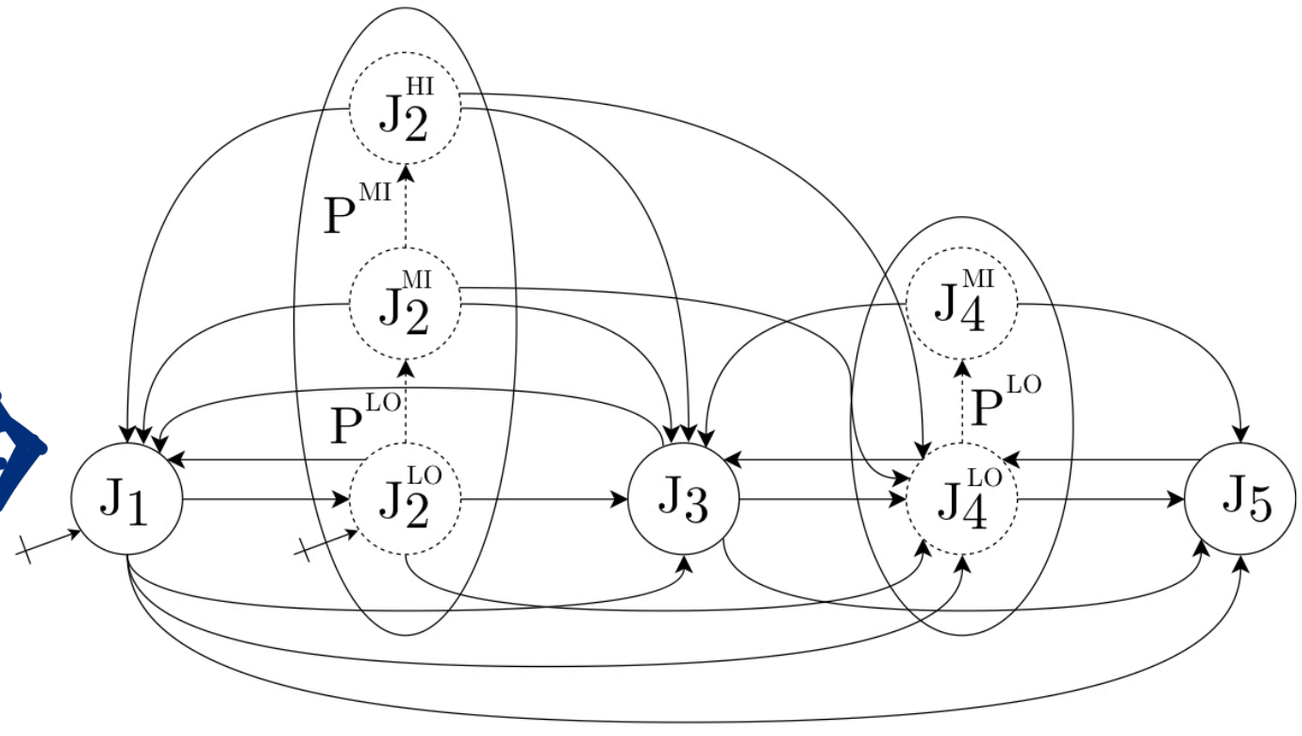
- Mix of tasks with three level criticality
- Each has a probability





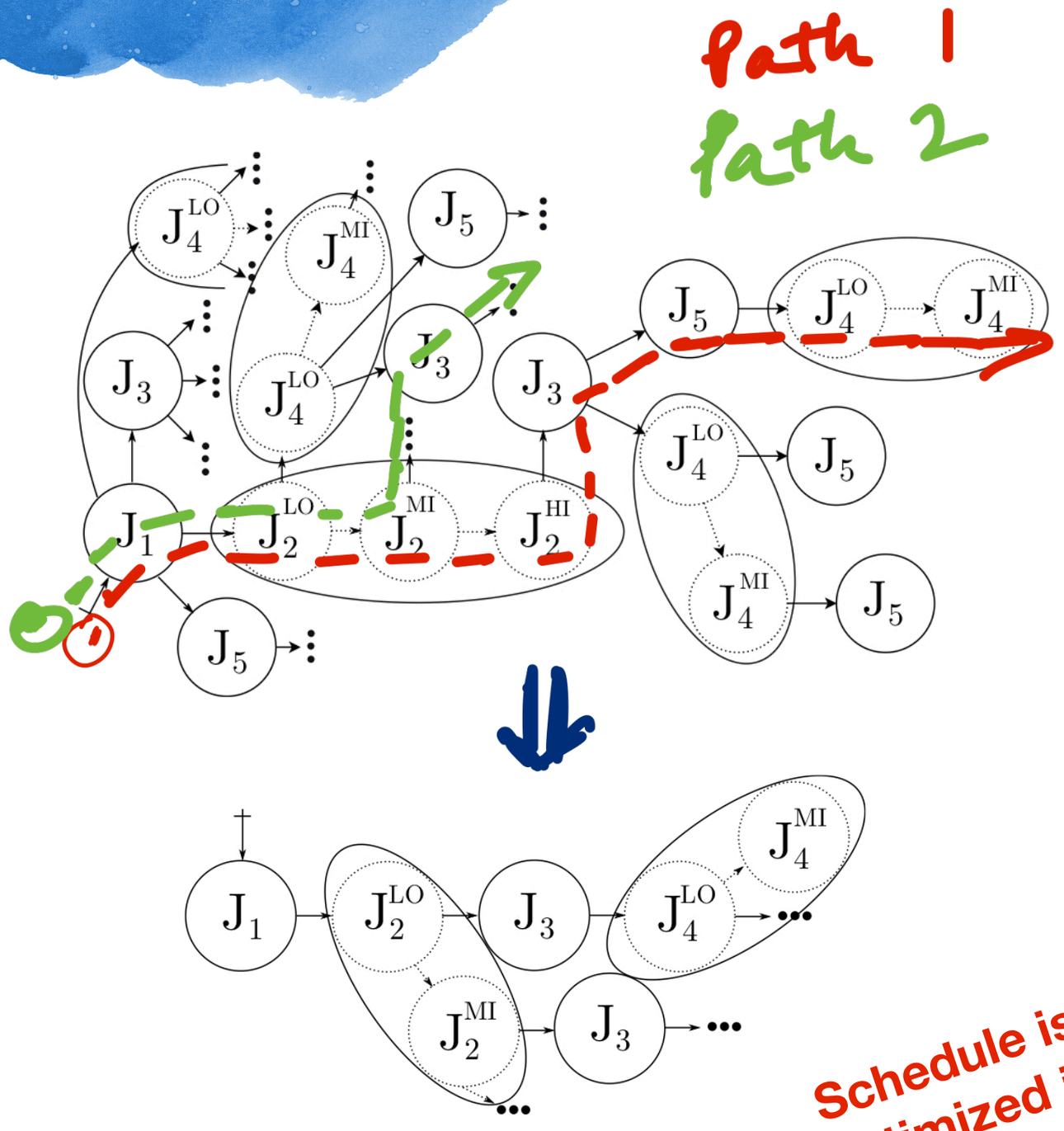






The Schedule

- **Graph -> Tree**
- Available paths: all jobs
- Valid paths: no job misses deadline (evaluate response time)
- Dangerous path: no job misses deadline in higher criticalities
- Schedule: Optimize (Tree minus non-valid and dangerous paths)
- Optimize: Allowing maximum jobs to execute, independent of job entering high criticality



Schedule is optimized in resource usage !

The Schedule

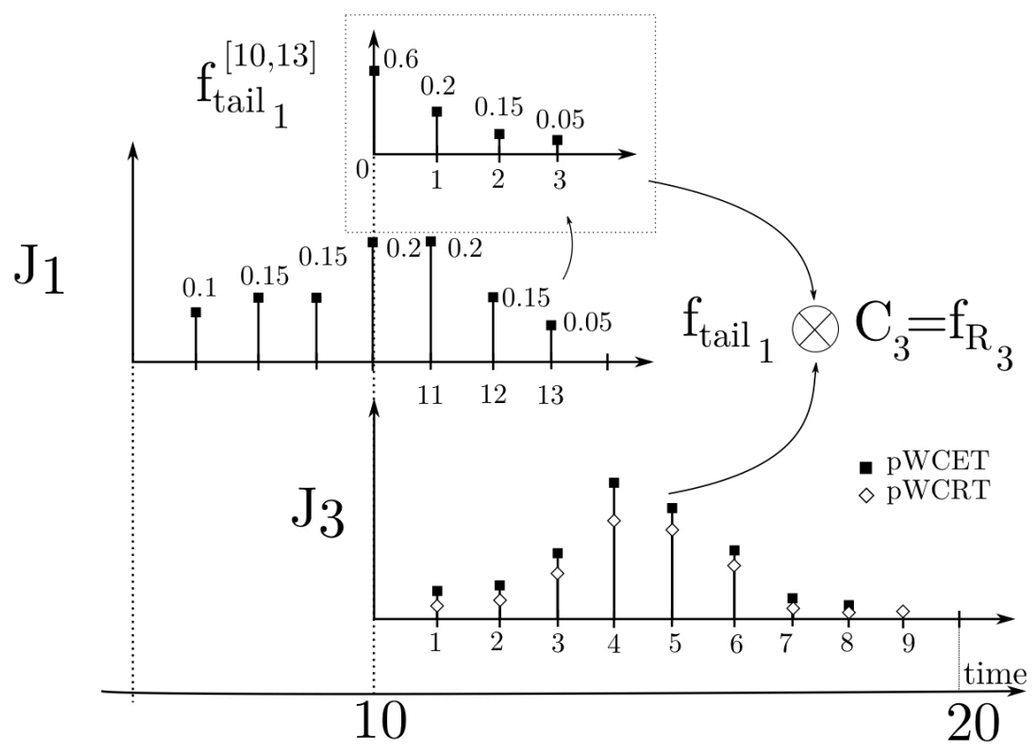
- No System-wide mode switch
- Ensured that no job misses deadline, in any criticality
- Schedule adjusts if job enters high criticality, drops only necessary ones, at lower criticalities, maximum utilization
- Schedule is a tree and knows which branch to take at which event
- Complexity is reduced by checking for deadline miss while tree construction
- Quantify the probability of system entering higher criticalities (we can only quantify)

Evaluation: Response Time

- Convolution has hidden assumption: task/jobs arrive at same time

- Convolution safe but pessimistic

- We propose:



Now Response time gives the probability of task entering HI ! NOT WCET

Propositions for Mixed Criticality

- **Response time for MC**: System HI mode is a run-time information

- **Probability and Schedule:** Probability comes into play, schedule can depend on the probability

- **Schedule for optimal Probability**: Probability from response time now depends on schedule

- **Be prepared for worst case**: execution scenarios upper bounded, schedule adapts for system entering higher mode; **Previous model to upper bound**

Thank you !