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
• 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

MC from PWCET

If one HI task takes longer than “usual”

Deterministic adjustment of pessimism in WCET!
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!