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Industrial Challenge

ANALYSIS AND OPTIMIZATION OF REAL-TIME APPLICATIONS RUNNING ON HETEROGENEOUS HARDWARE

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Challenge

- Analysis of performance bounds (Response Time and WCET Analysis)
- Optimization:
  - Data-flow analysis
  - Scheduling
  - Resource mapping
  - Shared resource interference

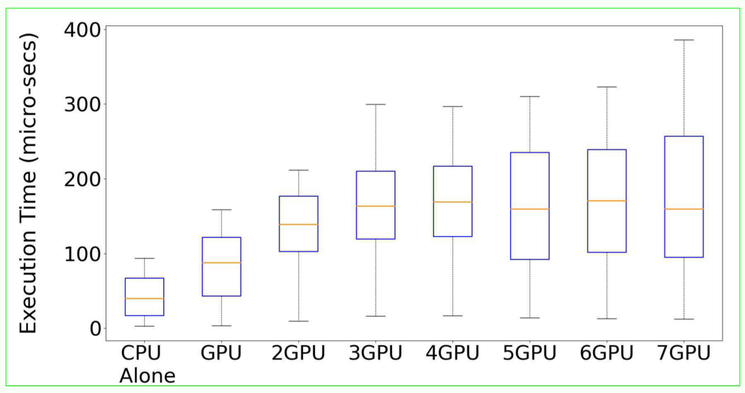
Early Stage proposal

Methodology based on two main aspects:

- Partition scheduling with strong temporal and spatial isolation.
- Modeling, schedulability analysis and optimization for distributed multipath end-to-end flows (DAGs).

Memory Interference

- WCET has a strong dependency on memory interference from CPUs-GPUs.
- Difficult to obtain precise measures of WCET values (interference may lead to very high upper bound of WCETs).
- WCET increases by a factor of 4 and the variability also widens.



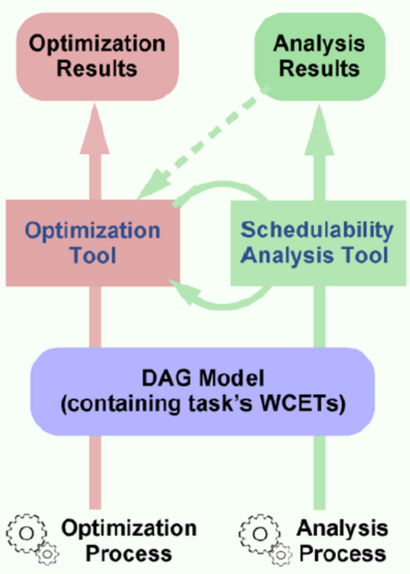
Impact of GPU on the CPU execution time on a Jetson AGX Xavier

MAST

- Modeling and analysis tool for Real-Time systems. [1][2]
- Aligned with OMG MARTE standard.
- MAST model supports offset-based response time analysis techniques.
- Available at: https://mast.unican.es/

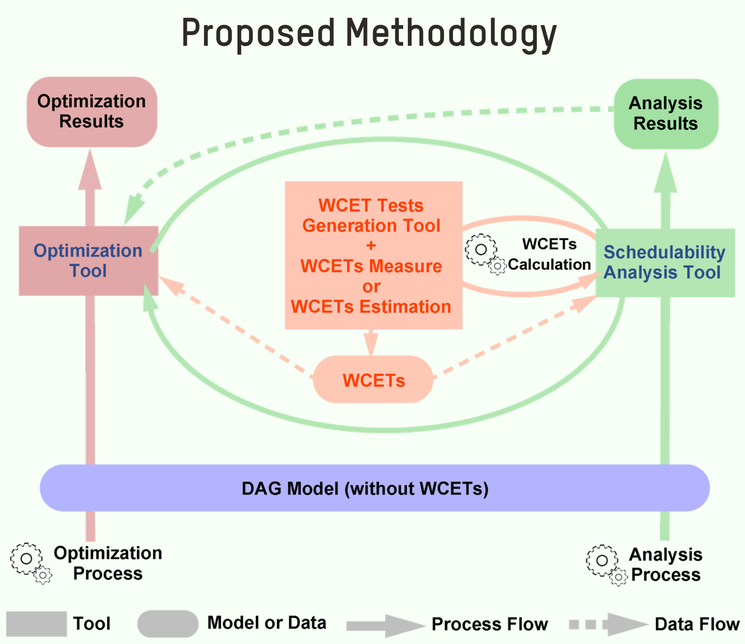
Analysis and Optimization Methodology

Traditional Methodology



WCETs are assumed known and constant

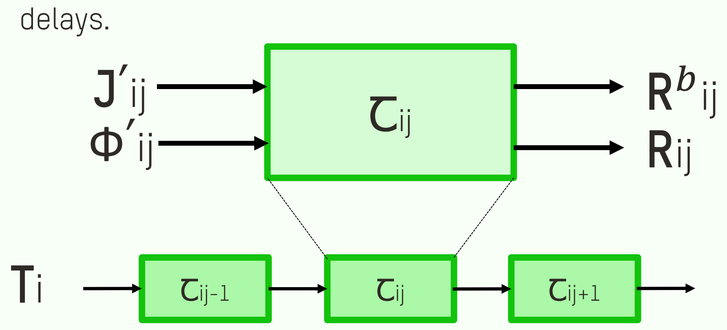
Proposed Methodology



WCETs must be obtained as part of the analysis and optimization process

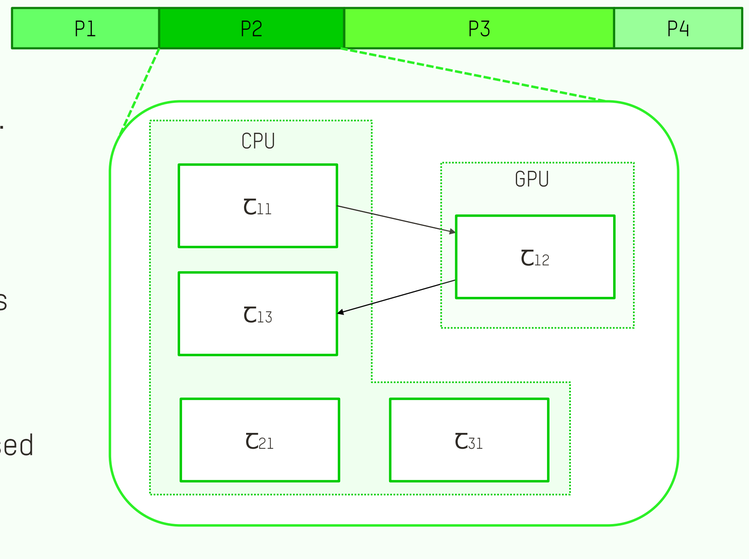
Task Model

- System composed by e2e flows, which can be activated by either periodic or sporadic events with a minimum interarrival time.
- Each task in e2e flow is activated by a minimum and a maximum release time offset Φ_{ij}.
- Equivalent jitters and offsets take into account the information from previous task in the e2e flow. [3]
- GPU operations can be modeled as activities, offsets or delays.



Model for Partitioned System

- A primary scheduler schedules temporal partitions located in different CPUs in a cyclic manner.
- A secondary FP scheduler allows optimizing RT Tasks groups.
- Assigned time window influences the accuracy of the analysis
- Assigned time window enables controlling the interference caused by GPU tasks.



Response Time Analysis

The proposed methodology is based on previous existing analysis techniques (available in MAST).

- Offset-based analysis algorithms [4][5].
- Offset-based analysis with precedence relations among tasks presented in [6].
- Offset-based analysis for hierarchical scheduling: linear [7] and multipath [8].

These techniques directly support e2e flows with GPU tasks:

- GPU is considered as grey box: Response times are estimated by any available technique, or they are directly measured and then integrated in the model as delays.
- The analysis with precedence relations [4] can only be applied to linear e2e flows while the other offset-based techniques [3][6] work also for DAGs [1].

References

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[3] J.M. Rivas, J. J. Gutiérrez, J.C. Palencia, and M. González Harbour. "Schedulability Analysis and Optimization of Heterogeneous EDF and FP Distributed Real-Time Systems," Proc. of the 23th Euromicro Conference on Real-Time Systems, Porto (Portugal), July 2011.
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