1. Motivation

- Variations in WCET/WCRT due to cache hit/miss.
- Low priority tasks may need to account for cache evictions due to execution of high priority tasks (CRPD).
- State-of-the-art approaches for CRPD calculation only consider the impact of high priority tasks on memory demand of low priority ones.
- However, state-of-the-art does not consider the effect of low priority tasks on the memory demand of high priority tasks.

2. Contributions

- Preempting task can have content persisting in the cache between successive job executions.
- We introduce the concept of cache persistence in the context of WCRT analysis.
- We model the effect of Persistent Cache Blocks (PCBs) on the memory demand of preempting tasks.
- We account for the number of PCBs that can be evicted, i.e., Cache Persistence Reload Overhead (CPRO).

3. Example

4. Calculating CPRO and CPRO

4.1 ECB-Union and UCB-union Multi-set Approaches

- CRPD is usually calculated using Evicting Cache blocks (ECBs) of the preempting task and Useful Cache Blocks (UCBs) of the preempted task.
- ECB-union approach considers ECBs of the preempting task $T_i$ as well as all tasks in $\text{hep}(i)$.
- UCBs of all tasks in $\text{aff}(i)$, i.e., $\text{hep}(i)$ and $\text{lp}(i)$ can be evicted by $T_i$.

$$\text{CRPD}_{ij} = \max_{vk \in \text{aff}(j)} \left(\left(\text{UCB}_{vk} \cap \left(\bigvee V \text{ECB}_{jl}\right)\right) \cup \text{MD}_{jl}\right)$$

- UCB-union multi-set approach improves upon the ECB-union approach by additionally taking into account the actual number of jobs released by $T_i$ and all tasks in $\text{aff}(i)$.

4.2 A Union approach for CPRO calculation

- Persistent Cache blocks (PCBs) of a preempting task $T_i$ executing during the response time of $T_j$ can be evicted due to executions of tasks in $\text{hep}(i)$.
- Similar formulation to ECB-union approach but considering PCBs of the preempting task $T_i$ instead of UCBs.
- PCBs of all tasks in $\text{hep}(i)$ can evict PCBs of $T_j$.

$$\text{CPR}_{ij} = \text{PCB}_{ij} \cap \left(\bigvee \text{ECB}_{jk}\right) \cup \text{MD}_{jk}$$

5. Improved WCRT Analysis

- Existing WCRT analysis for FPPS in the state-of-the-art only account for CRPDs.
- Our proposed WCRT analysis incorporates both CRPDs and CPRO, resulting in less pessimistic WCRT bounds.

$$R_i(t) = P_i + MD_i + \sum_{j \in \text{hep}(i)} P_j + \sum_{j \in \text{hep}(i)} \left[ \frac{T_j}{T_i} - 1 \right] + \text{PCB}_{ij} \cup \text{MD}_{ij} \cup \text{CPR}_{ij}$$

- Accounting for evictions of PCBs of $T_i$.
- Accounting for evictions of UCBs of $T_i$.
- Accounting for evictions of PCBs of $T_j$.

5.1 Preliminary Results

- Initial results show that WCRT analysis with CPRO dominates the ECB-union and UCB-union multi-set approaches.

6. Future Work

- In future, we plan to extend the analysis to set associative and data caches.
- Provide a less pessimistic multi-set approach to calculate CPRO.
- A combined approach to calculate both CRPD and CPRO.
- Extensive experimental evaluation using available benchmarks by varying different system parameters.

References