1. Motivation

- Caches produce time variability in task WCET/WCRT.
- Low priority tasks may need to account for cache evictions due to preemptions by the high priority tasks (CRPD).
- Memory demand of the preemptions tasks depends on the execution of all other tasks (CPRO).
- Independent calculation of CRPD and CPRO may lead to overestimations in WCET/WCRT of tasks.

2. Contributions

- Mutual dependency between CRPD and CPRO may lead to double accounting of same cache block evictions.
- We identify the cache blocks whose evictions can be accounted twice.
- We integrate the calculation of CRPD and CPRO to remove the pessimism in the existing analysis.
- The improved analysis ensures that the same cache block evictions are accounted only once either in CRPD or CPRO.

3. Example

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- Actual MO(R_J) = CRPD(R_J) + CPRO(R_J) = 12

SoA Memory Overhead (MO) Calculation

- Using UCB-union Approach, CRPD(R_J) = 3 x (CRPD_{3,1} + CRPD_{3,2}) = 12
- Using CPRO-Union Approach, CPRO(R_J) = 2 x (CPRO_{2,3} + CPRO_{1,3}) = 8
- MO(R_J) = 12 + 8 = 20 → Overestimation!

4. Existing Approaches for CRPD and CPRO Calculation

4.1 UCB-union Approach

- Accounts for the eviction of Useful Cache Blocks (UCBs) of the preempted task \( T_i \) due to preemptions by the high priority task \( T_j \).
- UCB-union approach considers that the UCBs of all intermediate priority tasks in \( aff(i,j) = hp(i) \cap ip(j) \) can be evicted by \( T_j \).
- UCBs of the preempting task \( T_j \) upper bound the number of UCBs of all tasks in \( aff(i,j) \) it can evict:

\[
CRPD_{i,j} = \{ UCB \cap (ECB_j) \ |
\forall k \in aff(i,j) \}
\]

4.2 CPRO-Union Approach

- Accounts for the eviction of Persistent Cache blocks (PCBs) of the preempting task \( T_j \) executing during the response time of \( T_i \).
- PCBs of \( T_j \) can be evicted due to executions of tasks in \( hp(l) \).
- CPRO-union approach considers that the PCBs of all tasks in \( hp(l) \) can evict the PCBs of \( T_j \):

\[
CPRO_{i,l} = \{ PCB \cap (ECB_j) \ |
\forall k \in hp(l) \}
\]

5. Proposed Solution

5.1 Identifying Double Accounting Cache Blocks

5.2 CRPO-aware CPRO-Union Approach

- Only tasks in \( hp(l) \), can contribute both to \( CPRO_{i,l} \) and \( CRPD_{i,l} \):

\[
CPRO_{i,l} = \{ PCB \cap (ECB_j) \ |
\forall k \in hp(l) \}
\]

\[
CPRO_{i,l}^{imp} = \{ PCB \cap (ECB_j) \ | \forall k \in aff(i,l) \}
\leftrightarrow \{ ECB \cap (UCB_j) \ |
\forall l \in hp(l) \}
\]

Only contribute to CRPD, thus is the same as for the CPRO-Union approach

UCBs whose evictions are accounted for in the CRPD are not considered in CPRO

6. Future Work

- Presented approach is applicable only if the CRPDs are calculated using the UCB-union approach. In future works, we plan to extend the analysis to less pessimistic multi-set approaches used for CRPD and CPRO calculations.
- Possibility of having a single term in the WCRT analysis that accounts for both CRPD and CPRO.
- Extensive experimental evaluation using available benchmarks by varying different system parameters.

References