Mixed-Criticality Systems with Partial Lockdown and Cache Reclamation Upon Mode Change

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The classic Vestal model with mode changes

- In each mode, only asks of a respective criticality or higher execute.

- Different WCET estimates for the same task in different modes.
  - By techniques with corresponding confidence levels.

- When a task overruns its WCET estimate for that mode, a mode change occurs (e.g., L → H, with two modes).

- Essentially, the processor resources originally for L-tasks are repurposed for the H-tasks upon mode change.

L-mode

τ_1 τ_2 τ_3
τ_4 τ_5 τ_6

processing capacity

H-mode

τ_1 τ_2 τ_3

processing capacity
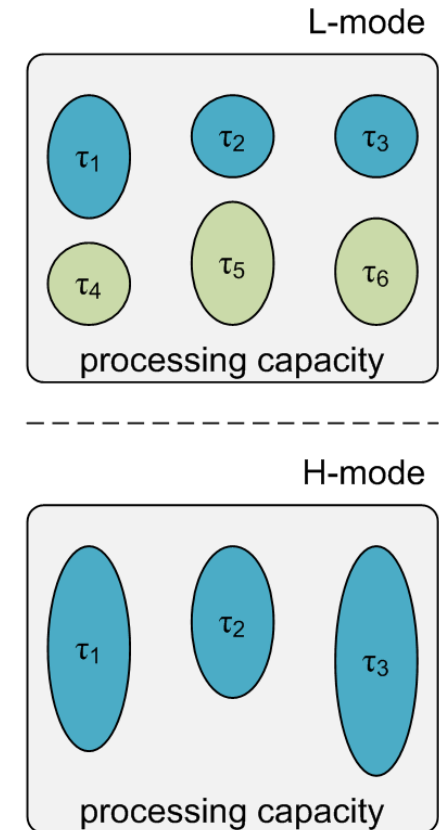
Idea: Reclaim more kinds of resources at mode change!

- Explored in our paper at the main track

- Resource targeted: the shared last-level cache of a multicore.

- The cache is partitioned to the tasks

- At mode change the cache partitions of the L-tasks are reclaimed and given to the H-tasks as additional resources.
  - The cache partitions can either be used to lock the hottest pages of the respective task in place (e.g., using Colored Lockdown);
  - Or they can be used dynamically by the task (e.g., under LRU policy).

- This WiP paper considers a more refined arrangement.

Partial Lockdown

- H-tasks:
  - Part of their cache partition is used for locked hot pages.
  - The rest of an H-task's cache partition is used dynamically
- L-tasks:
  - Their partitions are only used dynamically.
- At mode change:
  - The cache reclaimed from the L-tasks is used to enlarge the H-tasks' dynamically used partitions.

Illustration of the arrangement
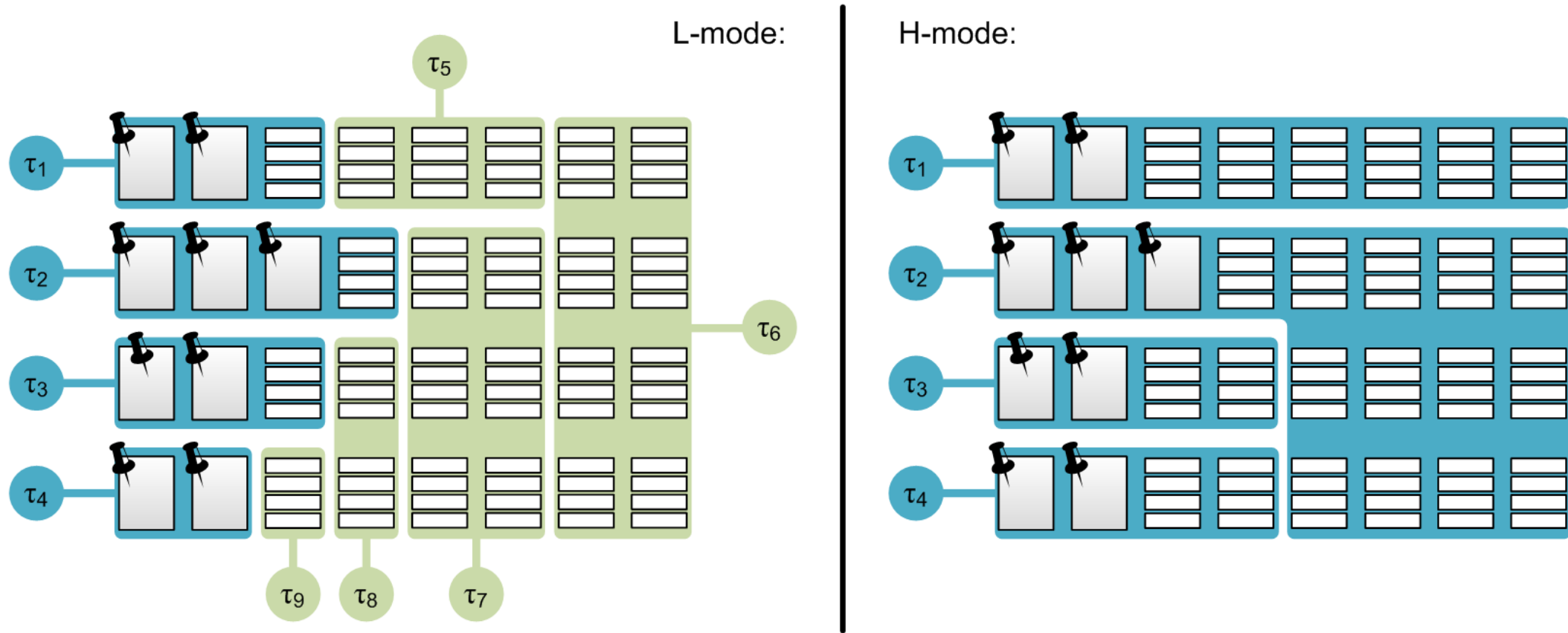
Tradeoffs and challenges

- WCET estimates depend on the mode and cache resources assigned.
  - Tractable and accurate parametric WCET estimation needed.
- How much cache per task to use for locking hot pages and how much to use dynamically?
  - Interesting and complex tradeoffs in terms of derivable WCET estimates, that extend to schedulability analysis.
- Reclaiming only dynamically used cache limits mode change overheads.
  - No unlocking, bringing in new page and locking anew needed.