Allocation of Real-Time Tasks onto Identical Core Platforms under Deferred fixed Preemption-Point Model

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2 Deferred preemption models for single-core processor

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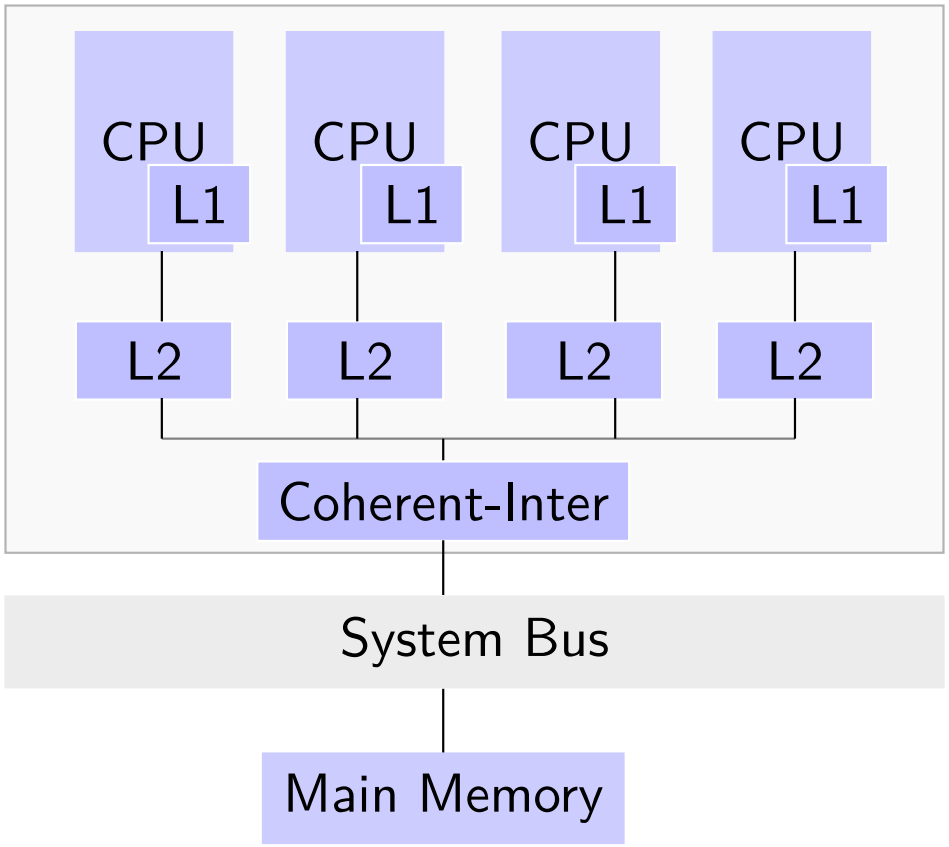

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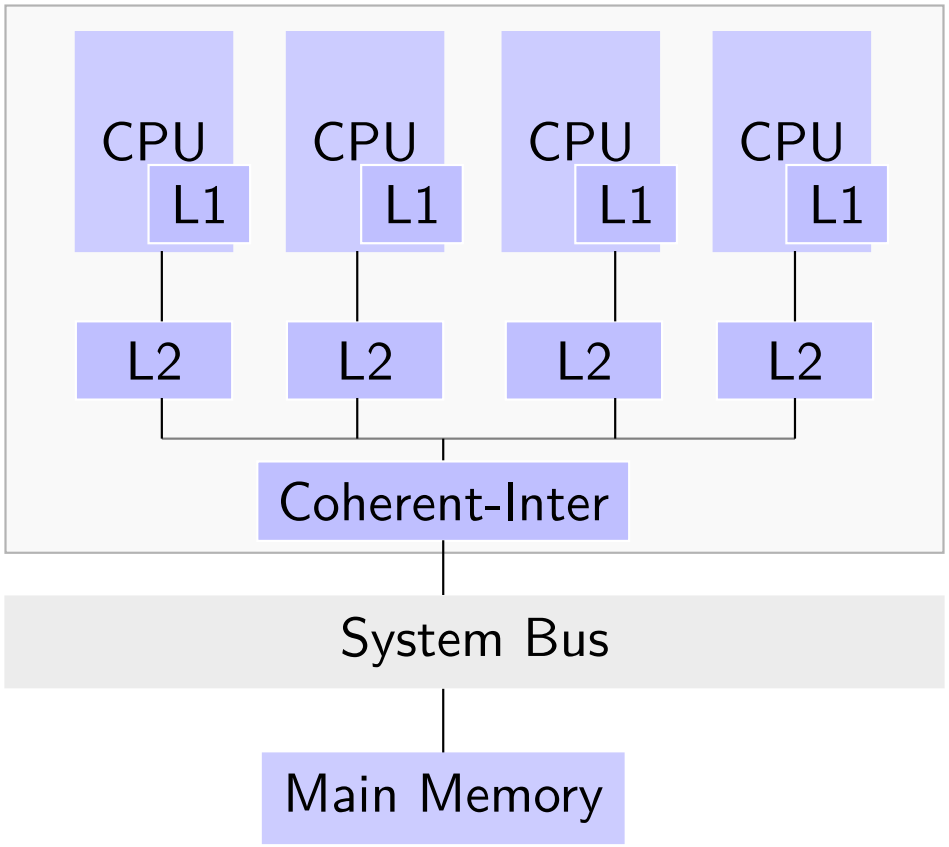

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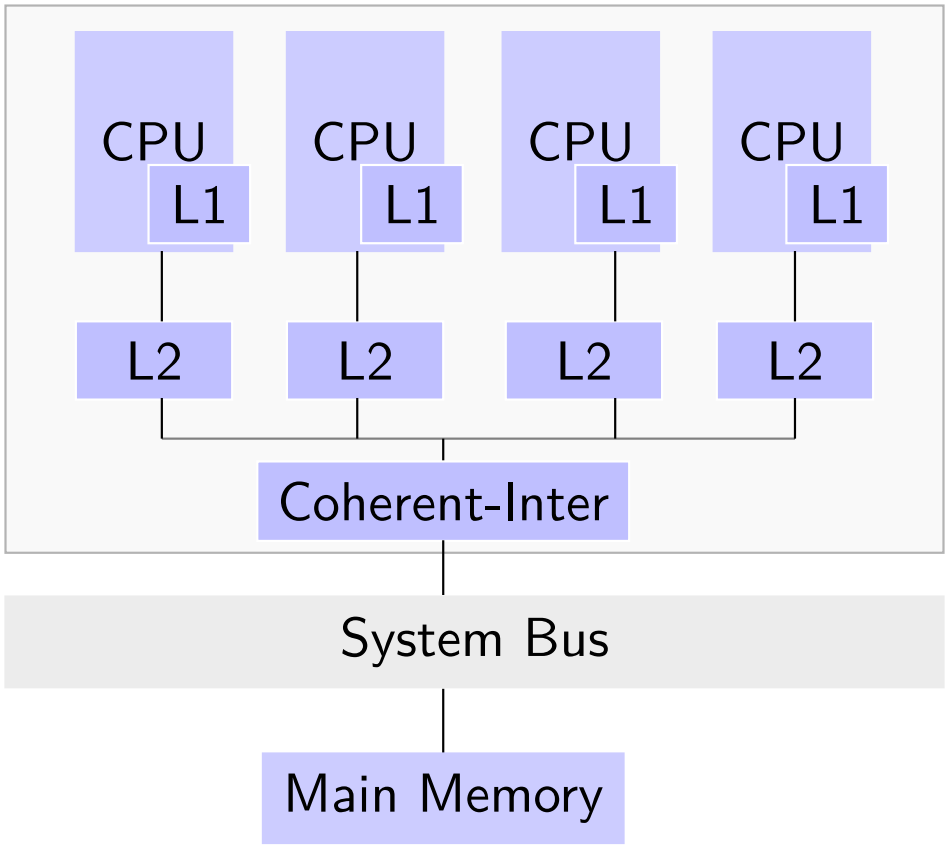

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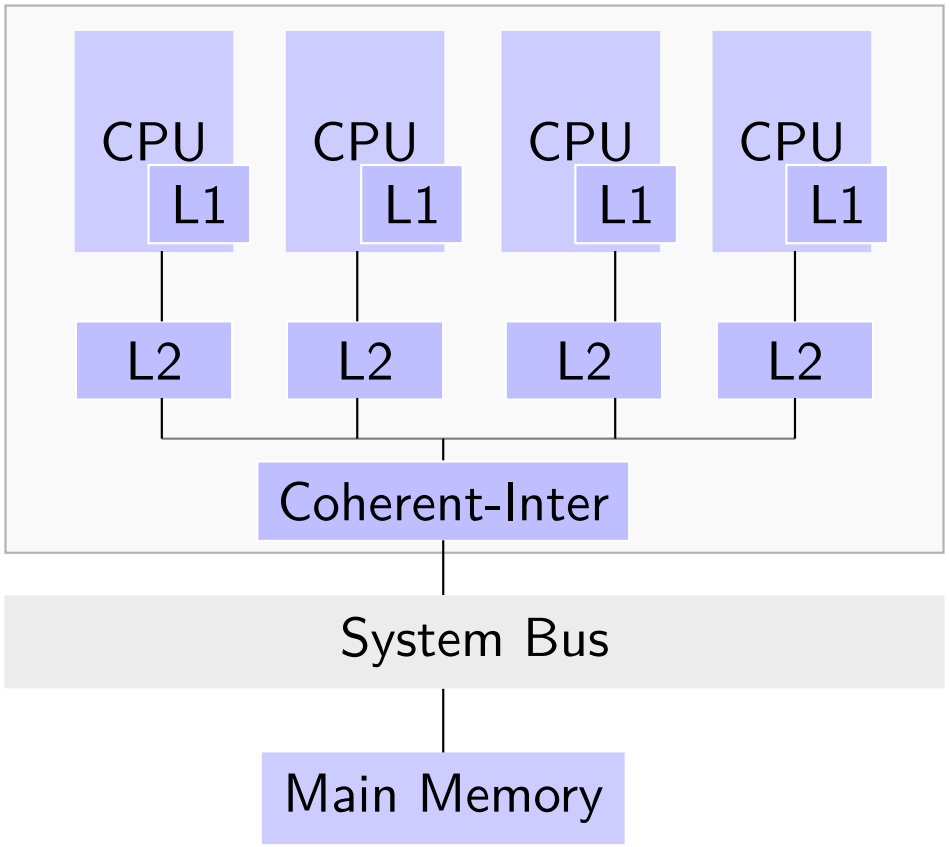

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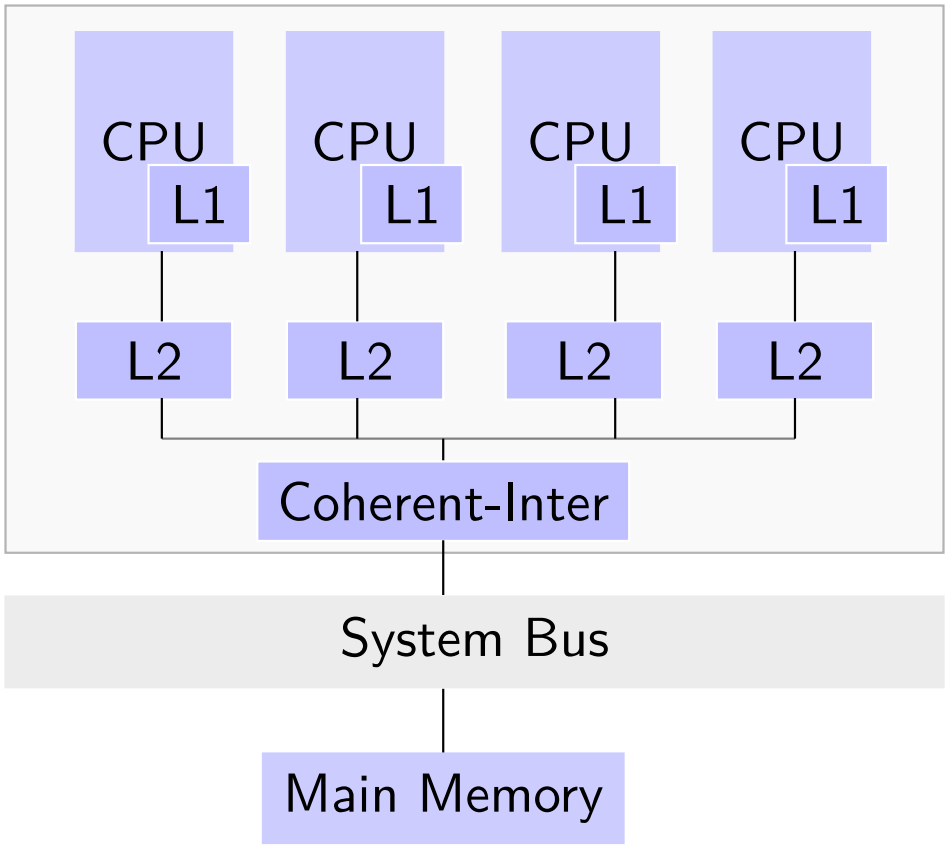

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    - Scheduler cost, Pipeline cost

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- Disabling preemption (non-preemptive scheduling) :

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- Hybrid preemption models : Deferred preemption approach 😉

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- All deadlines must be respected

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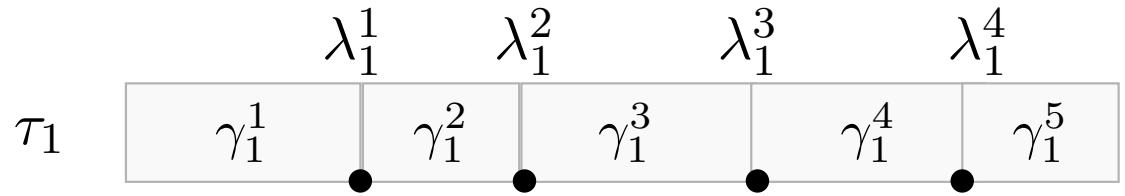
- Each task is divided into a sequence of statically defined non-preemptive chunks separated by np_i pre-defined preemption points



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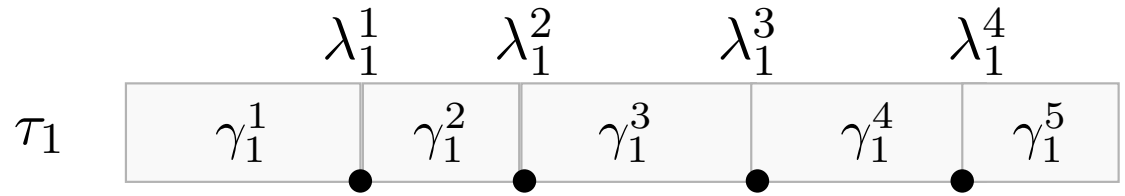

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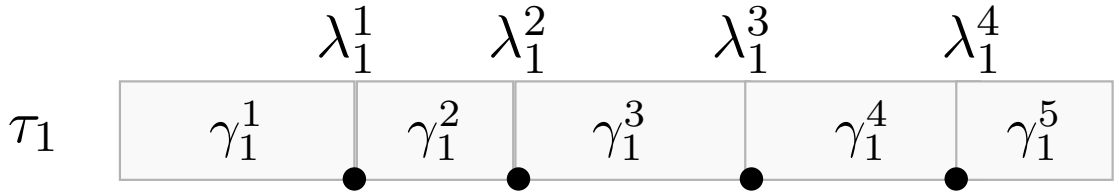

- The task may only be preempted at the pre-defined preemption points λ_i^j
- Advantages :
  - Predict the exact number of preemption
  - Compute tight upper bounds on the preemption cost
  - Obtain less pessimistic WCET bounds for each task

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- Tasks ordered for increasing relative deadlines :

$$SI_i^{EDF} = \min(t - \sum_{j=1}^{n} dbf(\mathcal{T}, t)), \qquad \text{with : } D_i < t \leq D_{i+1}$$

Selection of Effective Preemption points

- Select a subset $\overline{\Lambda}_i$ of preemption points from the pre-defined preemption point set (Marko Bertogna et al, ECRTS'11) :

$$\forall \tau_i \in \mathcal{T}, C(NPR_i^{max}) \leq Q_i$$

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- Include the preemption cost of any **Effective preemption point (EPP)** into *WCET* :

$$C(\tau_i, \overline{\Lambda}_i) = \sum_{j=1}^{np_i+1} C(\gamma_i^j) + \sum_{\lambda \in \overline{\Lambda}_i} C(\tau_i, \lambda) \qquad (1)$$

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Partitioned :

- Each core has its own ready-queue
- Final allocation of tasks onto cores

- Easy to implement : No task migration
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Global :

- One ready-queue shared between all cores
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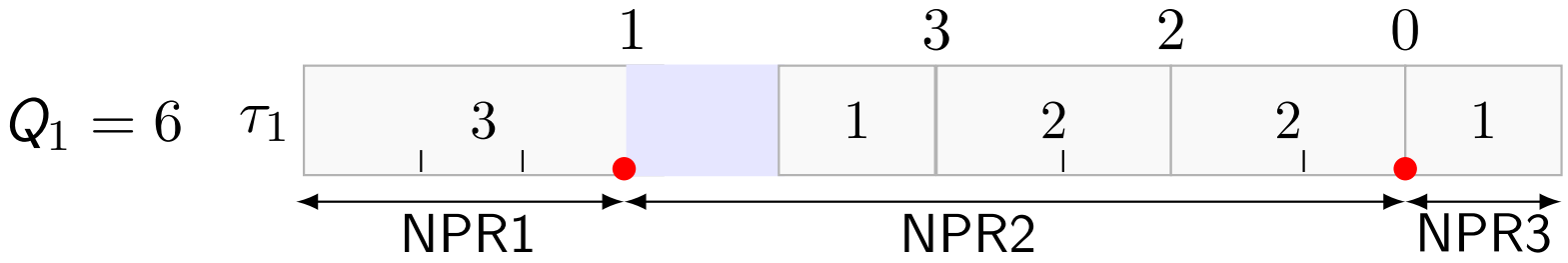

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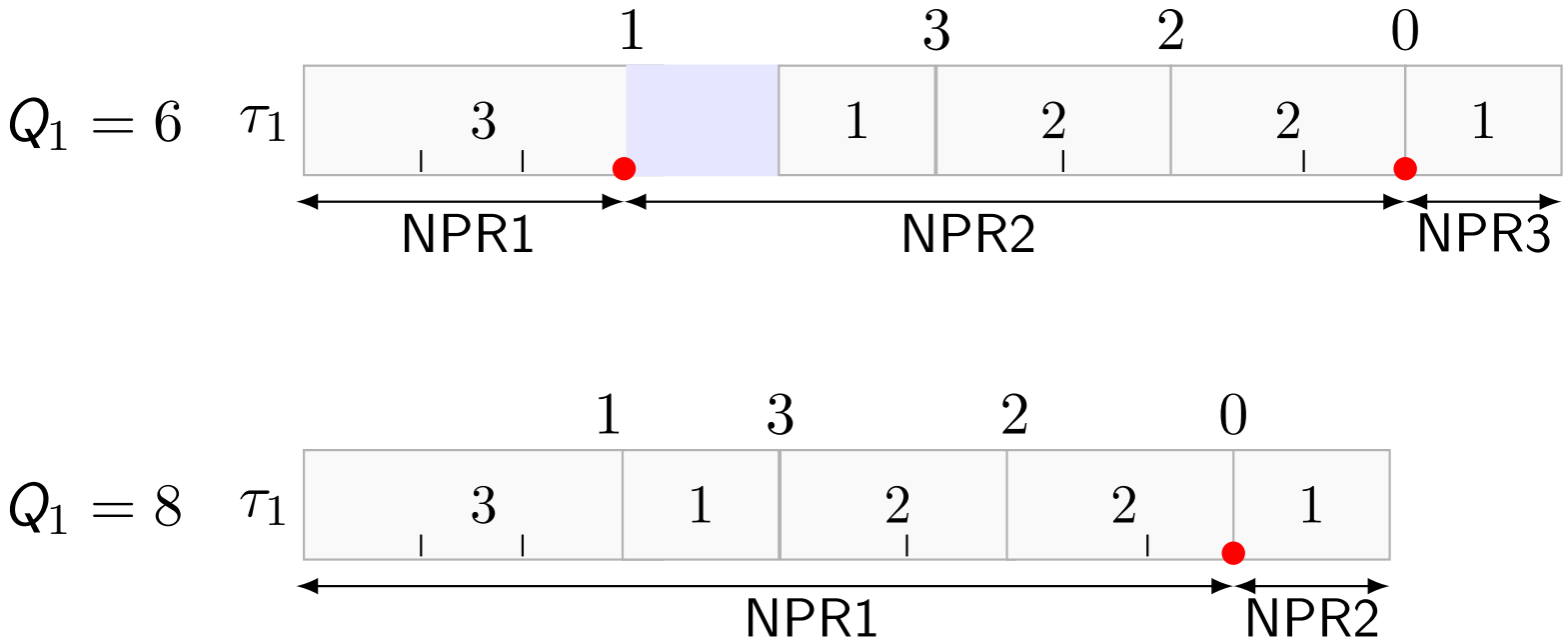

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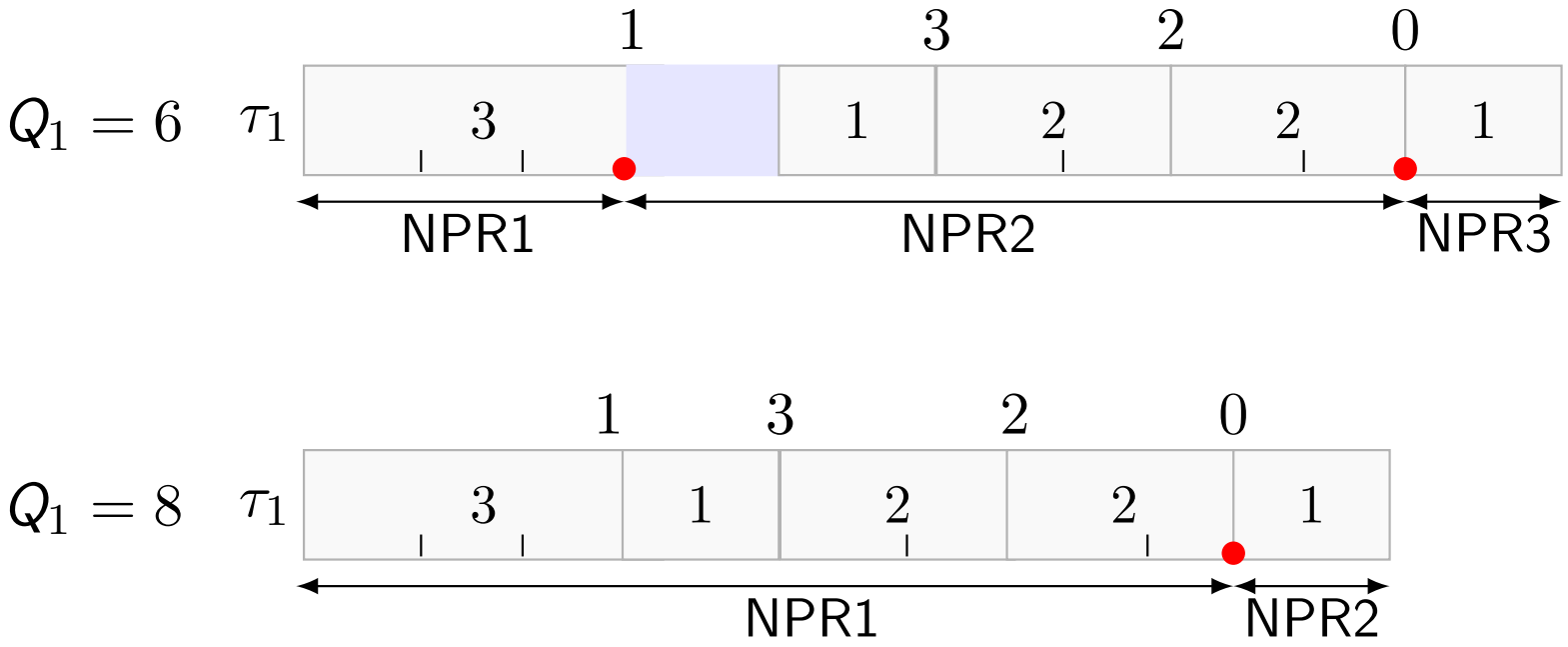

- A more relaxed non-preemptive interval leads to a lower preemption cost (optimality of EPP selection algorithm)

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  - Otherwise,
    - Select the **EPP** only for the studied task τ_i
    - Eliminate all **non schedulable/not optimal** branches/allocations

Example

- Platform with 2 cores and 4 real-time tasks

task	D_i	T_i	Γ_i	Λ_i
τ_1	1413	1500	{212,171,344,66,249}	{ 0,46,78,14,47 }
τ_2	5673	6000	{17,54,490,101,418,74}	{0,14,94,21,74,13}
τ_3	1498	1500	{146,347,136,37,121}	{0,90,32,7,19}
τ_4	1277	1500	{17,31,43,3,24,6}	{ 0,6,8,0,3,0 }

- $\tau_4 > \tau_1 > \tau_3 > \tau_2$

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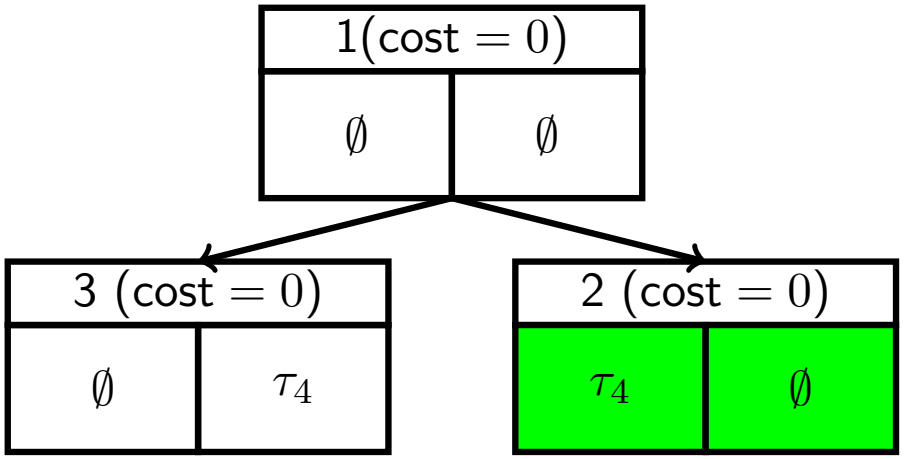

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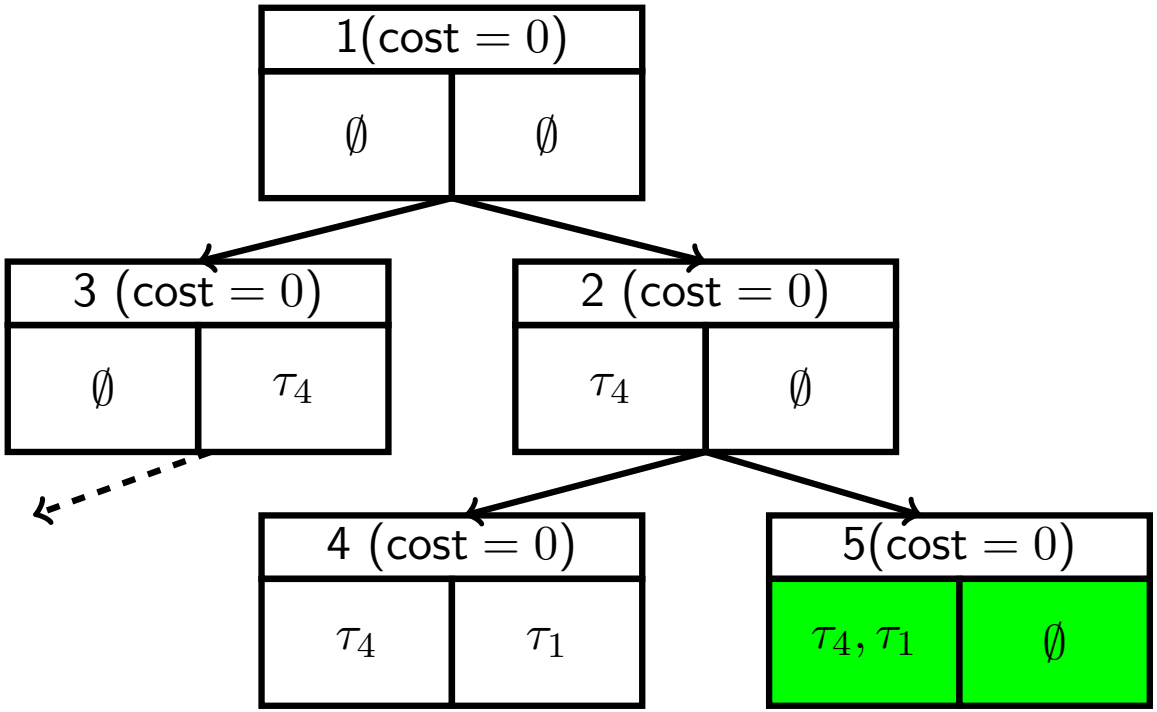
1(cost = 0)
∅
∅
3 (cost = 0)
∅
τ_4
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τ_4
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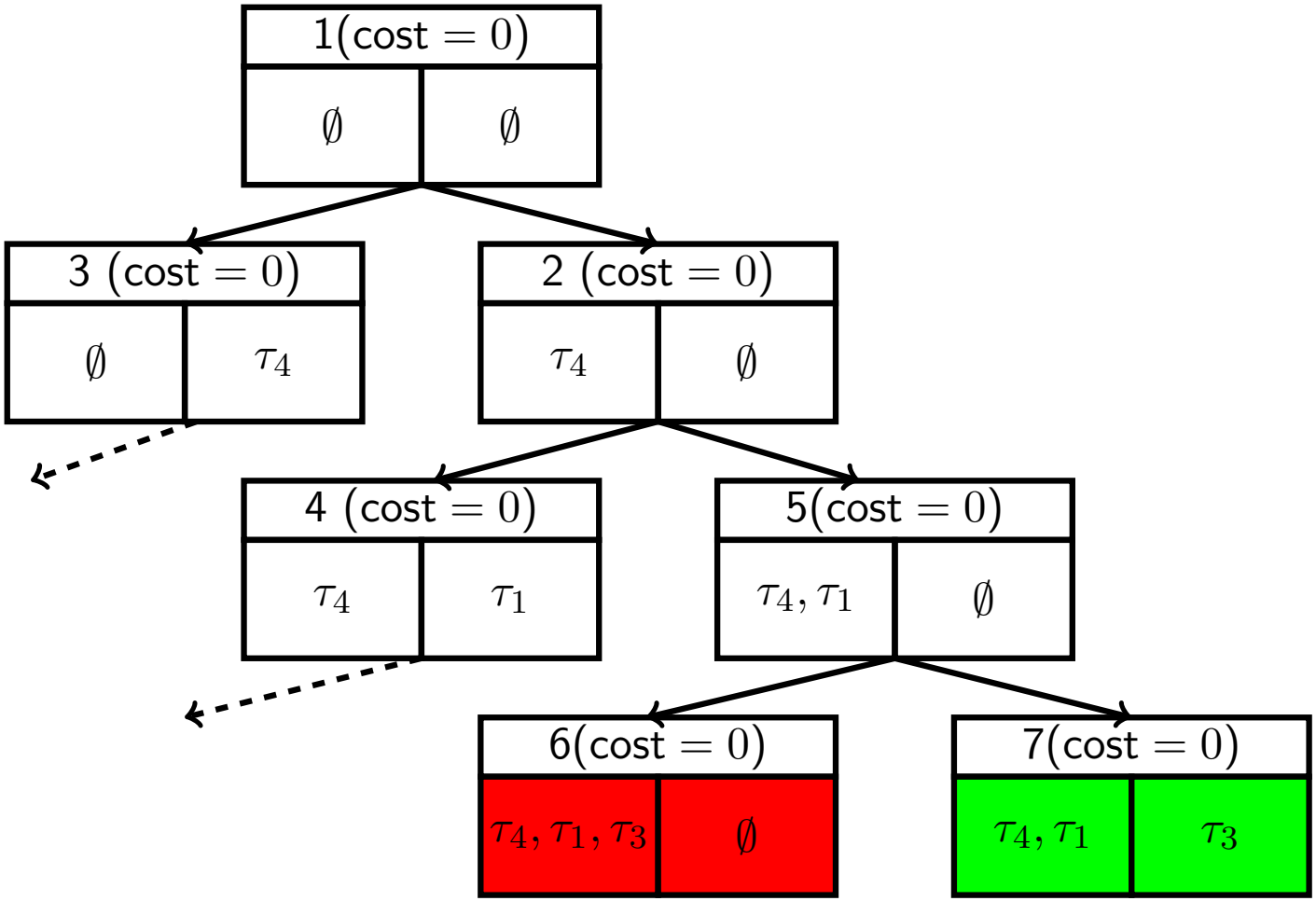
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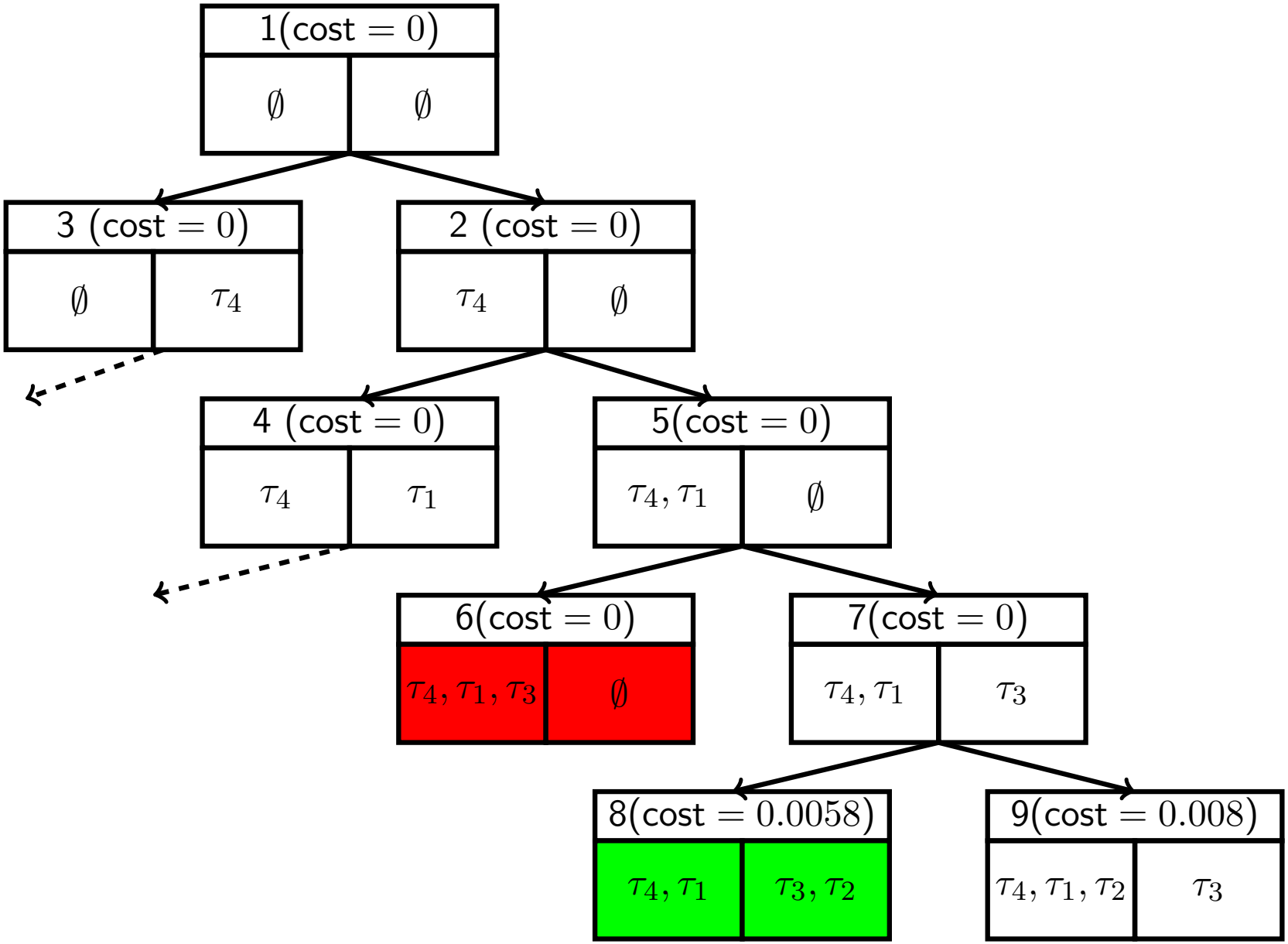
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τ_4, τ_1, τ_3
∅
7(cost = 0)
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τ_3
8(cost = 0.0058)
τ_4, τ_1
τ_3, τ_2
9(cost = 0.008)
τ_4, τ_1, τ_2
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  - The algorithm preserves the optimal solution at each branch level

The optimality of the branch and bound algorithm

- The enumeration algorithm explores all schedulable allocations and selects the optimal one
- The branch and bound algorithm is optimal :
  - Tasks can only be added to cores $\Rightarrow$ **the preemption cost can only increase**
  - All branches $\mathbf{S}(\cdot)$ generated by the algorithm having a preemption cost **greater** than the **lower** bound are **dominated** by the best known solution
  - The algorithm preserves the optimal solution at each branch level
  - The algorithm has an exponential execution time in the worst case

Allocation heuristics

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In all the graphs :

- 3 identical processing units

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  - 8 to 15 basic blocs
  - The block preemption cost is calculated using a random percentage between 0.1 and 0.2 of the block utilization
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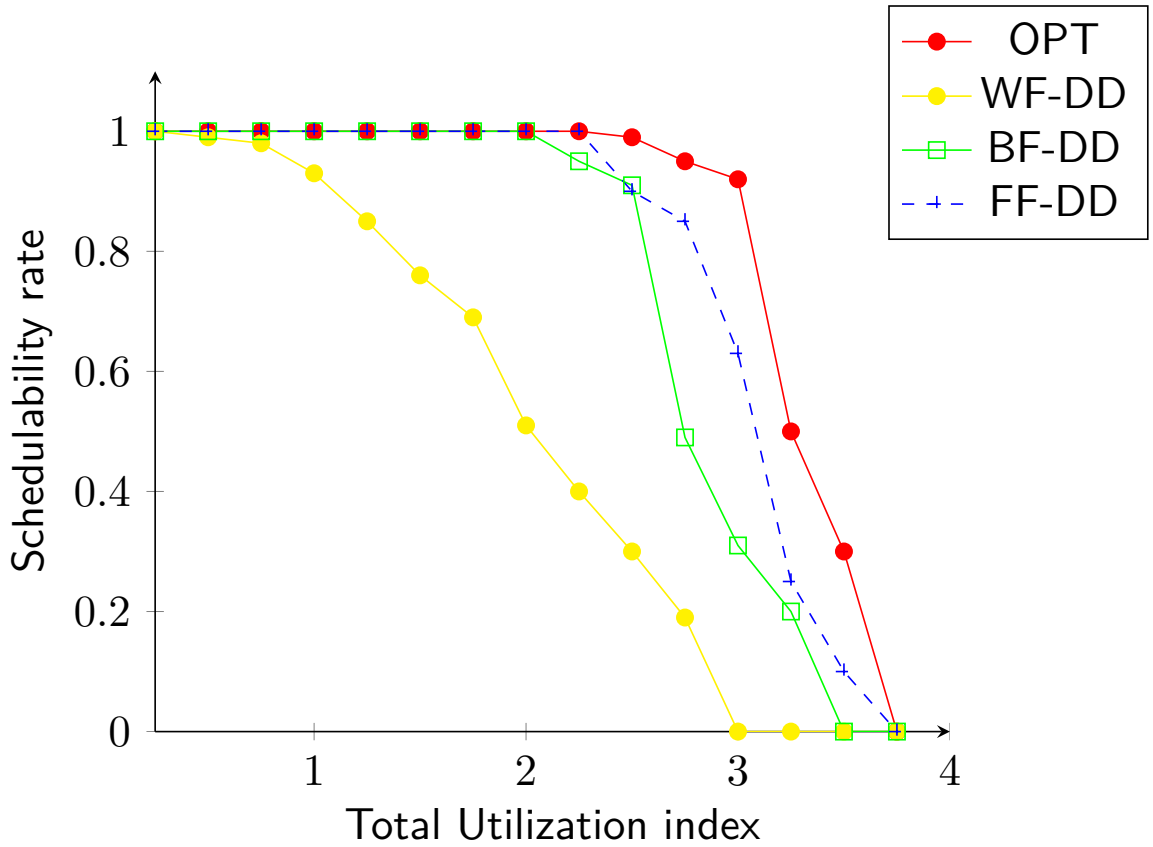
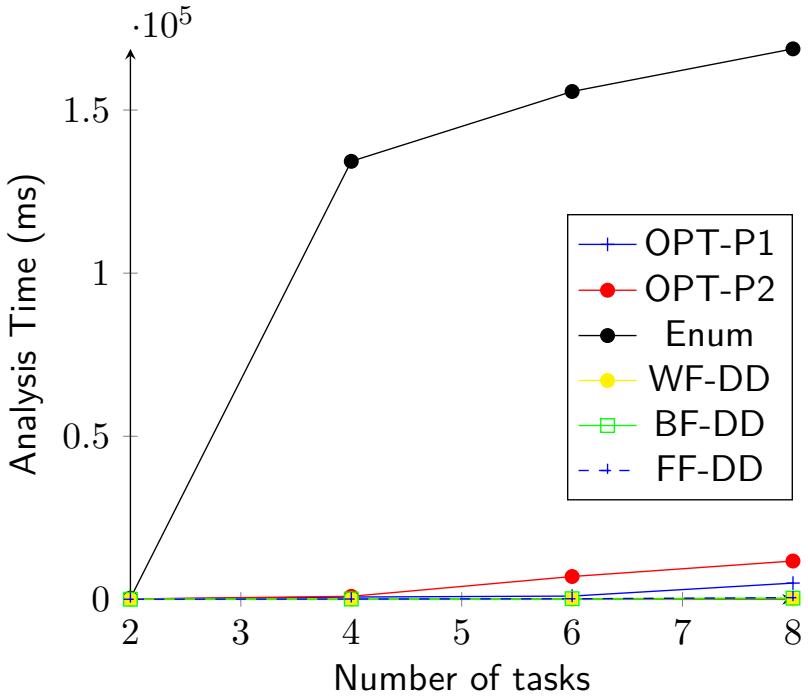
Schedulability for optimal solutions VS bin-packing heuristics

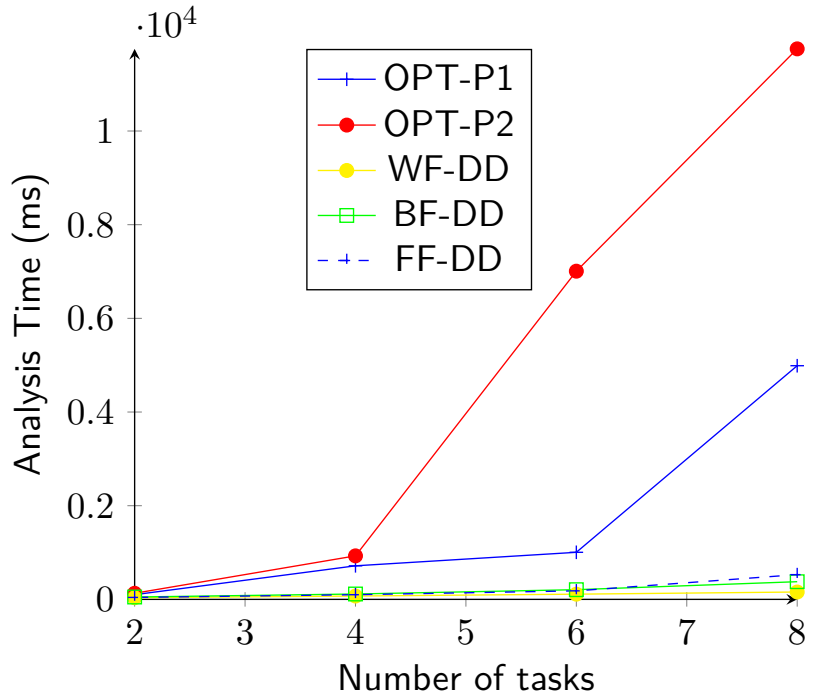
- Tasks are sorted according to their relative **deadlines** in **non-decreasing** order



The analysis time as a function of number of tasks

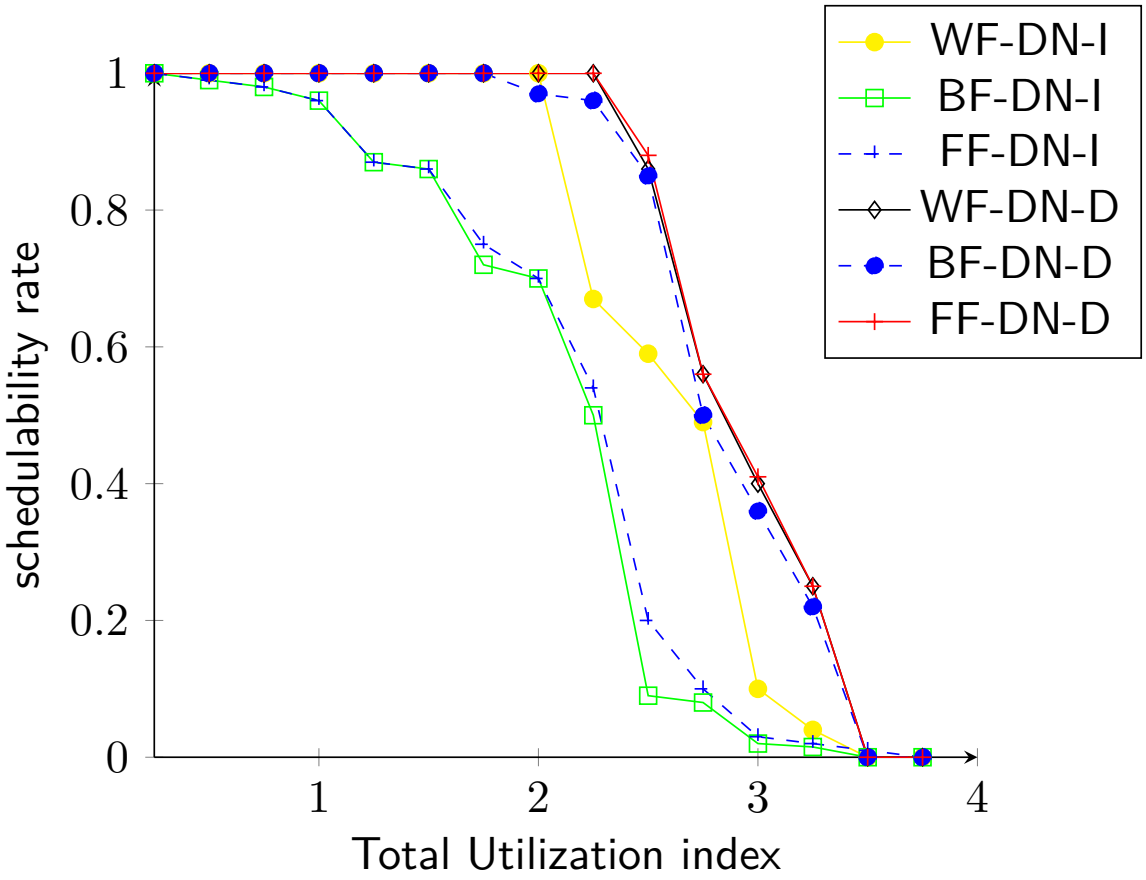
- Tasks are sorted according to their relative **deadlines** in **non-decreasing** order
- OPT-P1 : depth-first, OPT-P2 : breadth-first





Performance of BF, WF and FF using sorted tasks by density

- Tasks are sorted according to their **density** in **increasing (XF-DN-I)** order and **decreasing (XF-DN-D)** order.



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- We proposed allocation algorithms for real-time tasks with fixed preemption points on an identical core platform :
  - Two optimal algorithms (Enumerative and Branch and bound algorithms)
  - A set of allocation heuristics
  - Minimizing the preemption costs
- Extend the proposed approaches to consider dependent tasks

Thank you for your attention !