Bounding and Shaping the Demand of Mixed-Criticality Sporadic Tasks

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ECRTS 2012

Mixed-criticality sporadic tasks

Task τ_i

$C_i(\text{LO})$: WCET at low-criticality

$C_i(\text{HI})$: WCET at high-criticality

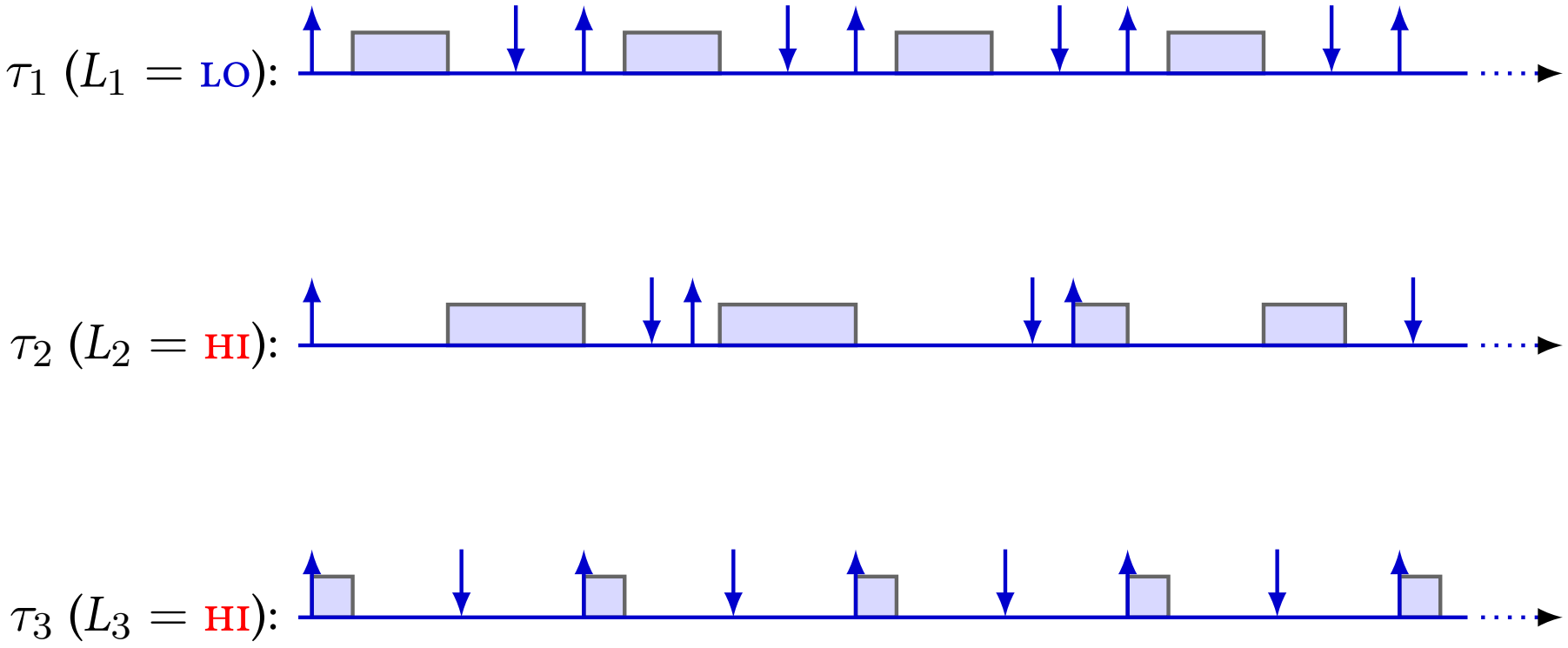
D_i: Relative deadline

T_i: Period

L_i: Criticality (LO or HI)

$(C_i(\text{LO}) \leqslant C_i(\text{HI}))$

Mixed-criticality sporadic tasks



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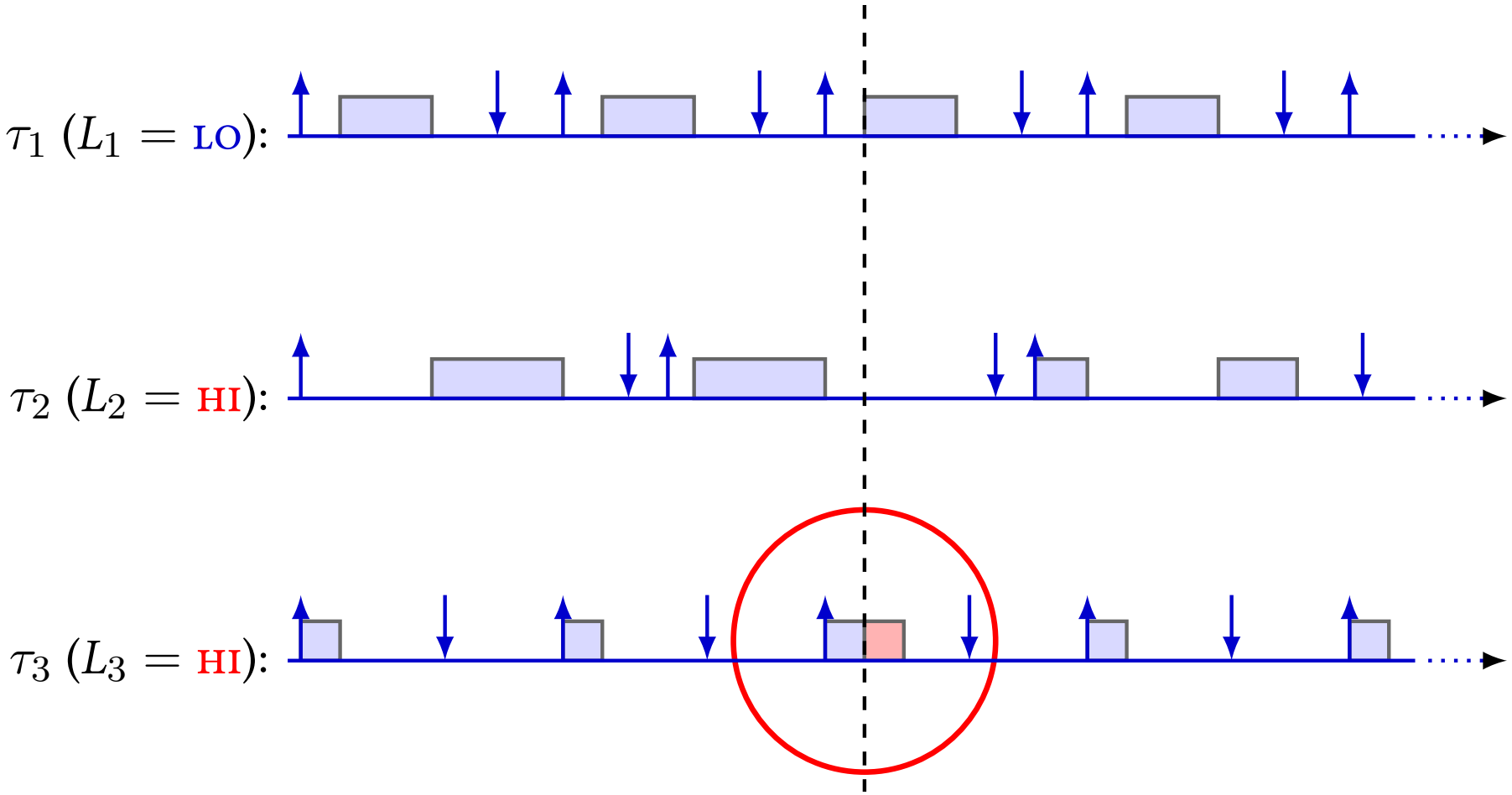

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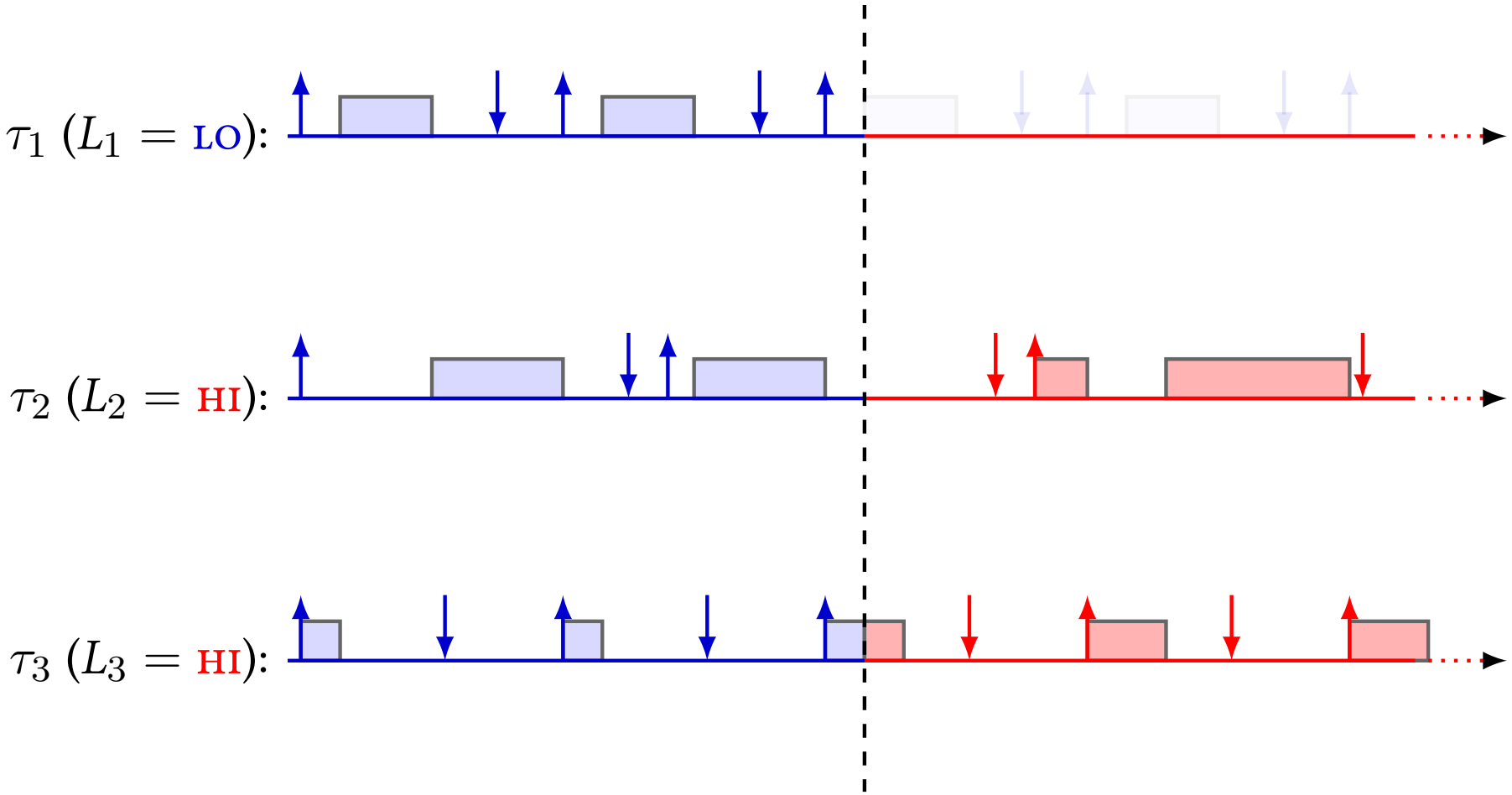

Schedulability analysis

Classic EDF analysis

A task set τ is schedulable if

$$\forall \ell \geqslant 0 : \quad \sum_{\tau_i \in \tau} \mathrm{dbf}(\tau_i, \ell) \leqslant \mathrm{sbf}(\ell).$$

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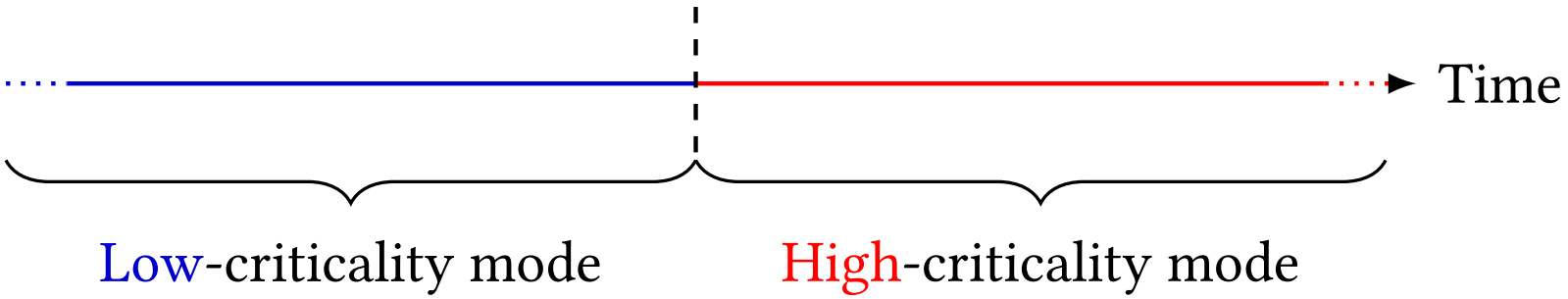

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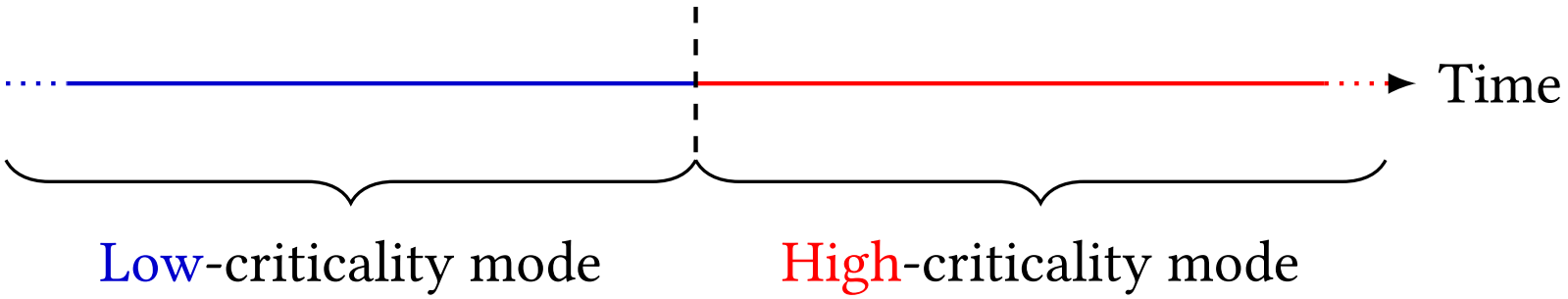
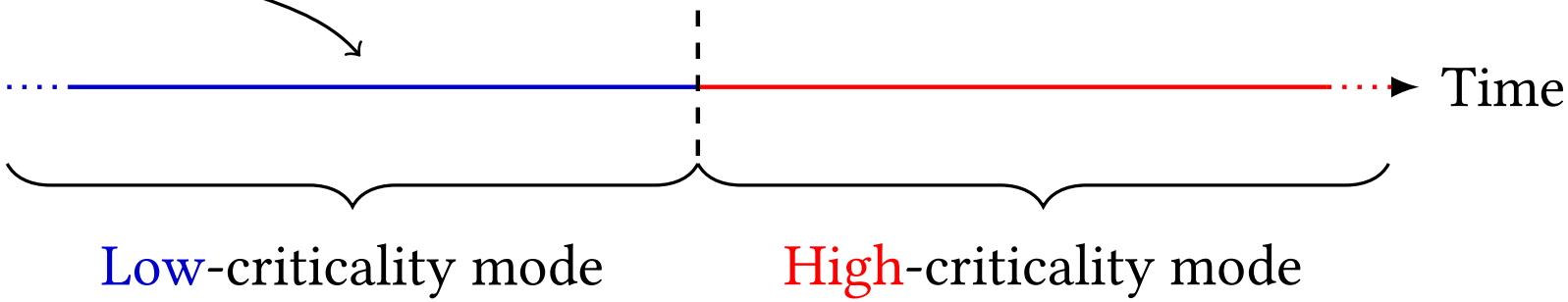


Demand-bound functions

Each τ_i behaves exactly like a standard sporadic task with WCET $C_i(\text{LO})$.



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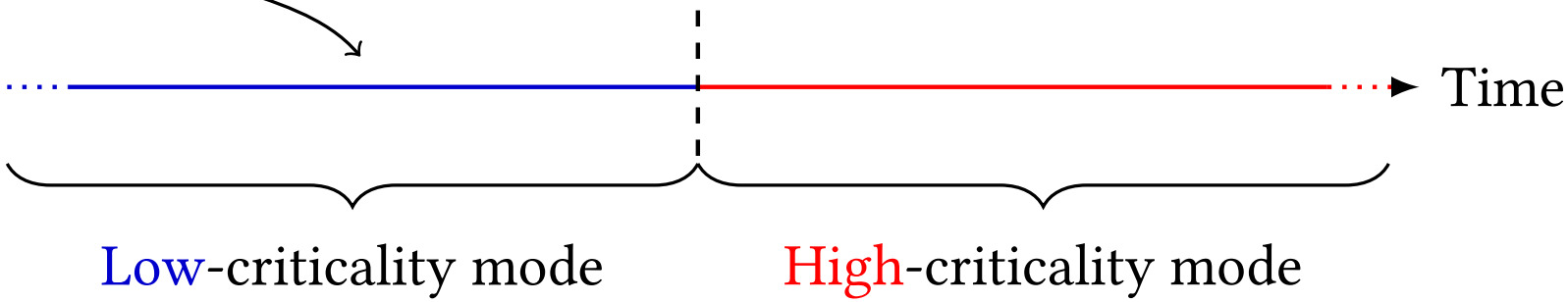

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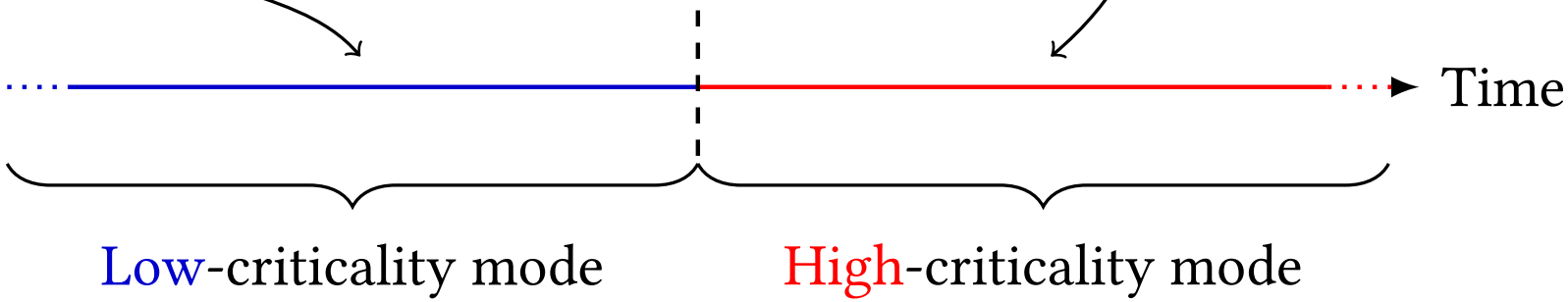

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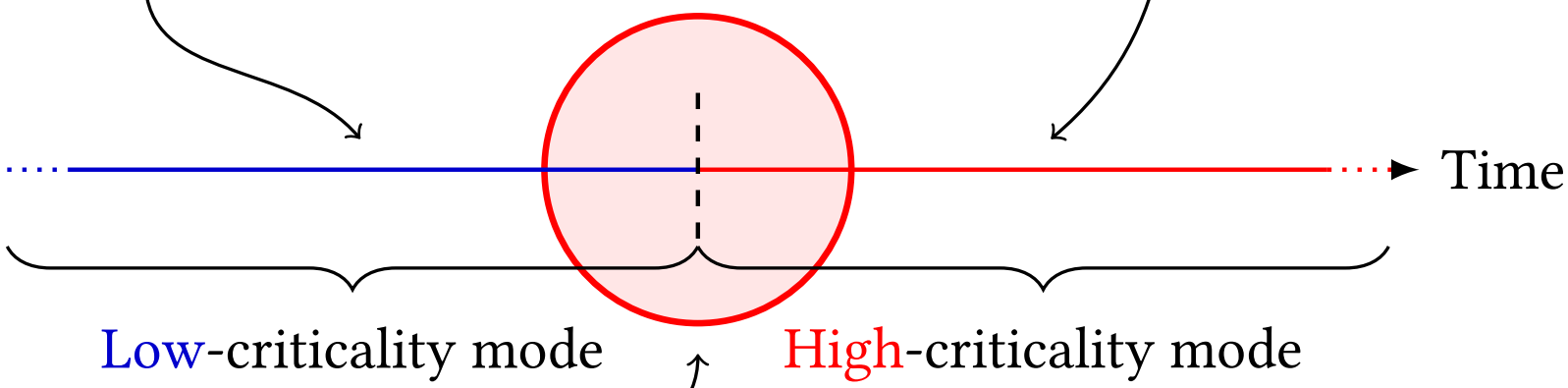
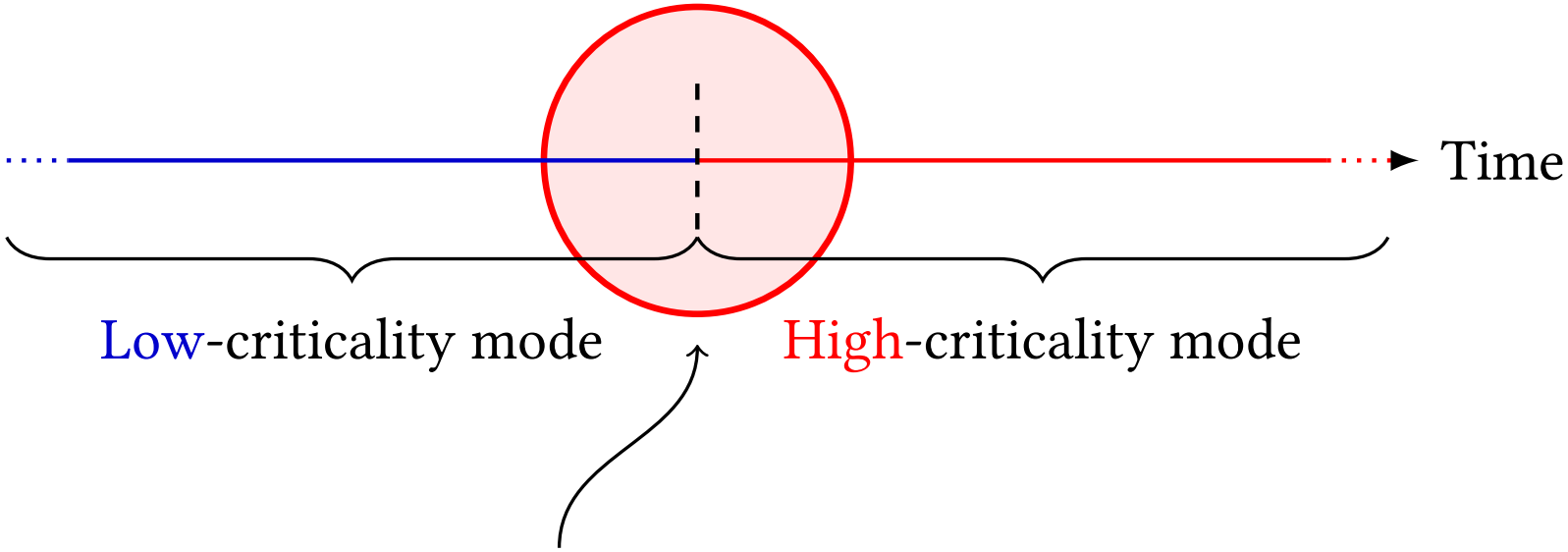


Half-finished jobs are carried over to high-criticality mode.

Carry-over jobs



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Restricting to the interesting cases

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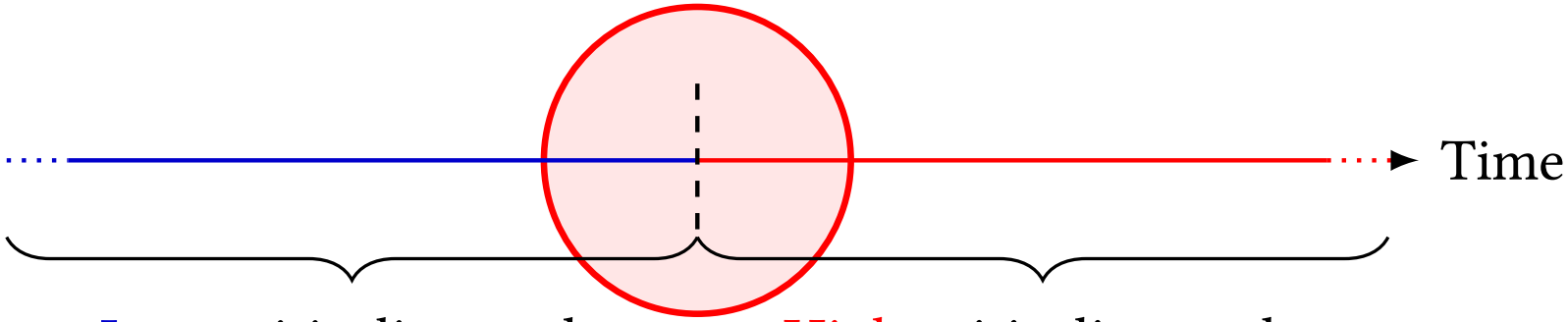

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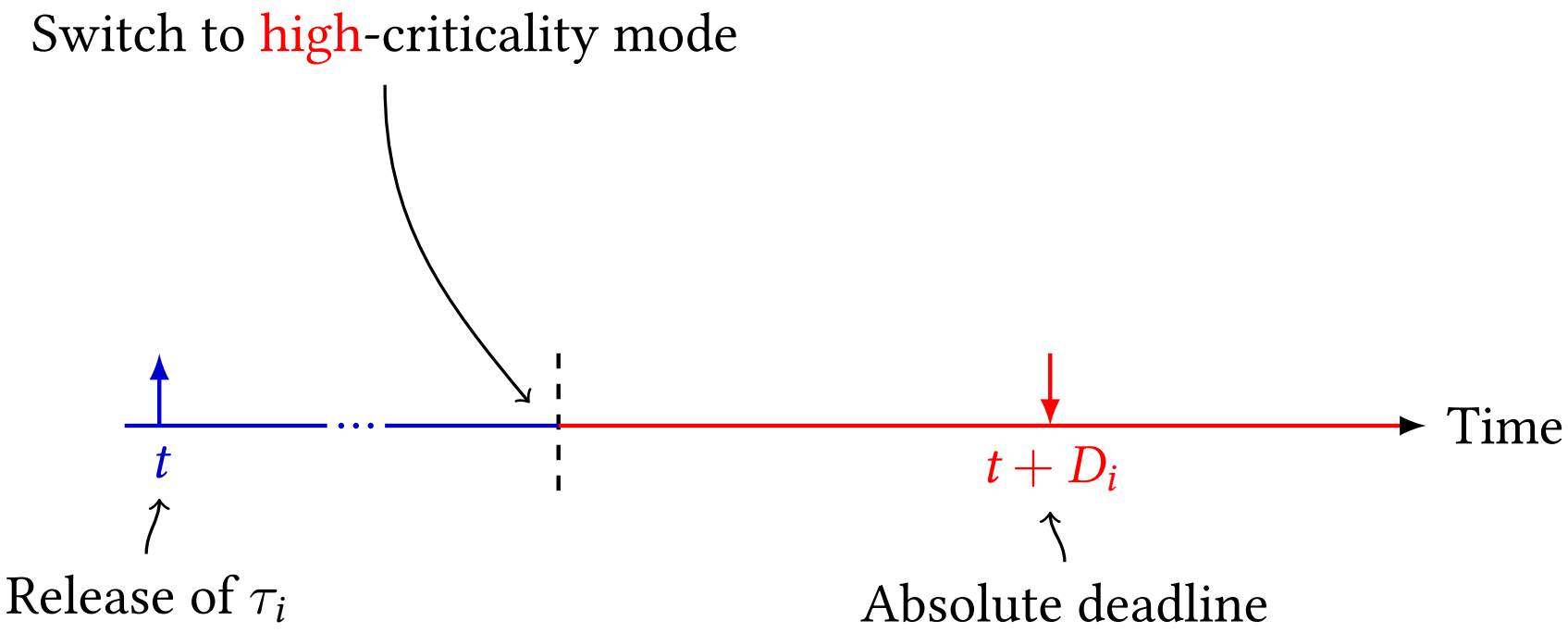

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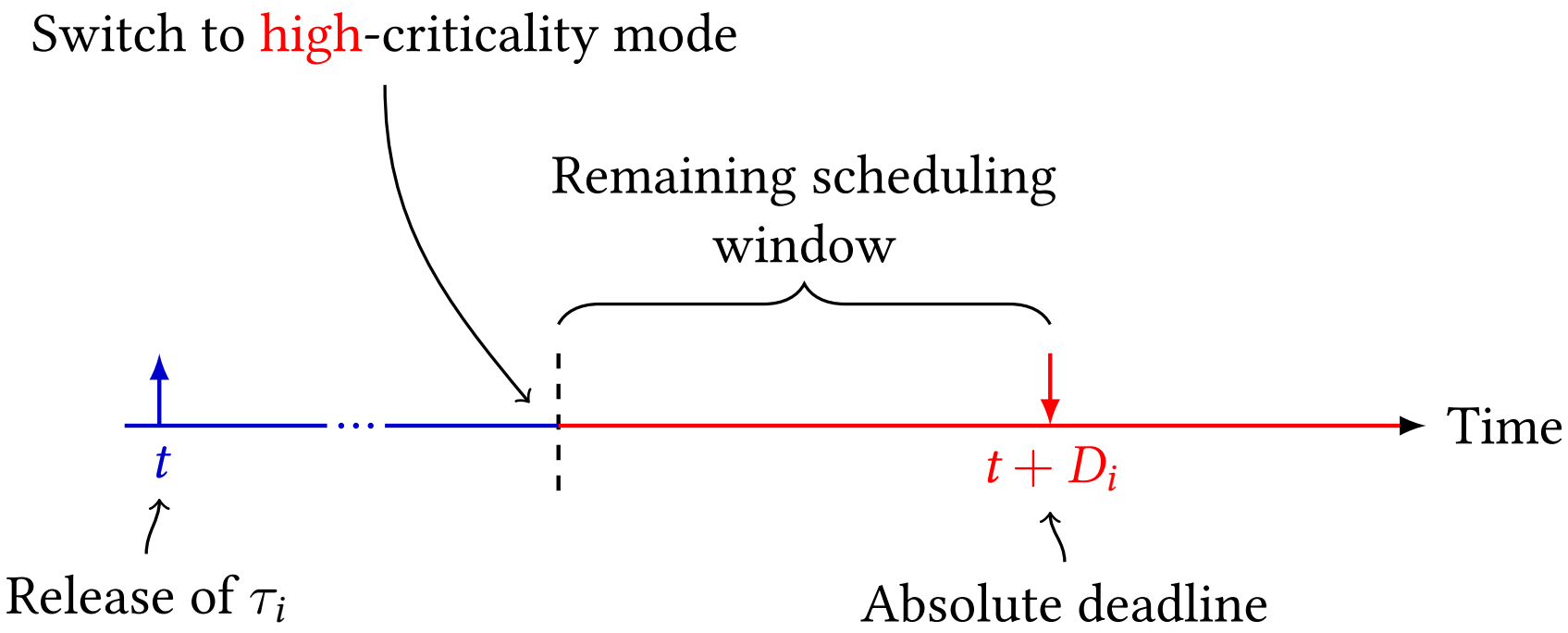

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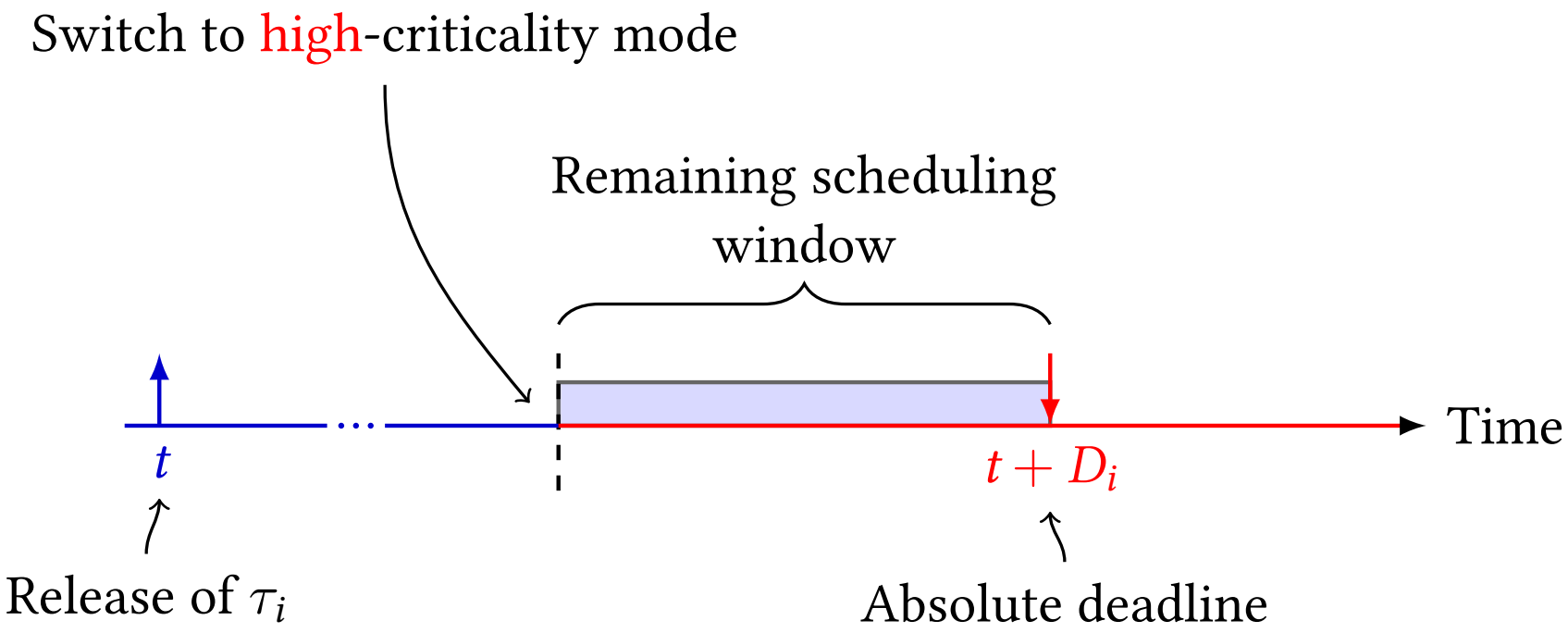

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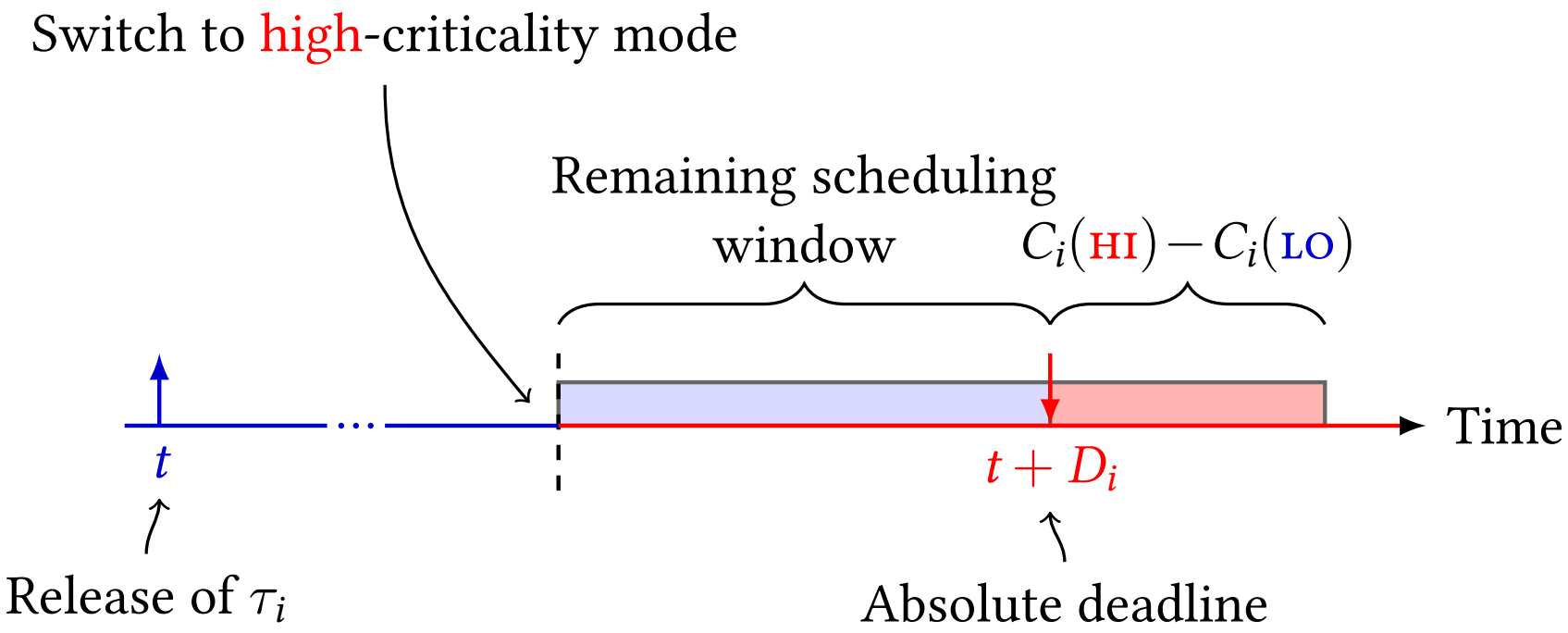
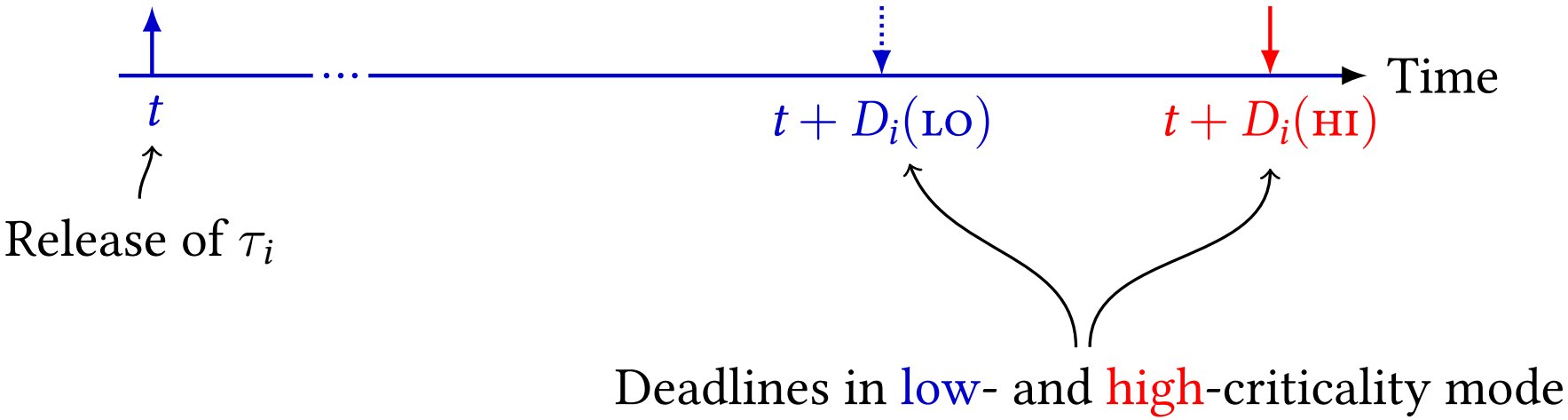


Adjusting the demand of carry-over jobs



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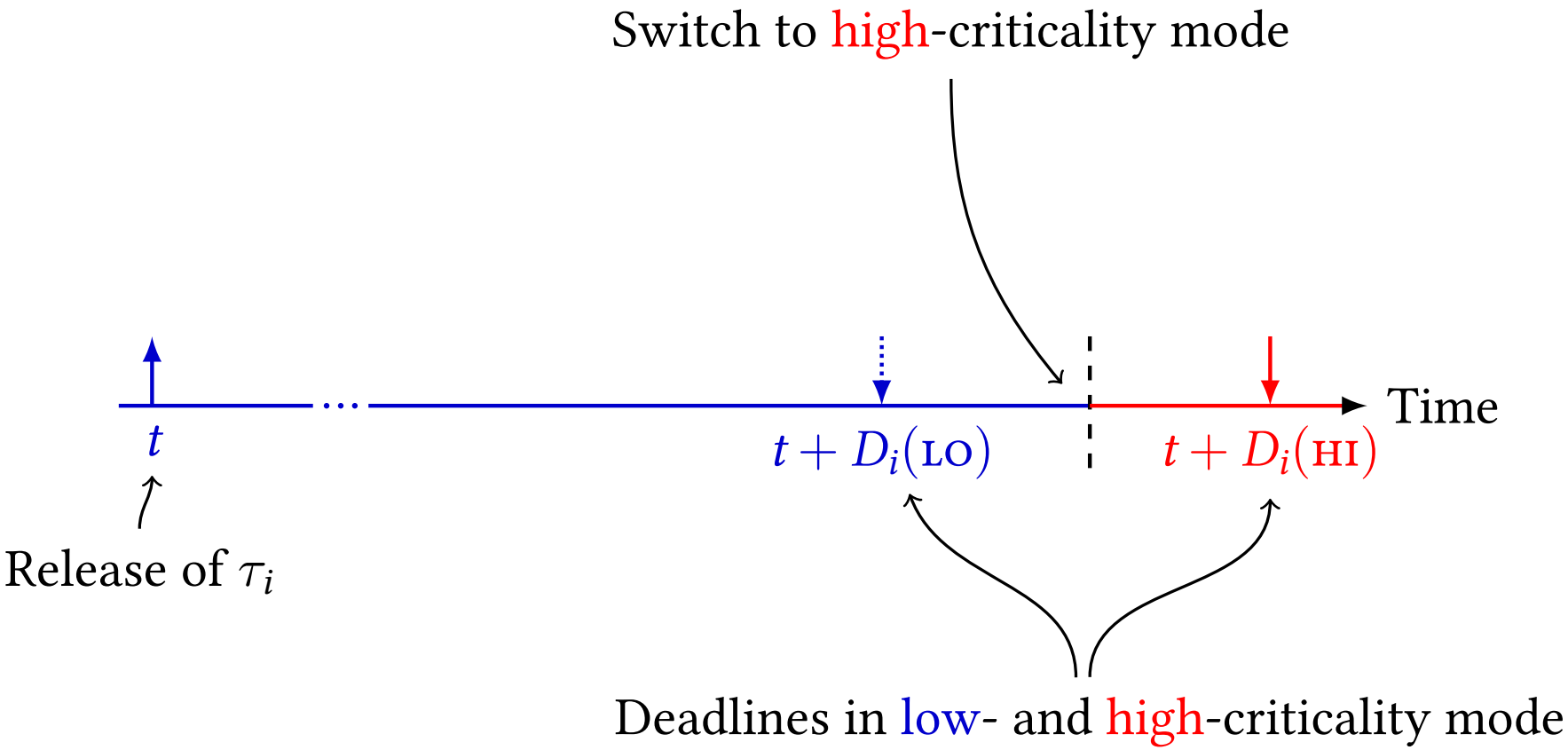

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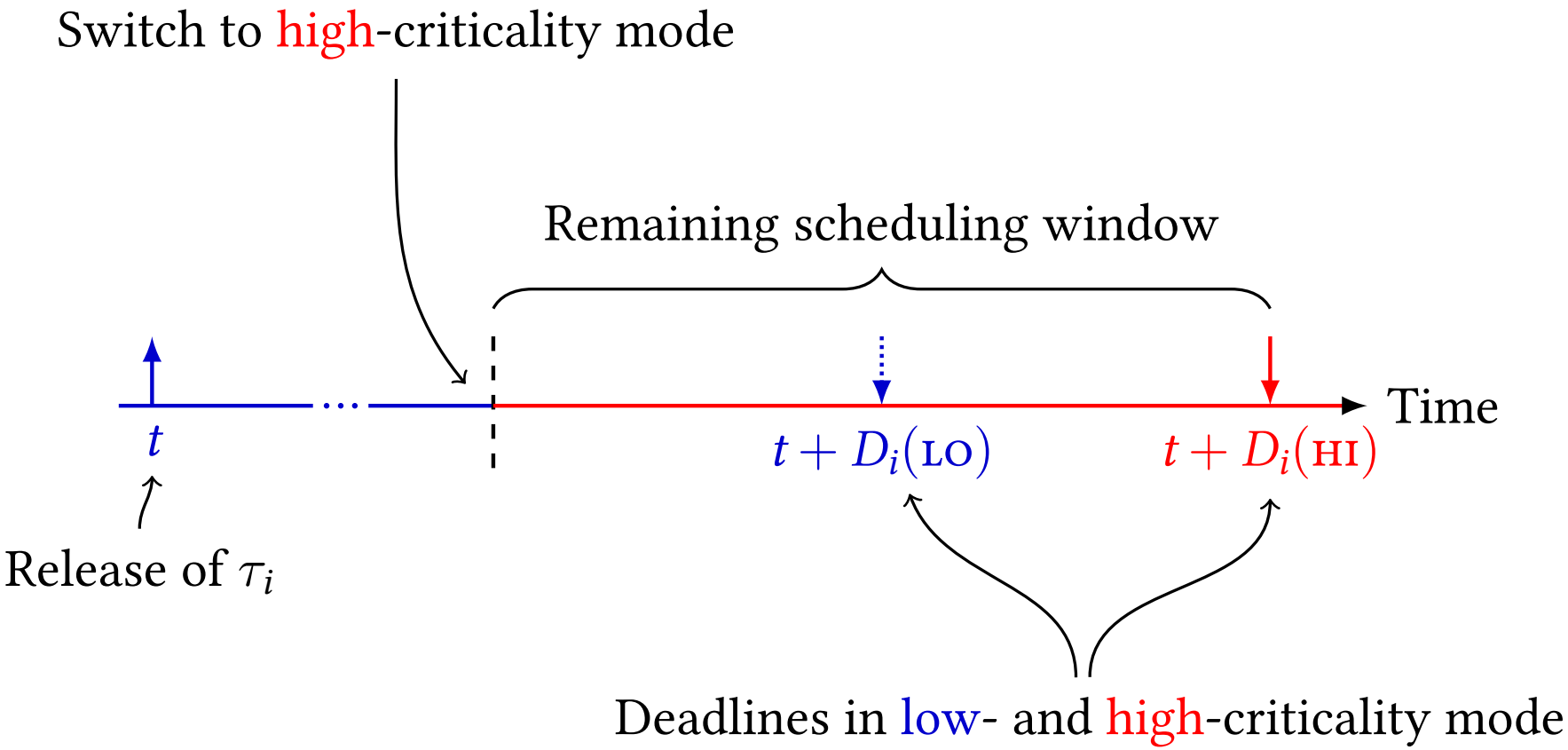

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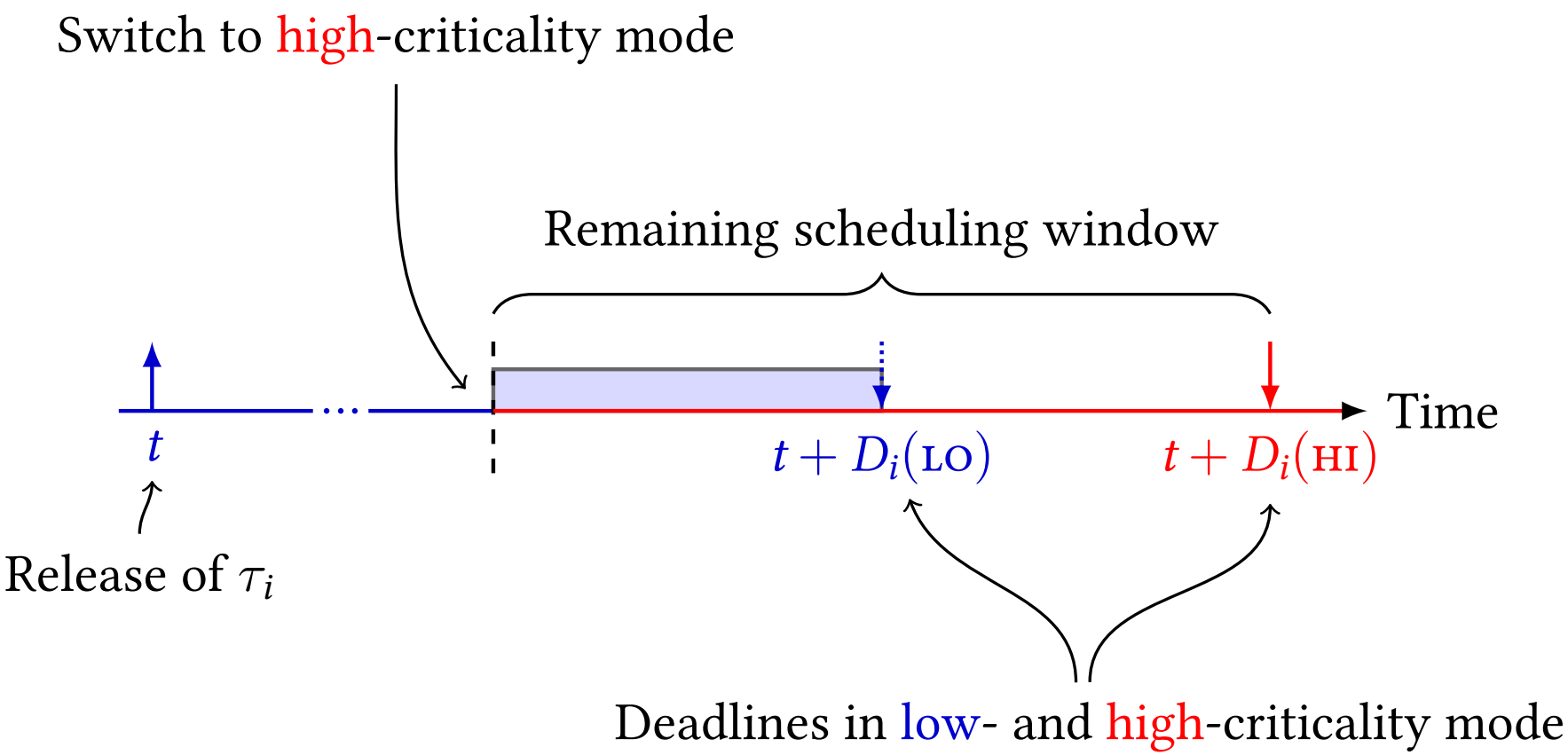

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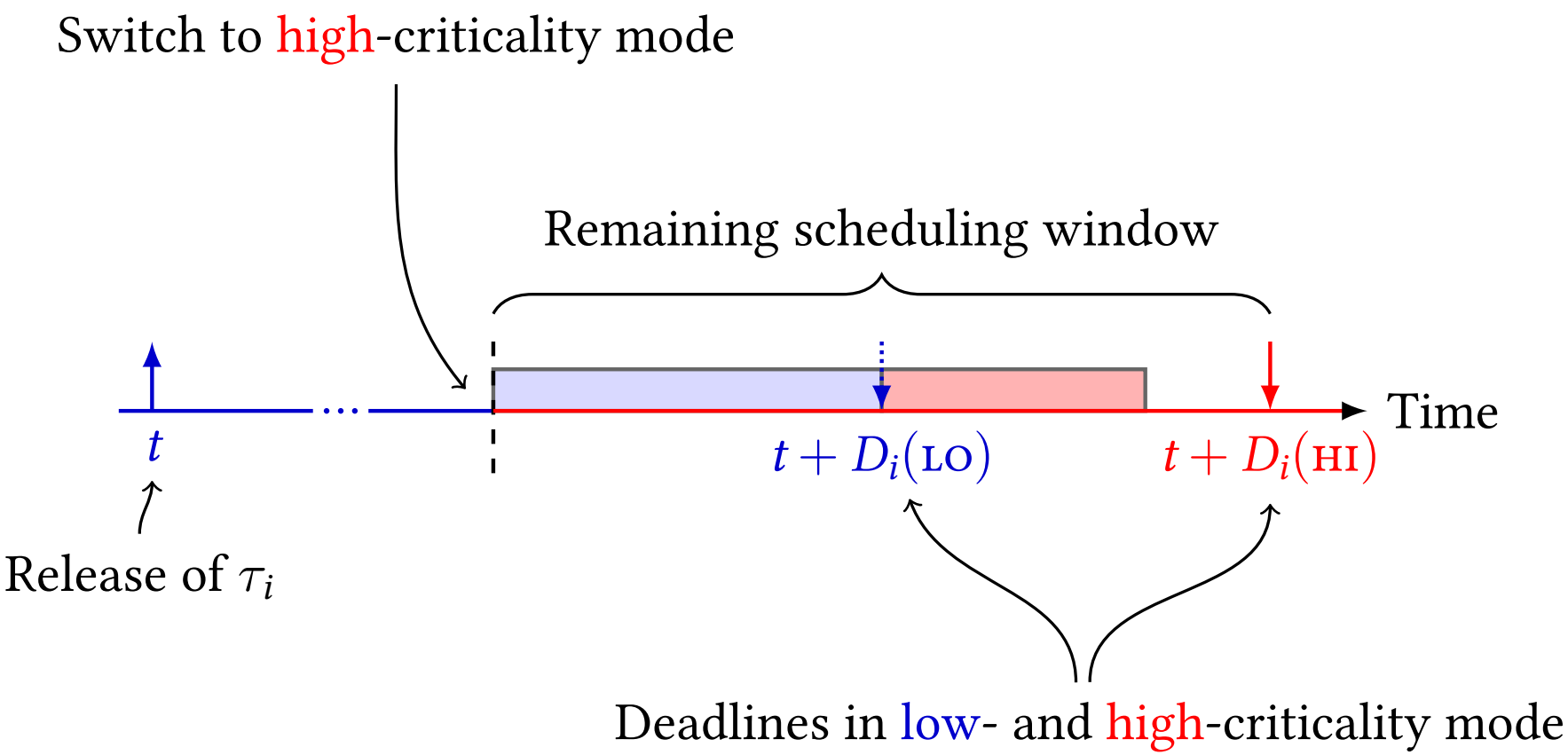
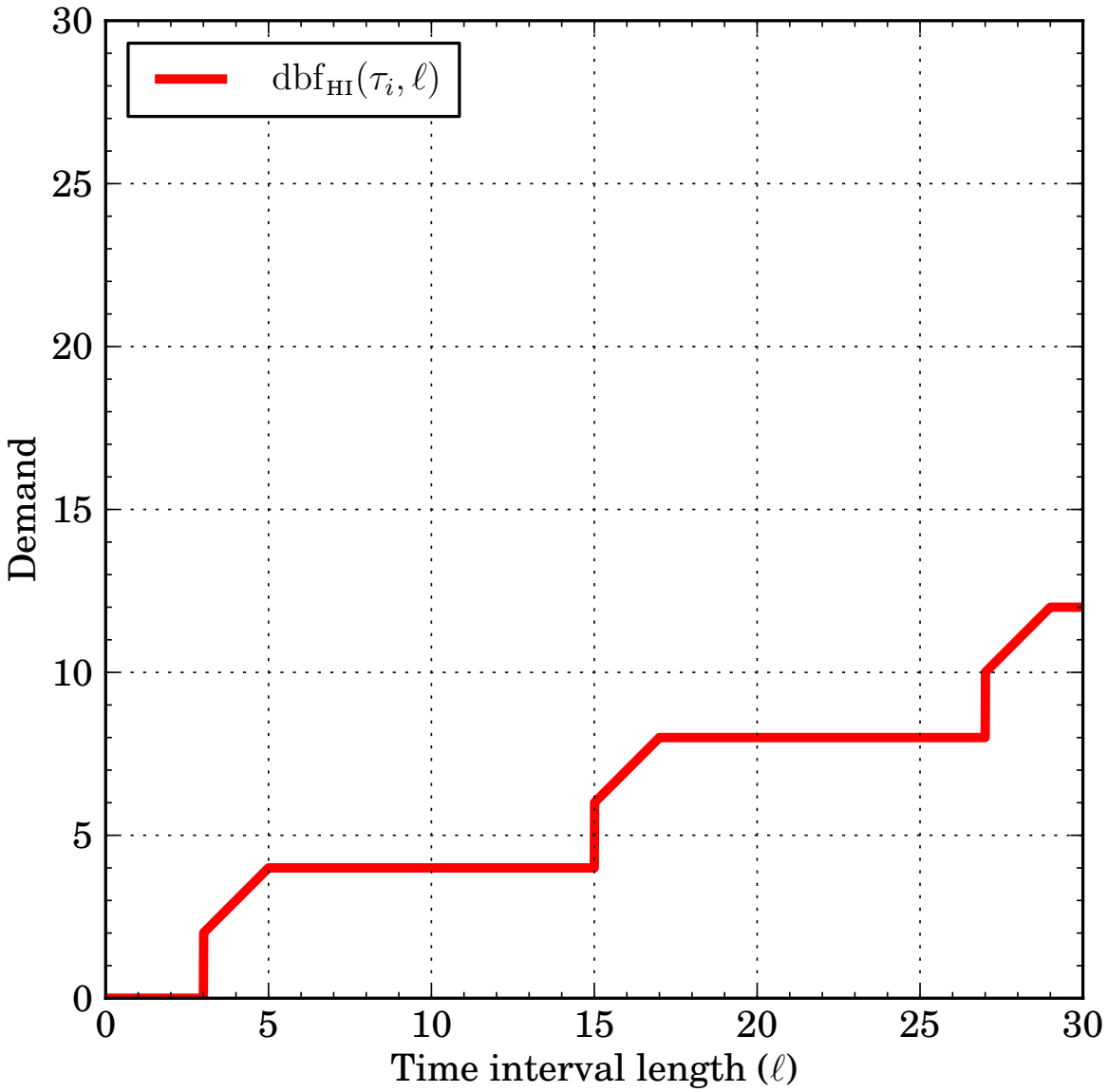


Demand-bound functions for high-criticality mode



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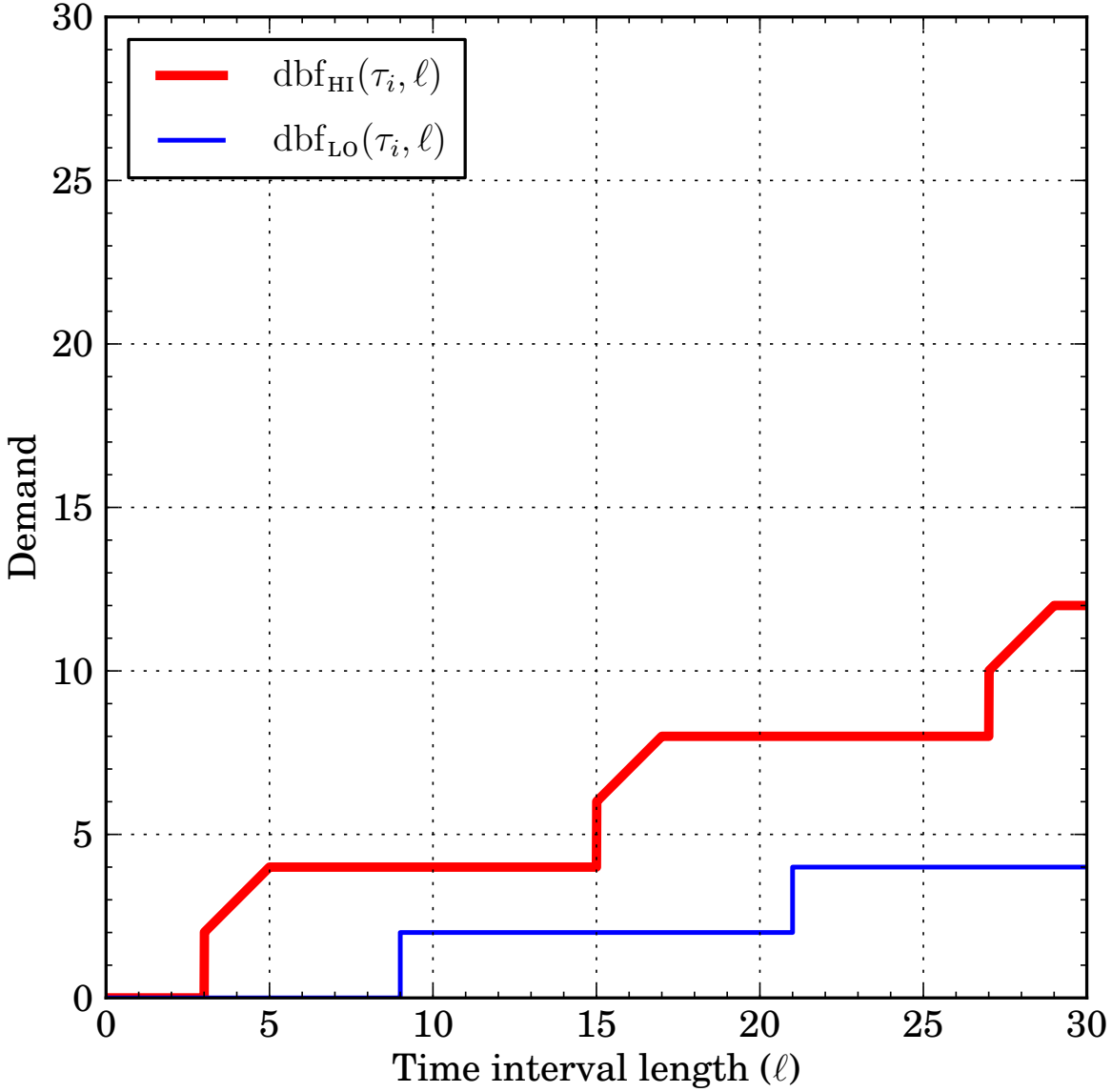

The effect of the low-criticality relative deadline

Shifting lemma

If $D_i(\text{LO})$ is decreased by $\delta \in \mathbb{Z}$, then

$$\begin{aligned} \text{dbf}_{\text{LO}}(\tau_i, \ell) &\rightsquigarrow \text{dbf}_{\text{LO}}(\tau_i, \ell + \delta) \\ \text{dbf}_{\text{HI}}(\tau_i, \ell) &\rightsquigarrow \text{dbf}_{\text{HI}}(\tau_i, \ell - \delta) \end{aligned}$$

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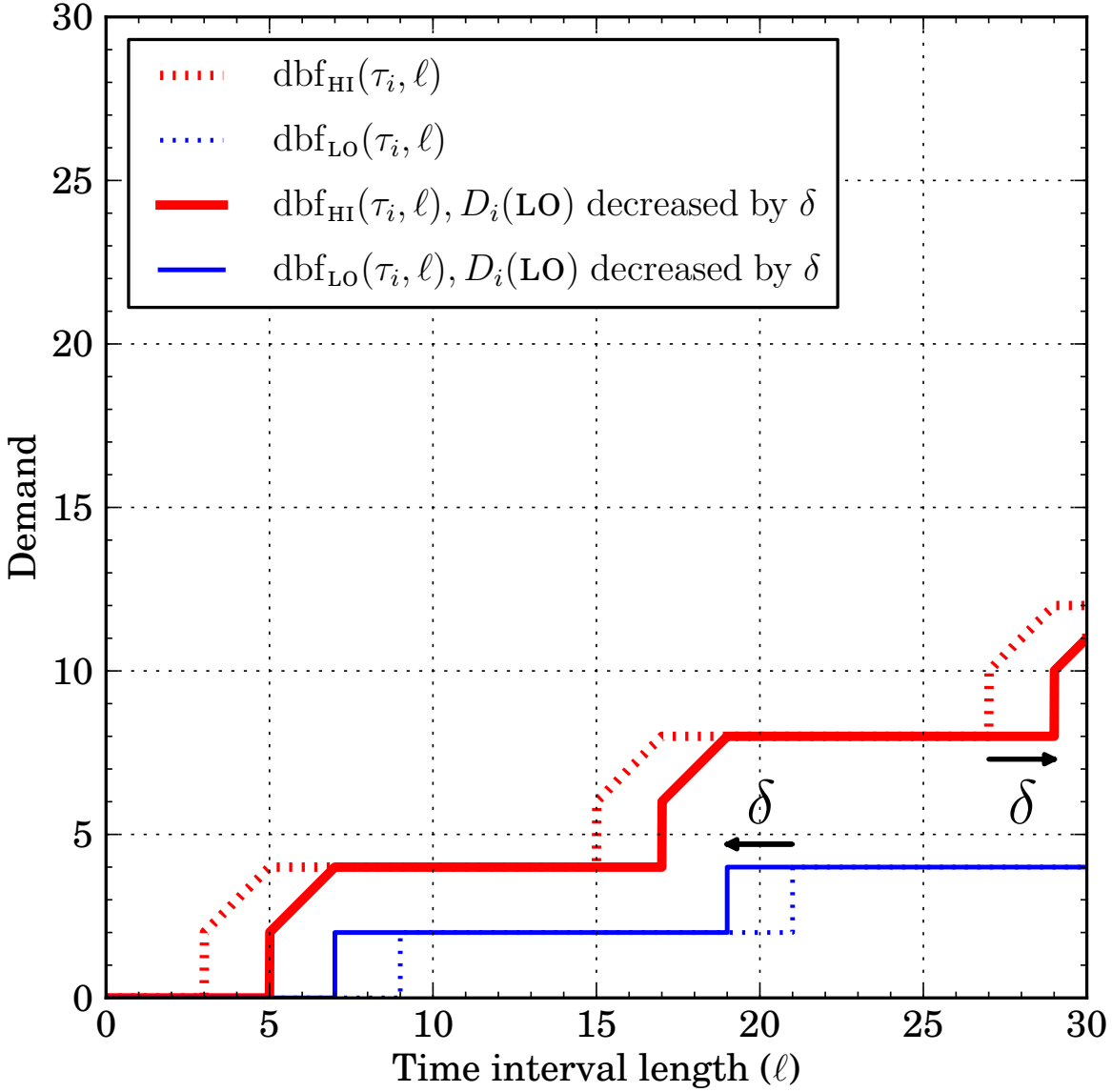

Shaping the demand of the task set

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A constraint satisfaction problem

Is there a valid assignment of $D_i(\mathrm{LO})$s to each high-criticality task τ_i such that both **A** and **B** hold?

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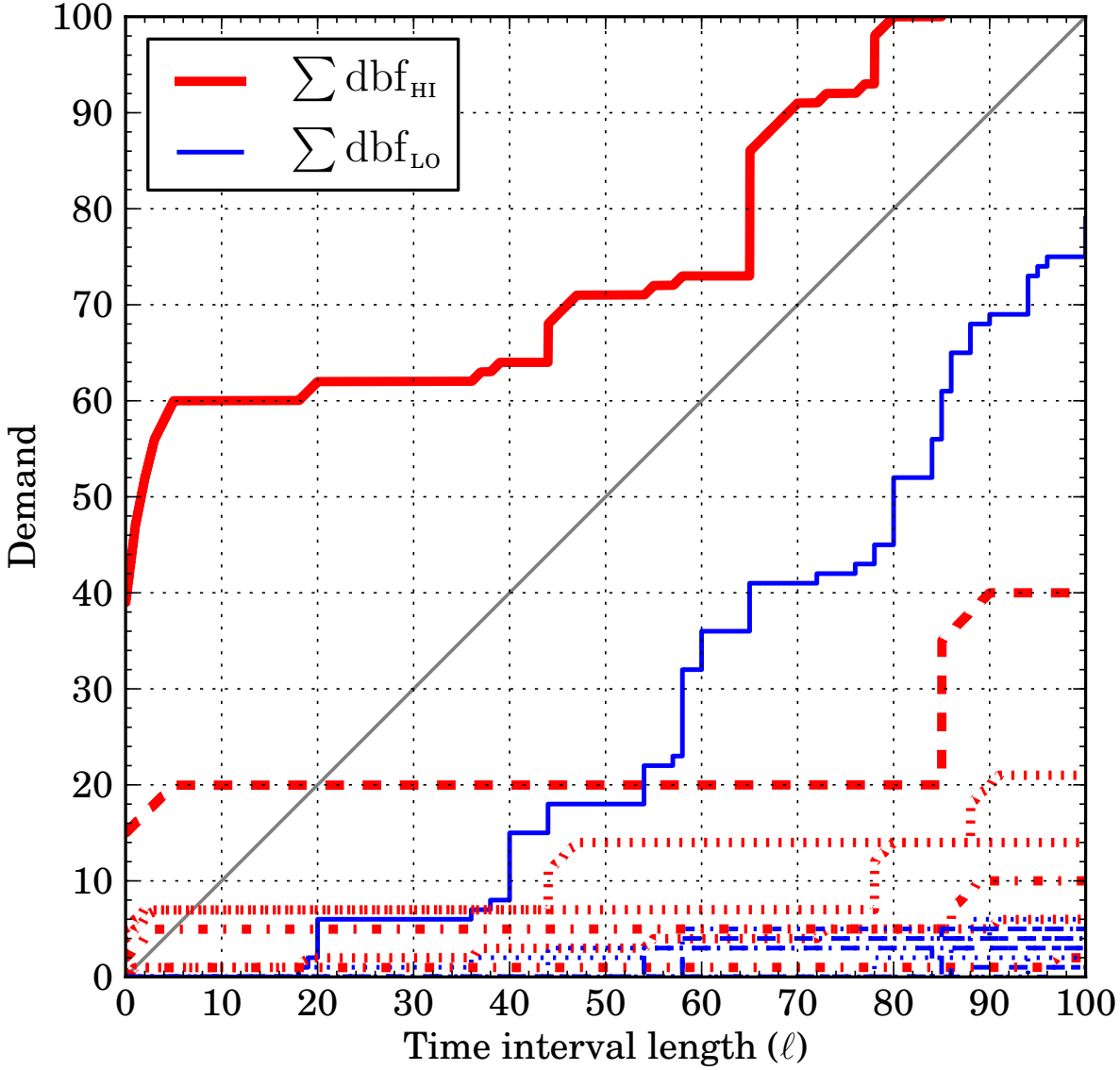

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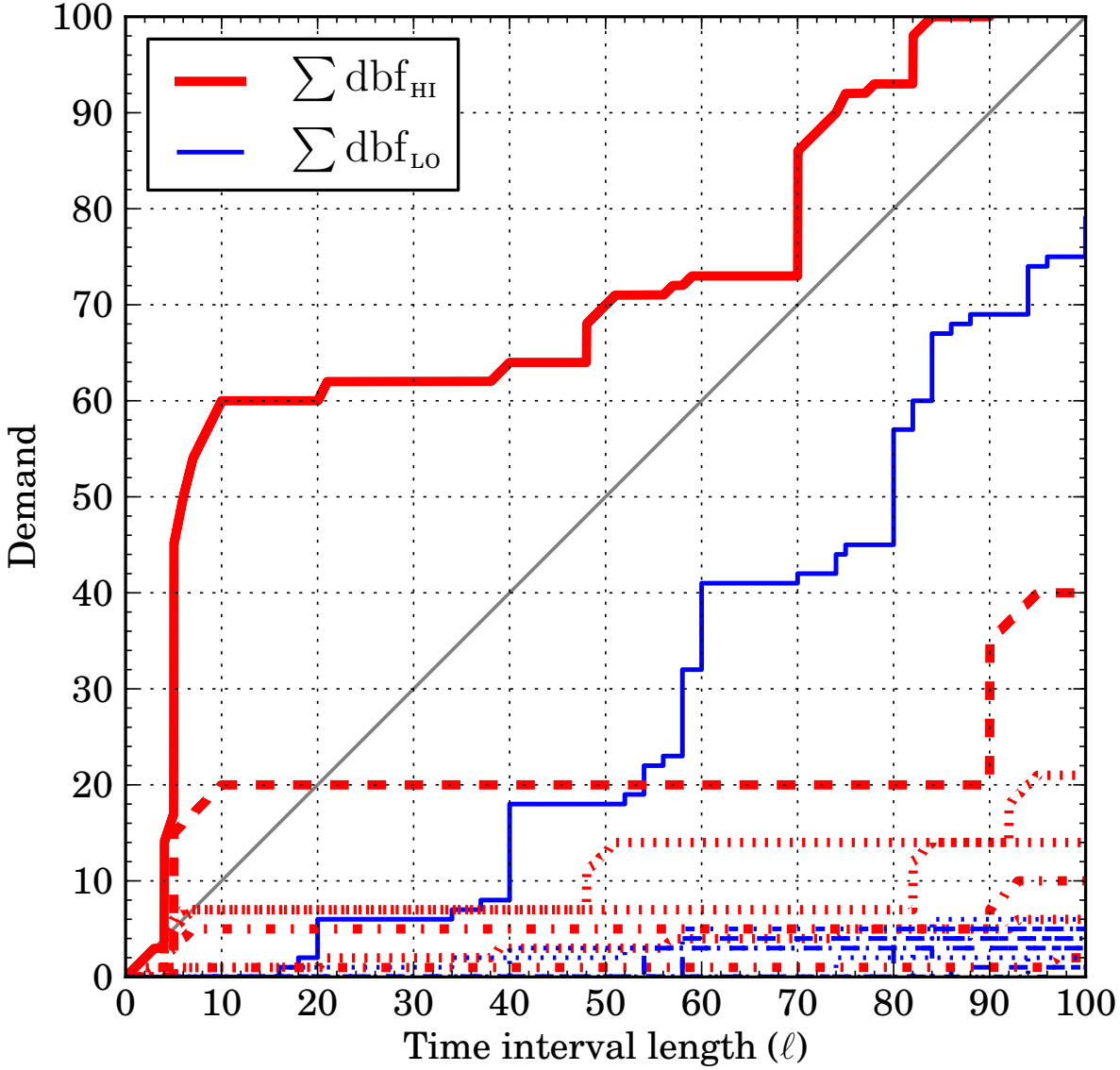

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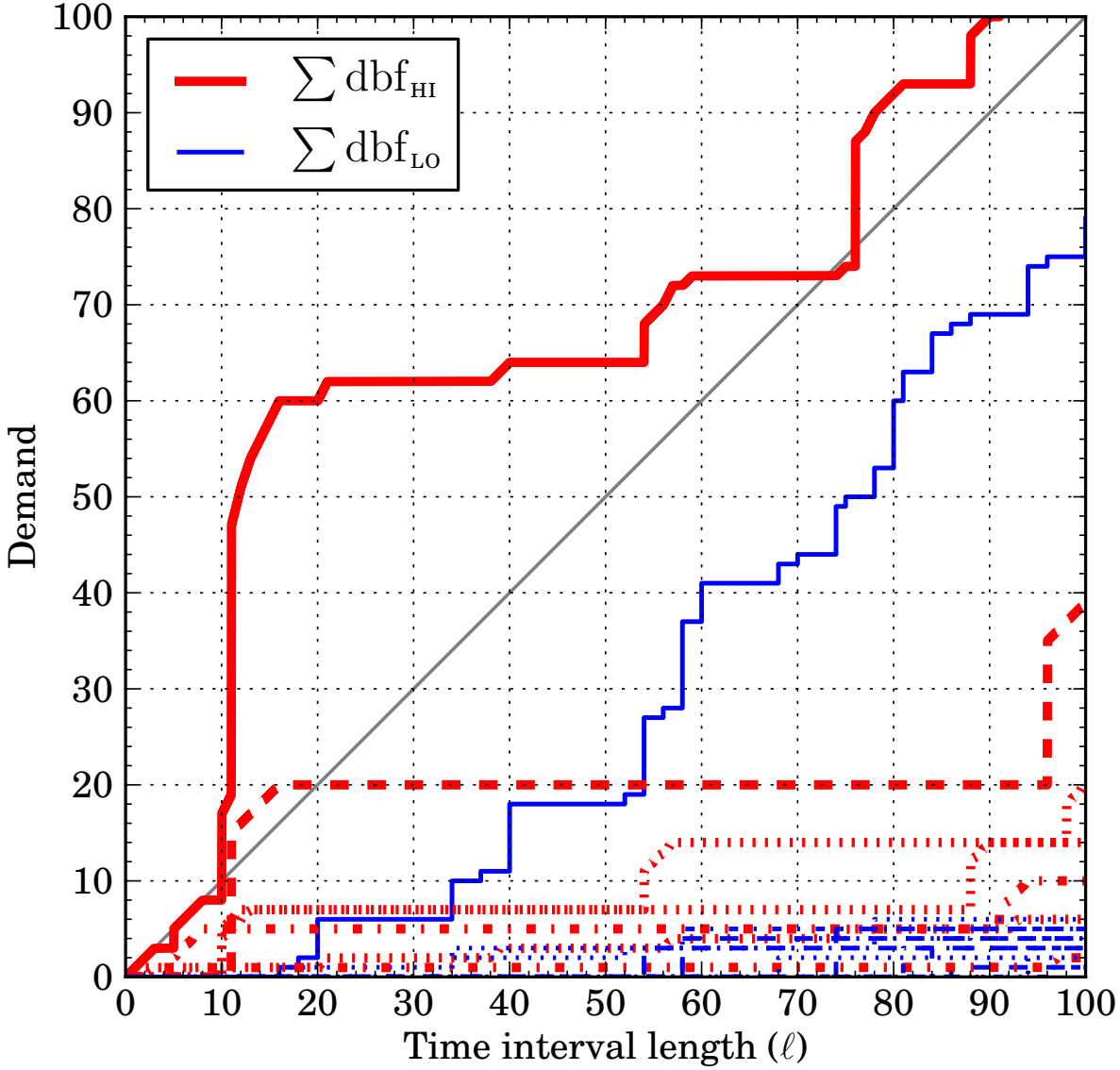

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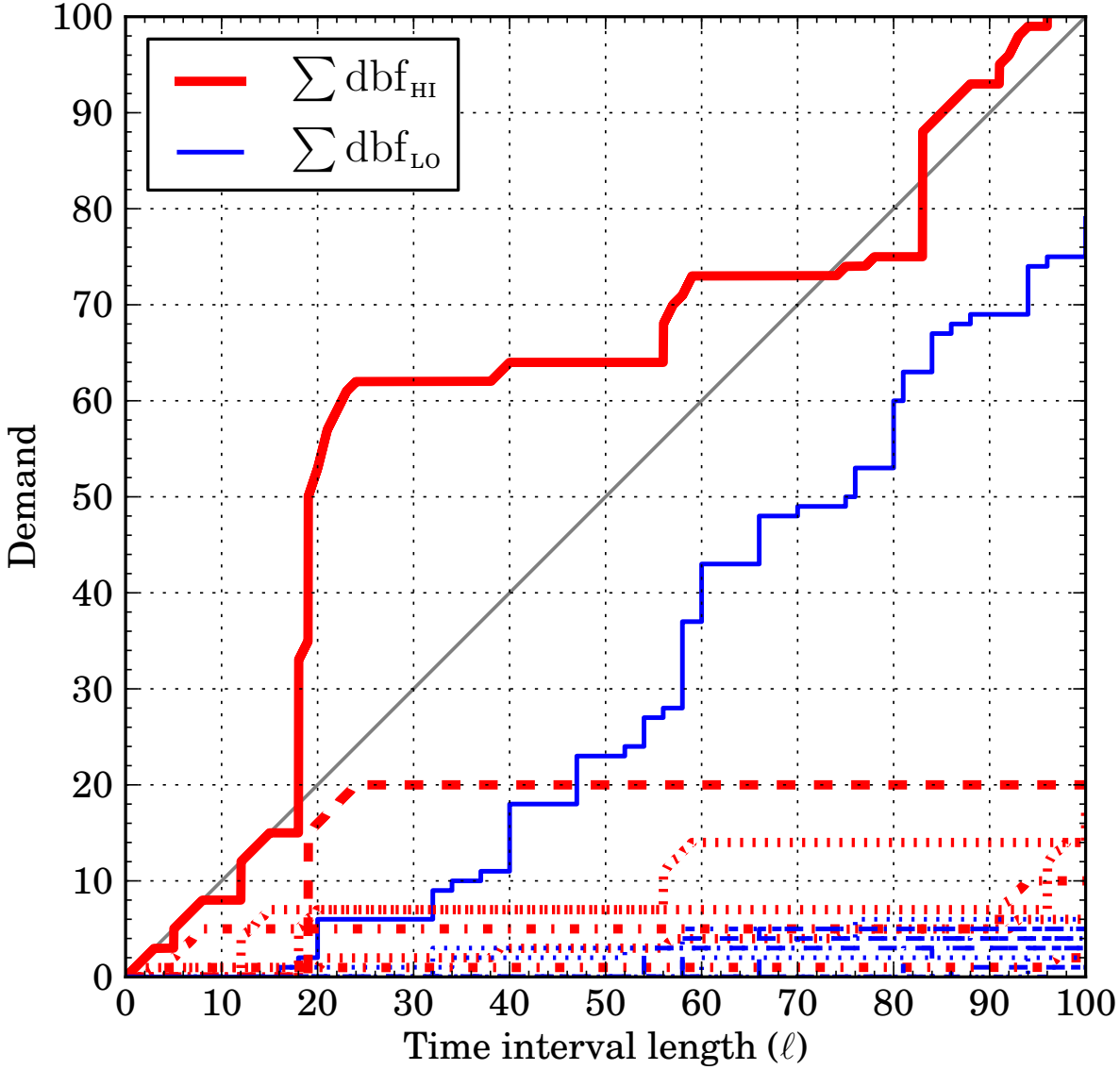

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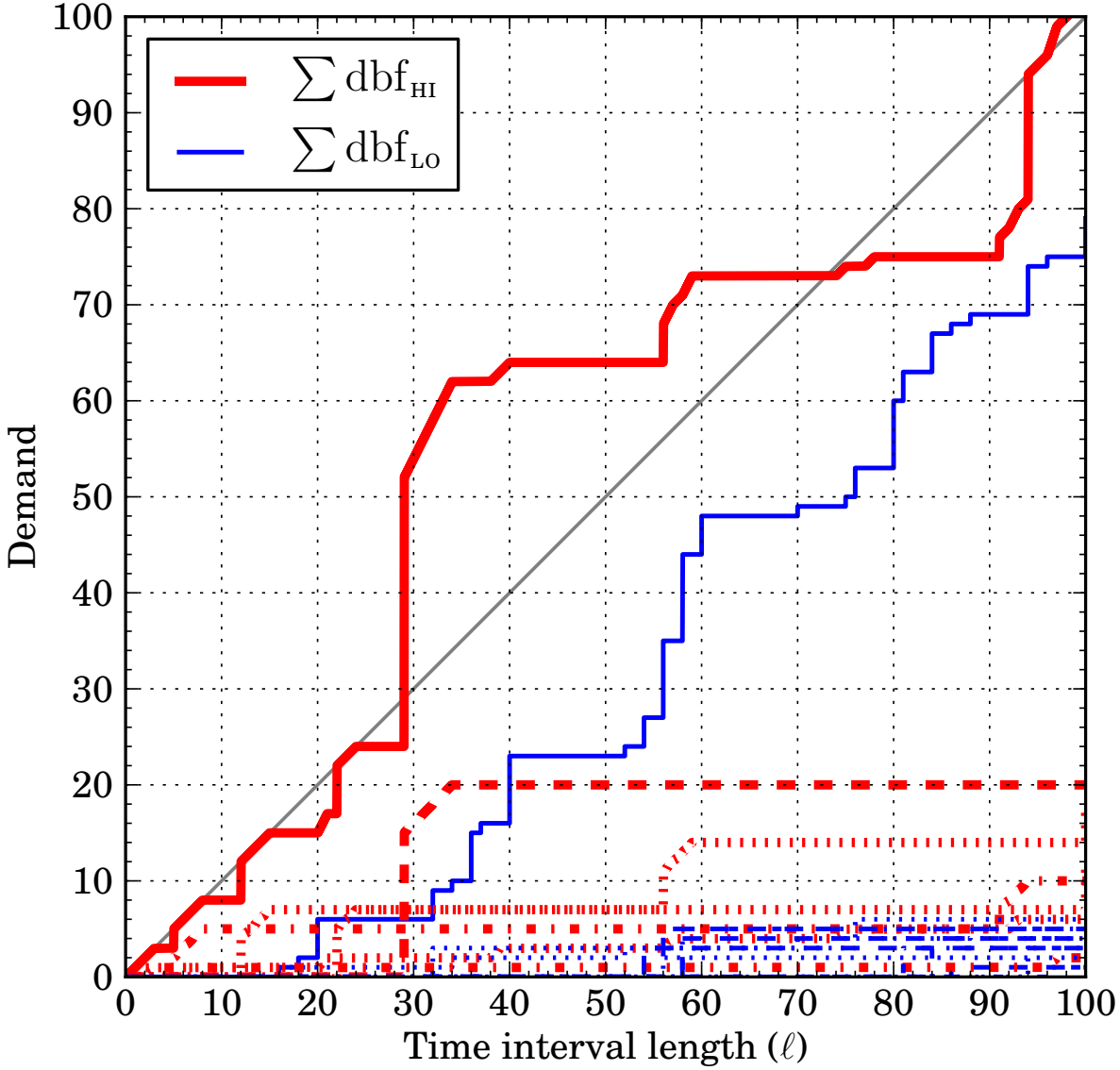

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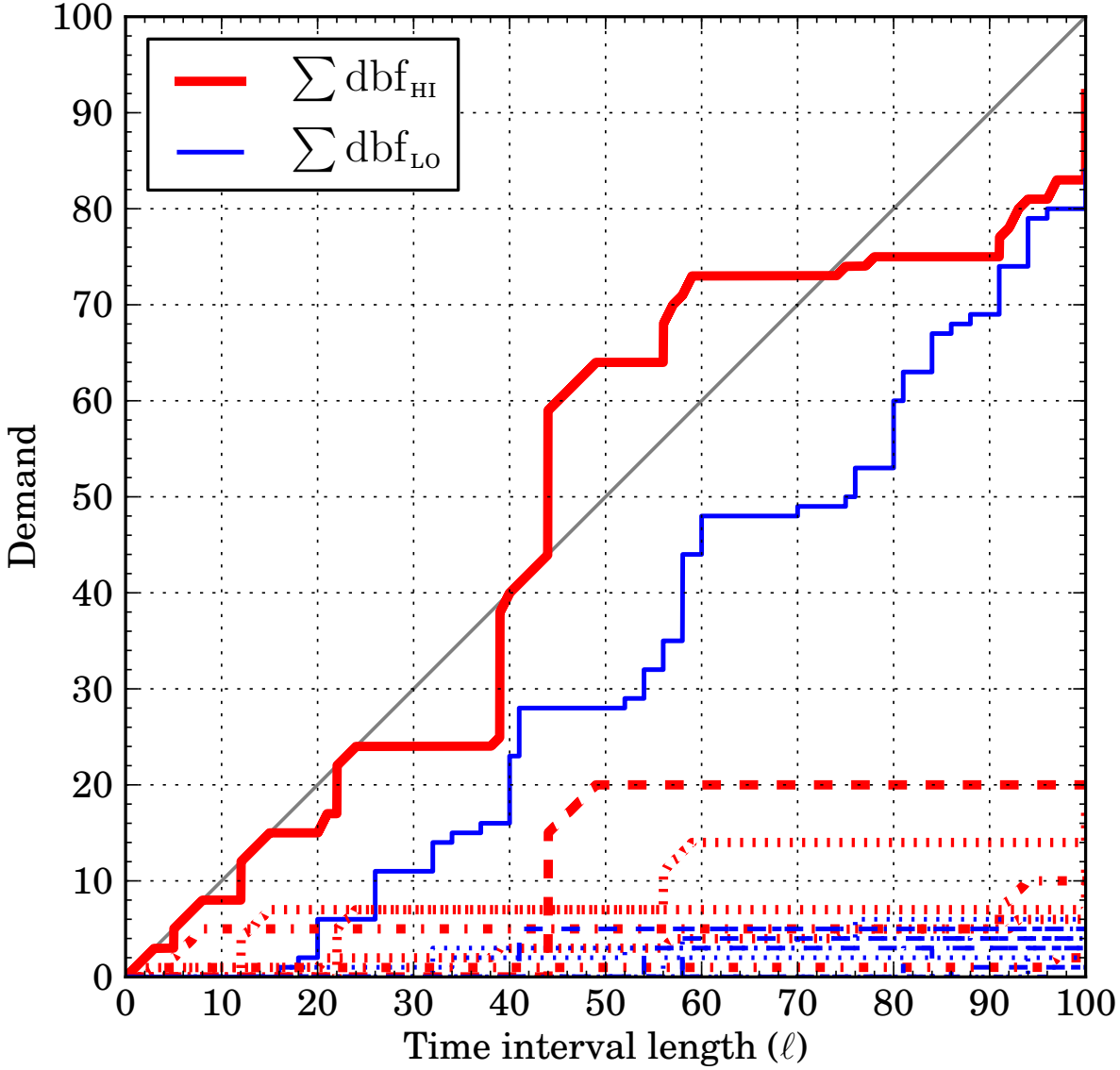

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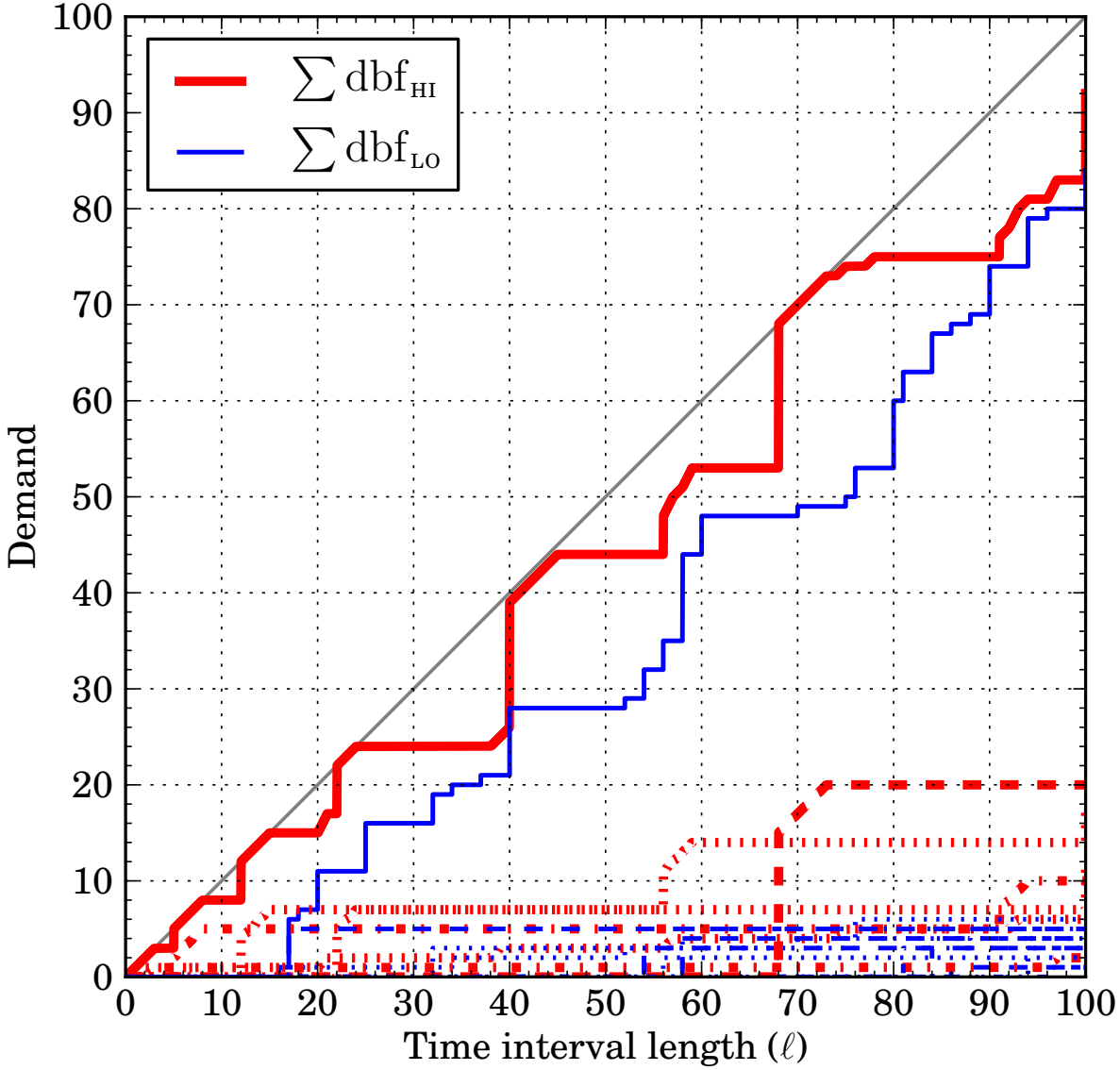

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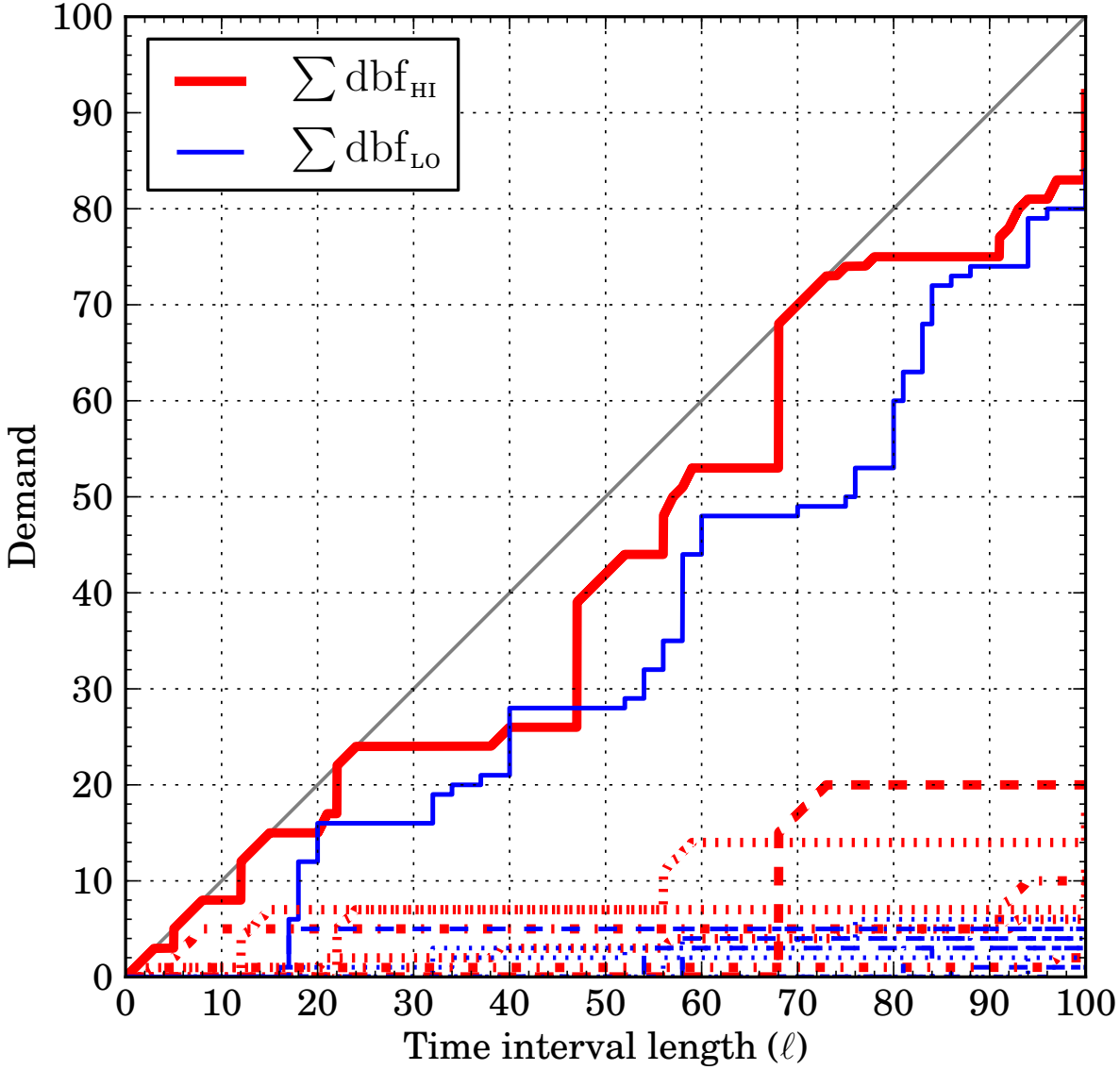
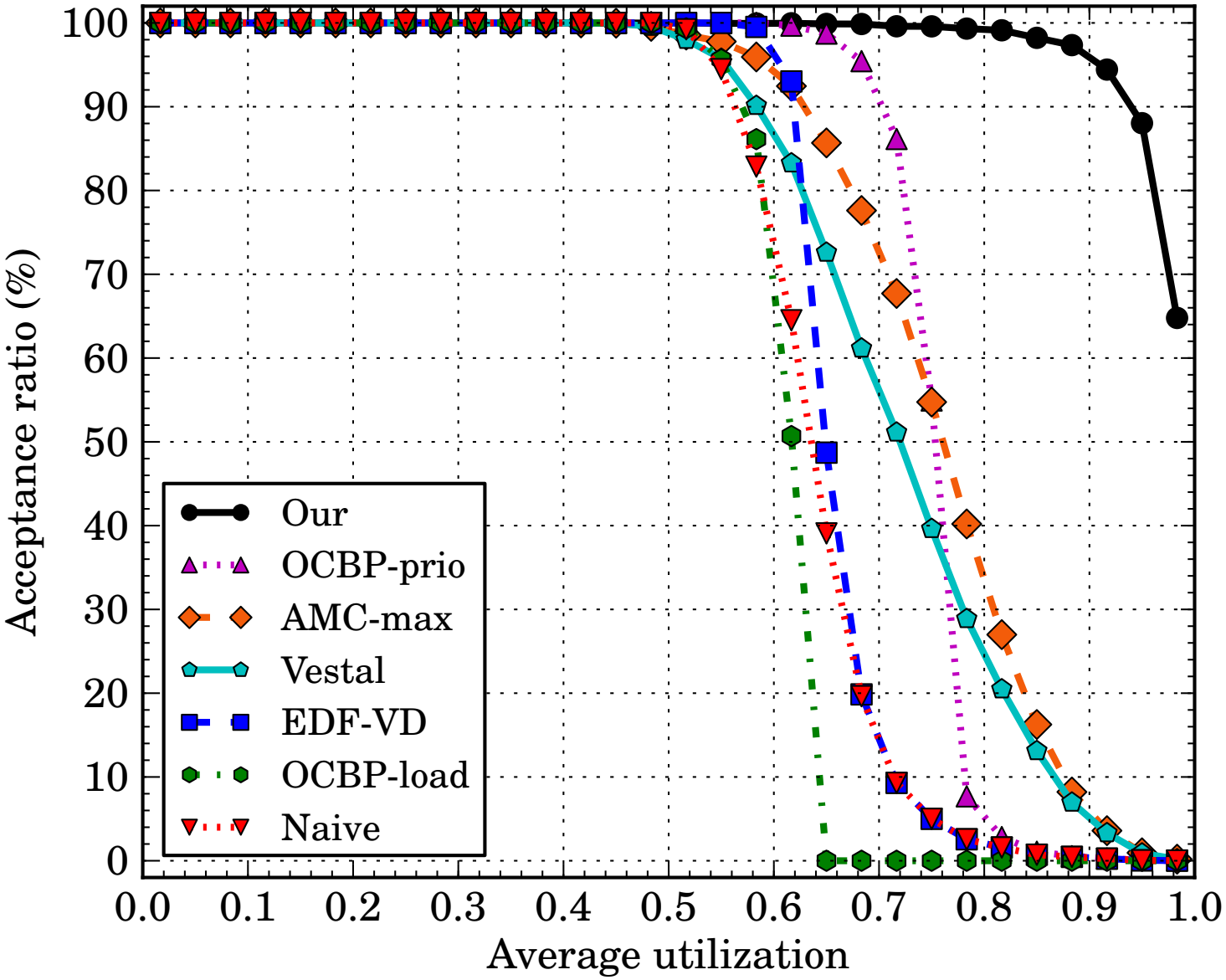
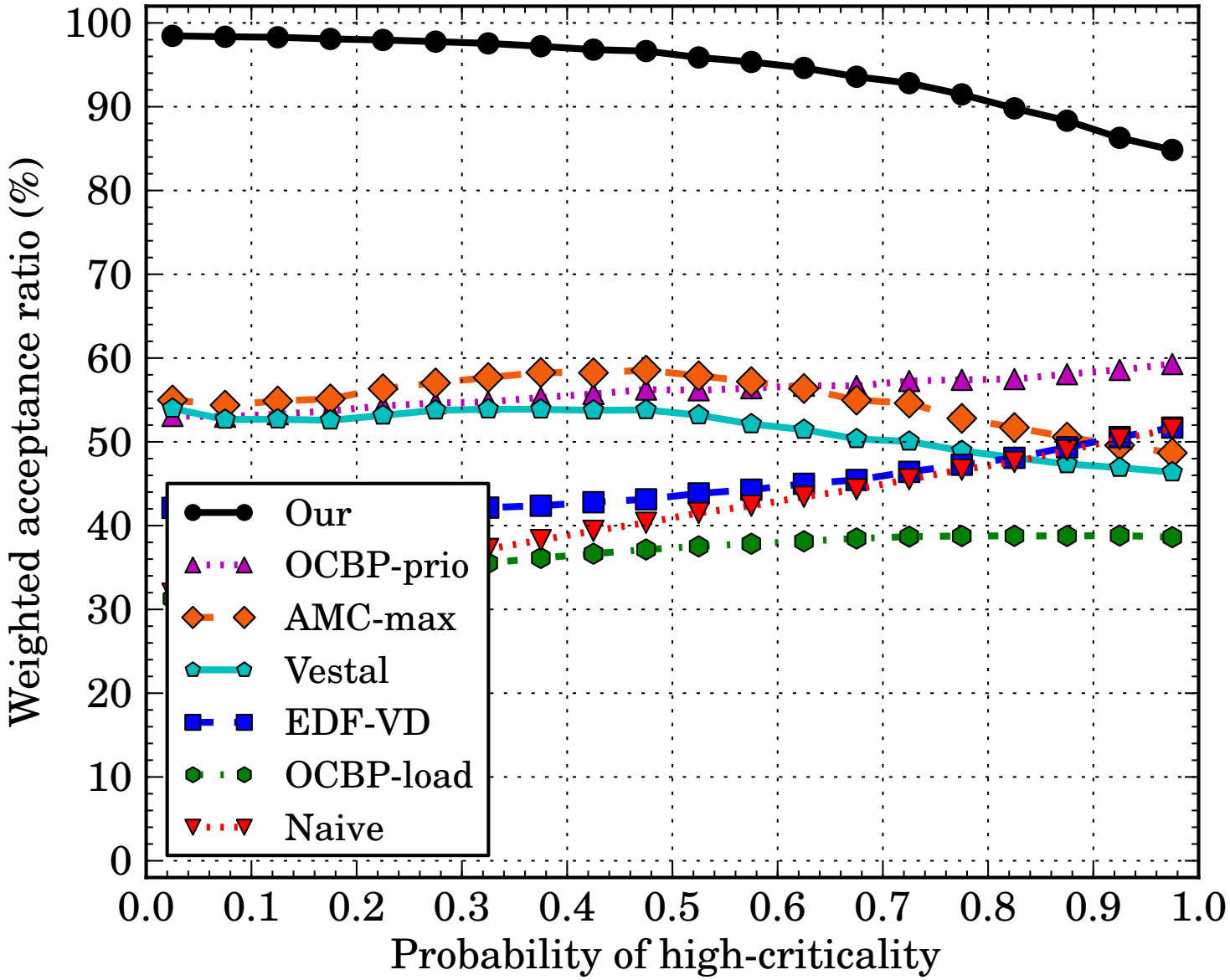


Evaluation


Acceptance ratio (%)
100
90
80
70
60
50
40
30
20
10
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Average utilization
Our
OCBP-prio
AMC-max
Vestal
EDF-VD
OCBP-load
Naive

Evaluation


Weighted acceptance ratio (%)
100
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60
50
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30
20
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Probability of high-criticality
Our
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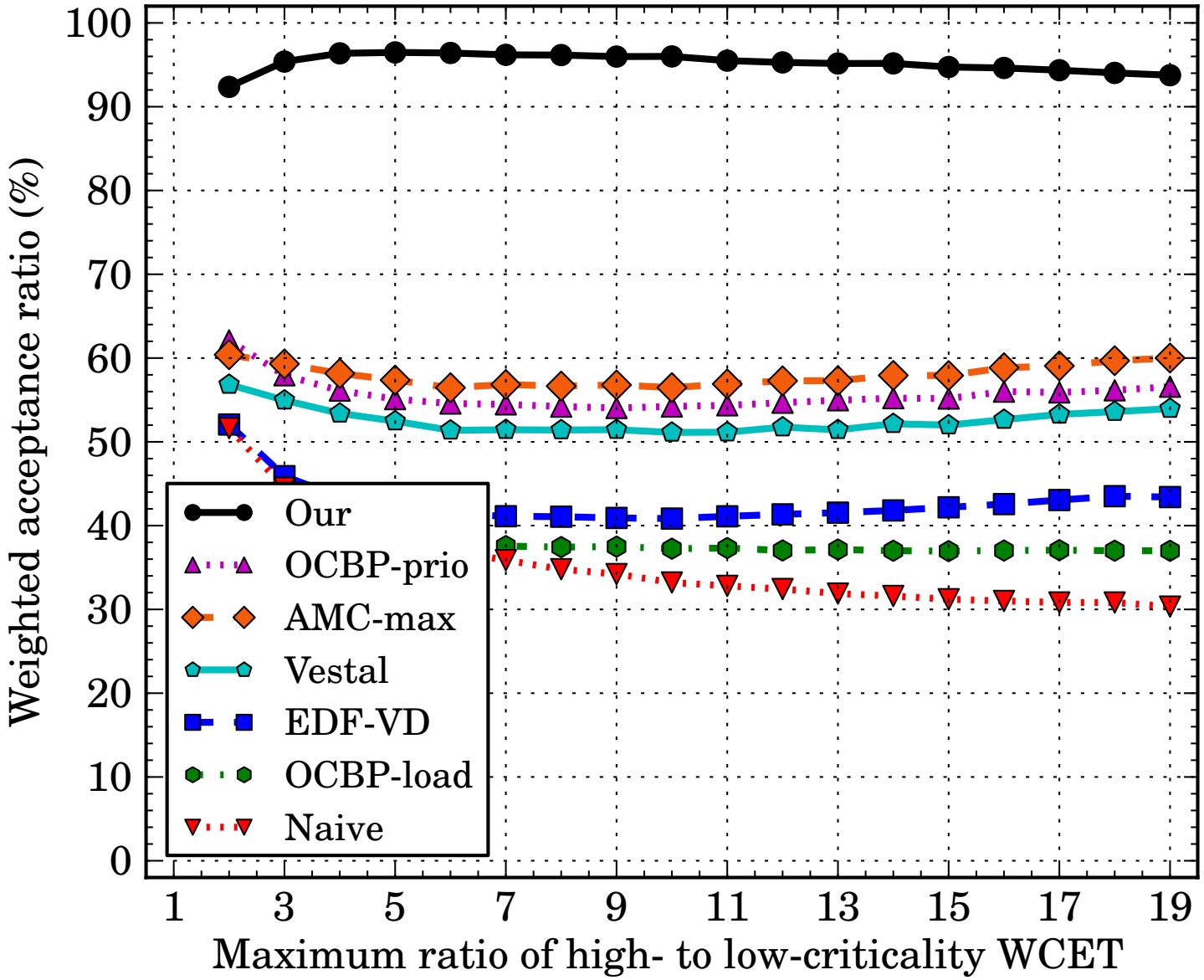
Evaluation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13
15
17
19
Maximum ratio of high- to low-criticality WCET
Our
OCBP-prio
AMC-max
Vestal
EDF-VD
OCBP-load
Naive

Conclusions

1. Demand-bound functions are useful *also for mixed-criticality systems*.
2. The particulars of mixed-criticality demand-bound functions allow us to easily *shape the demand* to the supply of the platform.
3. Experiments indicate that this approach *performs well*.

Questions?