Flexible Mixed-Criticality Scheduling with Dynamic Slack Management.

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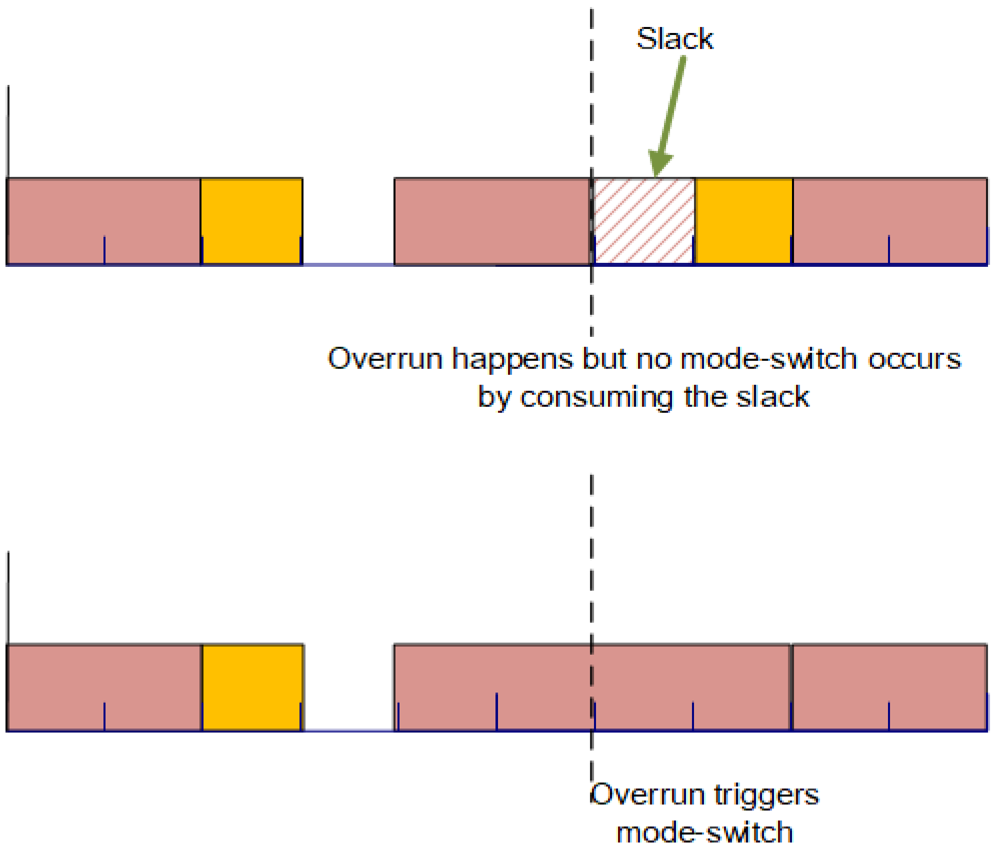
The assumption of Traditional MC work [1-4] :

- The behaviors of high-criticality tasks are bound together during overrunning time
- Low-criticality tasks should be dropped after mode-switches

The assumption of FMC work [5] :

- The overruns of high-criticality tasks are independent
- Low-criticality tasks can be provided with service degradation after mode-switches

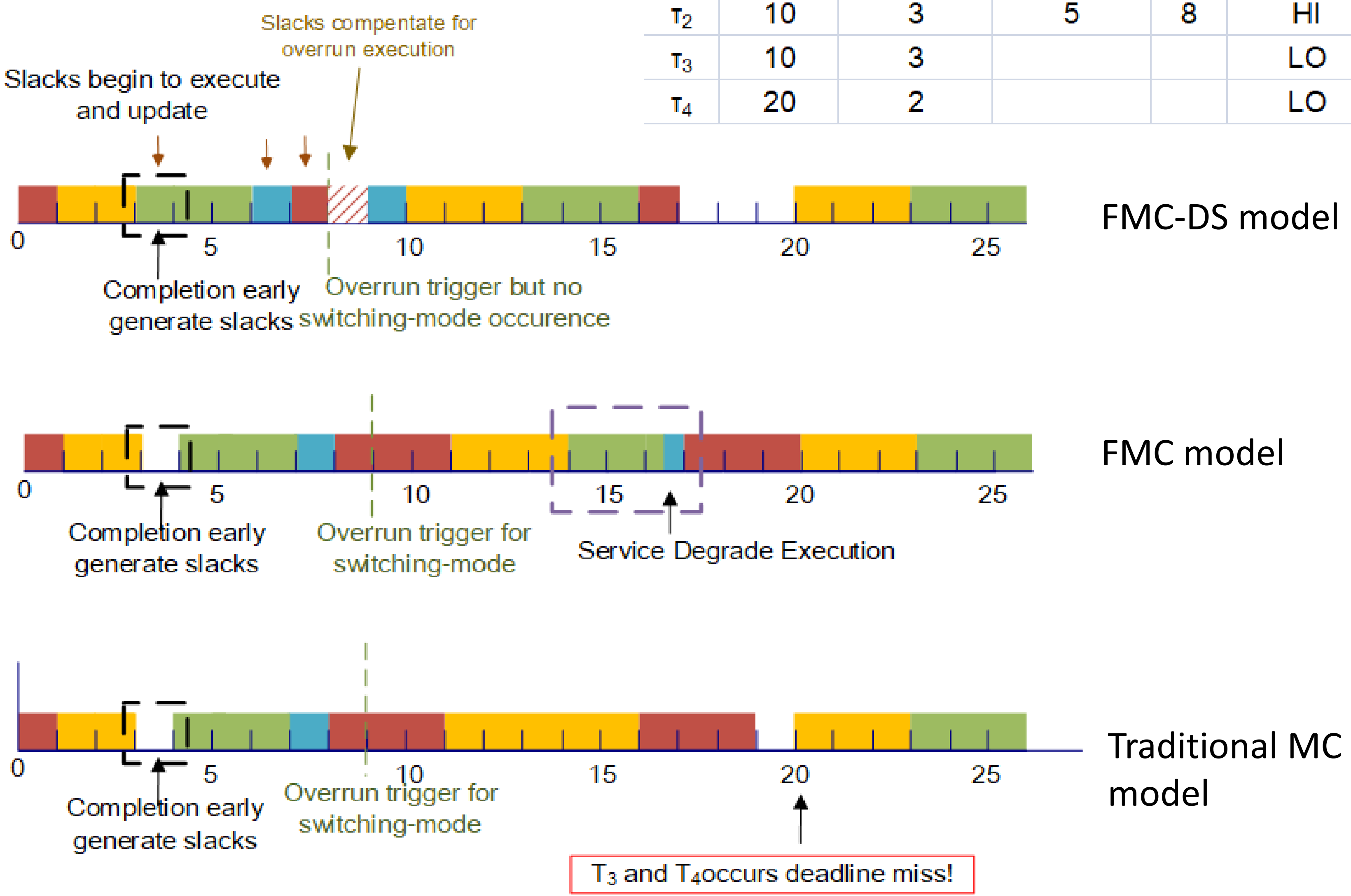

Slack
Overrun happens but no mode-switch occurs
by consuming the slack
Overrun triggers
mode-switch

Our work :

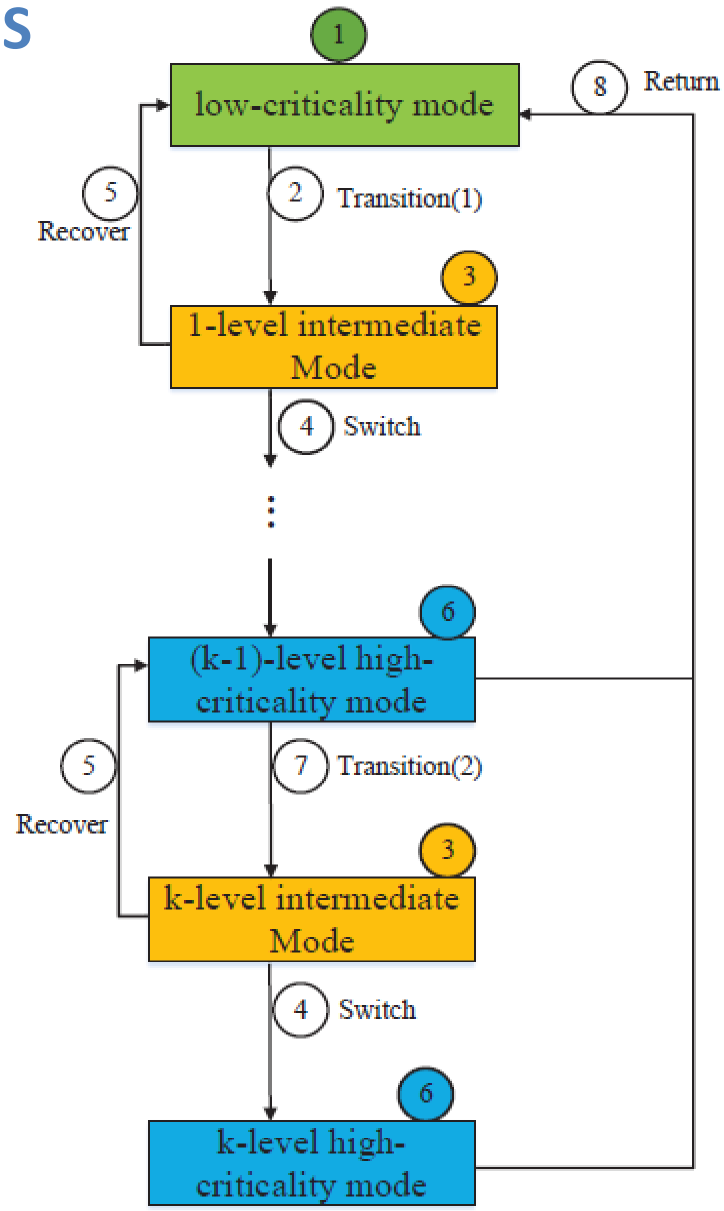
- We developed a light-weight slack management protocol that efficiently monitors and manages dynamic slacks that may be generated during run-time been studied in FMC scheduling framework
- we developed an extended mode-switch scheme to efficiently utilize the remaining slacks under FMC scheduling framework

An illustrative example

	Period	WCET(LO)	WCET(HI)	VD	criticality
τ_1	8	1	3	5	HI
τ_2	10	3	5	8	HI
τ_3	10	3			LO
τ_4	20	2			LO



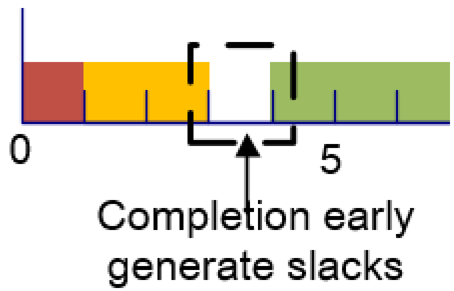
The overview of FMC-DS



The slack management protocol

Model

slack → **Real-time job**



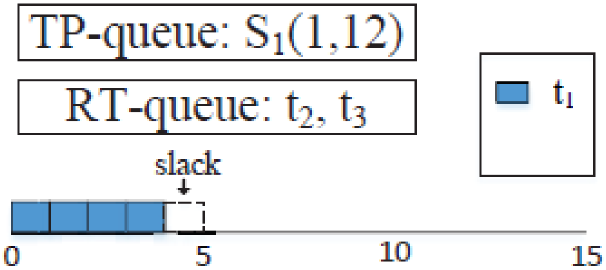
task	Period	WCET	Deadline
τ	8	1	8

Slack management protocol

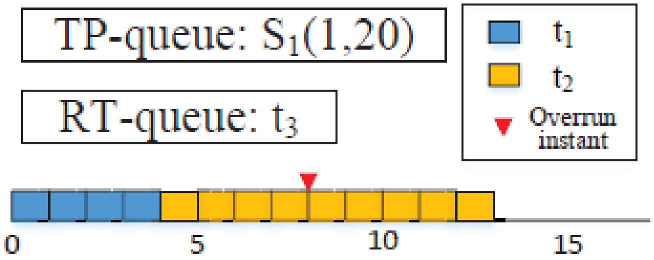
- Slack Collection
- Slack Consumption
- Slack Update

An illustrative example

	Period	WCET(LO)	WCET(HI)	VD	criticality
τ_1	15	5	7	12	HI
τ_2	20	4	9	15	HI
τ_3	20	3			LO



(a)



(b)

An illustrative example

	Period	WCET(LO)	WCET(HI)	VD	criticality
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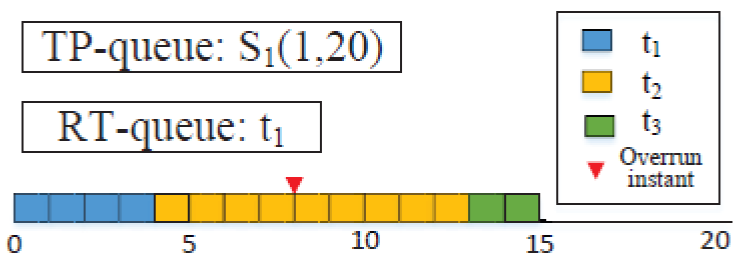
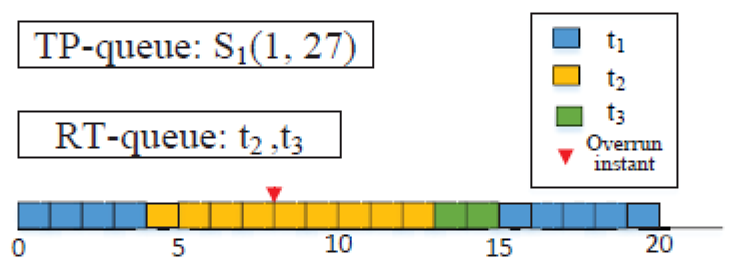
τ_2	20	4	9	15	HI
τ_3	20	3			LO



(c)



(d)

An illustrative example

	Period	WCET(LO)	WCET(HI)	VD	criticality
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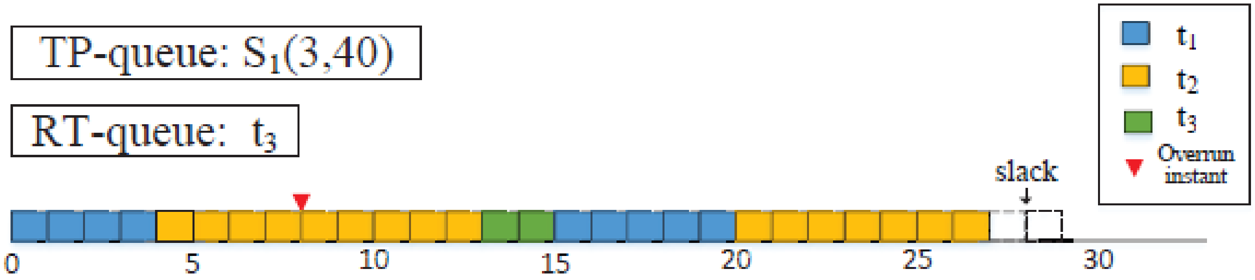

(e)

An illustrative example

	Period	WCET(LO)	WCET(HI)	VD	criticality
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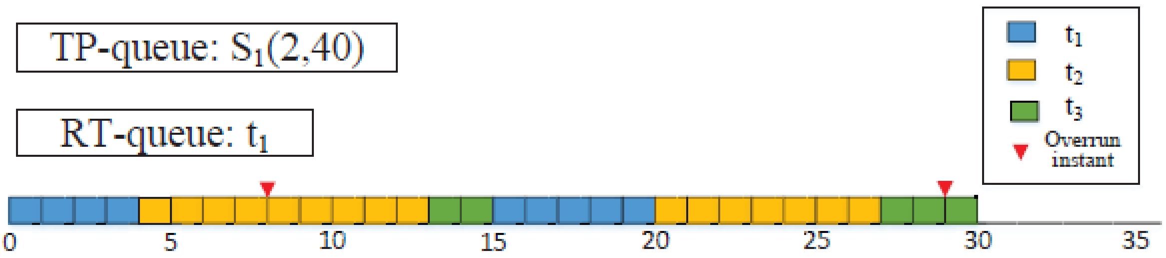

(f)

An illustrative example

	Period	WCET(LO)	WCET(HI)	VD	criticality
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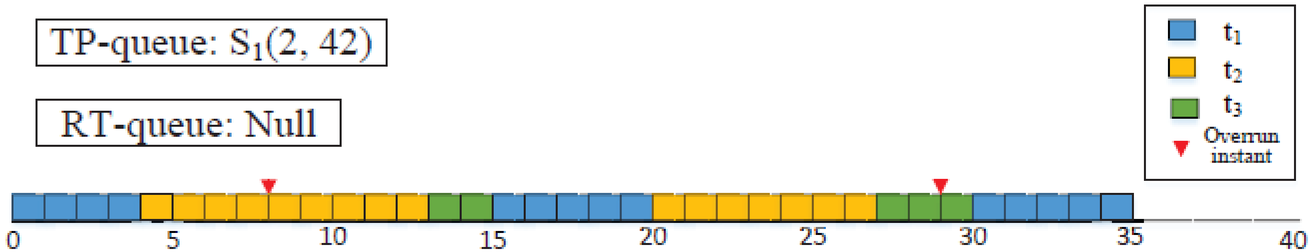

(g)

An illustrative example

	Period	WCET(LO)	WCET(HI)	VD	criticality
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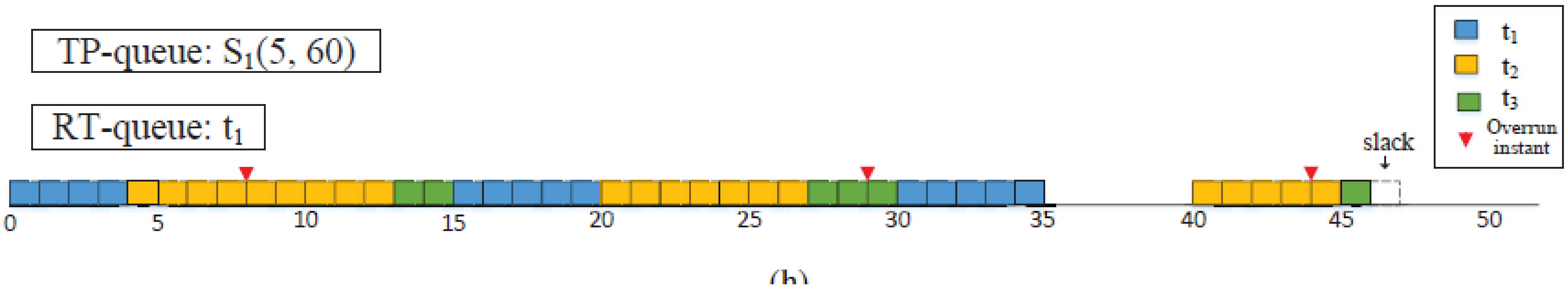
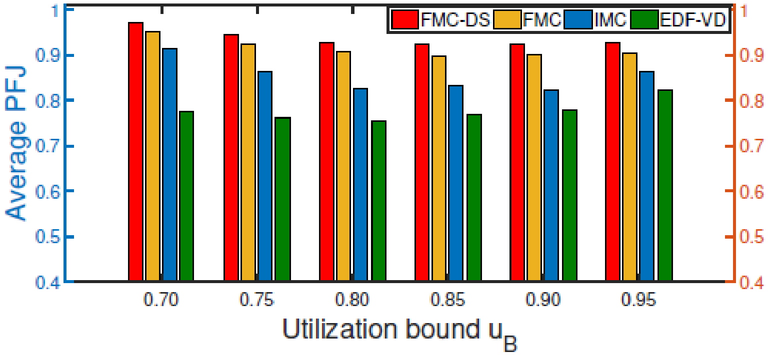
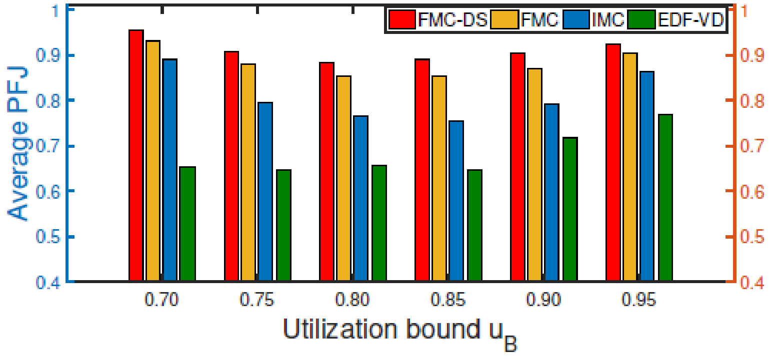


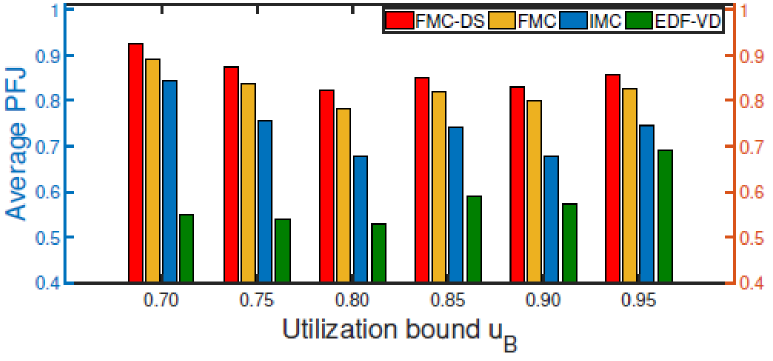
The Experimental performance



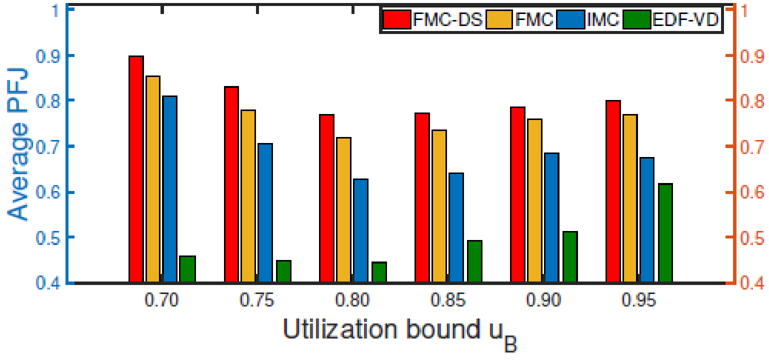
(a) $op = 0.1$



(b) $op = 0.3$

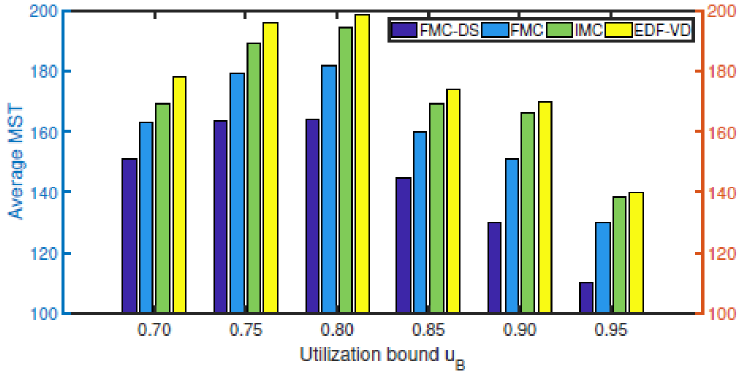


(c) $op = 0.5$

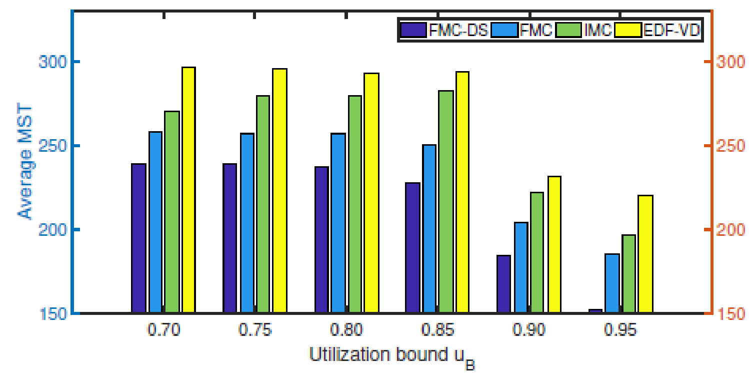


(d) $op = 0.7$

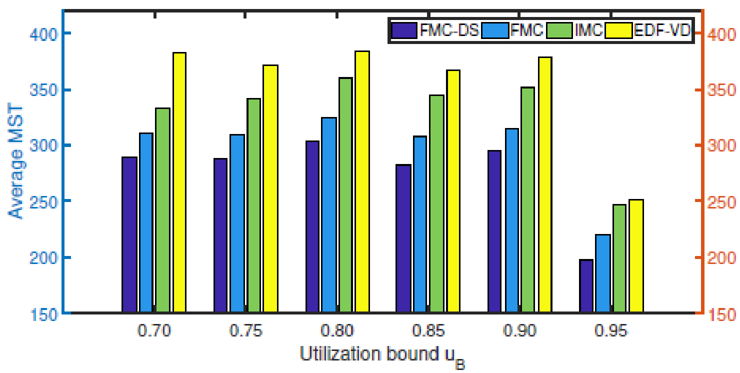
The Experimental performance



(a) $op = 0.1$



(b) $op = 0.3$



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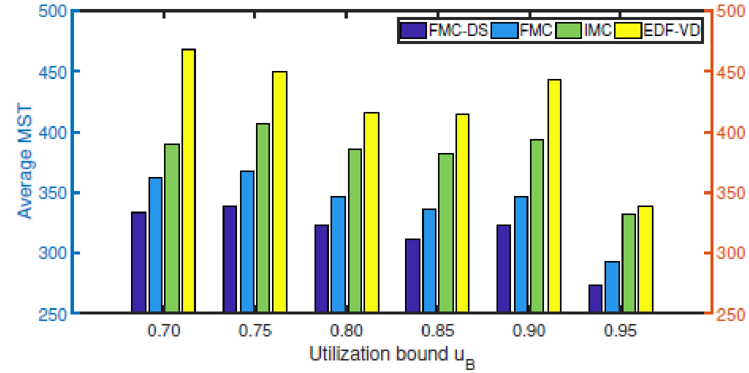

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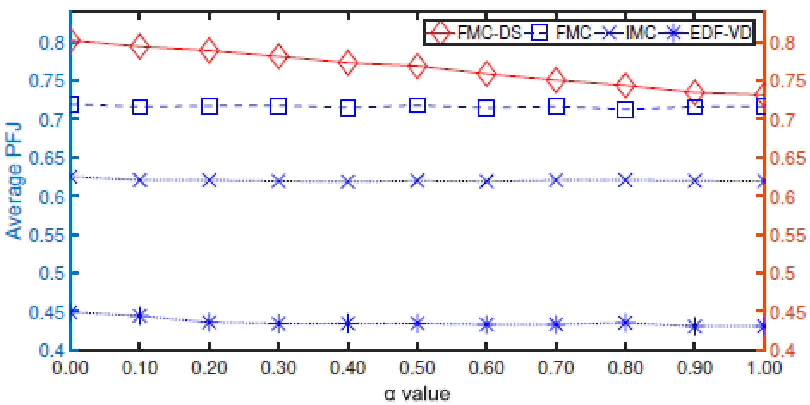
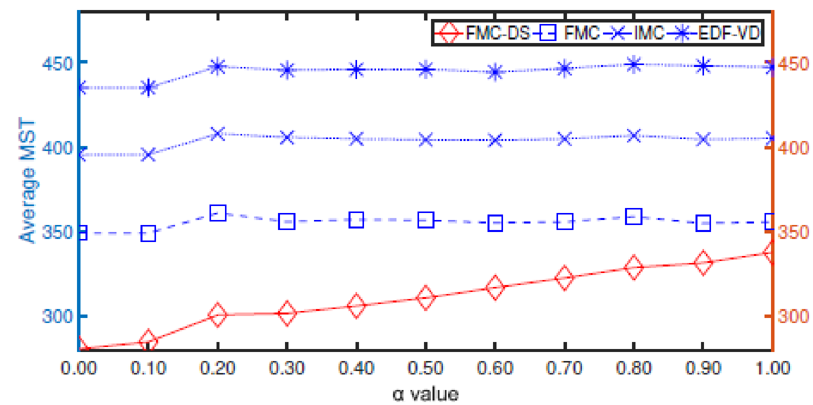
The Experimental performance



(a) PFJ for different α



(b) MST for different α

Reference

[1] S. Baruah. at al. Response-time analysis for mixed criticality systems. In 2011 the 32nd IEEE Real-Time Systems Symposium, 2011.
[2] S. Baruah et al. Towards the design of certifiable mixed-criticality systems. In 2010 the 16th IEEE Real-Time and Embedded Technology and Applications Symposium, 2010.
[3] S. Baruah et al. Mixed-criticality scheduling of sporadic task systems. In 2021 the 19th European Conference on Algorithms, 2011.
[4] S. Baruah et al. The preemptive uniprocessor scheduling of mixedcriticality implicit-deadline sporadic task systems. In 2012 the 24th Euromicro Conference on Real-Time Systems, 2012.
[5] Gang C. et al. Utilization-based scheduling of flexible mixed-criticality real-time tasks. IEEE Transaction on Computers, 2018.

Thank you