Schedulability Analysis for the Abort-and-Restart (AR) Model

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Outline

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- Tighter analysis and results
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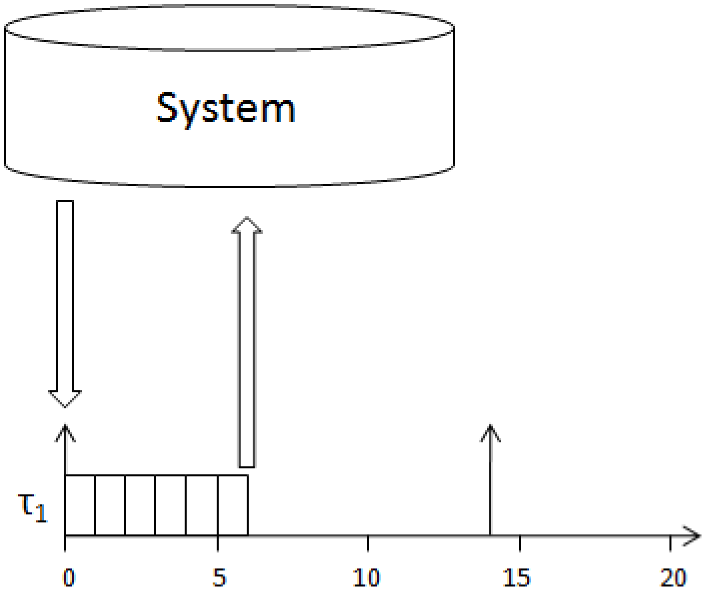
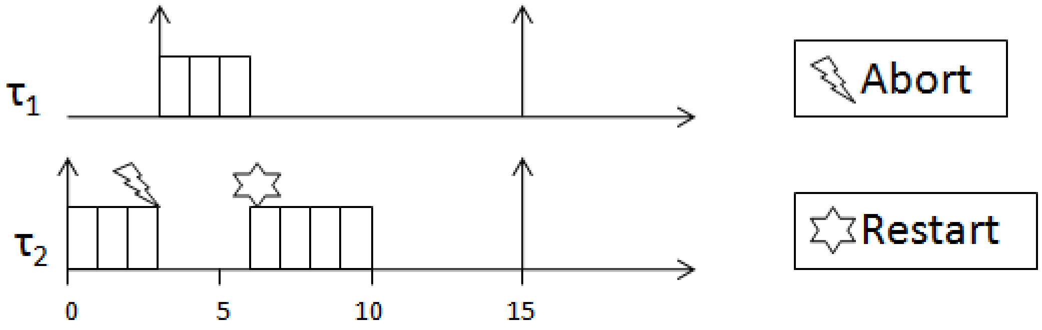
Introduction





Motivation

- Nowadays, computers have more power of execution than before. In concurrent programming, sometimes programmers consider how to enhance the correctness of programs rather than reduce the overhead. For a real-time system, it is more complicated because of timing constraints and priorities. A concurrency control mechanism for a system is important because it affects the correctness and the schedulability.

- Atomic execution - support P-FRP
- No shared resources problems
- Preemptible Atomic Regions (PAR) - similar

System model

- Fixed priority scheduling
- On a single processor
- Periodic / sporadic tasks
- $D \leq T$

Analysis

- The standard response time analysis cannot apply to the AR model.

$$R_i = C_i + \sum_{\forall j \in hp_i} \left\lceil \frac{R_i}{T_j} \right\rceil \cdot C_j$$

- New Formulation

$$\tilde{C}_j^i = C_j + \max_{\forall k \in hep_i \bigcap lp_j} C_k$$

Example

Task	Period	C	$\tilde{C}_j^4$	Priority
τ_1	28	2	7(2+5)	1
τ_2	120	3	8(3+5)	2
τ_3	140	4	9(4+5)	3
τ_4	200	5	5(5+0)	4

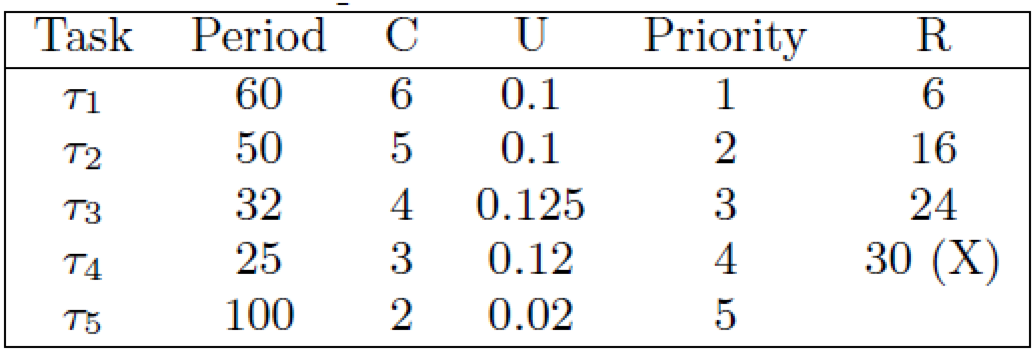
1. $R_4^1 = 5 + (\lceil \frac{5}{28} \rceil \cdot 7 + \lceil \frac{5}{120} \rceil \cdot 8 + \lceil \frac{5}{140} \rceil \cdot 9) = 29$
2. $R_4^2 = 5 + (\lceil \frac{29}{28} \rceil \cdot 7 + \lceil \frac{29}{120} \rceil \cdot 8 + \lceil \frac{29}{140} \rceil \cdot 9) = 36$
3. $R_4^3 = 5 + (\lceil \frac{36}{28} \rceil \cdot 7 + \lceil \frac{36}{120} \rceil \cdot 8 + \lceil \frac{36}{140} \rceil \cdot 9) = 36$

Priority assignment

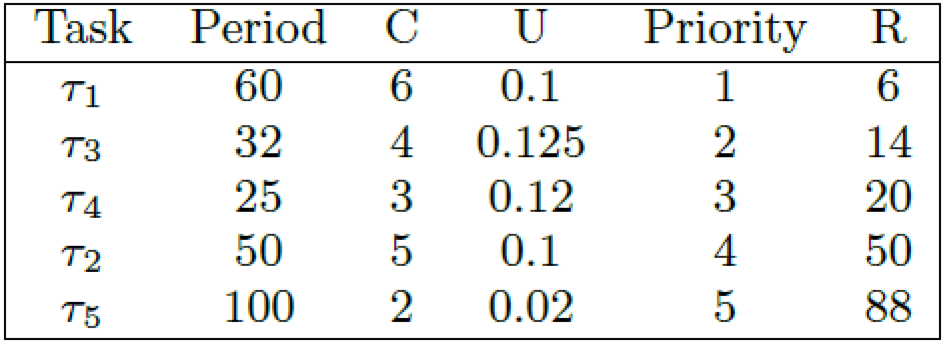
Execution-time-toward-Utilisation Monotonic (EUM) priority assignment.

- Execution-time Monotonic (EM) - assigns a higher priority to a task which has a bigger worst-case execution time
- Utilisation Monotonic (UM) – assigns a higher priority to a task which has higher utilisation

Example

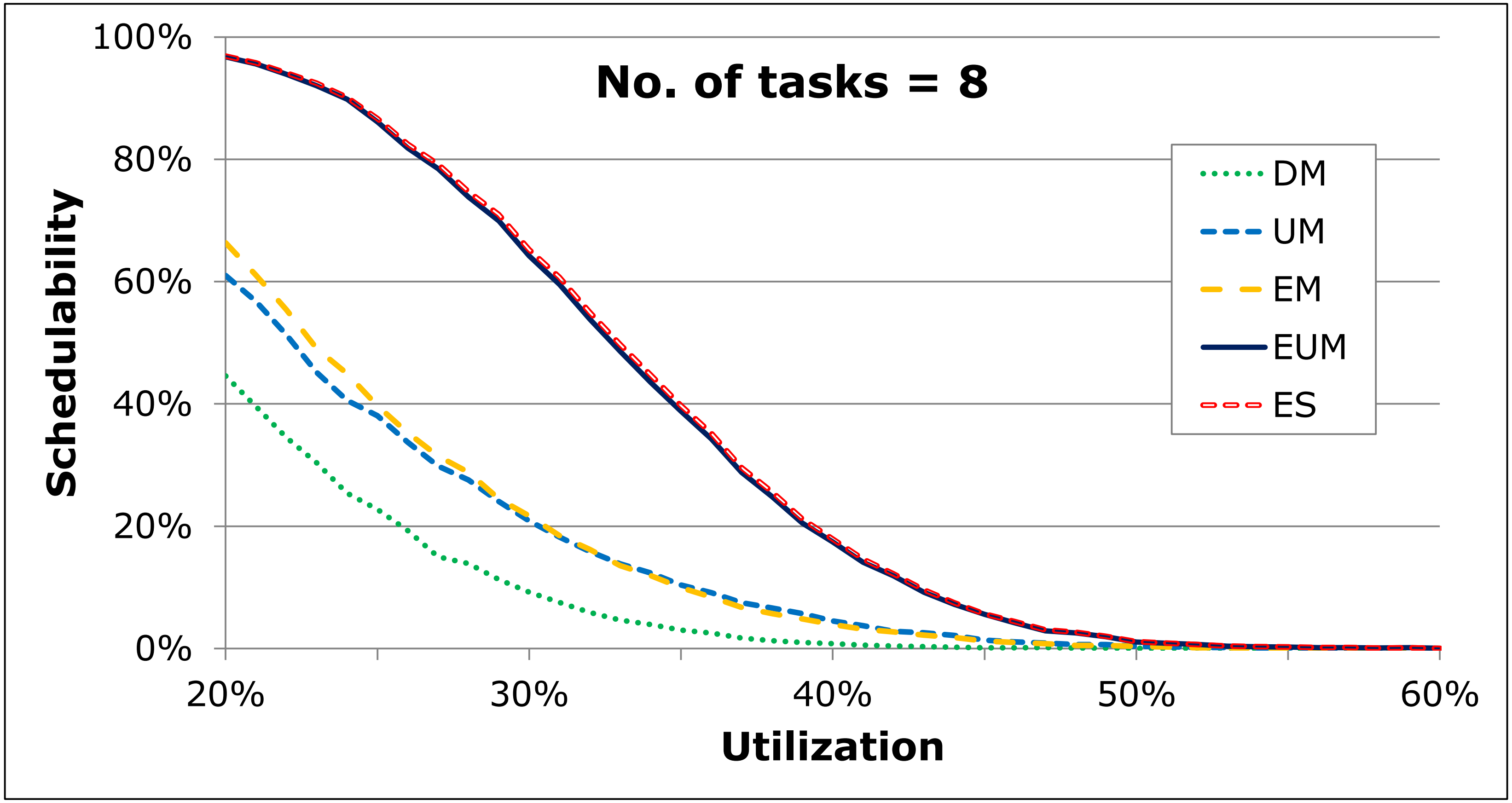


Task	Period	C	U	Priority	R
τ_1	60	6	0.1	1	6
τ_2	50	5	0.1	2	16
τ_3	32	4	0.125	3	24
τ_4	25	3	0.12	4	30 (X)
τ_5	100	2	0.02	5	



Task	Period	C	U	Priority	R
τ_1	60	6	0.1	1	6
τ_3	32	4	0.125	2	14
τ_4	25	3	0.12	3	20
τ_2	50	5	0.1	4	50
τ_5	100	2	0.02	5	88

Results


No. of tasks = 8
Schedulability
100%
80%
60%
40%
20%
0%
20%
30%
40%
50%
60%
Utilization
DM
UM
EM
EUM
ES

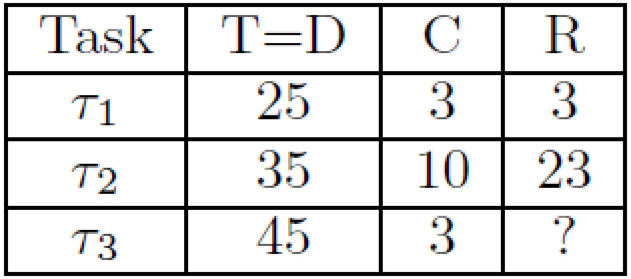
Tighter analysis

- It is too pessimistic because higher priority tasks cannot always abort the lower priority task with the biggest execution time on each release. In this case, the higher priority task aborts the task with second biggest execution time. The multi-set approach [1] from CRPD has a similar property to the AR model.

[1] S. Altmeyer, R. Davis, and C. Maiza. Improved cache related pre-emption delay aware response time analysis for fixed priority pre-emptive systems. Real-Time Systems, 48(5):499-526, 2012.

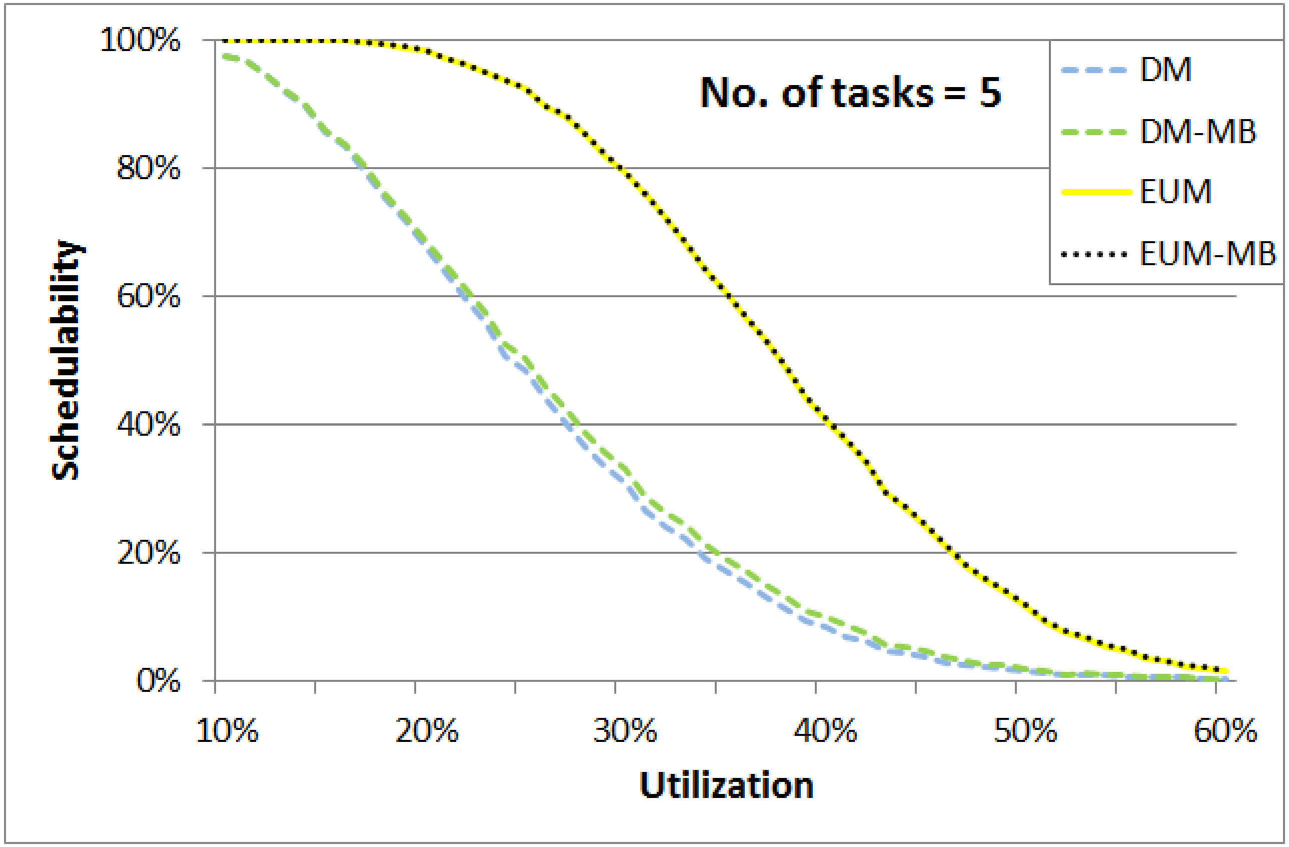
Multi-bag approach

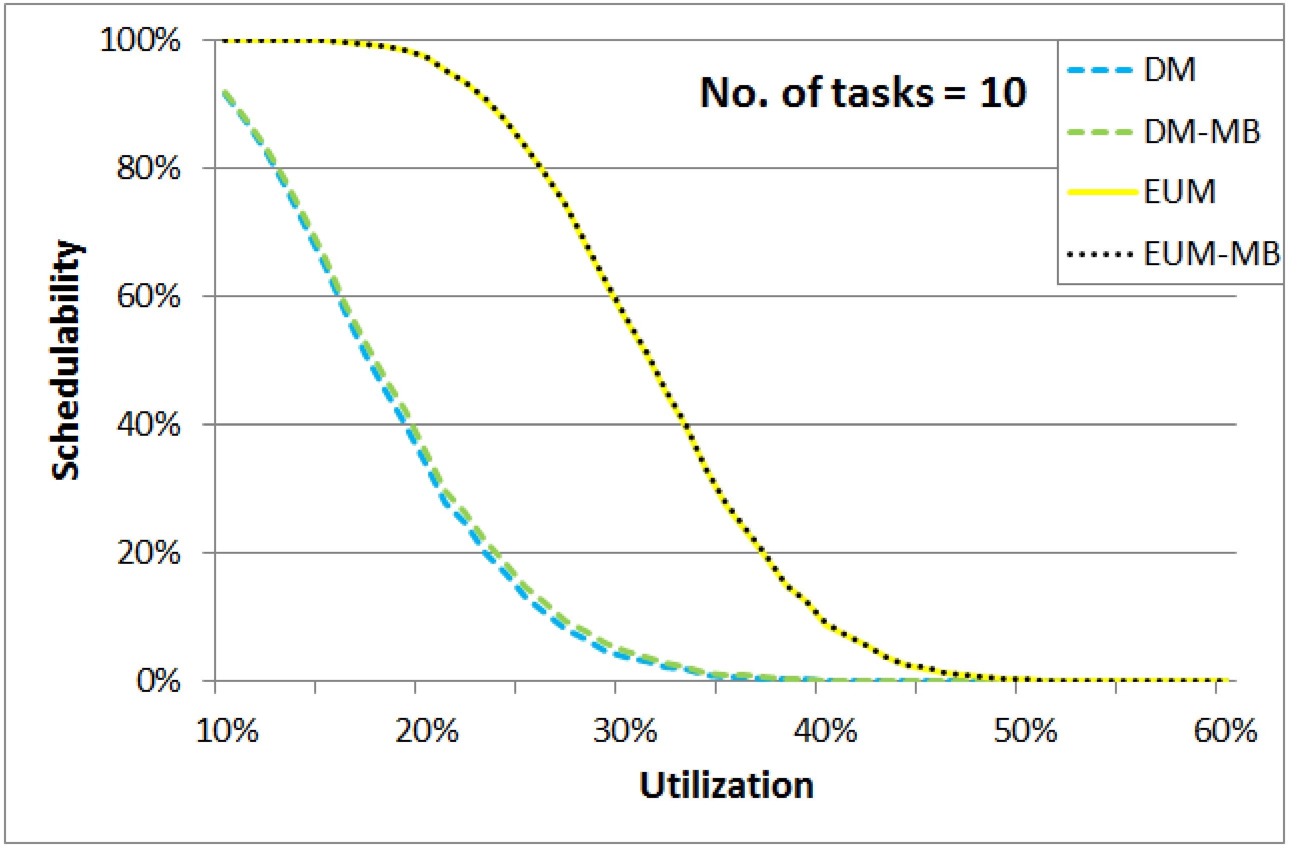
- Each task has a bag to contain a series of abort cost from tasks $t_k \in$ hep(i) ∩ lp(j), with the number is decided by $E_j(R_k)$. A task-set has a number of bags for each task. Therefore, we call this approach, the multi-bag.

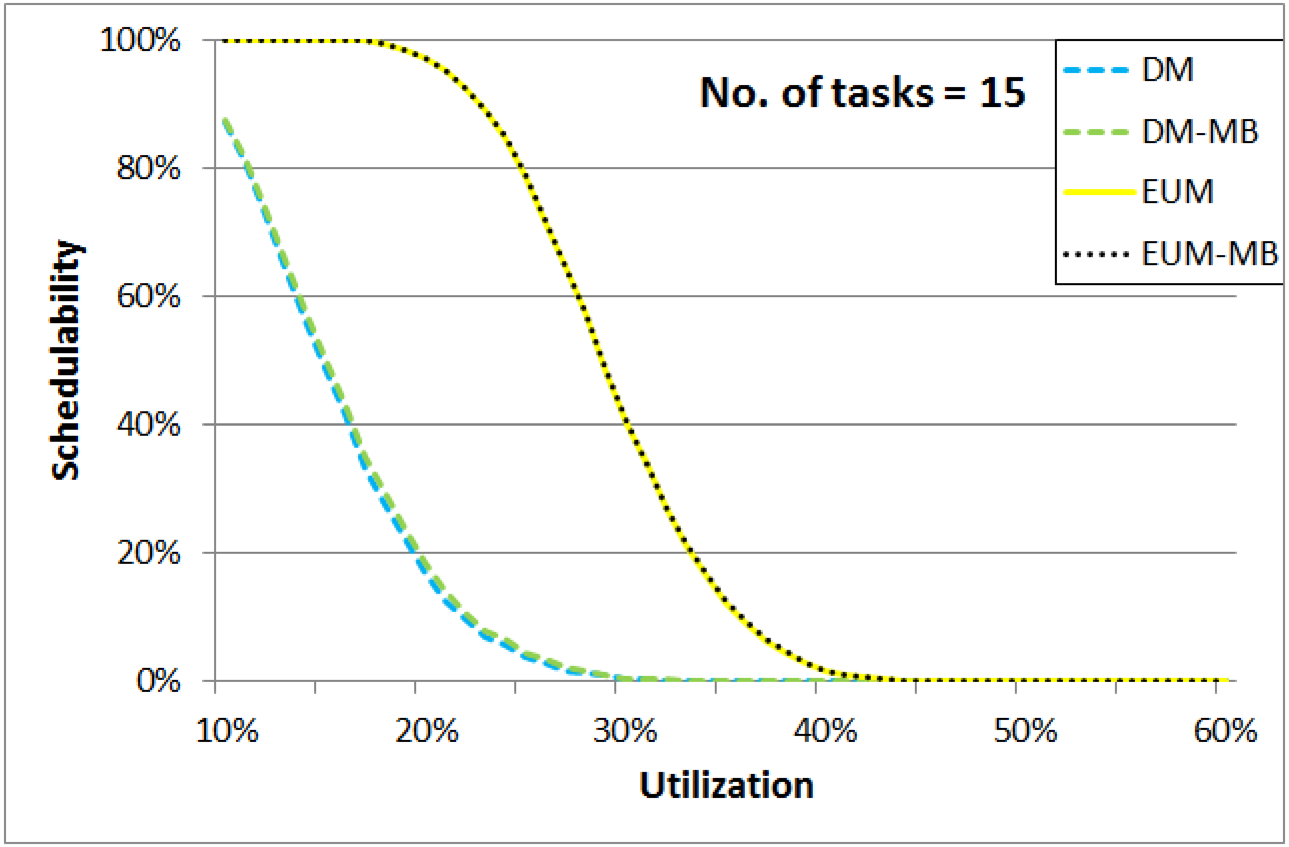


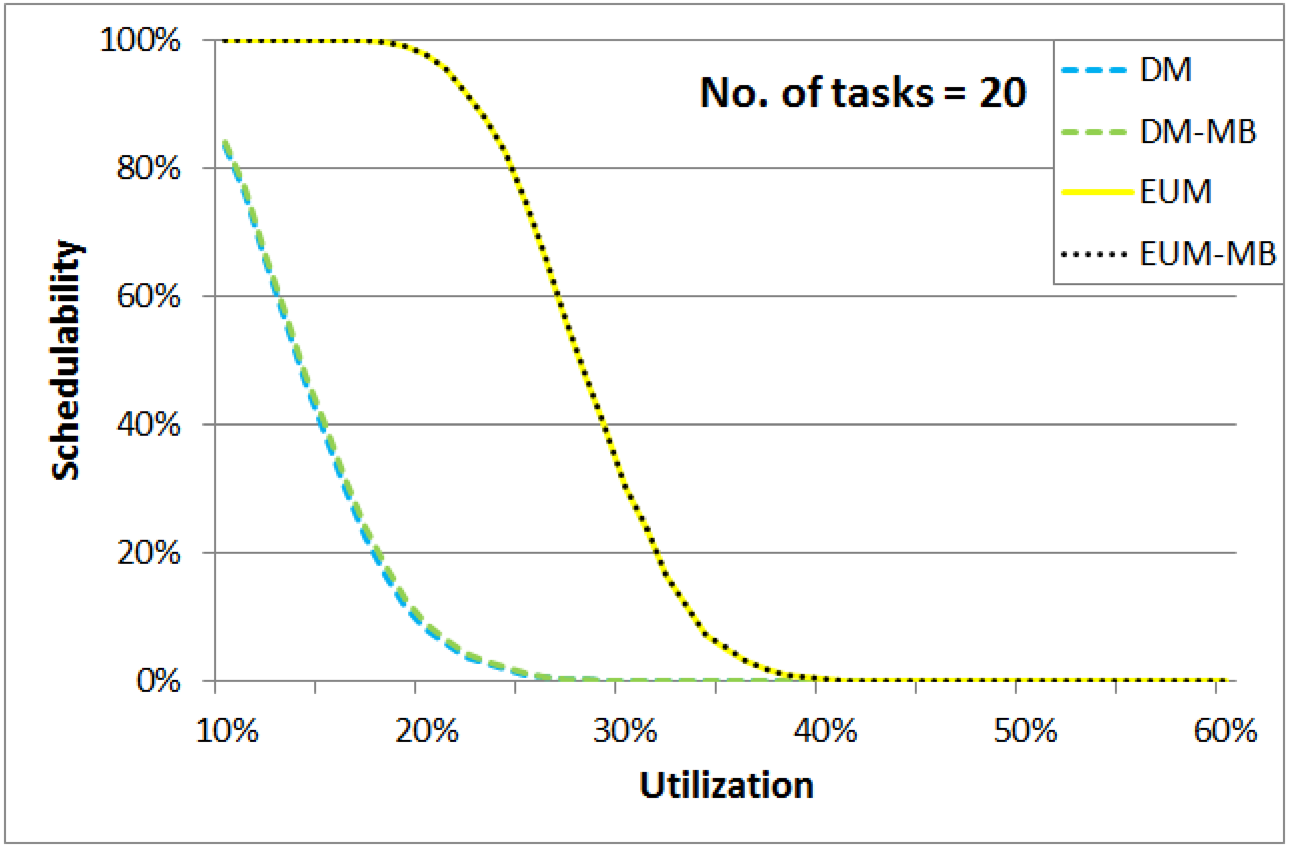
Task	T=D	C	R
τ_1	25	3	3
τ_2	35	10	23
τ_3	45	3	?

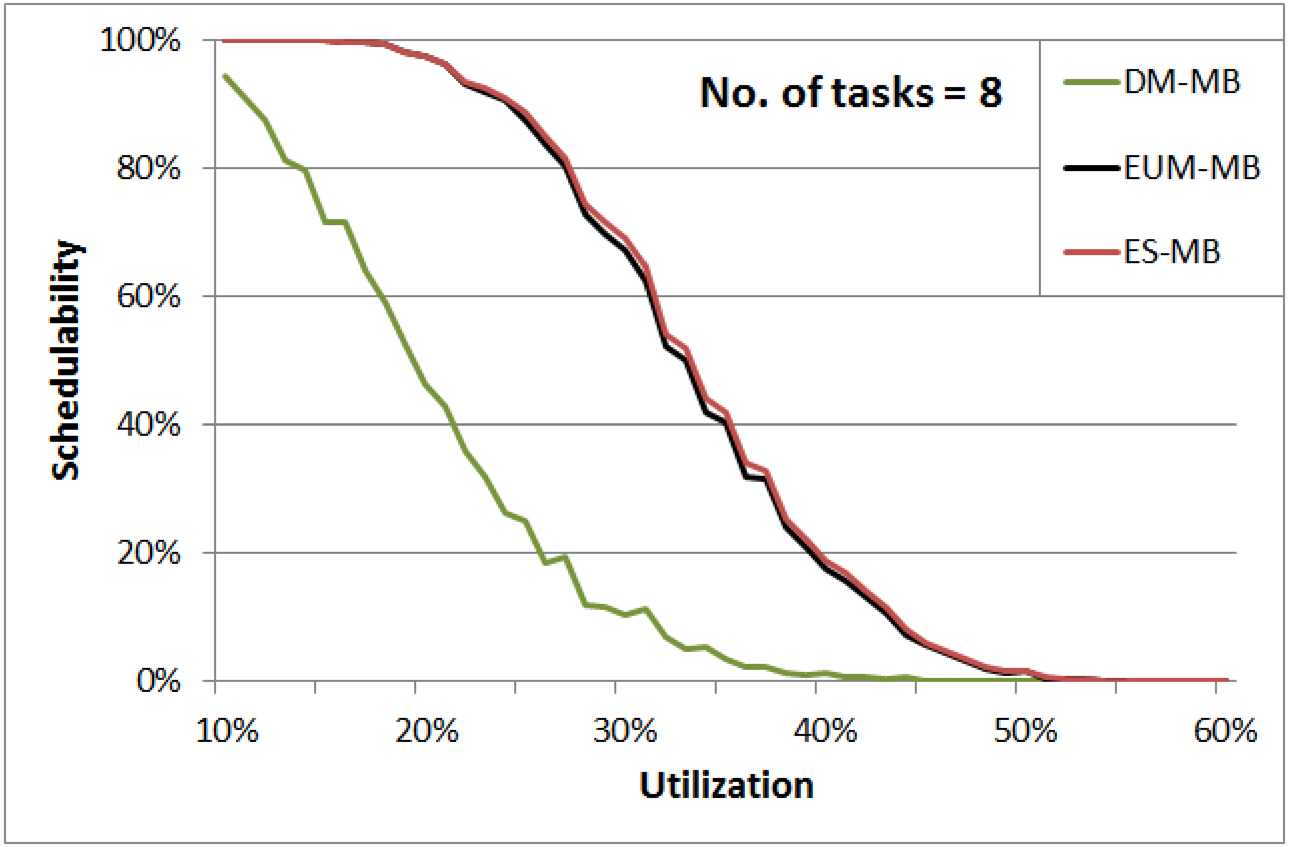
Results


No. of tasks = 5
DM
DM-MB
EUM
EUM-MB
Schedulability
100%
80%
60%
40%
20%
0%
10%
20%
30%
40%
50%
60%
Utilization


No. of tasks = 10
Schedulability
100%
80%
60%
40%
20%
0%
10%
20%
30%
40%
50%
60%
Utilization
DM
DM-MB
EUM
EUM-MB


No. of tasks = 15
DM
DM-MB
EUM
EUM-MB
Schedulability
100%
80%
60%
40%
20%
0%
10%
20%
30%
40%
50%
60%
Utilization


No. of tasks = 20
DM
DM-MB
EUM
EUM-MB
Schedulability
100%
80%
60%
40%
20%
0%
10%
20%
30%
40%
50%
60%
Utilization


No. of tasks = 8
DM-MB
EUM-MB
ES-MB
Schedulability
100%
80%
60%
40%
20%
0%
10%
20%
30%
40%
50%
60%
Utilization

Conclusion

- A new formulation to use the standard response time analysis
- EUM is a do-able priority assignment for the AR model
- Tighter analysis is introduced
- Current and future work – Deferred abort

Questions

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