



oCPS

*Platform-aware Model-driven Optimization of
Cyber-Physical Systems*

Runtime Execution Control for Mixed-Criticality Systems

oCPS Fall School
28-31 October 2019

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This project has received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under grant agreement no 674875.





MSCA-ITN PLATFORM-AWARE MODEL-DRIVEN
OPTIMIZATION OF CYBER-PHYSICAL SYSTEMS

<https://youtu.be/BXTxMy9FvJw>

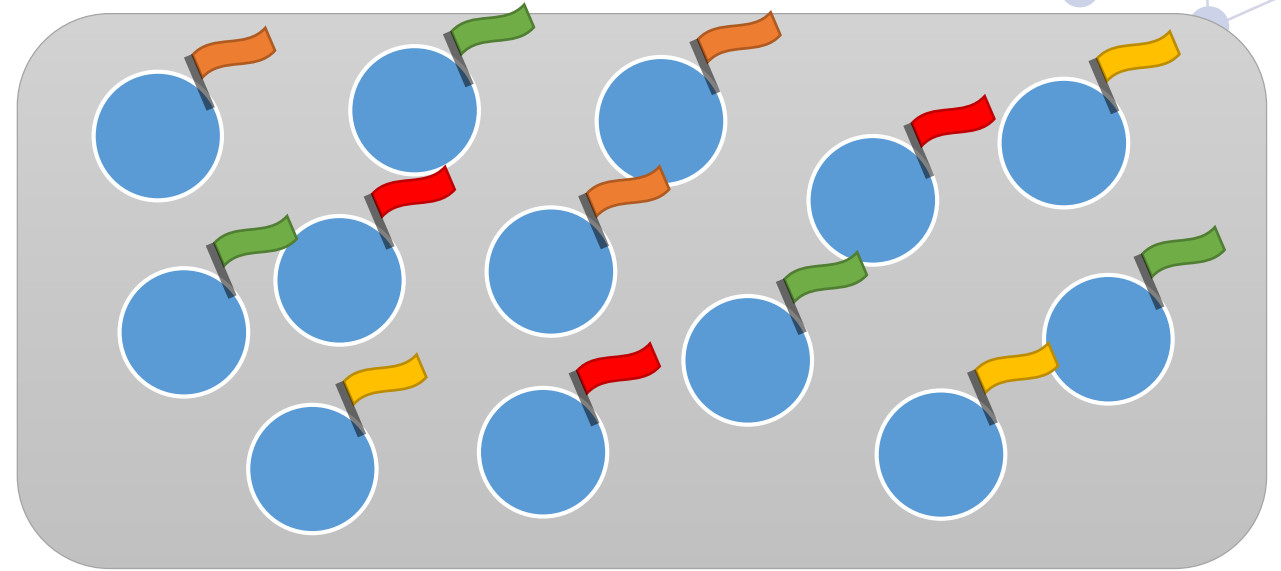
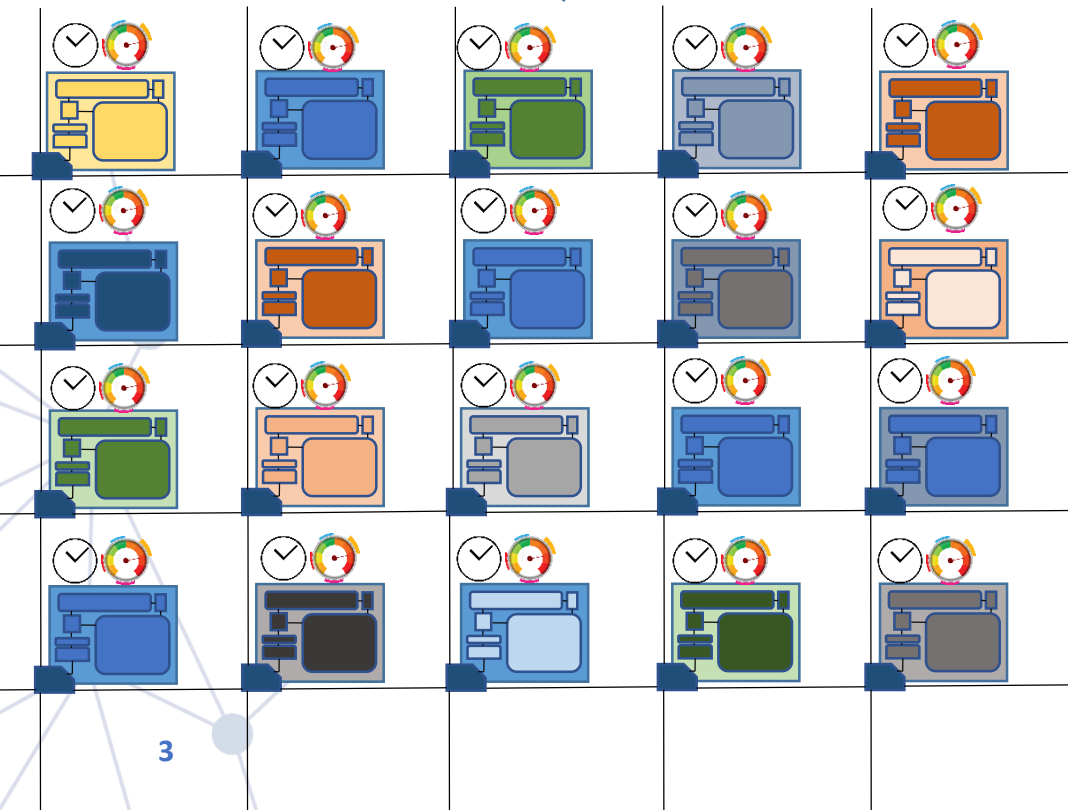
Imsys



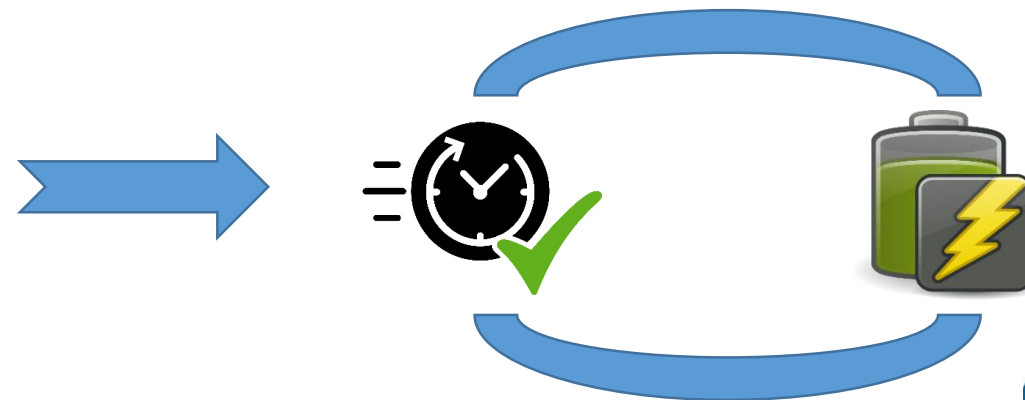
Mixed-Criticality Systems

Execution

Control



Energy-Efficient Execution



Imsys



Runtime Execution Control for Mixed-Criticality Systems

- Precisely Bounded Deadline Misses as Quality of Service (QoS)
- Dynamic Tuning of QoS Requirements between Hard and Soft Real-Time
- Dynamic Trade-off between Throughput and Energy Consumption
- Mapping, Scheduling, and Power Management Combined

Content

- **Dynamic Constraints for Mixed-Criticality Systems** (Juhász, Jantsch, COINS 2019)
 - Mixed-Criticality Scheduling Theory
 - Weakly-Hard Real-Time Systems
 - Dynamic Quality-of-Service Requirements
- **Implementation Considerations** (Paper in preparation)
 - Window-based Approximation
 - Min-Plus Containers

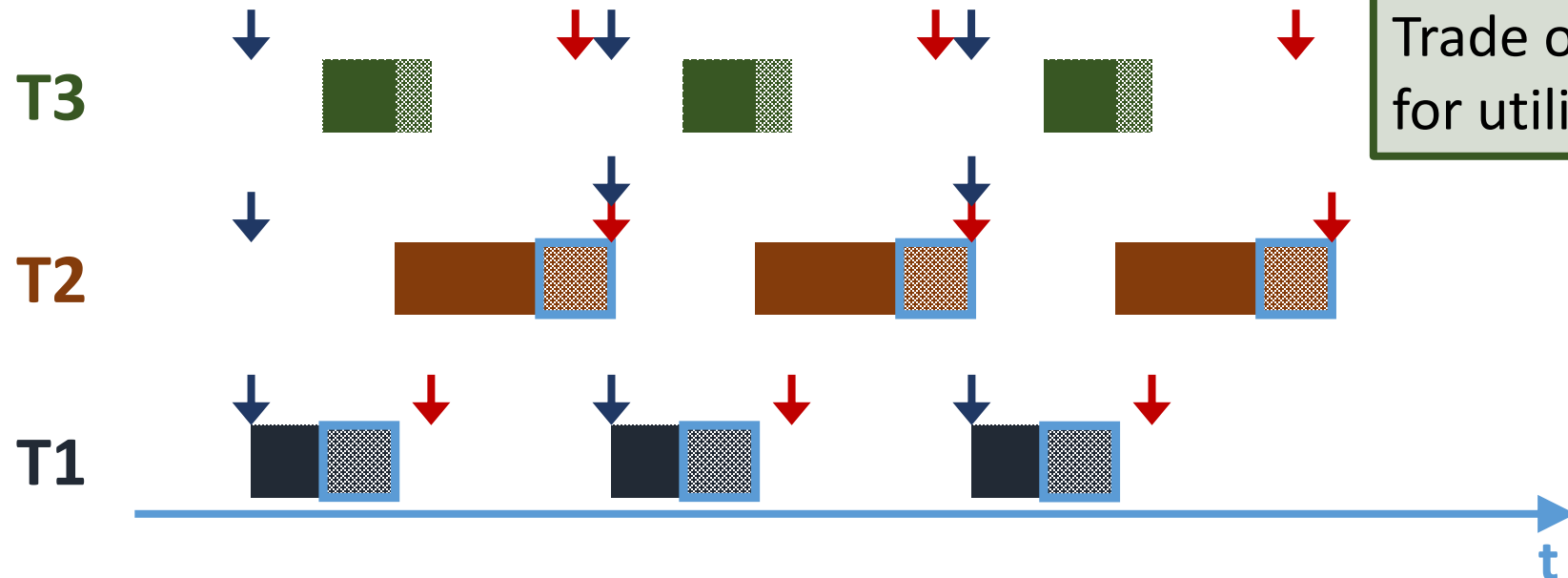
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- **Dynamic Constraints for Mixed-Criticality Systems**
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Real-Time Systems

Task	Period	Deadline	WCET	ACET
T1	10	5	4	2
T2	10	10	6	4
T3	10	9	3	2

- Real-Time Systems
- Static Guarantees
 - Overprovisioning

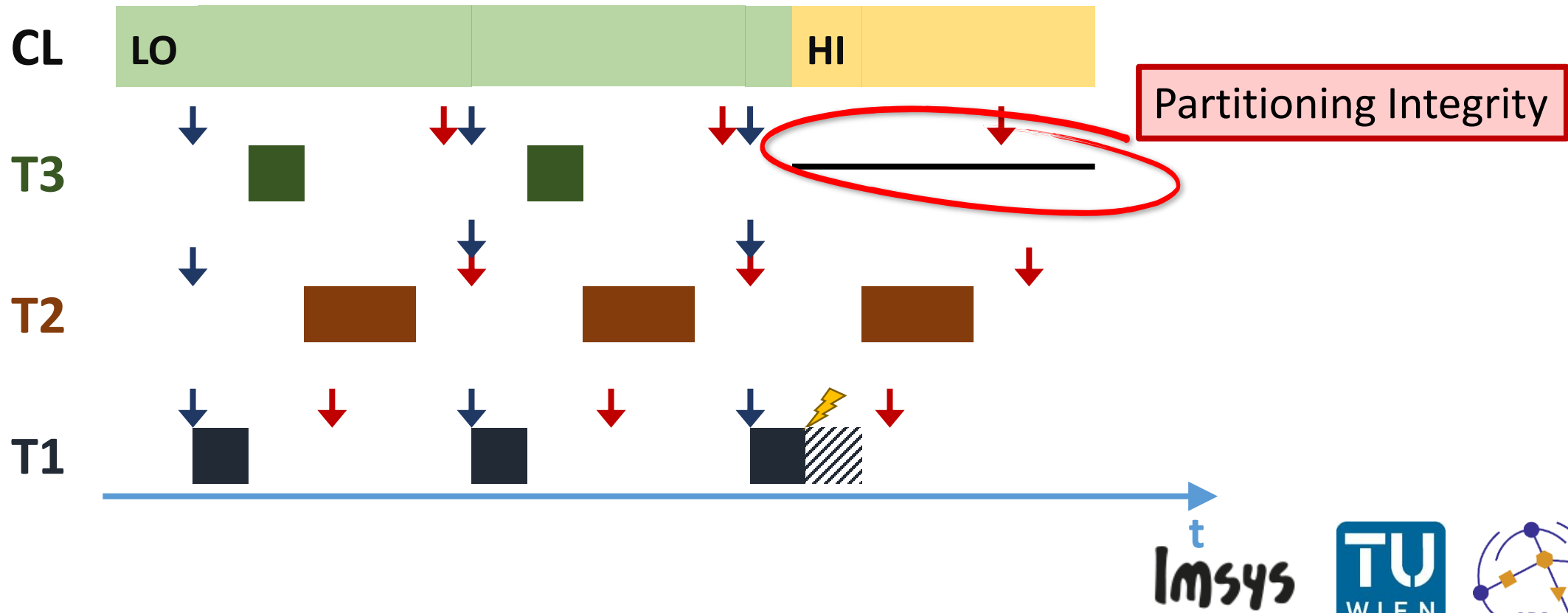


Trade off guarantees for utilization

Mixed-Criticality Scheduling Theory

Dynamic Task Importance

Task	CL	Period	Deadline	WCET
T1	HI	10	5	[2, 4]
T2	HI	10	10	[4, 6]
T3	LO	10	9	[3]



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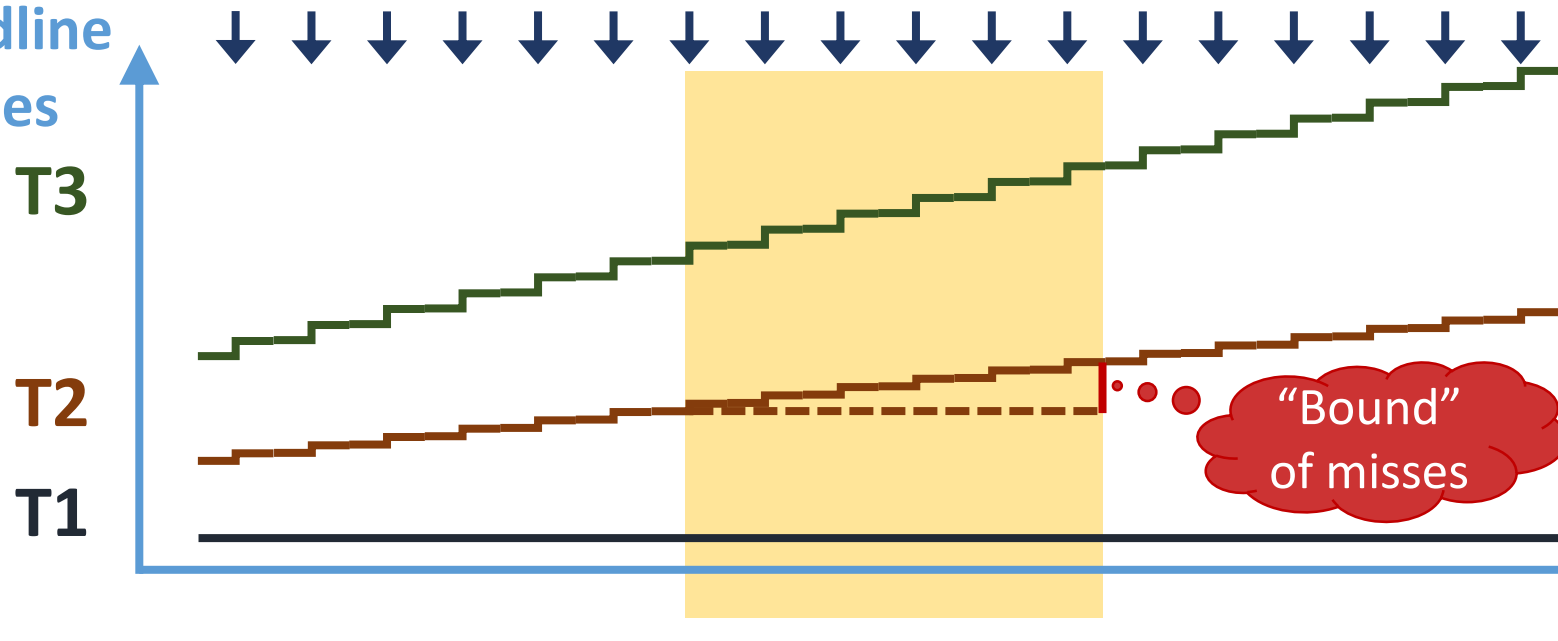
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Weakly-Hard Real-Time Systems

Task	QoS	Period	Deadline	WCET
T1	Q1	10	5	4
T2	Q2	10	10	6
T3	Q3	10	9	3

allowed
deadline
misses



$Q3 = 0$
Best-Effort

$0 < Q2 < 1$
Weakly-Hard Real-Time

$Q1 = 1$
Strongly-Hard Real-Time

The distribution of met and missed deadlines during a window of time is precisely bounded.

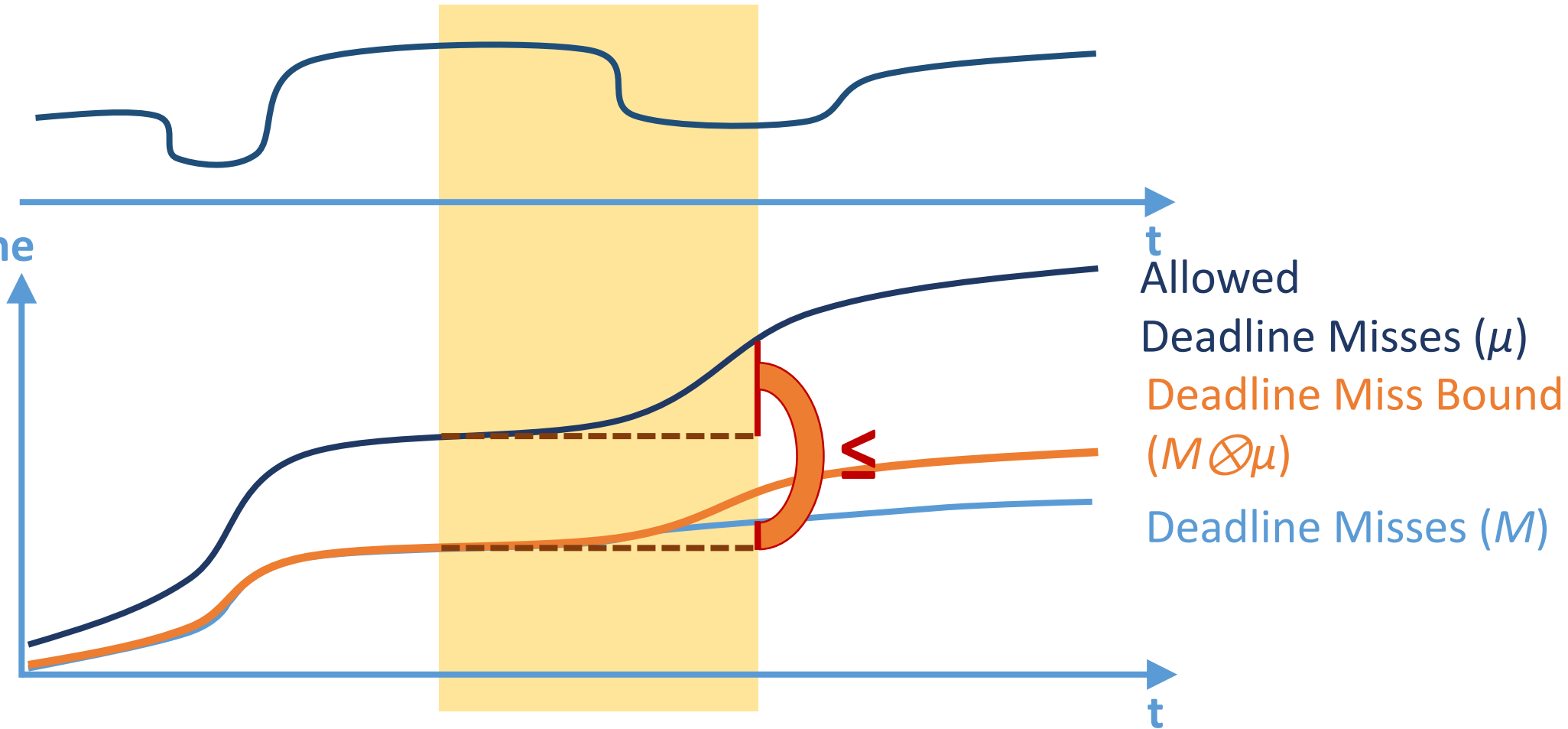
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Quality-of-Service Constraints

Dynamic QoS
Parameter

deadline
misses

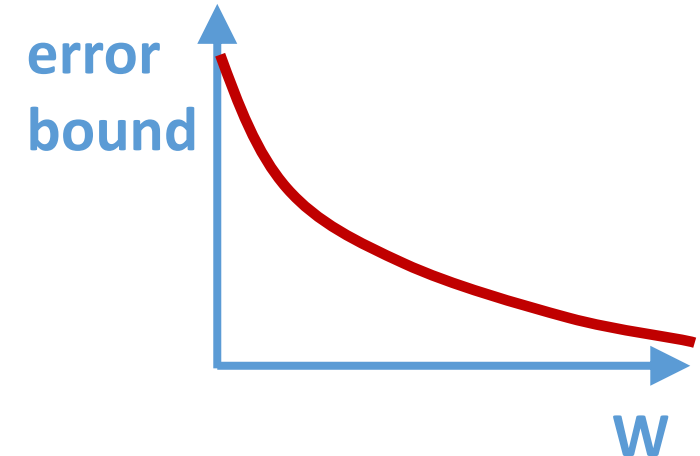
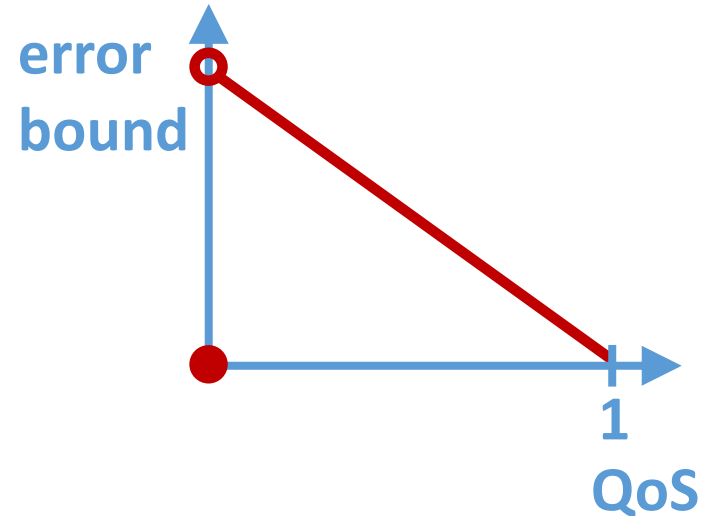
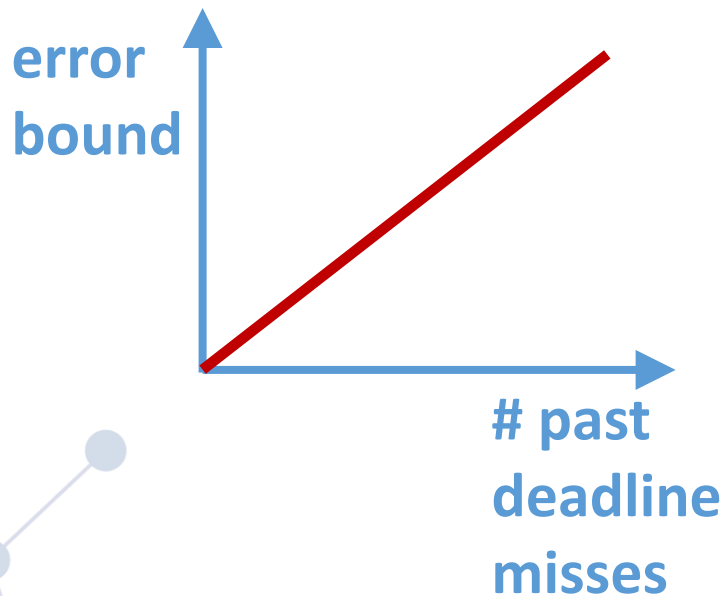
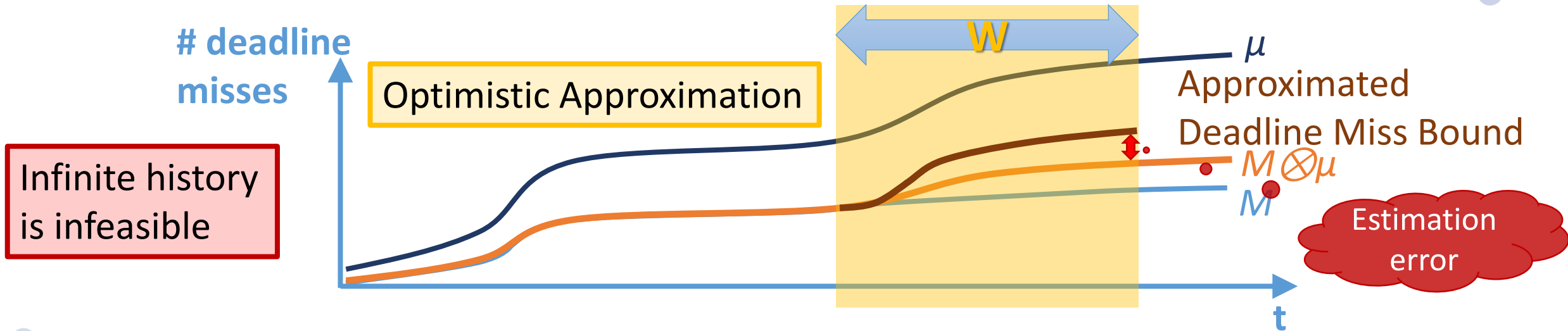


Valid execution: $M \leq M \otimes \mu$

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Window-based Approximation of Constraints



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Min-Plus Convolution

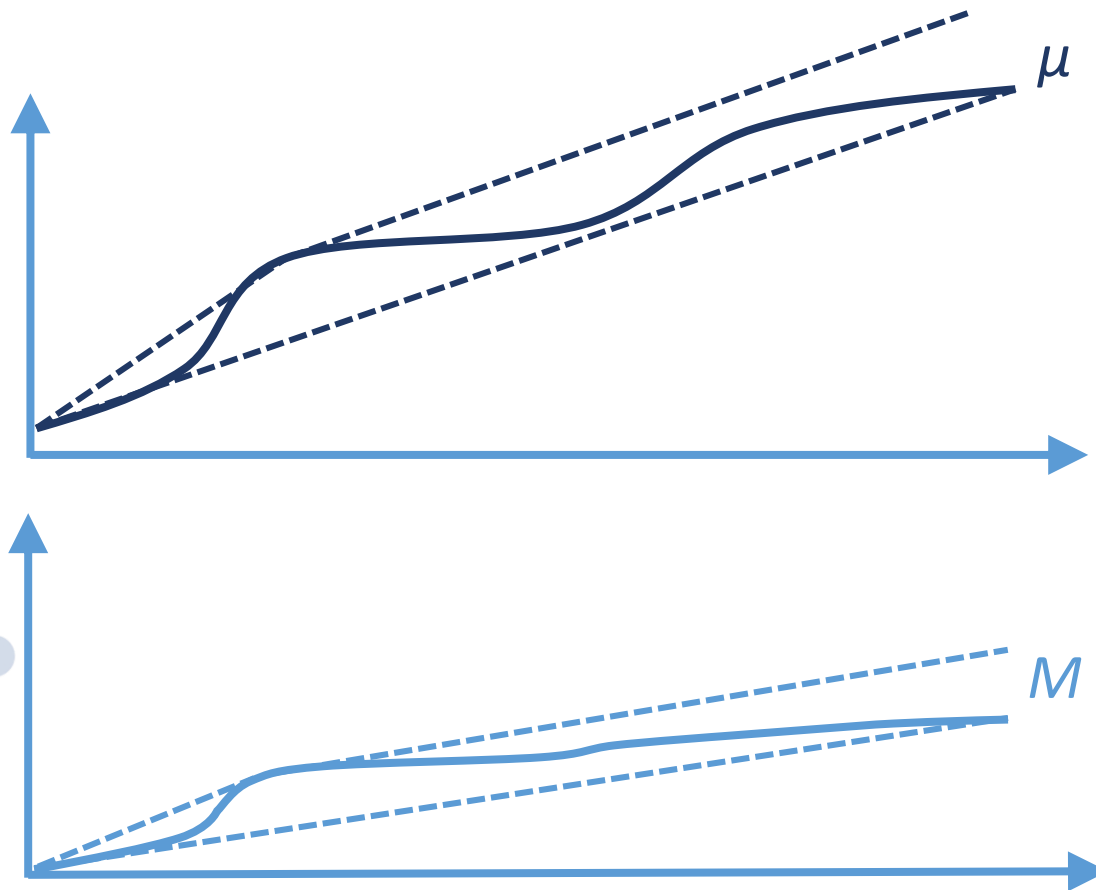
$$(f \otimes g)(t) = \min_{0 \leq s \leq t} \{f(t - s) + g(s)\}$$

Naive implementation: quadratic time complexity

$$O(N_T W^2)$$

Min-Plus-Container-based Implementation

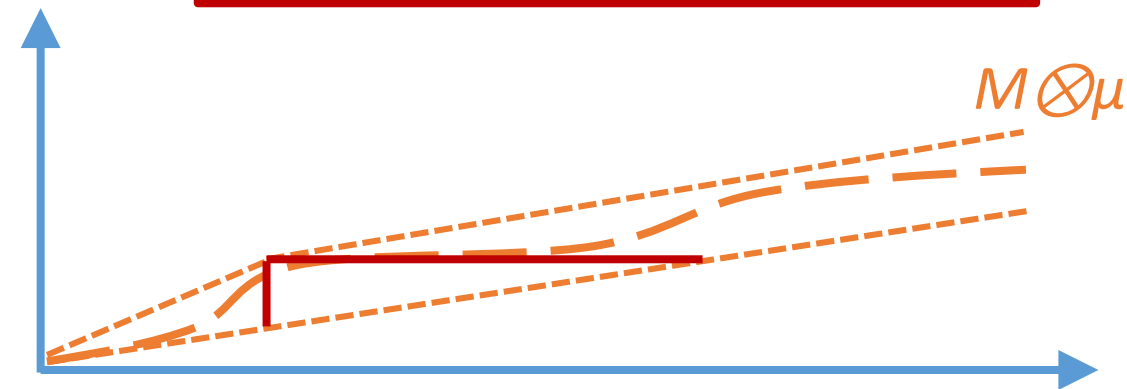
(Bouillard et al. Deterministic Network Calculus, 2018)



Build min-plus containers
in linear time

Reduced time complexity: $O(N_T W)$

Uncertainties in the container



Calculate inclusion function
in linear time

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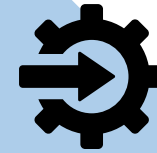
Runtime Execution Control for Mixed-Criticality Systems



Problem
Formulation
Simulation-based
Proof of Concept



Implementation
Feasibility
Energy
Optimization



Dependent Tasks
Real-World
Validation



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