

Study of the Reliability of Statistical Timing Analysis for Real-Time Systems

**Dorin Maxim, Frank Soboczanski,
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Premises:

- One can derive response time distributions based on measurements taken during runtime
Lu et al. RTSS 2012

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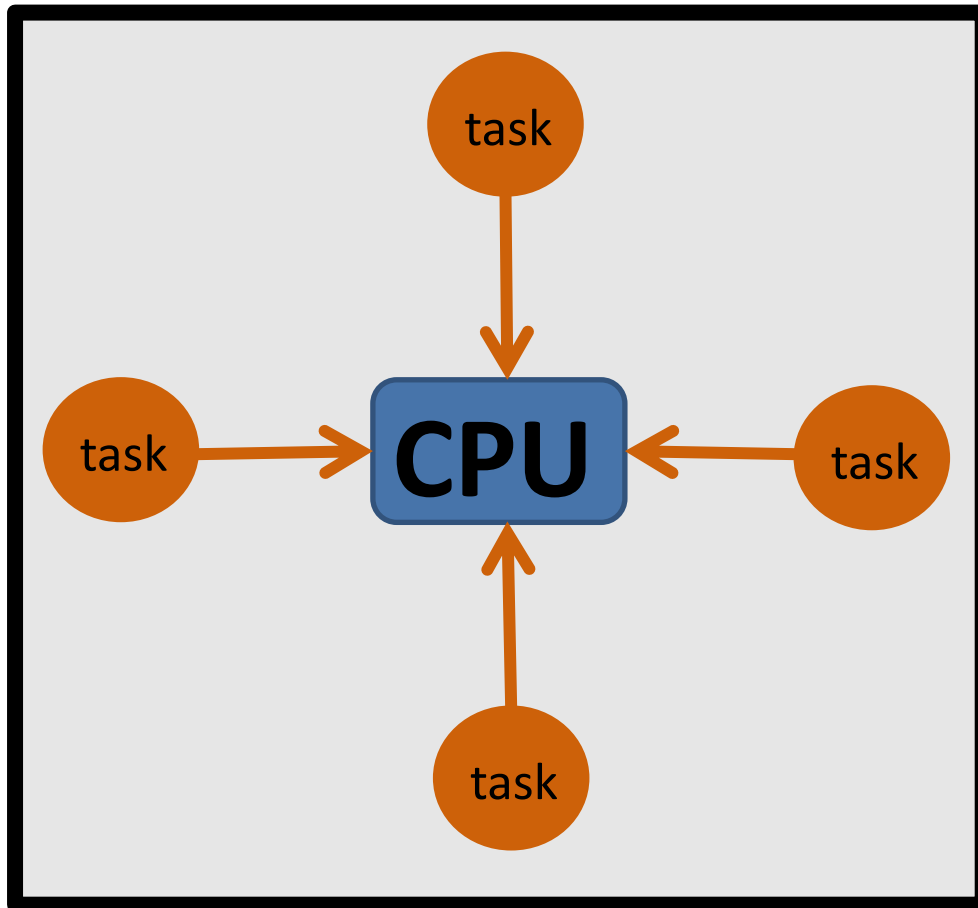
- Given a task-set described by probabilistic parameters, one can derive response time distributions using mathematical tools
Maxim and Cucu RTSS 2013

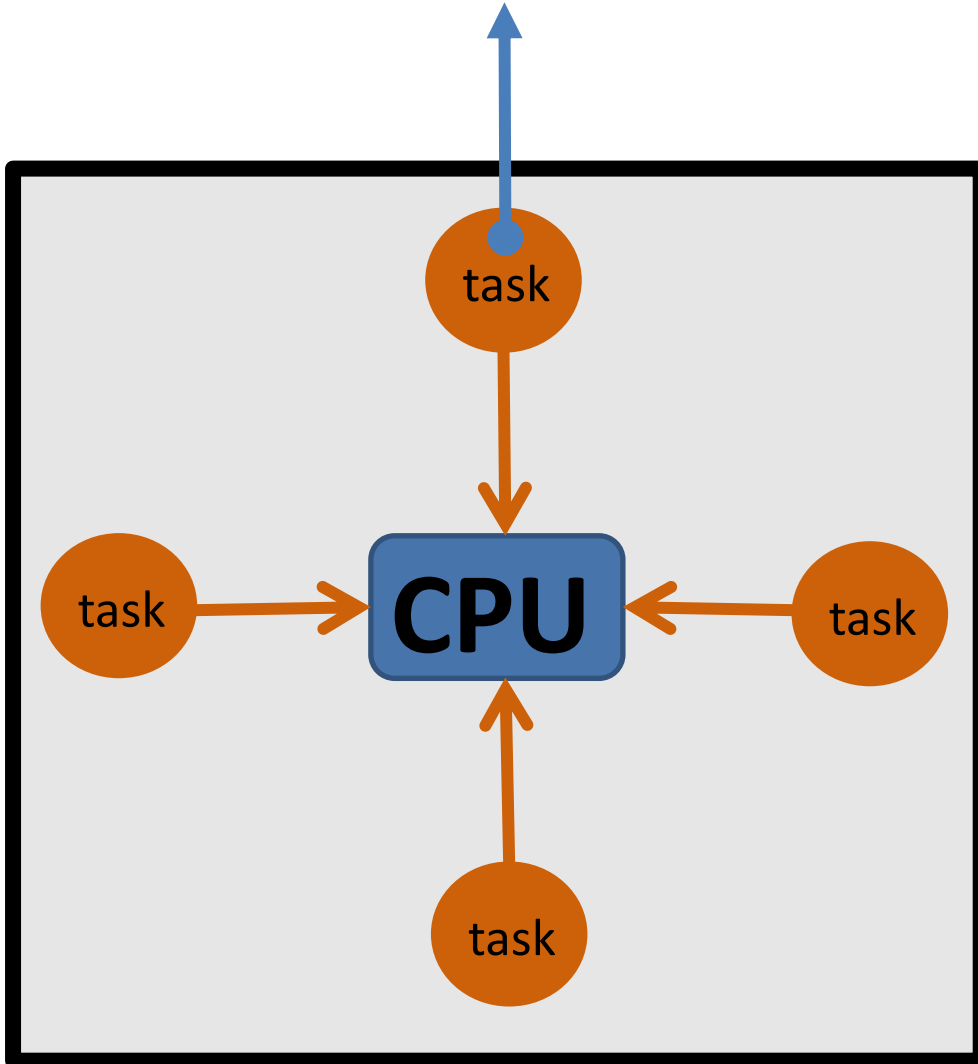
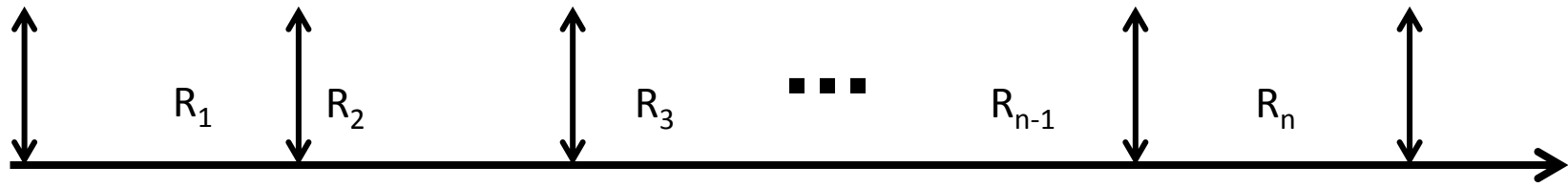
Response Time Distributions from **Measurements**

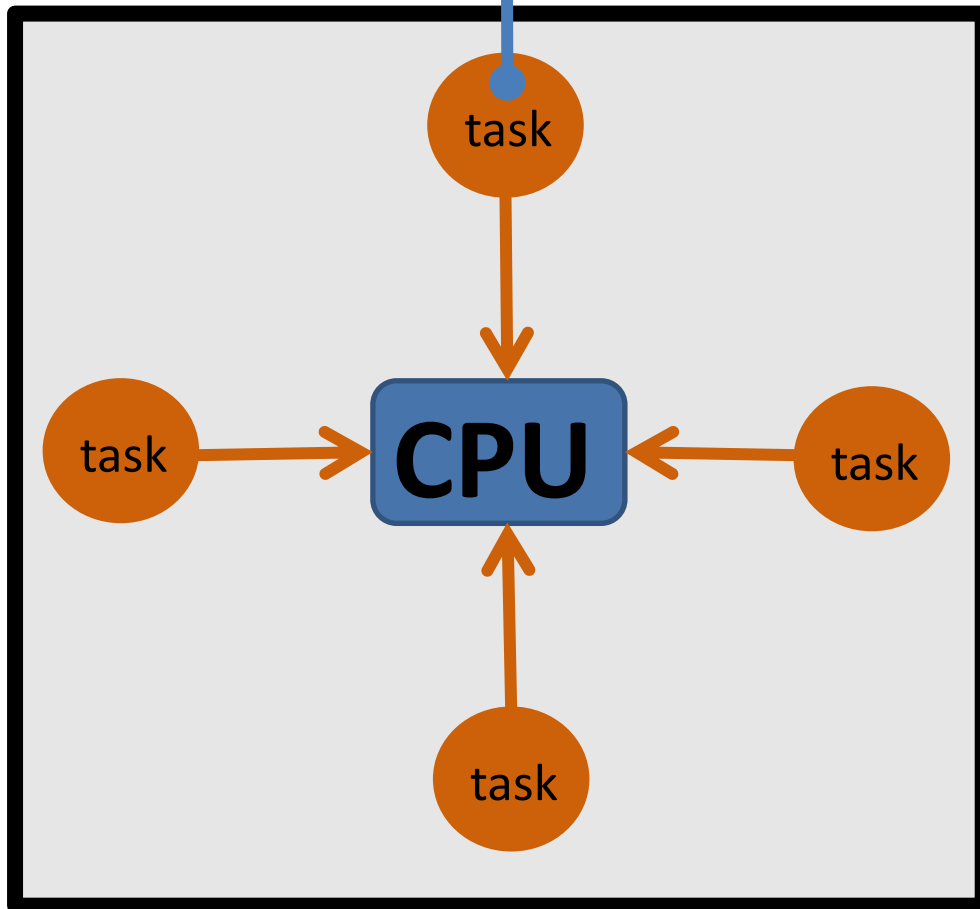
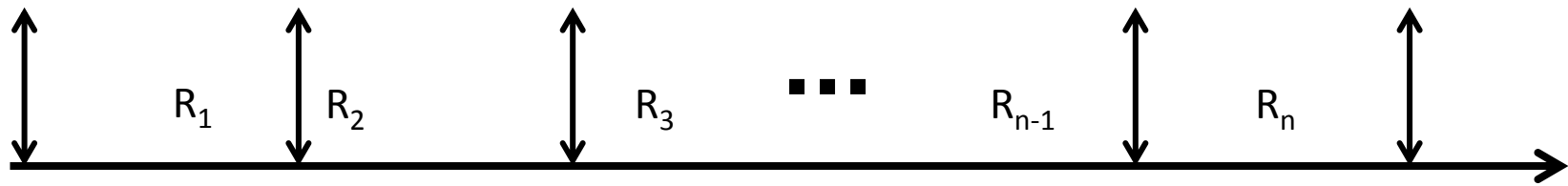


Real-Time System

Response Time Distributions from **Measurements**



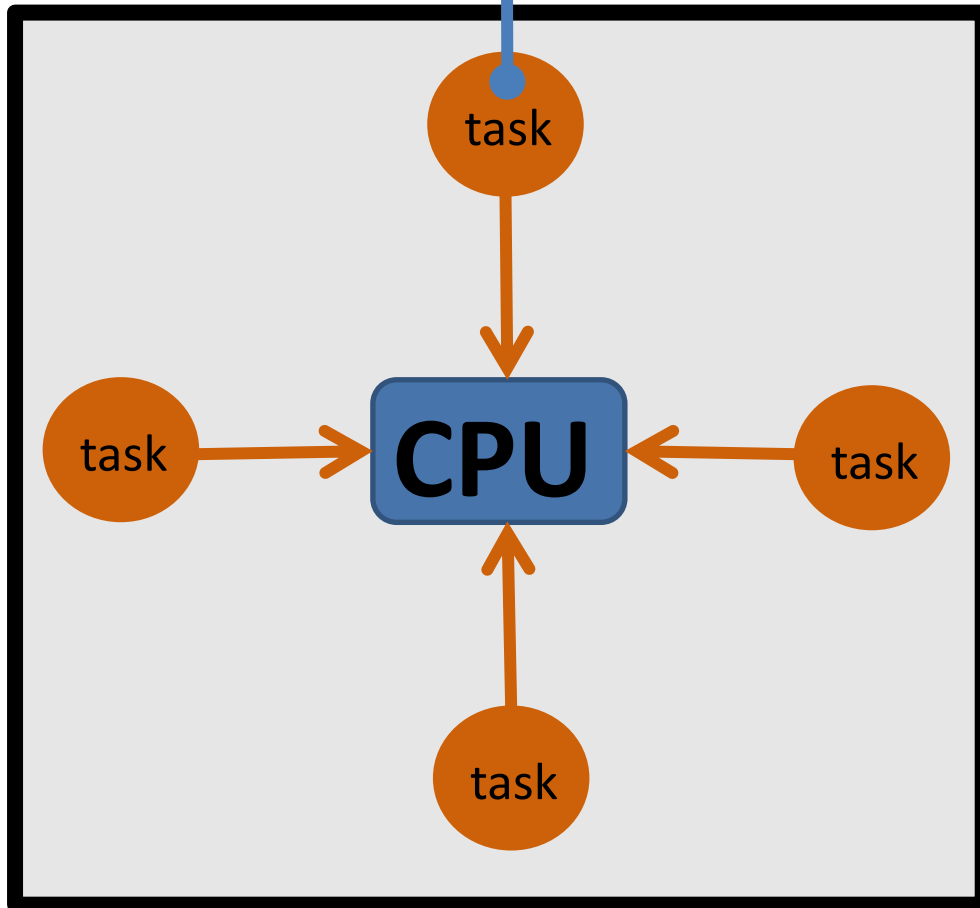
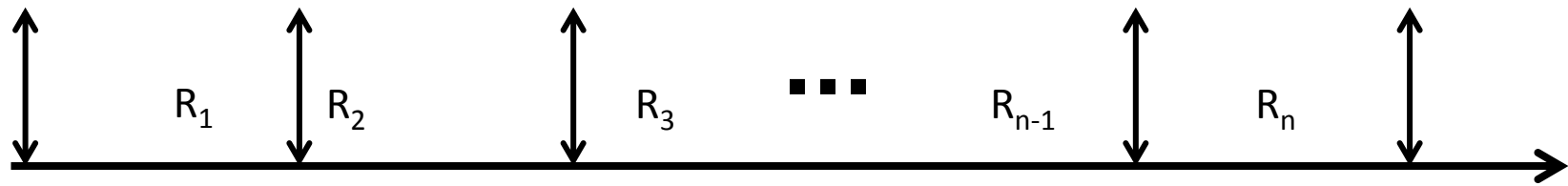




$R_1,$
 $R_2,$
 $R_3,$
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 $R_{n-1},$
 R_n

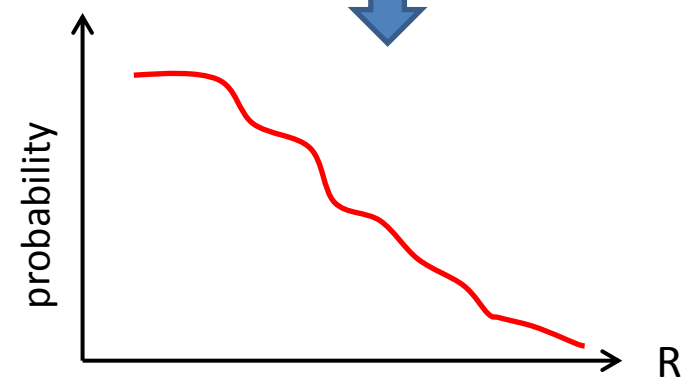


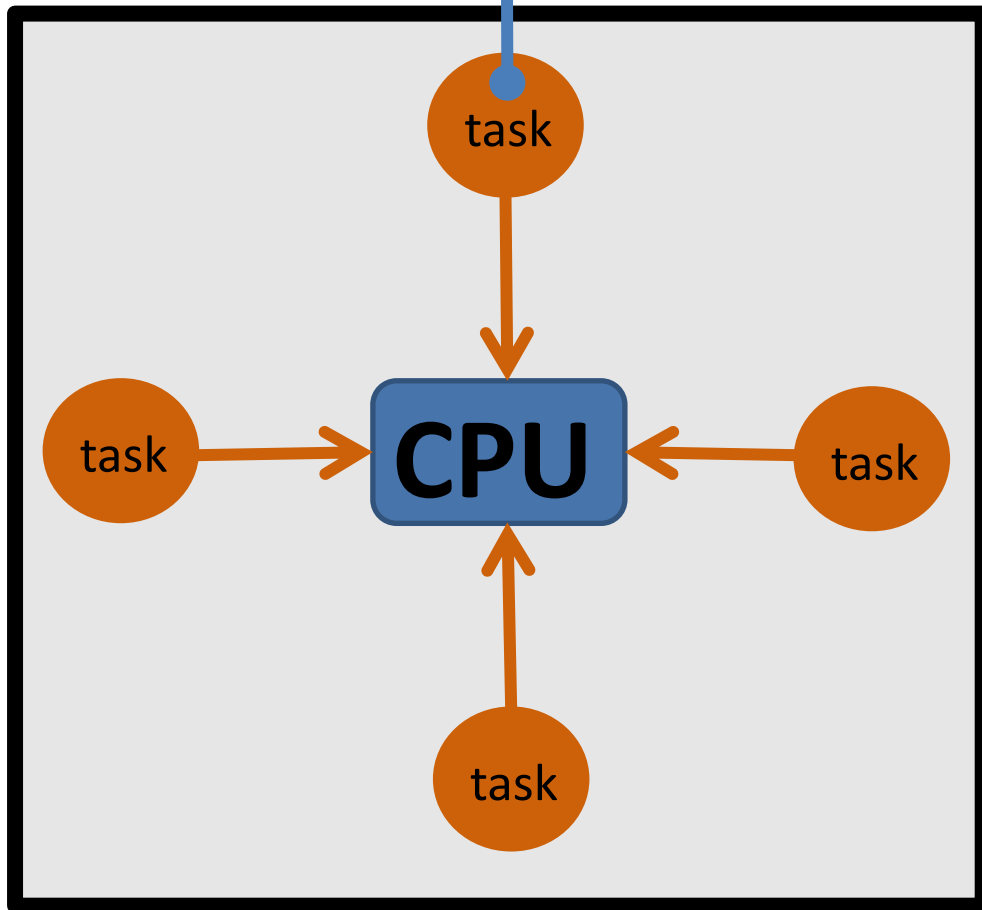
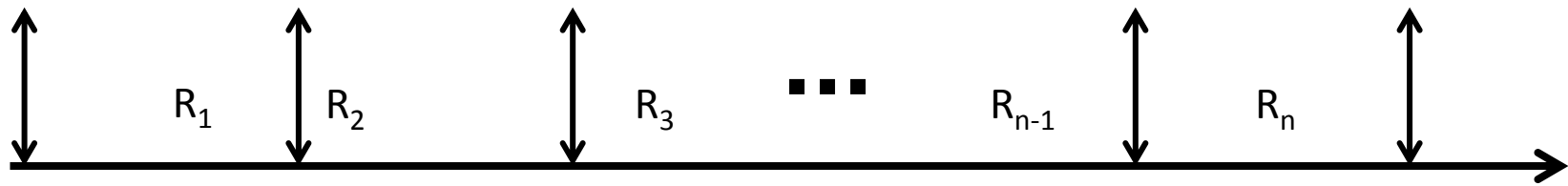
**Statistical
 Analysis
 Tool**
 Lu et al. RTSS2012



$R_1,$
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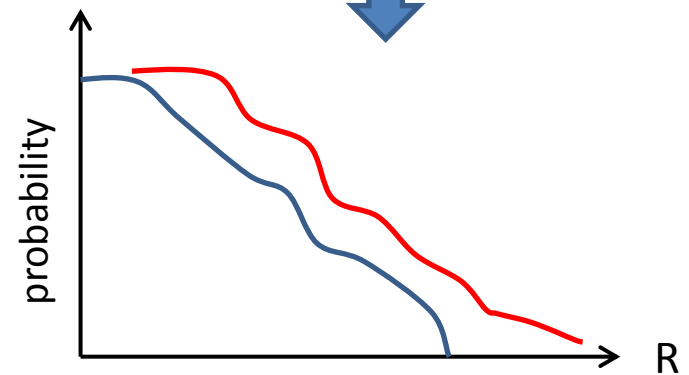
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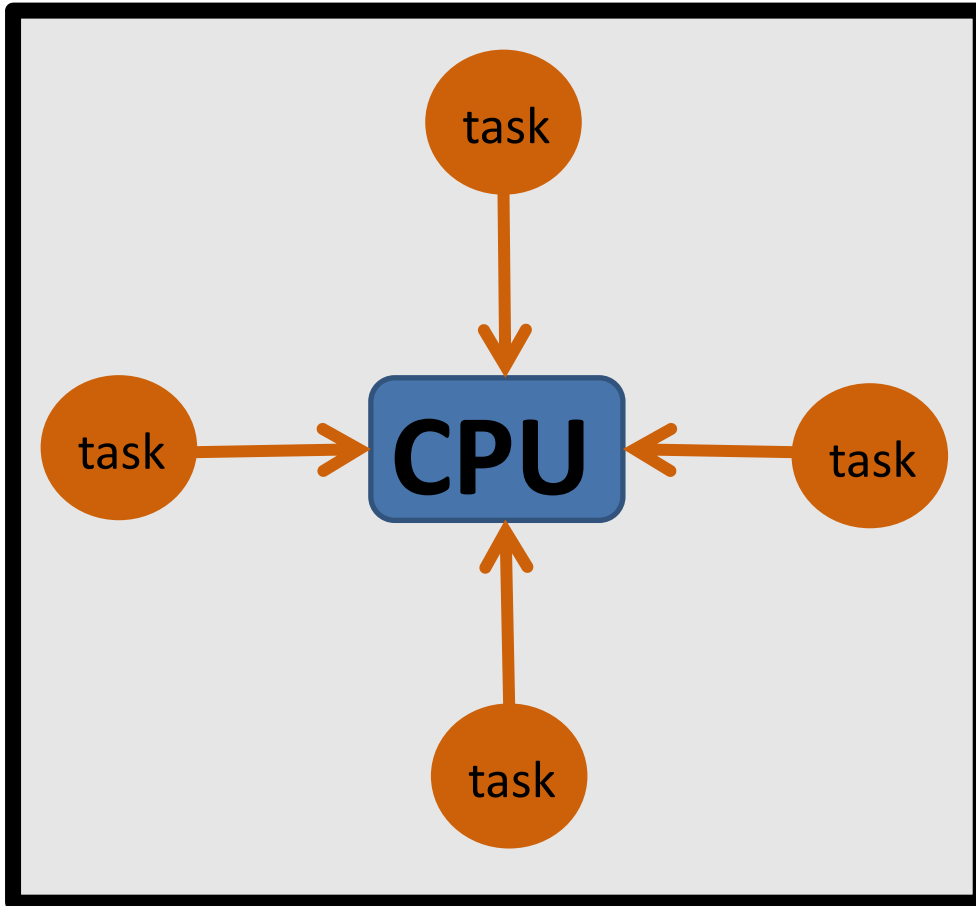


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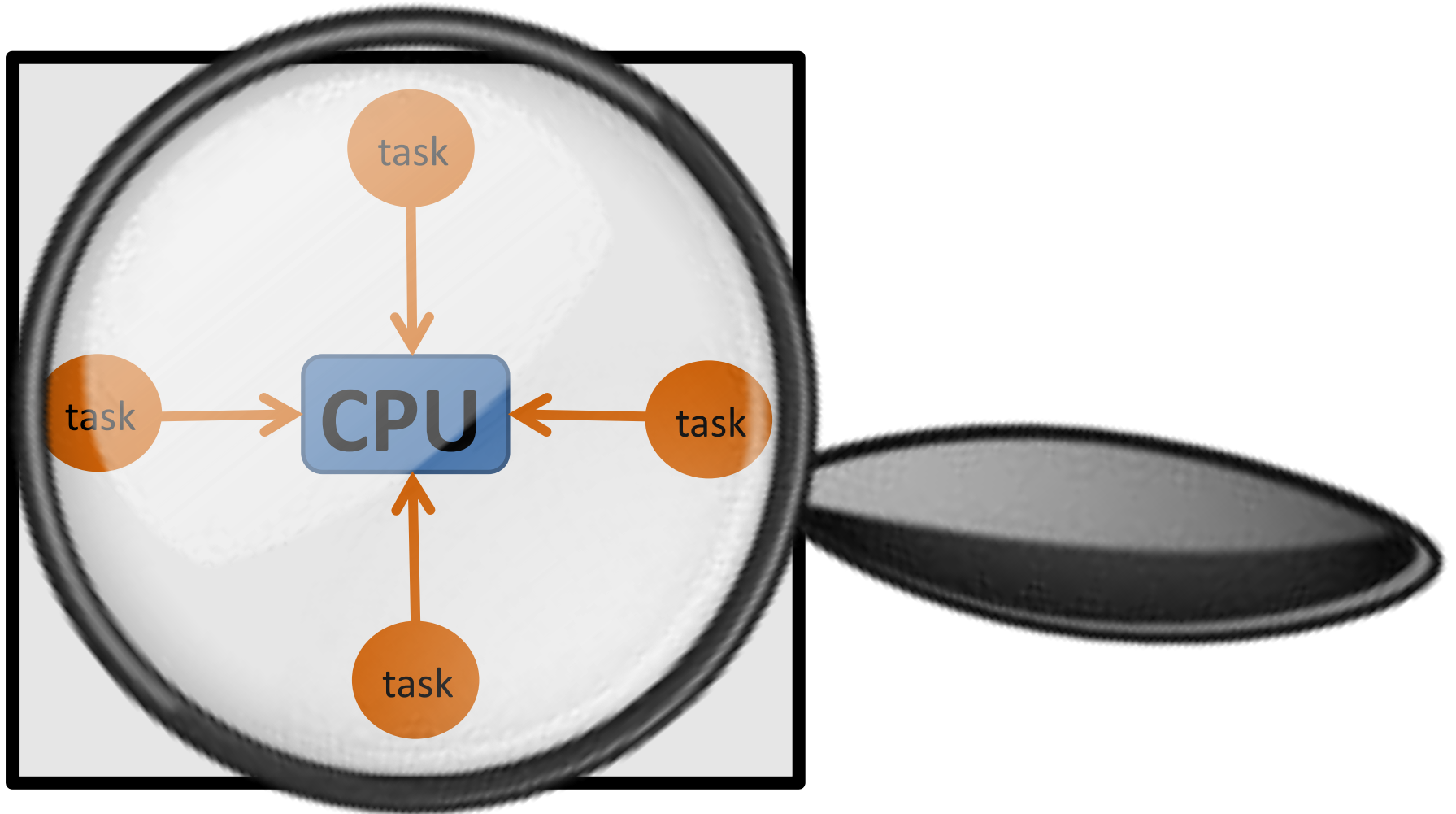
Statistical Analysis Tool
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Response Time Distributions from **Analysis**



Response Time Distributions from **Analysis**



Response Time Distributions from **Analysis**



task₁: parameters₁
task₂: parameters₂
task₃: parameters₃
.
.
.
task_n: parameters_n

Task-set parameters



task₁: parameters₁

task₂: parameters₂

task₃: parameters₃

.

.

.

task_n: parameters_n

Task-set parameters



**Probabilistic
Response-Time
Analysis
Tool**
Maxim and Cucu
RTSS2013



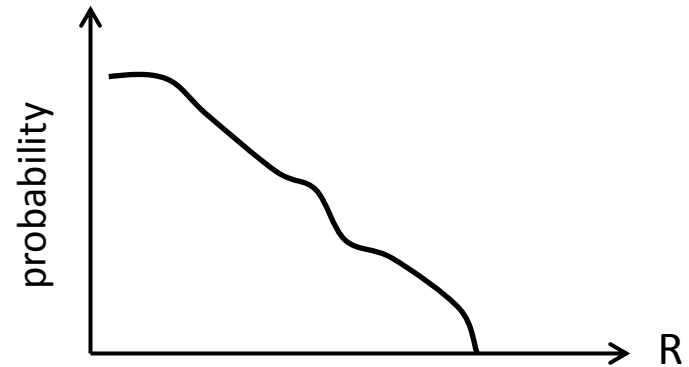
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**Probabilistic
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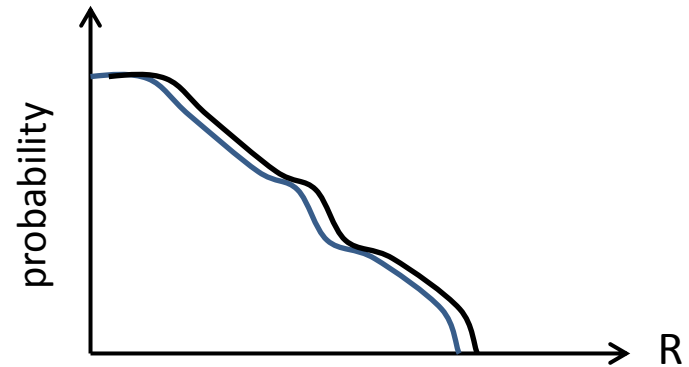
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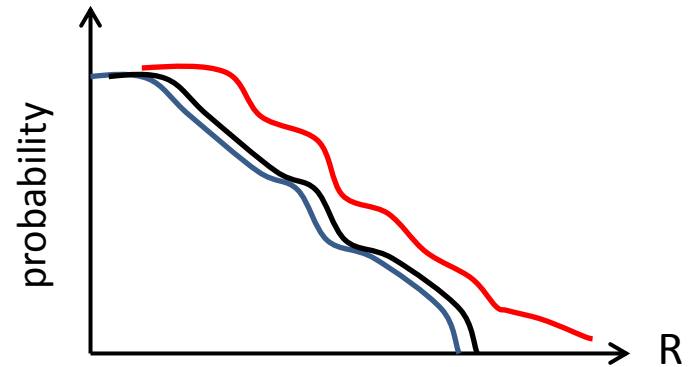
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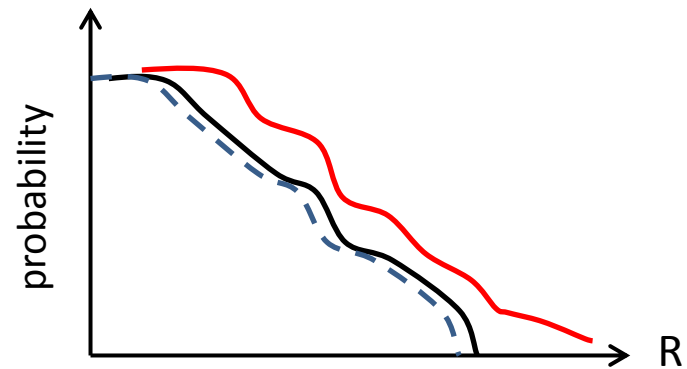
Task-set parameters



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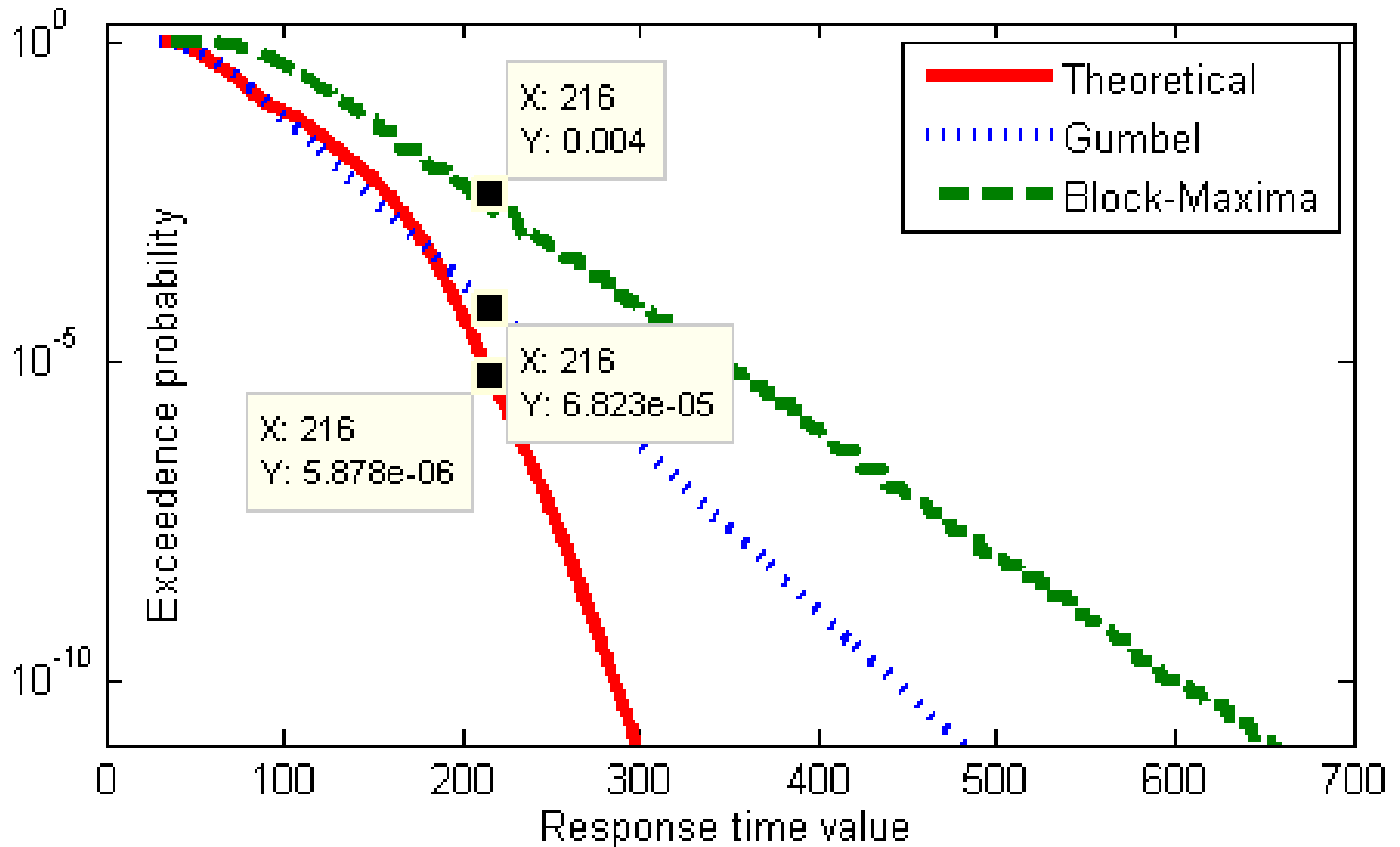


task₁: parameters₁
task₂: parameters₂
task₃: parameters₃
.
.
.
task_n: parameters_n



**We use the theoretical probability
distribution as a tight upper-bound of
the exact response-time distribution**

Example of Response Time Distributions



Methodology

- Randomly generated synthetic task-sets, processed in two ways:

Methodology

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- Randomly generated synthetic task-sets, processed in two ways:
 - Theoretically compute response time distributions using state of the art tools
 - Simulate its execution and collect response time traces, which are then analyzed with the statistical tool
- Compare the distributions obtained in the two ways and see how close/far they are

Methodology

Statistical distributions used in the statistical tool:

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1. fitting a **Weibull (W)** distribution;

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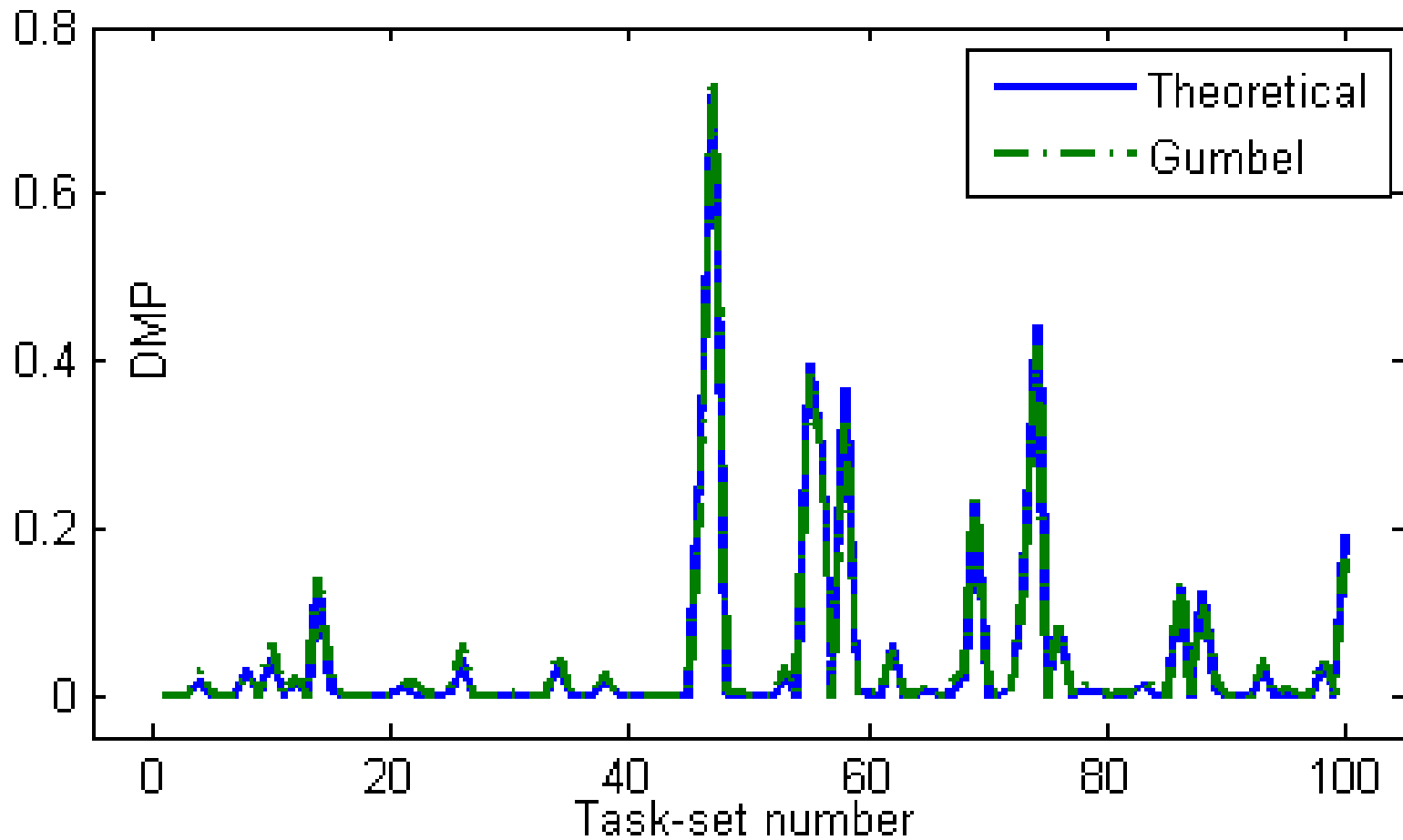
1. fitting a **Weibull (W)** distribution;
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Methodology

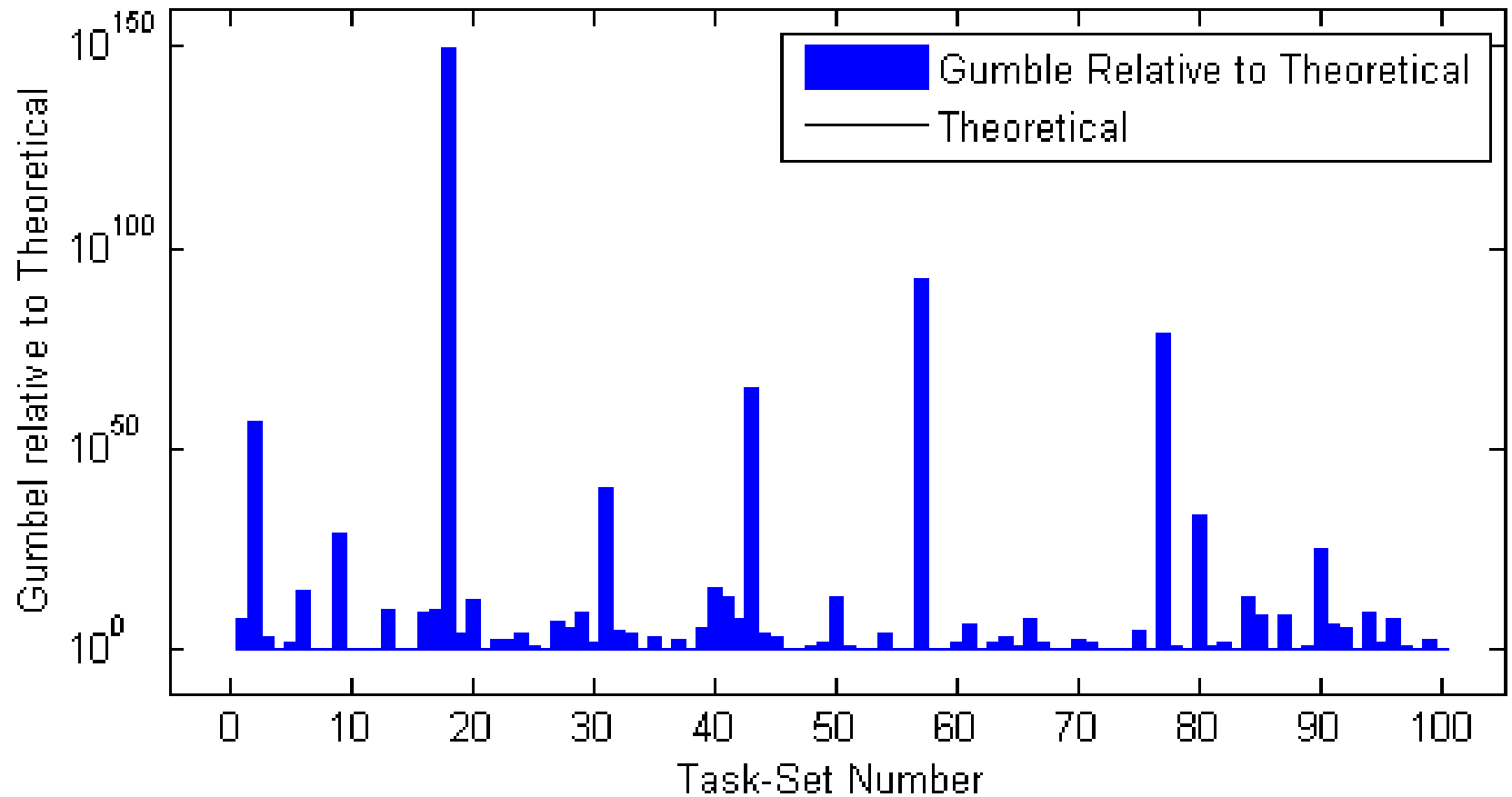
Statistical distributions used in the statistical tool:

1. fitting a **Weibull (W)** distribution;
2. fitting a **Gumbel-Max (G)** distribution;
3. fitting a **Normal (N)** distribution;
4. applying the **Block-Maxima (BM)** method presented in *Lu et al. RTSS 2012*

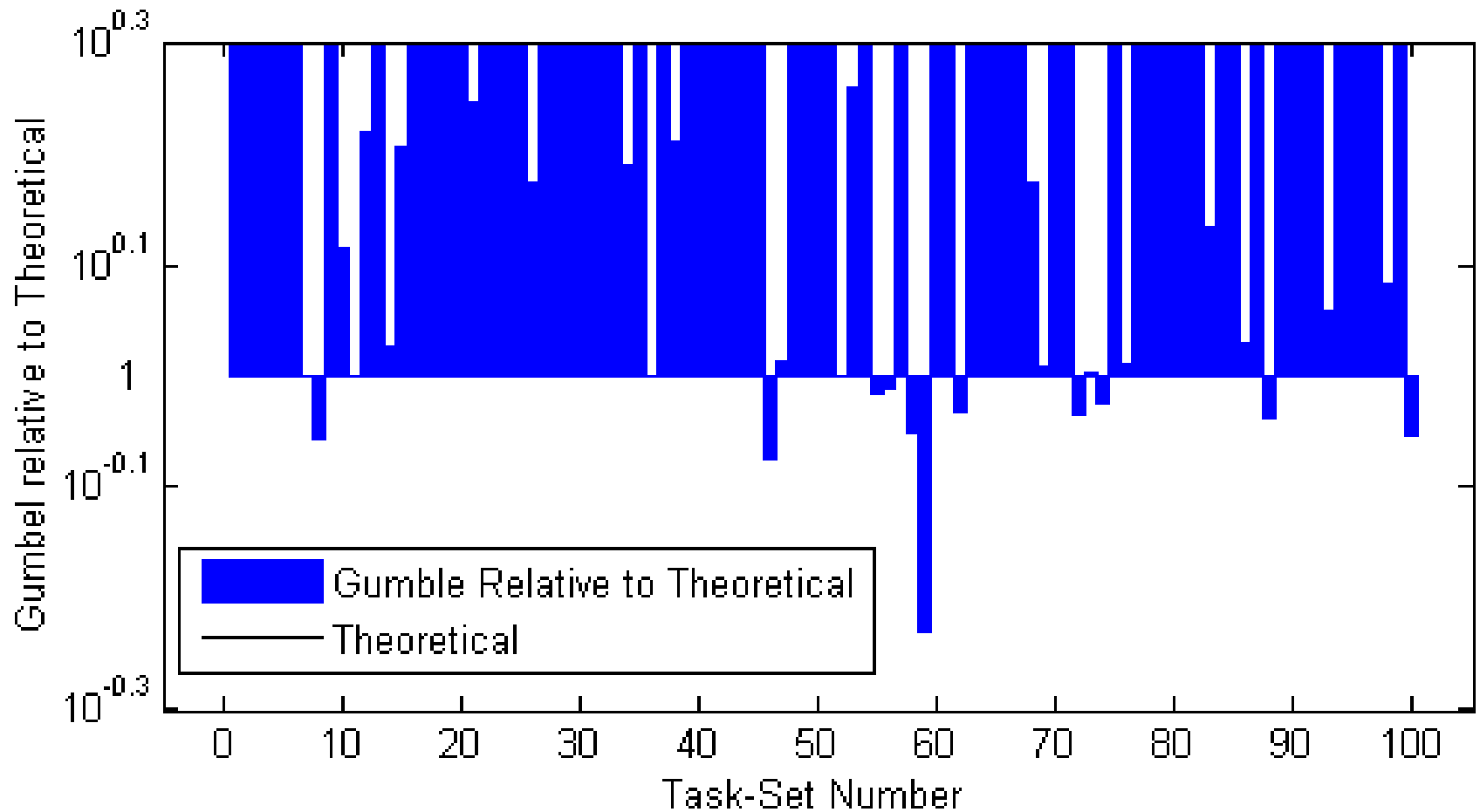
Results: 1. Gumble-Max Distribution



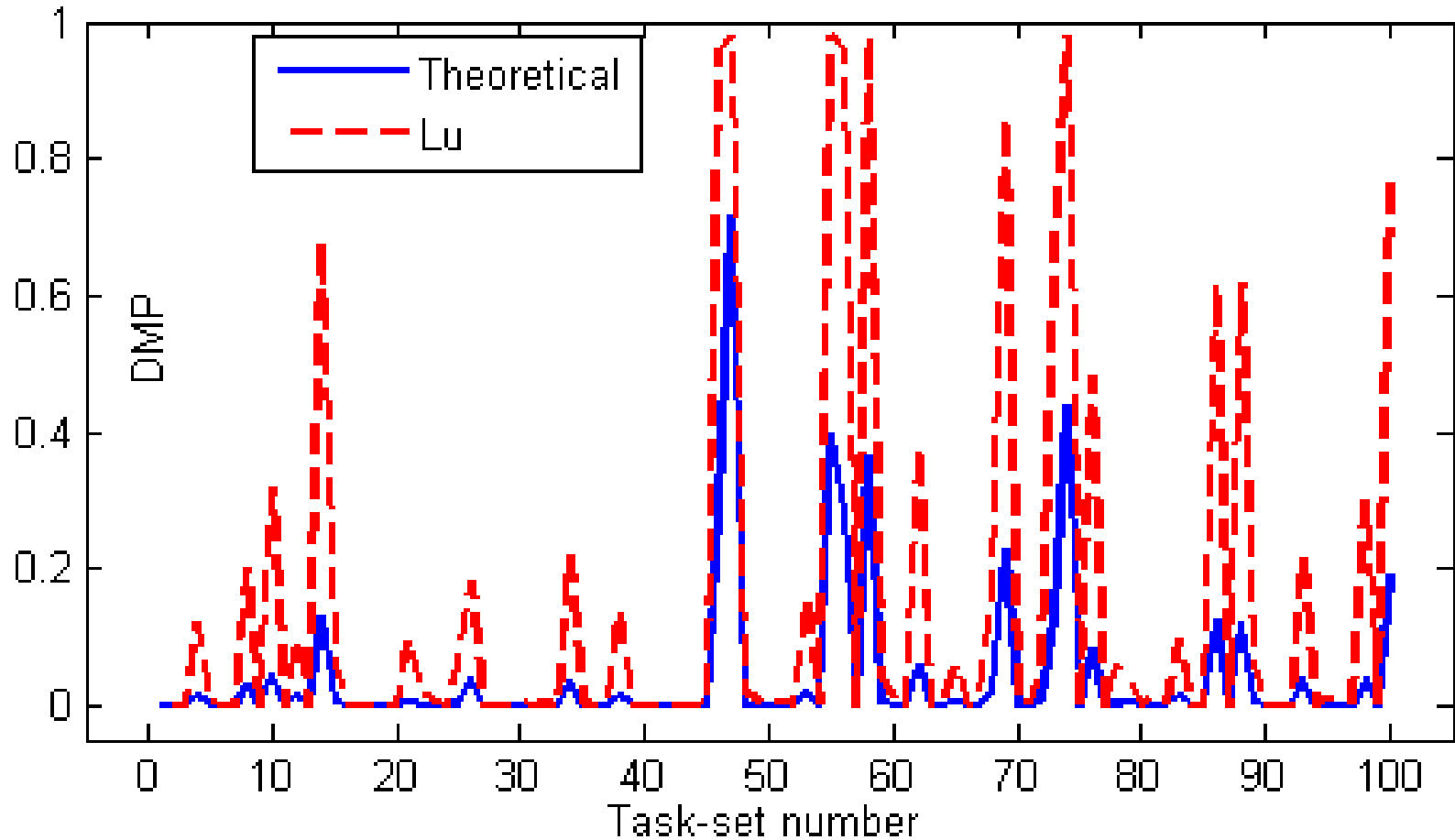
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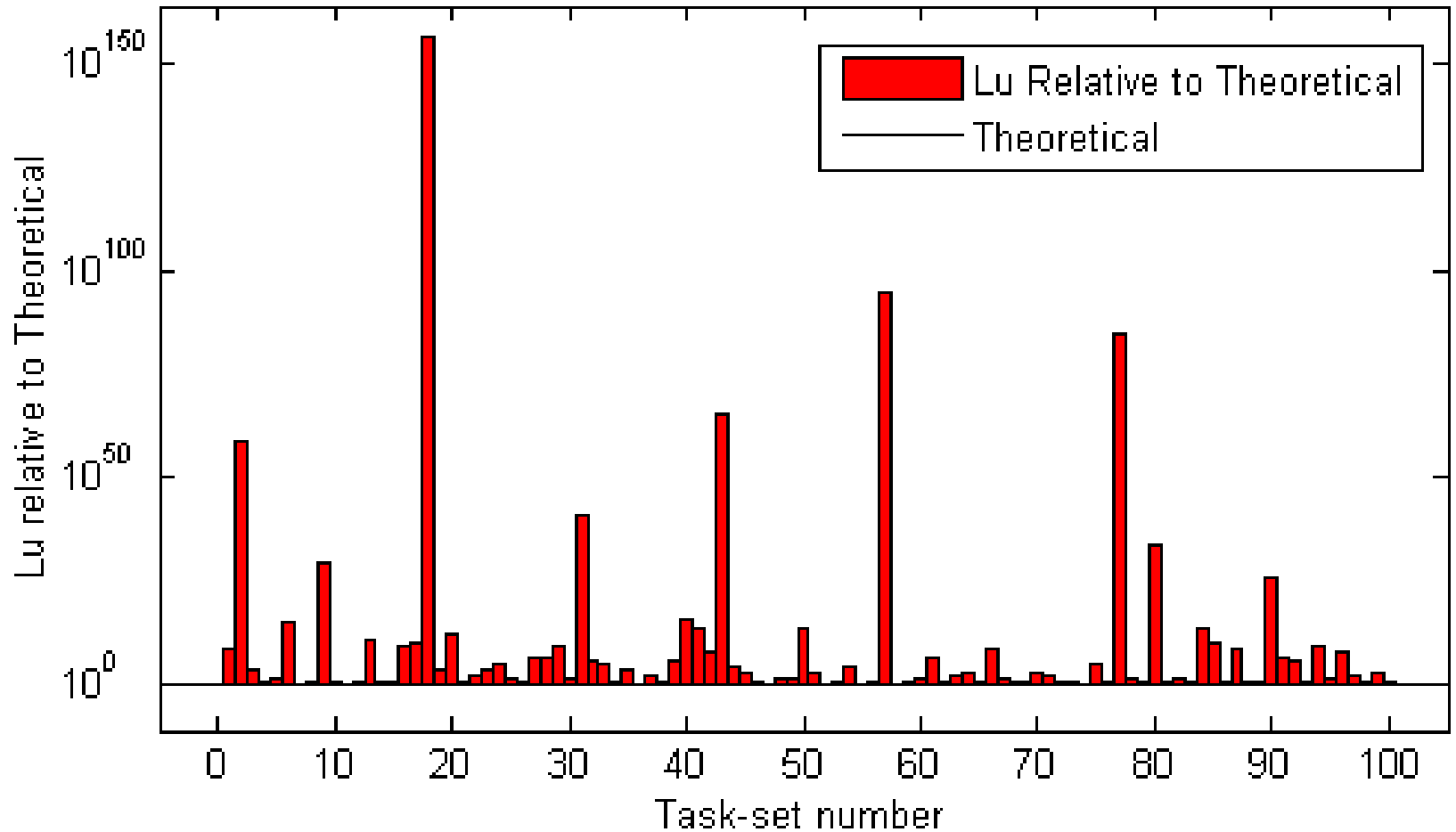
Results: 1. Gumble-Max Distribution



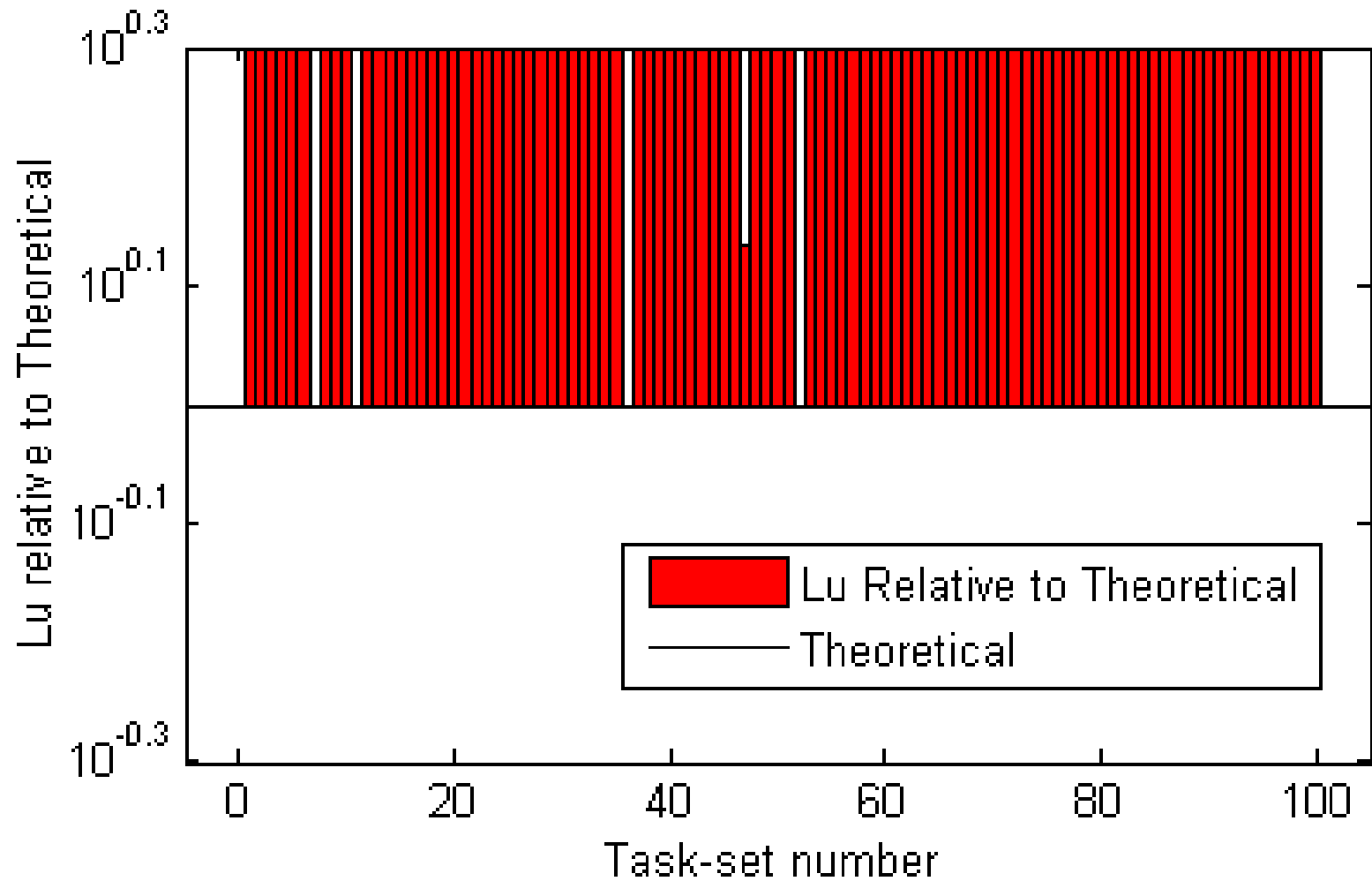
Results: 2. Block-Maxima Technique



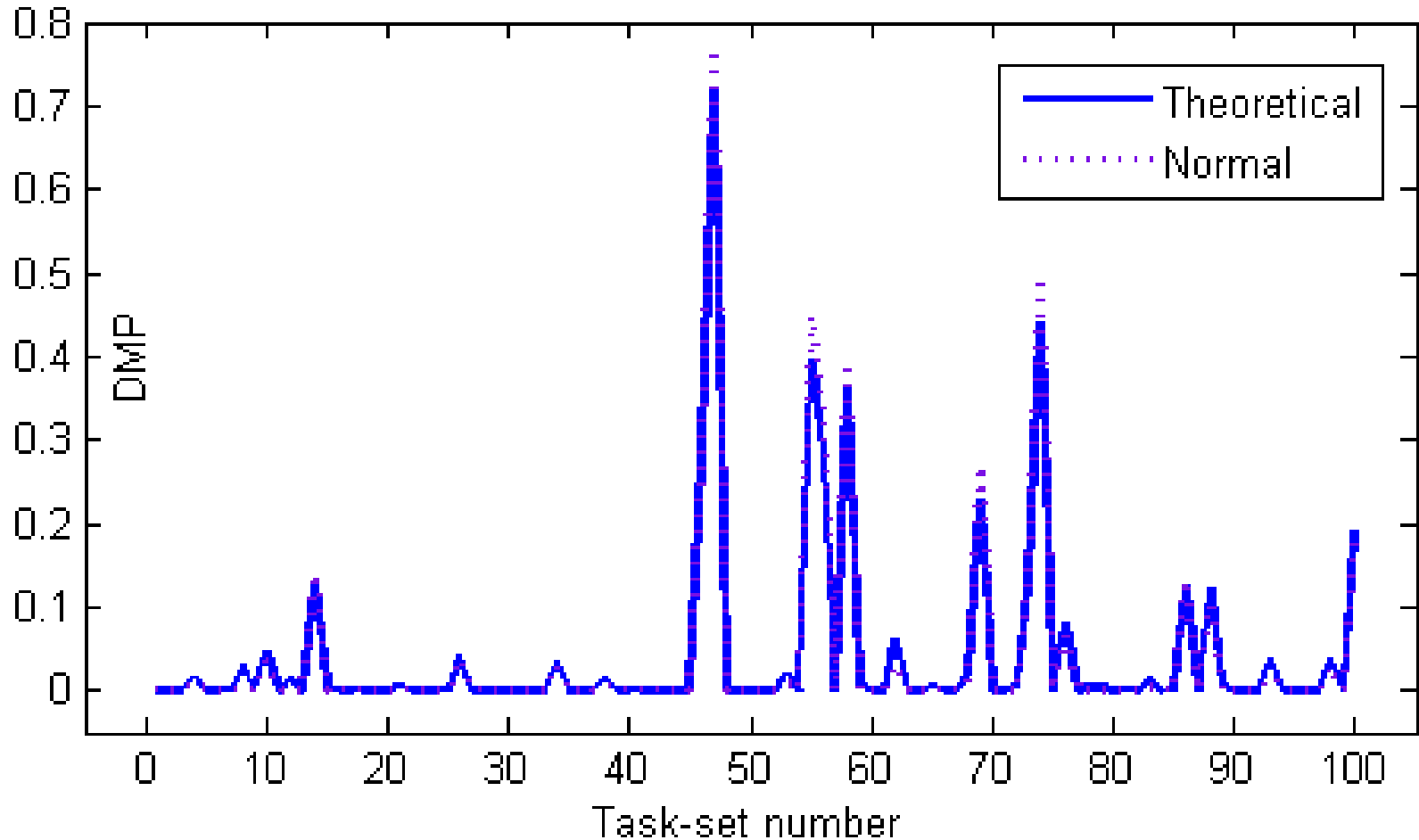
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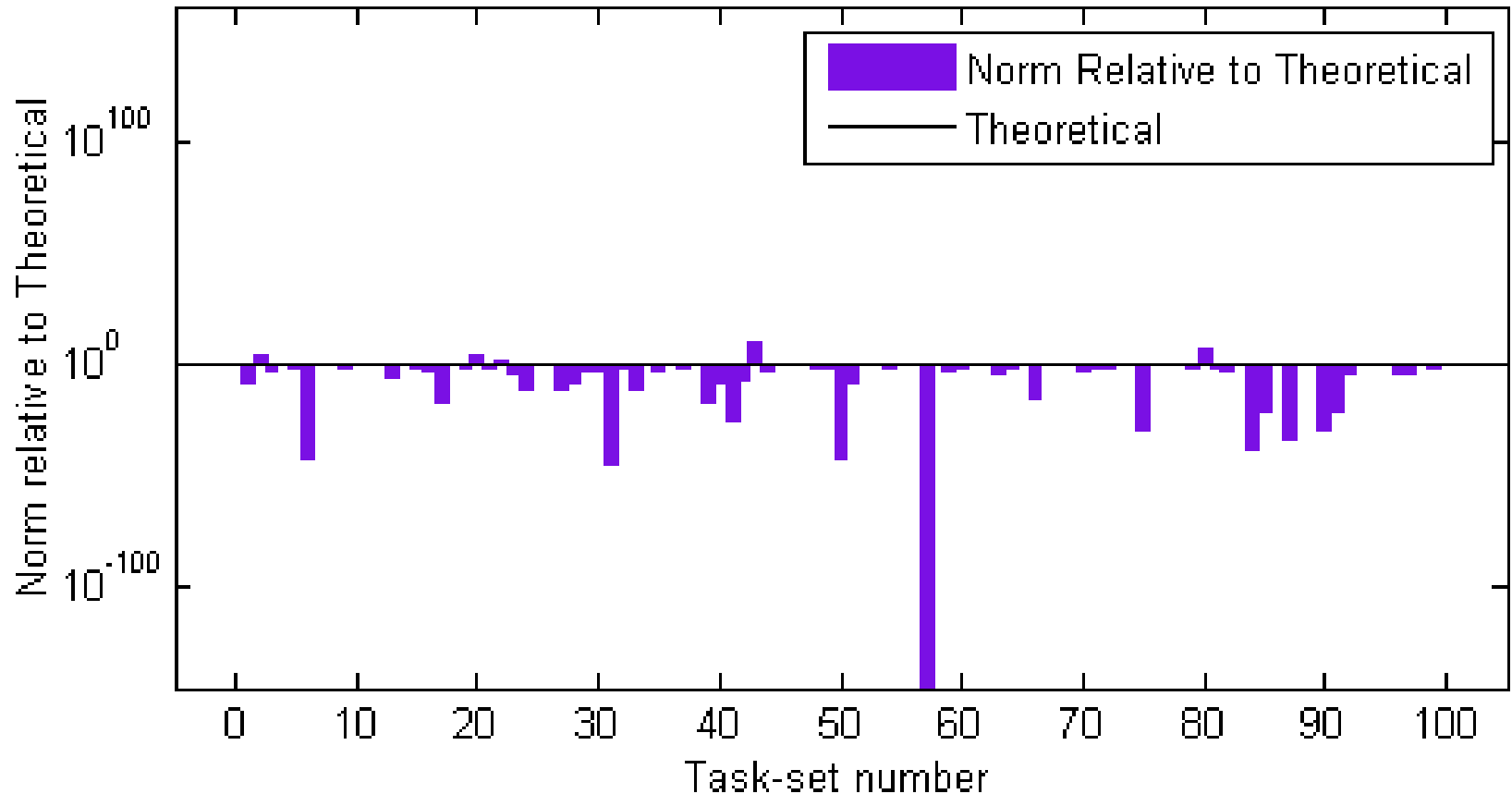
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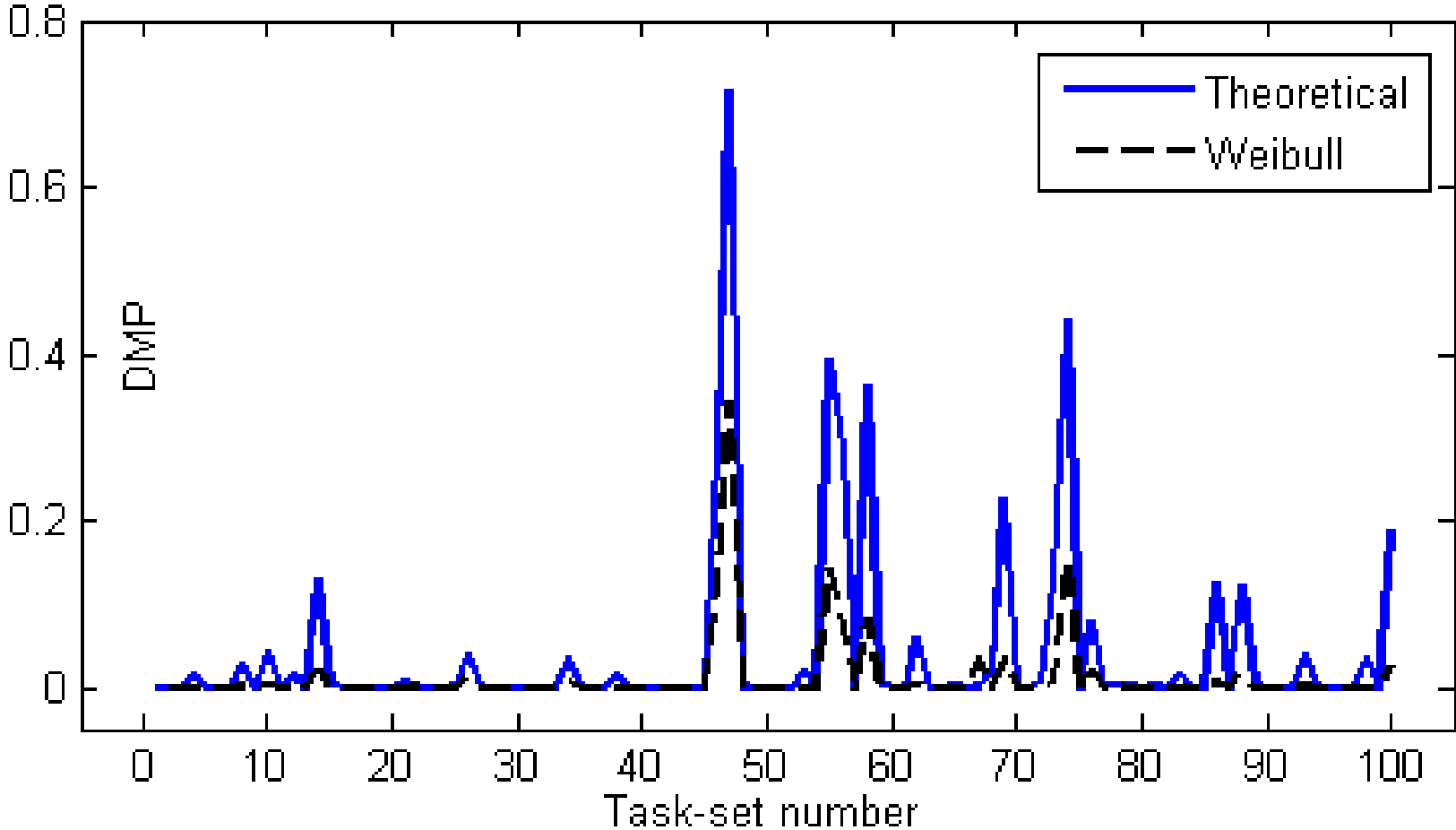
Results: 3. Normal Distribution



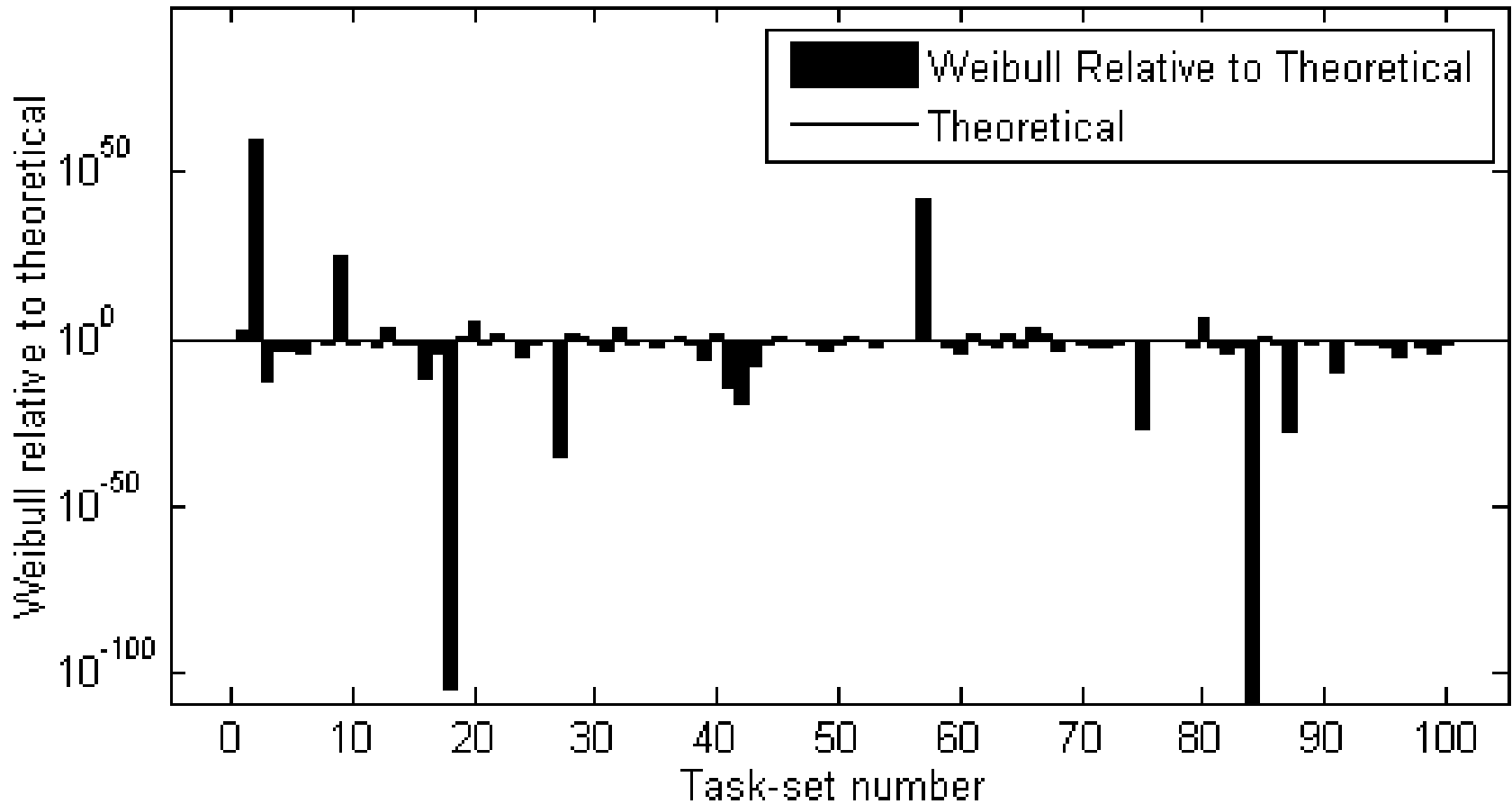
Results: 3. Normal Distribution



Results: 3. Weibull Distribution



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Results: 4. Conclusions on the four techniques

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- Block-Maxima approach always provides safe results, though at the price of an increased amount of pessimism
- The Gumbel-Max technique provides the tightest approximations, but slightly optimistic at times
- Normal and Weibull distributions are not adequate for use in the statistical analysis of real-time systems

Thank you !

