ETH zürich

Framework for stochastic analysis of mixed-criticality scheduling

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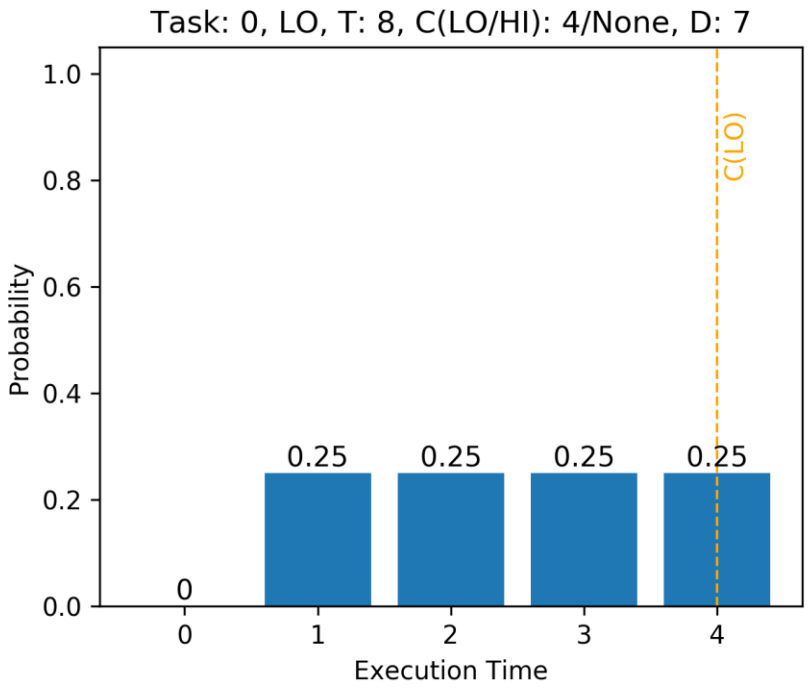
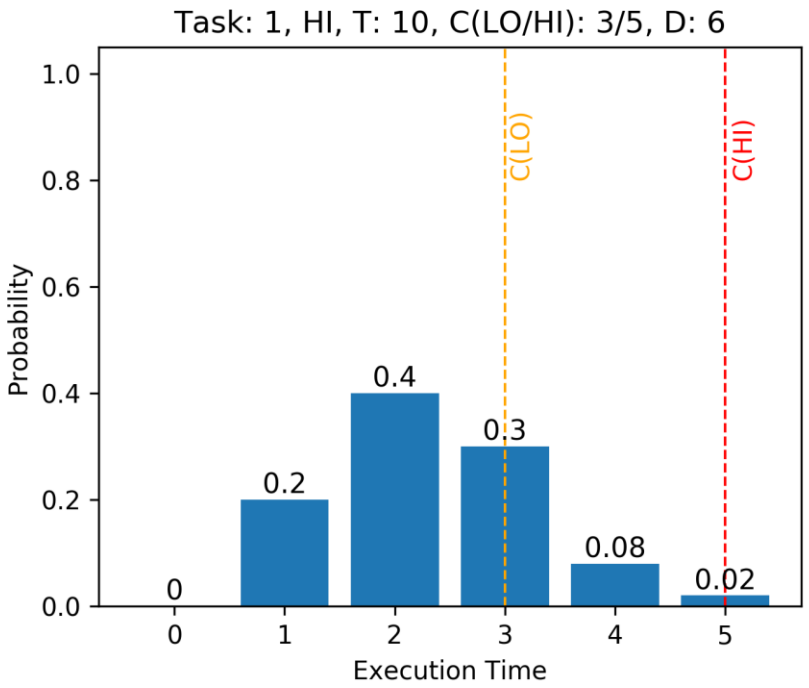
Mixed Criticality

- Task = τ_i(
  - χ_i: Criticality ∈ $\{LO, HI\}$
  - T_i: Period,
  - $C(LO)$: *LO*-mode Worst-case execution time (WCET),
  - $C(HI)$: *HI*-mode WCET,
  - D_i: Deadline)

Stochastic Analysis





Motivation

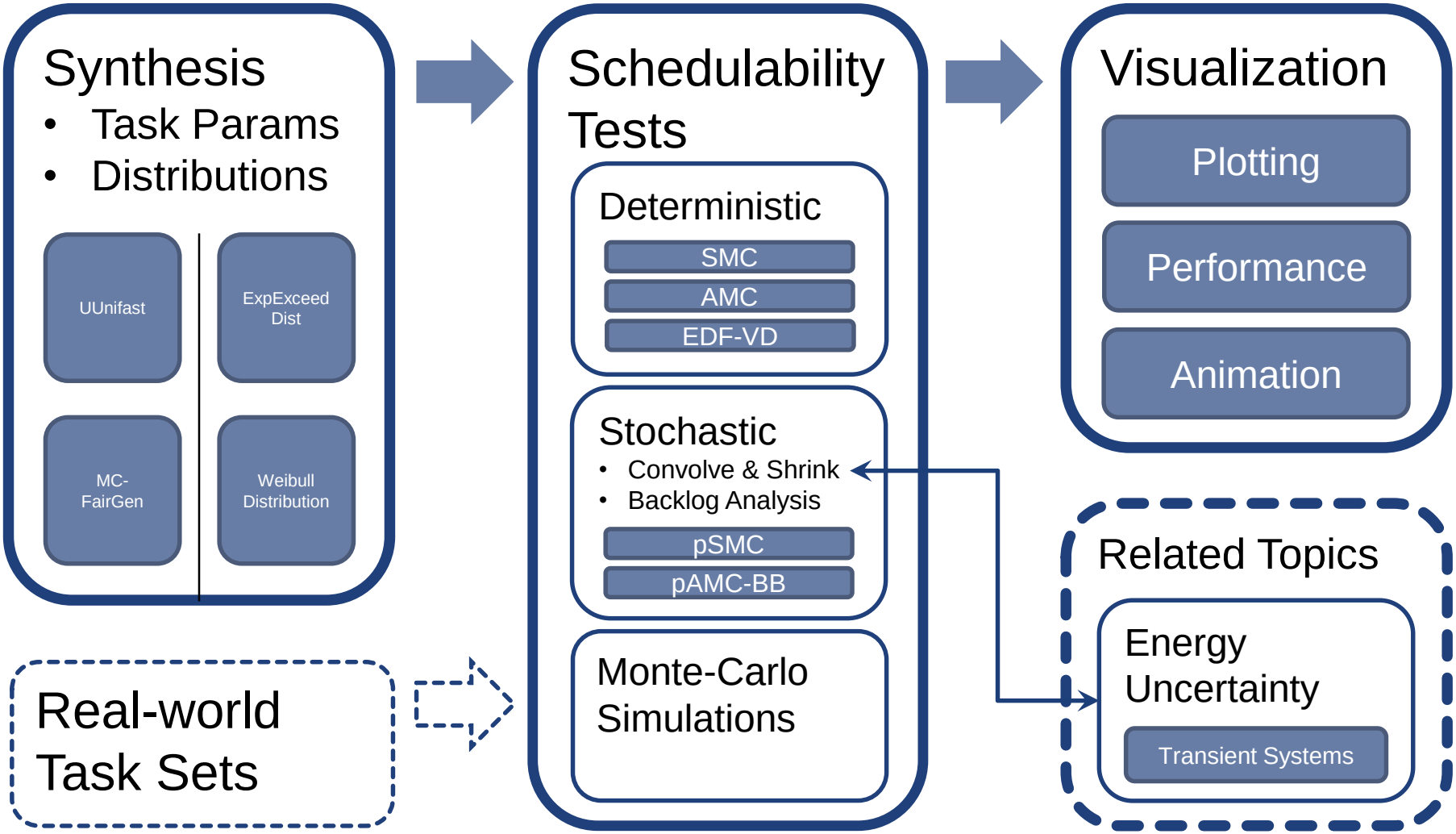
- «Build an extensible framework

  offering a wide range of analysis tools,

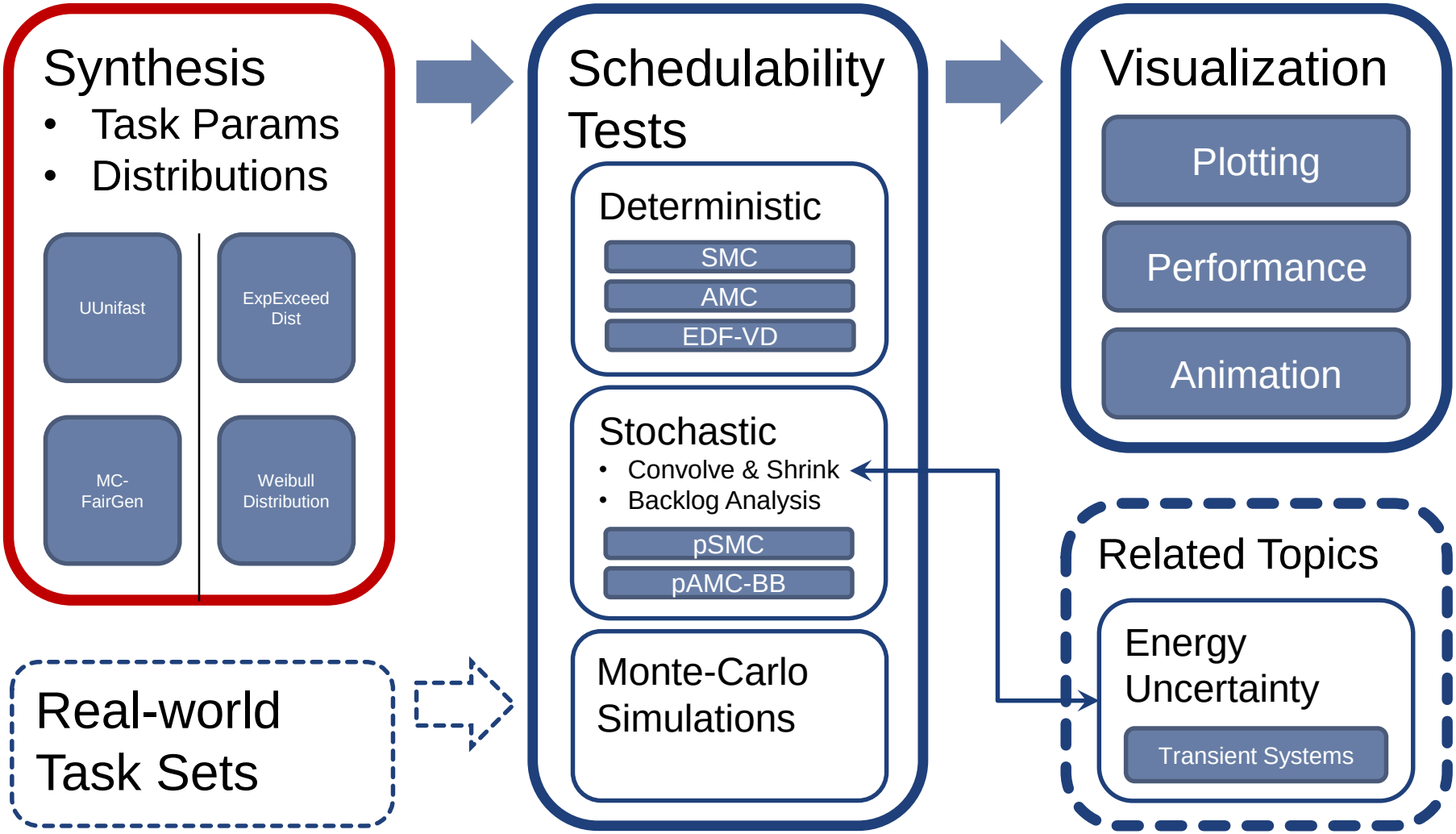
  covering and comparing different scheduling

  schemes.»

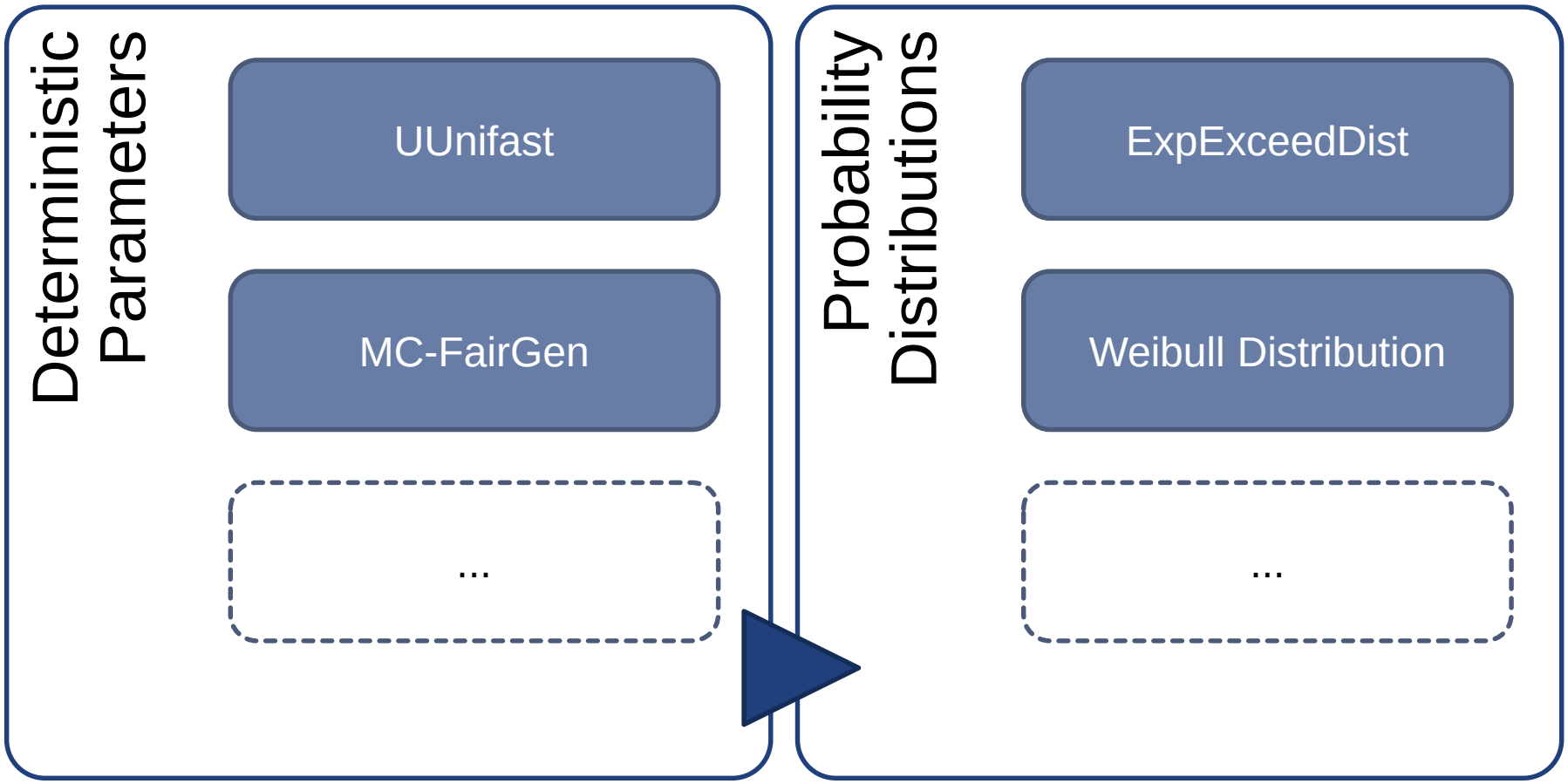
The Framework



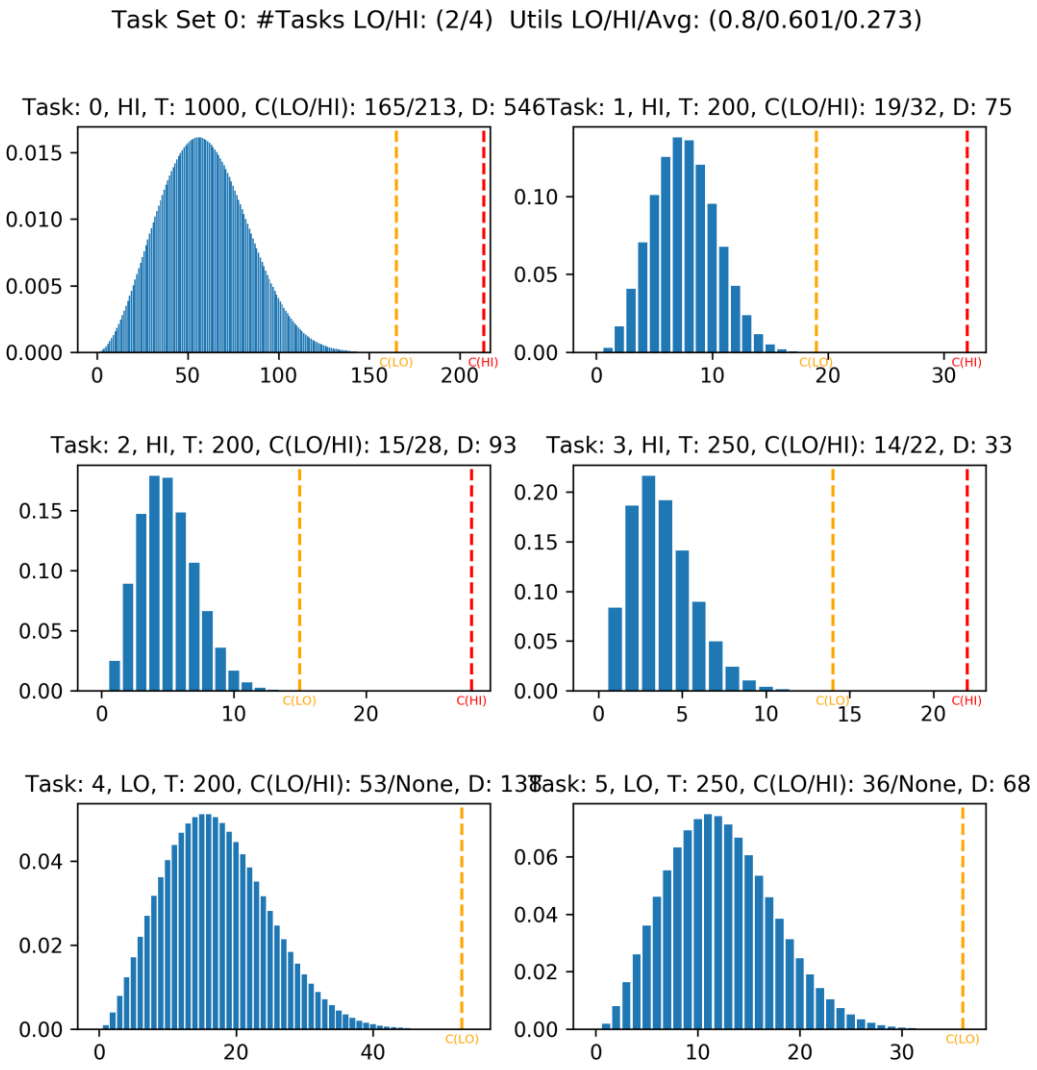
Task Set Synthesis



Task Set Synthesis



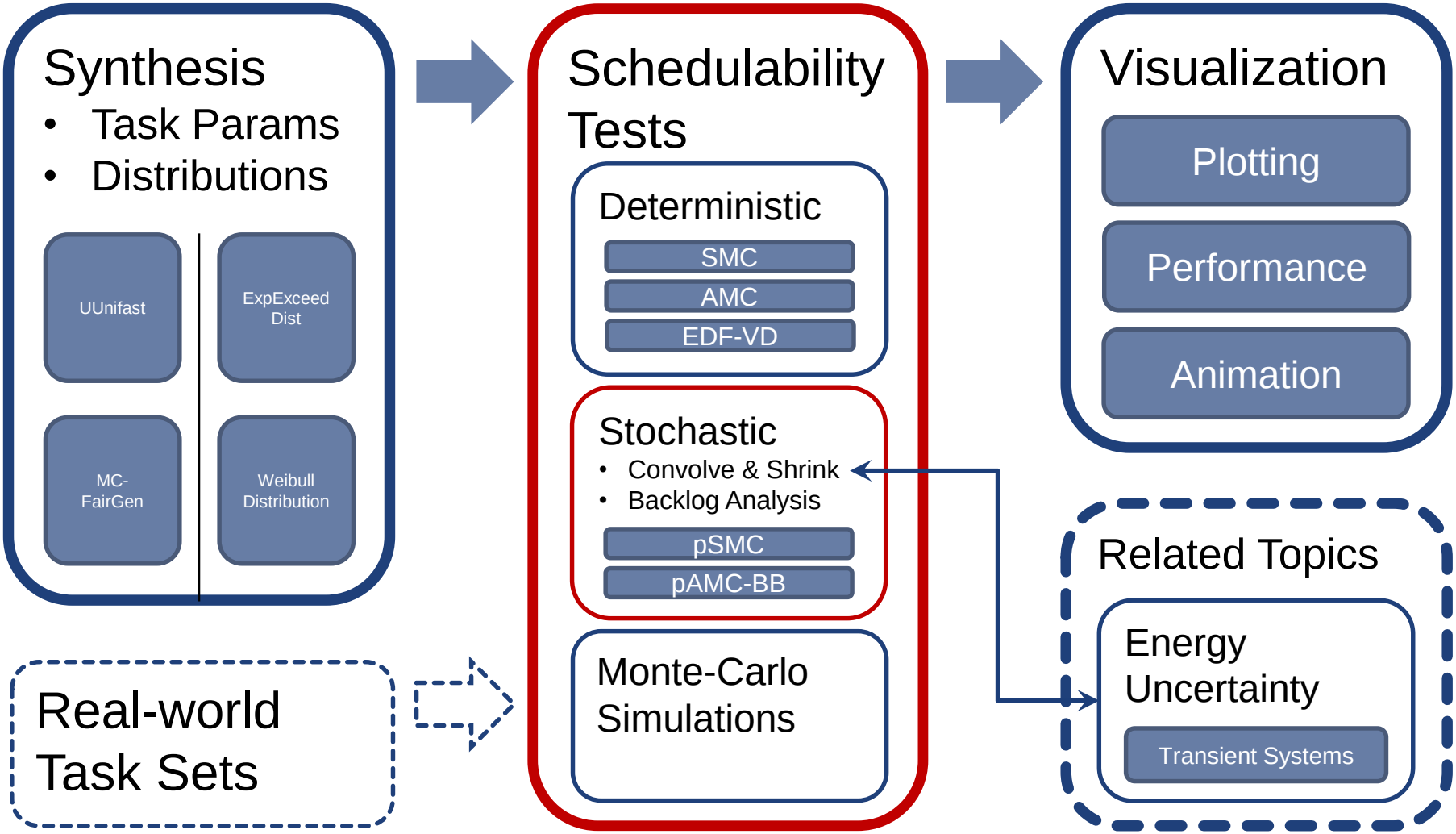
MC-FairGen with Weibull Distributions



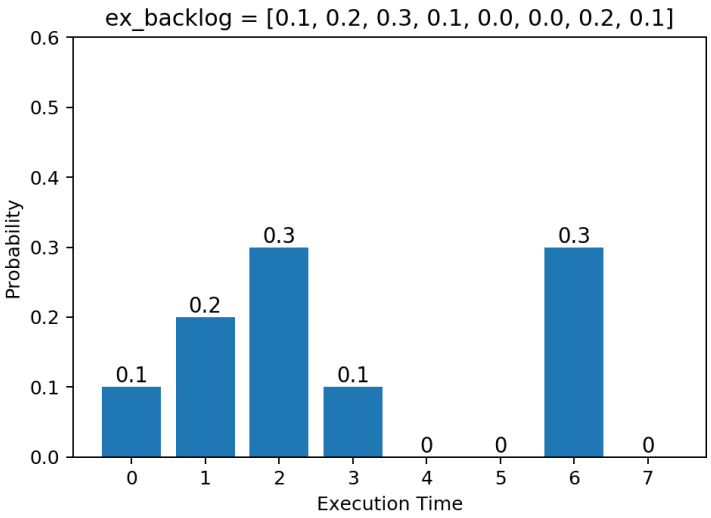
Exceedance Probabilities

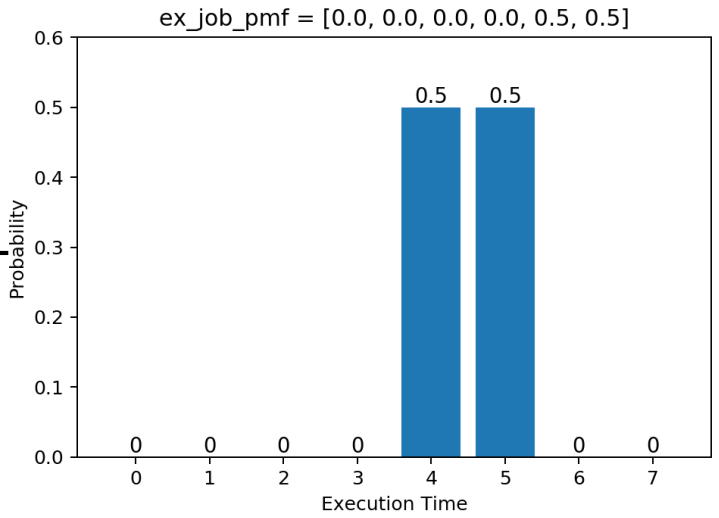
- C(LO): 10^{-5}
- C(HI): 10^{-9}

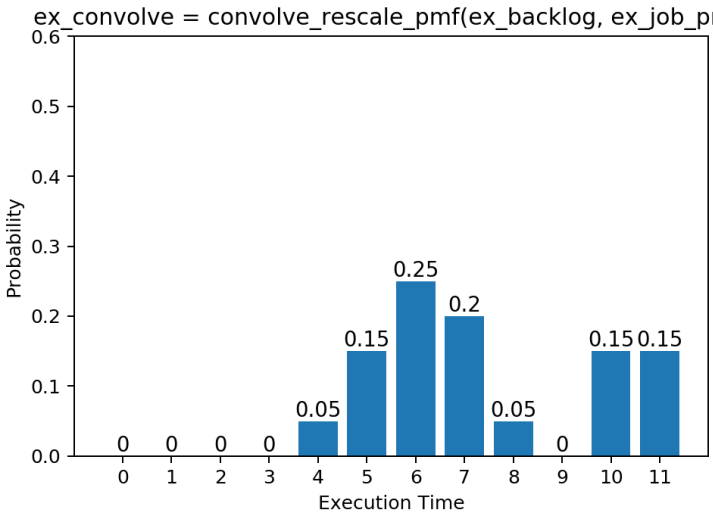
Stochastic Analysis



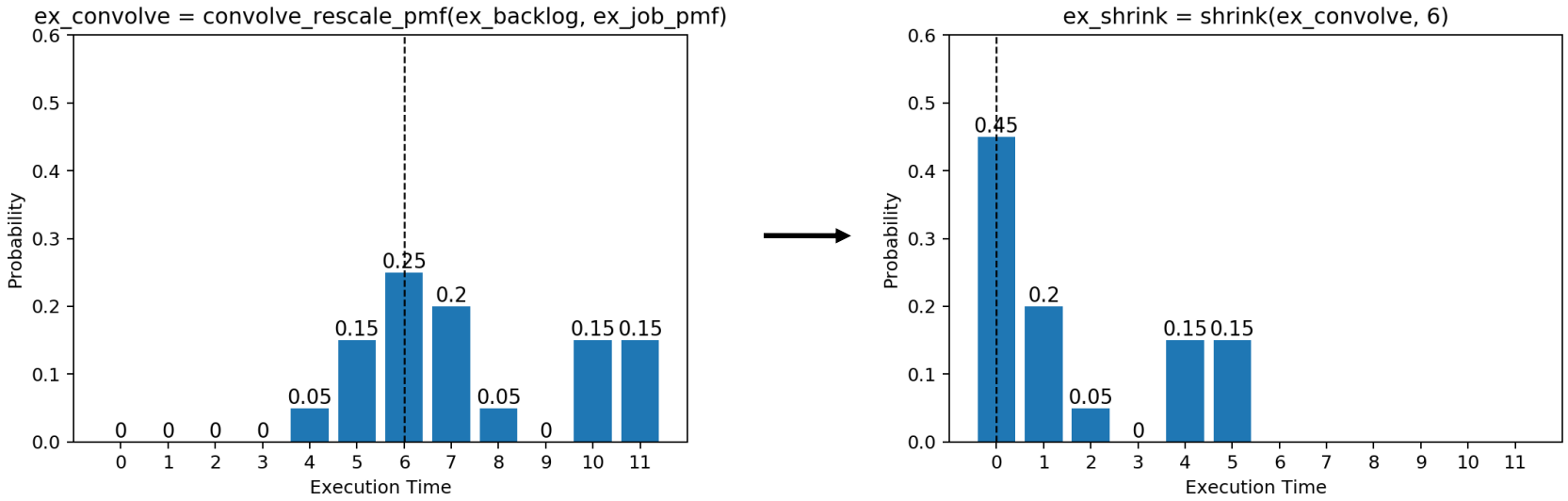
Convolution







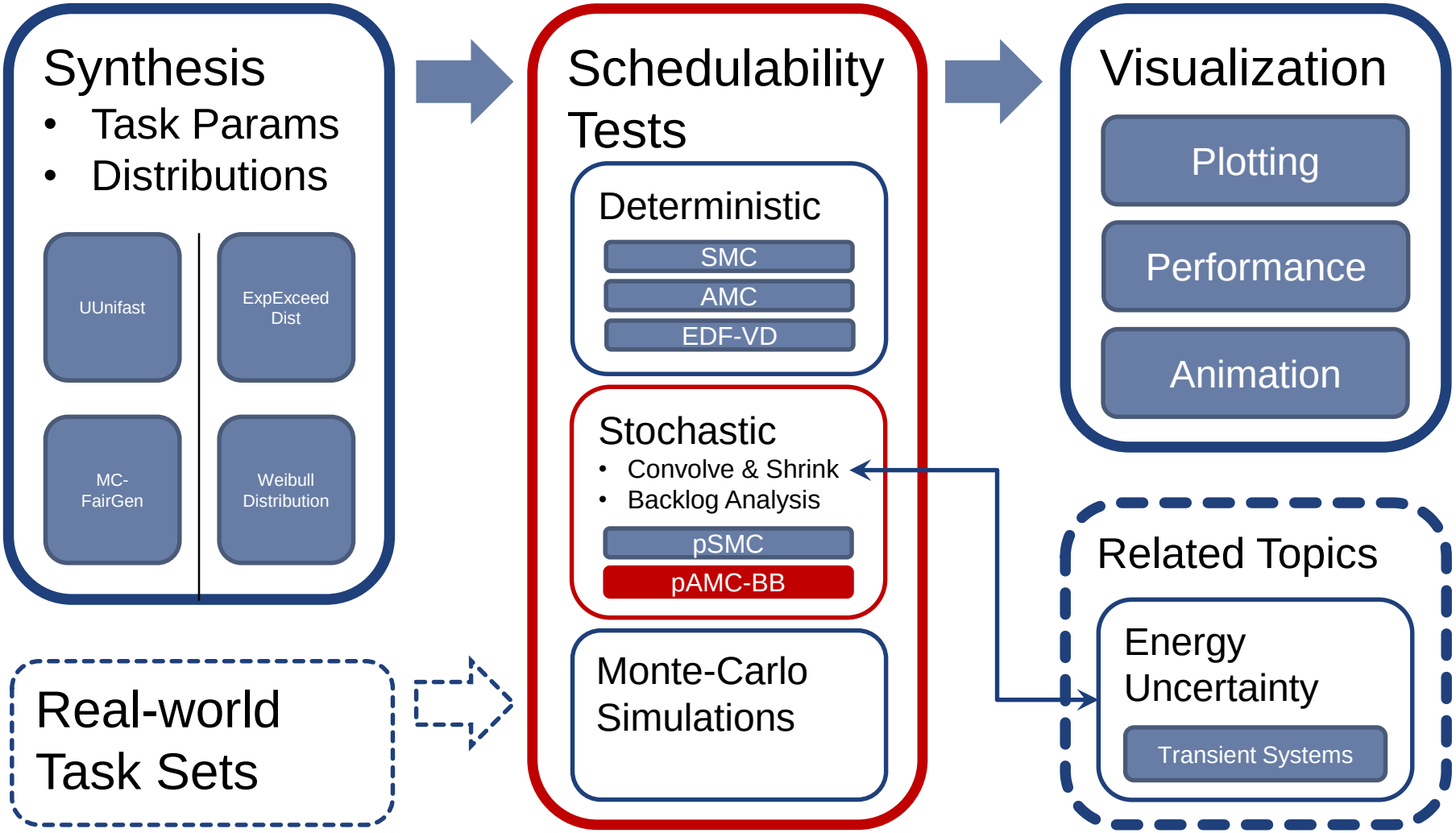
Shrinking


ex_convolve = convolve_rescale_pmf(ex_backlog, ex_job_pmf)
Probability
Execution Time
0 0 0 0 0.05 0.15 0.25 0.2 0.05 0 0.15 0.15
ex_shrink = shrink(ex_convolve, 6)
Probability
Execution Time
0.45 0.2 0.05 0 0.15 0.15

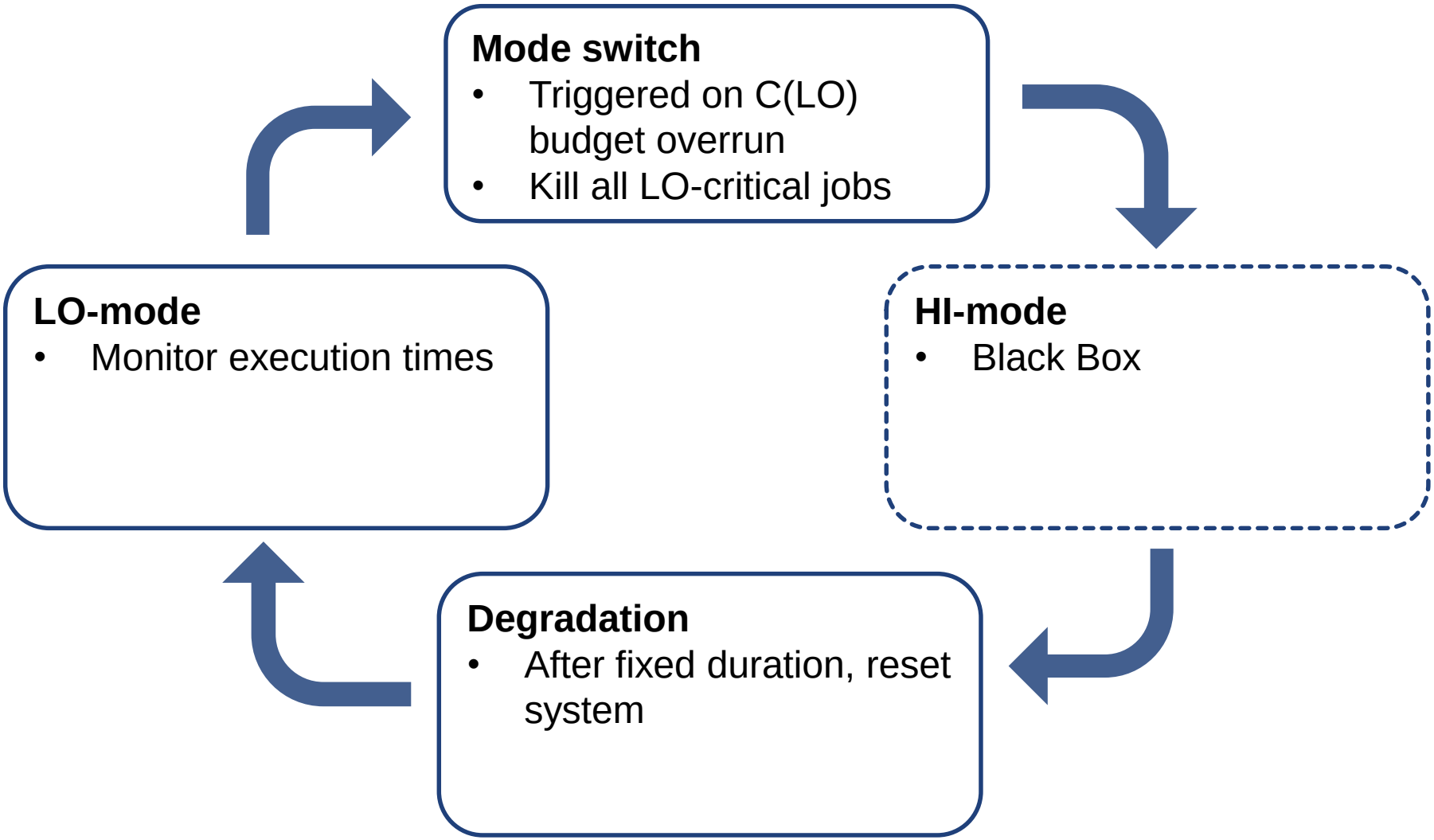
Backlog Analysis

→ Animation: Iterative backlog computation

pAMC-BB


Synthesis
• Task Params
• Distributions
UUnifast
ExpExceed Dist
MC-FairGen
Weibull Distribution
Real-world Task Sets
Schedulability Tests
Deterministic
SMC
AMC
EDF-VD
Stochastic
• Convolve & Shrink
• Backlog Analysis
pSMC
pAMC-BB
Monte-Carlo Simulations
Visualization
Plotting
Performance
Animation
Related Topics
Energy Uncertainty
Transient Systems

pAMC-BB


Mode switch
• Triggered on C(LO) budget overrun
• Kill all LO-critical jobs
HI-mode
• Black Box
Degradation
• After fixed duration, reset system
LO-mode
• Monitor execution times

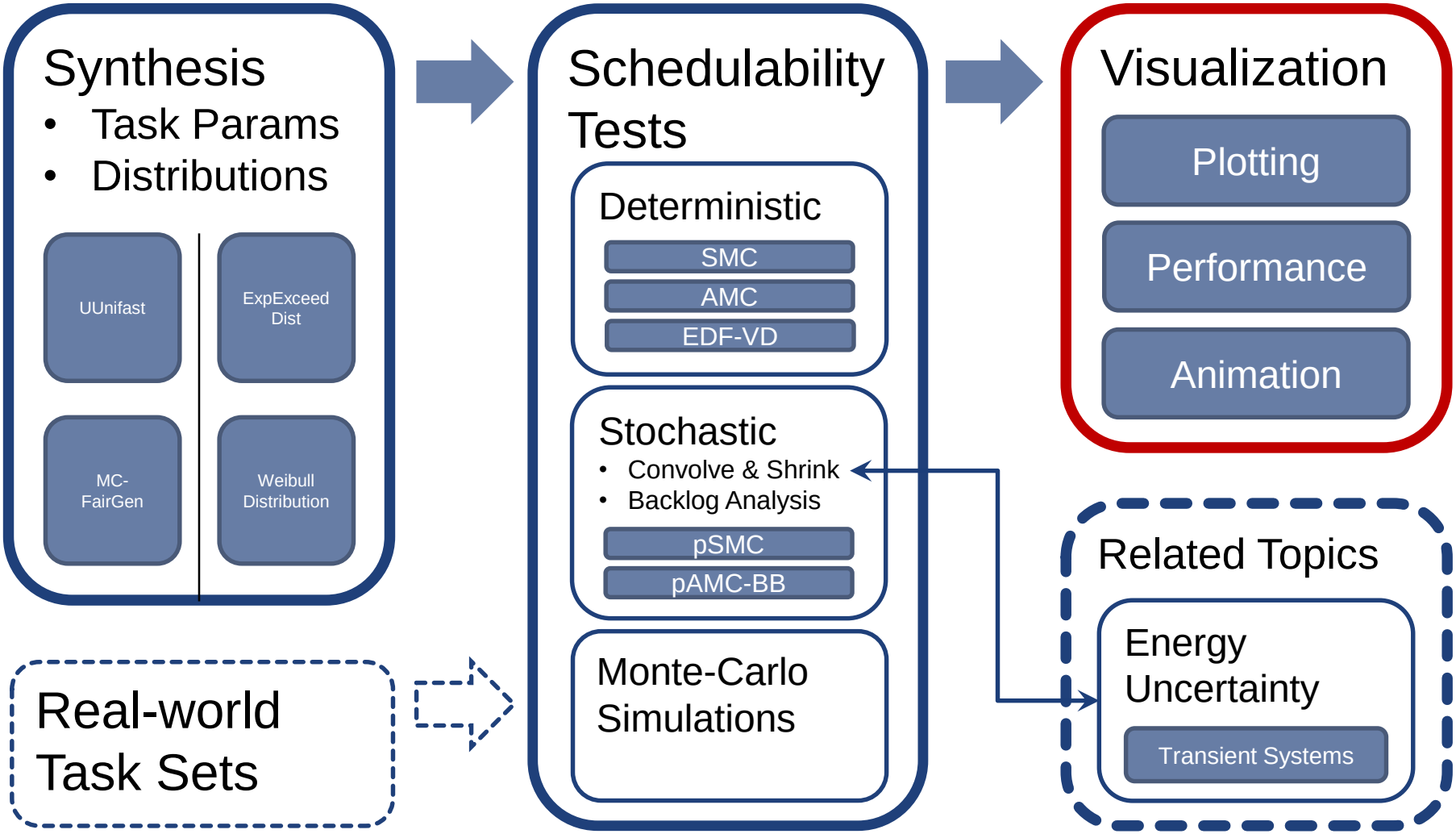
pAMC-BB

Analysis:

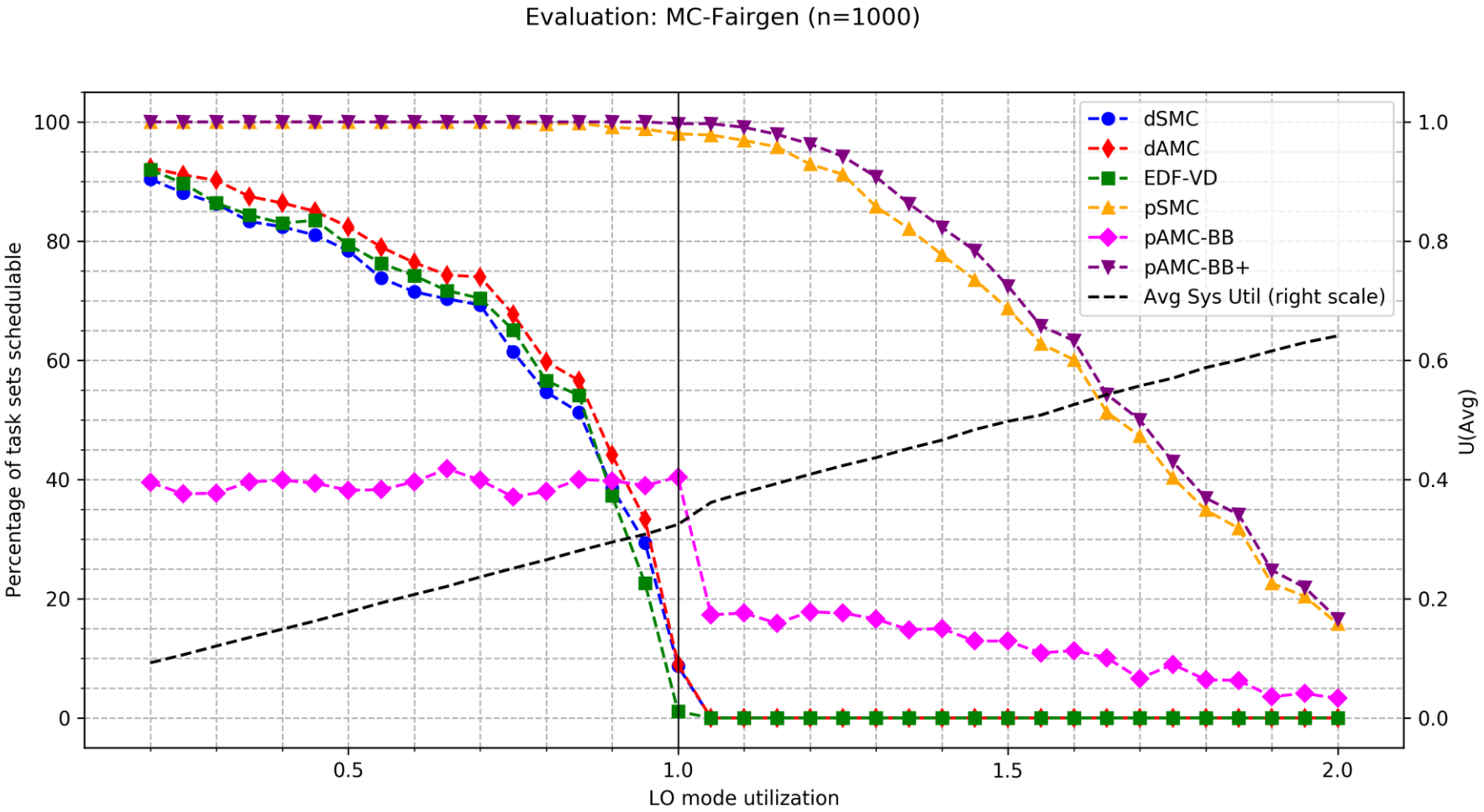
1. Find response time distribution for every job using convolution and shrinking.
2. Compare resulting response time PMF with job deadline to get job-specific deadline miss probability.
3. For every task, check:
   $reltime_{LO} \times DMP_{LO} + reltime_{HI} \times DMP_{BB} \leq Threshold$

Lines of Python Code: ~30 + reusable methods

Visualization

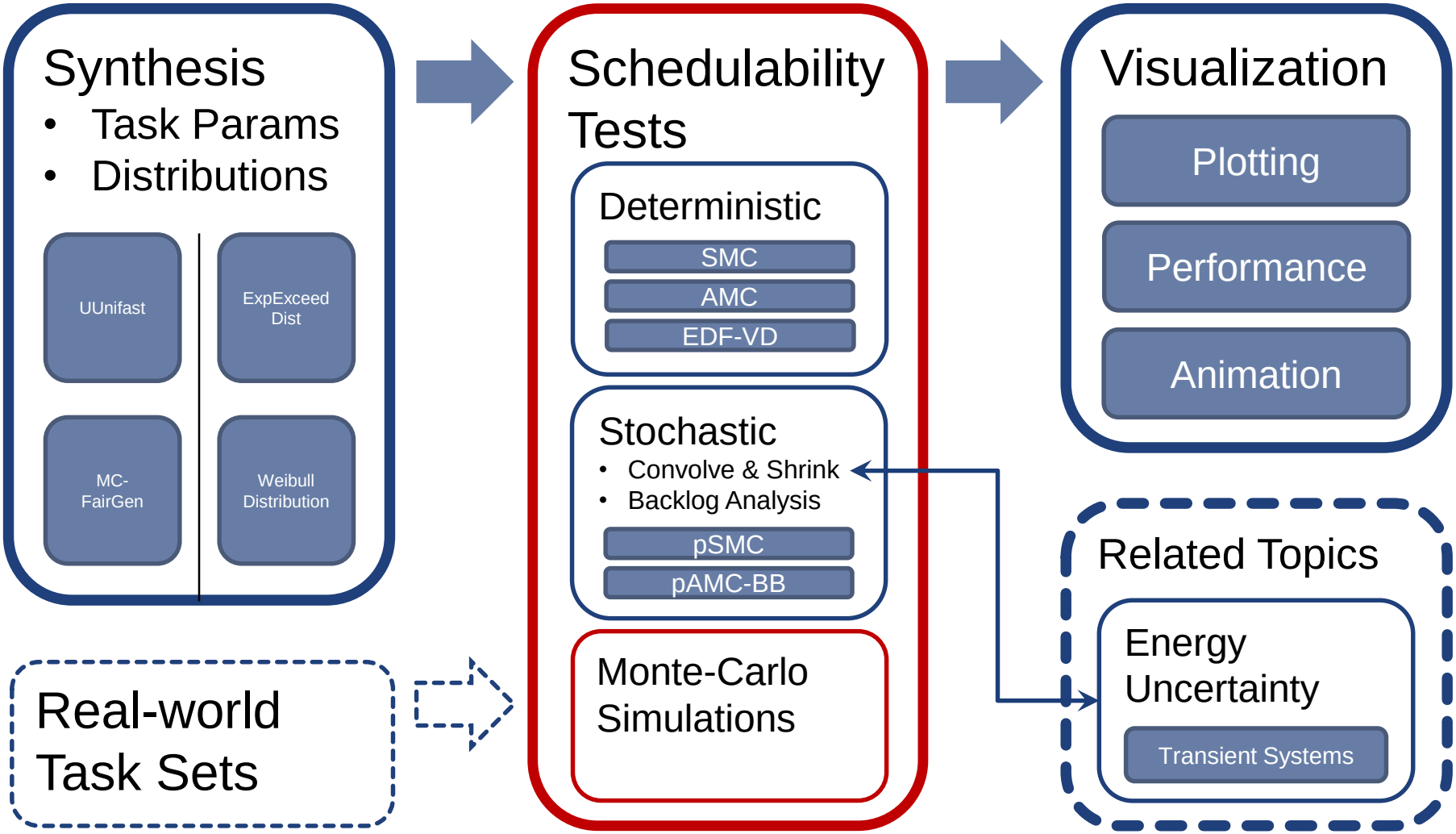


Visualization: Deterministic vs. Probabilistic

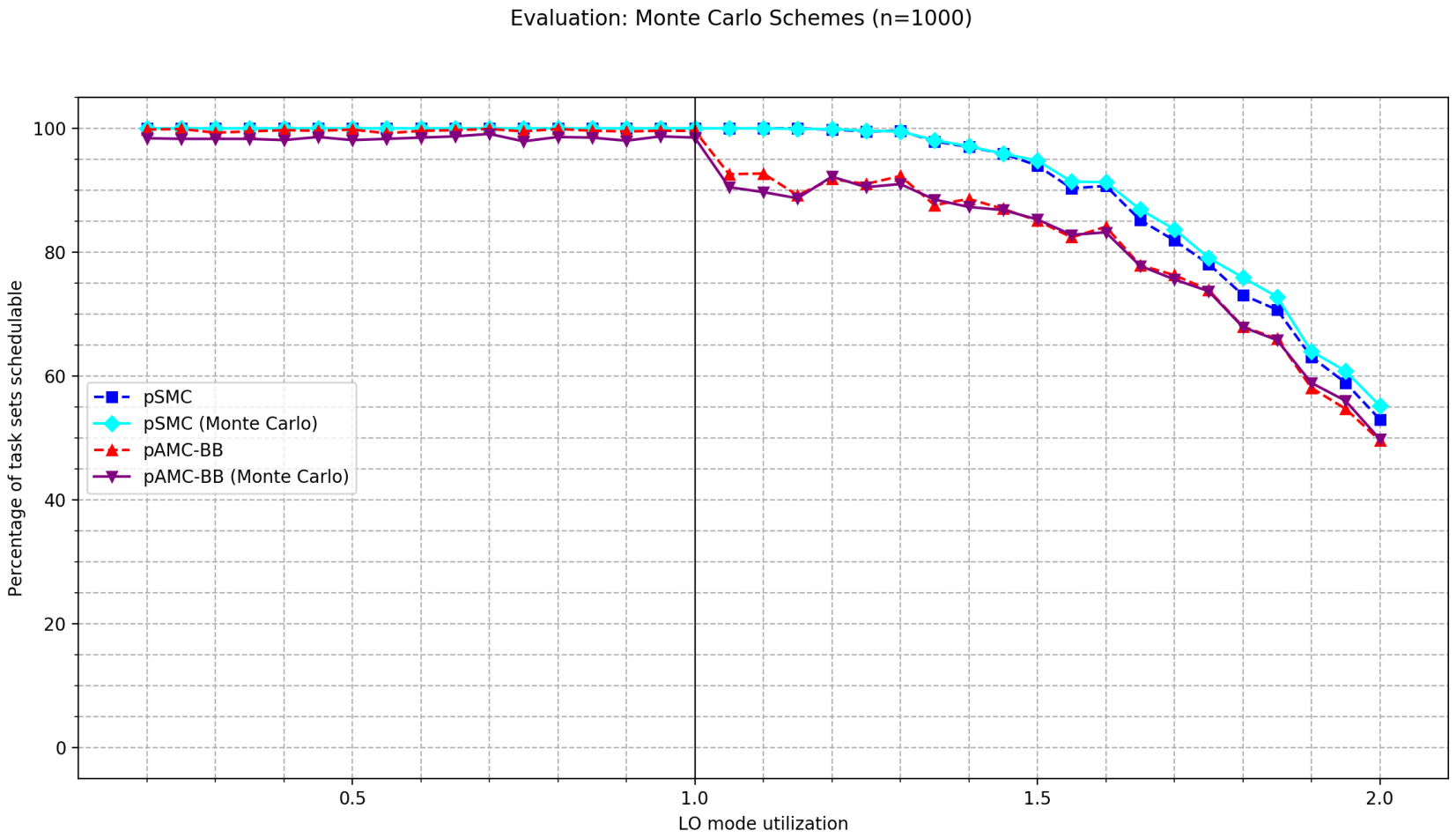


Time measured: 1h 21min 28s, Intel i5-7600K, 4 cores @ 3.8 GHz

Monte-Carlo Simulation



Visualization: Monte-Carlo Simulation



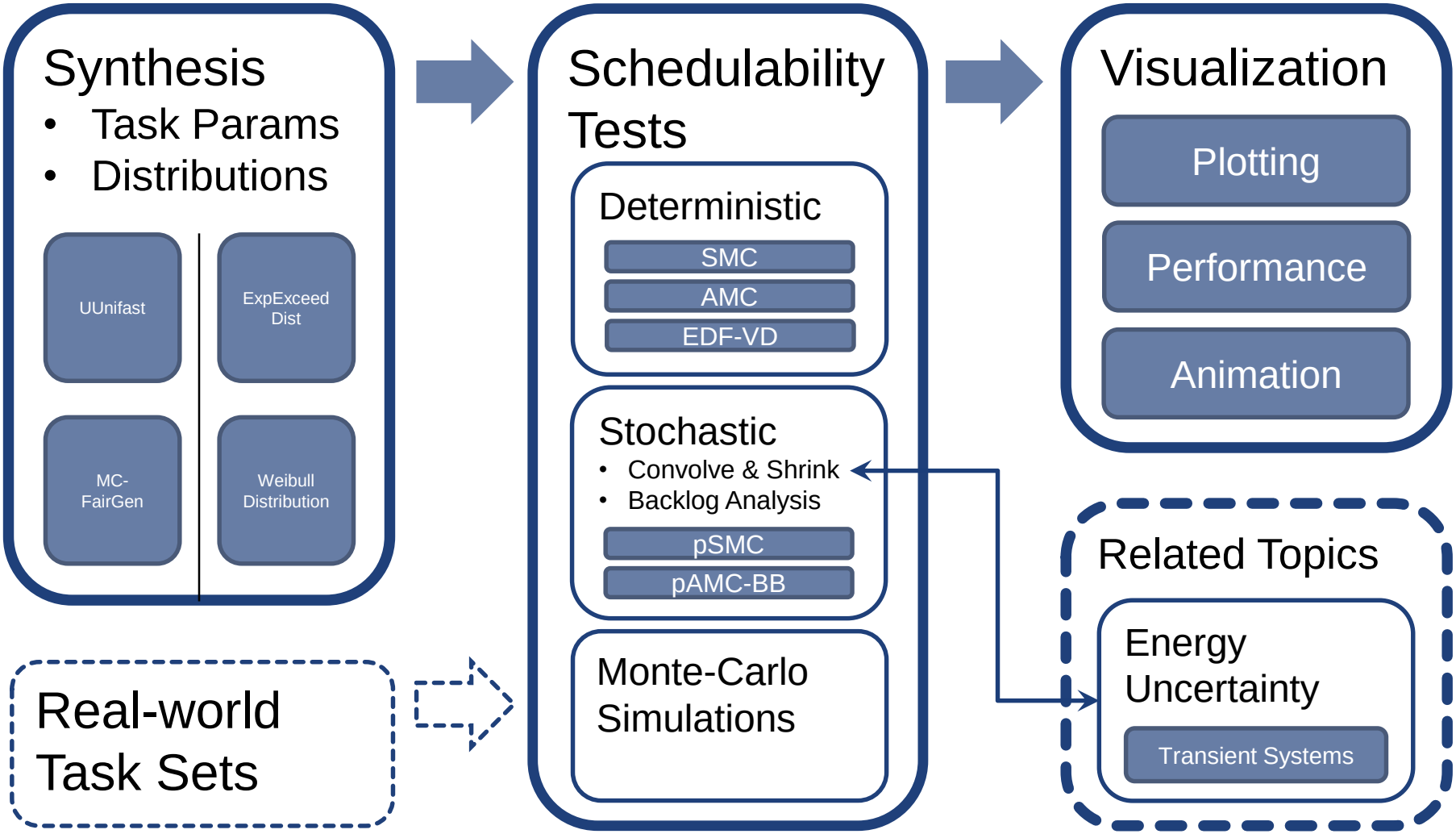
Time measured: 23h 20min 13s, Intel i5-7600K, 4 cores @ 3.8 GHz

Conclusion

- **Still at the beginning!**

- Future work:
  - Task Set Synthesis (distributions, influence of different parameters)
  - Stochastic HI-mode analysis
  - Expand on related topics (e.g. energy uncertainty)

Discussion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