AdaptMC: A Control-Theoretic Approach for Achieving Resilience in Mixed-Criticality Systems (Artifact)*

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Abstract

A system is said to be resilient if slight deviations from expected behavior during run-time does not lead to catastrophic degradation of performance: minor deviations should result in no more than minor performance degradation. In mixed-criticality systems, such degradation should additionally be criticality-cognizant. The applicability of control theory is explored for the design of resilient run-time scheduling algorithms for mixed-criticality systems. Recent results in control theory have shown how appropriately designed controllers can provide guaranteed service to hard-real-time servers; this prior work is extended to allow for such guarantees to be made concurrently to multiple criticality-cognizant servers. The applicability of this approach is explored via several experimental simulations in a dual-criticality setting. These experiments demonstrate that our control-based run-time schedulers can be synthesized in such a manner that bounded deviations from expected behavior result in the high-criticality server suffering no performance degradation and the lower-criticality one, bounded performance degradation.

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1 Scope

AdaptMC is a control-based approach for dynamically adapting the allocated budget to mixed-critical servers, while providing hard real-time guarantees. This artifact includes the necessary scripts for computing what are the feasible parameters that can be used for the controller design, compute and plot the corresponding supply bound functions, and compare the obtained performance with the Period-Preserving Approach (PPA) described in the paper.

The following figures of the paper include a numerical result that can be reproduced by this artifact:

- Figure 2: Region of feasible control gains. The illustrated regions correspond to the values of $K_i \in \{0, 0.01, 0.02, 0.05, 0.1, 0.2, 0.3, 0.35\}$, respectively from the larger region to the smaller one. Black dots represent the gains of the controllers selected for the examples illustrated in Section 6.
- Figure 5: Supply functions for the considered set of control parameters.
- Figure 6: Effect of constant disturbances with various selection of K_{ij} , $i, j \in \{\mathrm{H}, \mathrm{L}\}$.
- Figure 7: Comparison between AdaptMC and PPA.

The remaining figure do not contain any numerical result, and they support the description of the paper as illustrations.

2 Content

The artifact package includes:

- `adaptMC_sim.m`: Simulate AdaptMC over time.
- `computeConv.m`: Auxiliary function for computing the convolution of two signals.
- `computeJI.m`: Auxiliary function for computing $\mathcal{J}(n)$ and $\mathcal{I}(n)$ terms.
- `computeJInL.m`: Auxiliary function for computing $\mathcal{J}(n)$ and $\mathcal{I}(n)$ terms.
- `computeNnL.m`: Auxiliary function for computing $\mathcal{N}(n)$ term.
- `csvwrite_with_headers.m`: Function for saving the raw data in CSV format with a header.
- `generateFigure5.m`: Generates Figure 5.
- `generateFigure6.m`: Generates Figure 6.
- `generateFigure7.m`: Generates Figure 7.
- `imp.m`: Compute the impulse function at a generic time t.
- `jury.m`: Generates the Jury table for the assessment of the stability of a Linear-Time Invariant System.
- `plottingResults_comparison.m`: Auxiliary function for plotting results of Figure 7.
- `PPA_sim.m`: Simulate PPA over time.
- `ram.m`: Compute the ramp function at a generic time t.
- `rampResp.m`: Compute the ramp response of for AdaptMC.
- `stability.m`: Generates the stability conditions for AdaptMC.
- `StabilityRegion.cdf`: Generates Figure 2 (Wolfram CDF player required).
- `StabilityRegion.nb`: Generates Figure 2 (Wolfram Mathematica required).
- `stepResp.m`: Compute the step response of for AdaptMC.
- `stp.m`: Compute the step function at a generic time t.
- `supplyFunH.m`: Compute the supply bound function for the HI-Criticality server.
- `supplyFunL.m`: Compute the supply bound function for the LO-Criticality server.

3 Getting the artifact

The artifact endorsed by the Artifact Evaluation Committee is available free of charge on the Dagstuhl Research Online Publication Server (DROPS). In addition, the artifact is also available at: `https://github.com/apapadopoulos/AdaptMC`.

4 Tested platforms

The two main software platforms that are used are Matlab, and Wolfram Mathematica (or Wolfram CDF player). In particular,

- Matlab R2016a or higher: We tested the codes on Matlab R2016a, R2016b, R2017a, but the lower is not confirmed.
- Control System Toolbox of Matlab.
- For Figure 2, the symbolic expressions are obtained in Matlab, but the regions have been obtained with Wolfram Mathematica. In order to reproduce such graph the following **alternatives** can be used:
  - Wolfram Mathamatica 11 (license needed).
  - Wolfram CDF player 11.3 (`https://www.wolfram.com/cdf-player/`), no need of any license.

The adopted software can be used across different platform, including Linux, Mac OSX, and Windows.

5 License

The artifact is available under license GNU General Public License v3.0. (`http://www.gnu.org/licenses/gpl`)

6 MD5 sum of the artifact

08cc8ca42937f56f1b22e410ded78412

7 Size of the artifact

3.60 MB