AMALTHEA-based Task-Chain Analysis using Worst- and Best-Case Response Times

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Contents

CHAPTER 1

under Partitioned Fixed-Priority Preemptive Scheduling

Modern automotive software runs on a centralized, high-performance system with multiple heterogeneous CPUs, accelerators, and GPUs. Since it is important to achieve systems' real-time determinism for modern HPC applications, an application that can help developers analyze the response time with various constraint concepts in a heterogeneous platform is essential.

The purpose of this research project is to come up with an application that analyzes the worst- and best-case response time for each software component and E2E latency for understanding task chain behaviors under several constraint configurations. The application is developed on *Eclipse APP4MC 0.9.7* API platform which provides the whole design flow in the context of *AMALTHEA* toolchain.

The used approaches are introduced in *Metrics for Timing Analysis Chapter* and demonstrated in *Implementation Chapter*. *Measurement and Discussion Chapter* shows the measurement results in regard of response time and task chain latency under a certain set of constraint configuration with discussion. Moreover, the final conclusion and the issues which expand the project further are addressed in *Conclusion and Future Work Chapter*.

1.1 Chapters

1.1.1 Introduction

Motivation

With the transition from homogeneous to heterogeneous multi-core platforms, there is an increasing demand for software mapping that minimize the latency of a task chain to facilitate high computing performance.

While achieving the minimum task response time is a key to solving the challenge, satisfying the optimized response time for every task is hard to realize since the limited number of processing units and task deadlines are concerned.

Therefore, it is reasonable to analyze mapping models based on the sum of all tasks' response time and extract the model with the minimum sum value. Finding the optimized solution is taken care of by a meta-heuristic algorithm such as GA or SA. This leads to the need for establishing an application that has a built-in response-time calculation algorithm and works with the meta-heuristic which would make the entire developing circle quicker.

Furthermore, the response time results obtained through the meta-heuristic are used to measure E2E task chain latency to help determine how long it would take to execute a certain set of software instructions. E2E latency measurement depends on the measurement target, the communication model and the simulation scenario. The ultimate goal of this project is to devise E2E latency measurement methodologies in an analytical way, and analyze the results of the methodologies to determine how a specific set of constraints configurations affects E2E latency.

AMALTHEA

AMALTHEA is a project as well as its results with a purpose to provide AUTOSAR compatible environment for efficient multi-core system development which is publicly available open-source. The project results cover a comprehensive system model, trace model, and framework which provides support tools when needed. The *[11] WATERS Industrial Challenge (-, 2019)* model used in this project is also created with the AMALTHEA framework and can be utilized and manipulated on *[3] APP4MC (-, 2020)* version 0.9.7 platform.

1.1.2 Metrics for Timing Analysis

1.1.3 Implementation

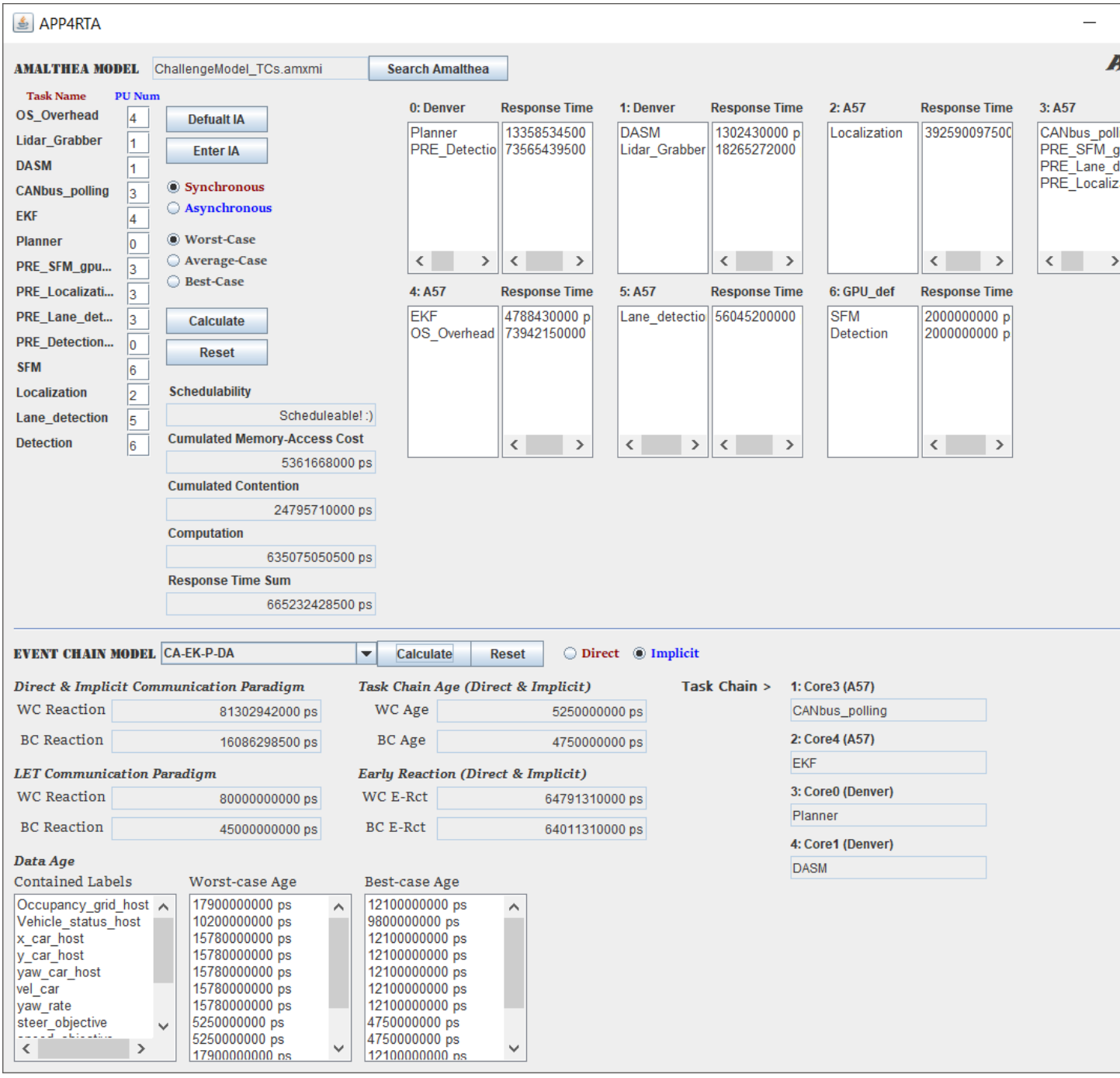
1.1.4 Measurement and Discussion

1.1.5 Conclusion and Future Work

1.1.6 User Interface (APP4RTA)

Set Up

For analyzing response time & end-to-end event-chain latency

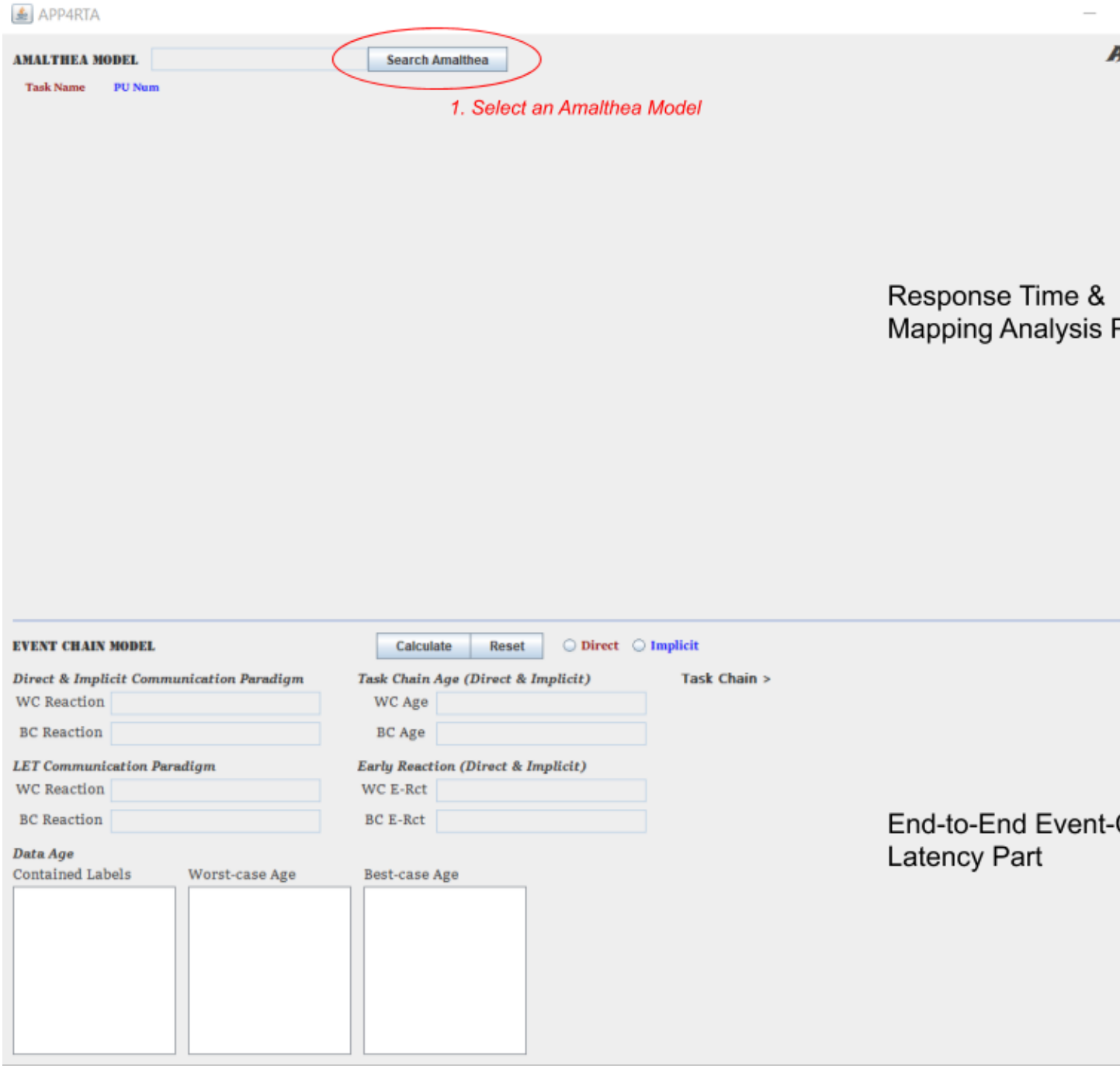


Before executing the code, please install the Java GUI softwares.

- To install Java GUI softwares:

1. Eclipse > `Help`
2. `Install New Software` > Work with: Eclipse Repository (http://download.eclipse.org/releases/oxygen)
3. `General Purpose Tools` > all click from `Swing Designer` to `WindowBuilder XML Core (requires Eclipse WTP/WST)`
4. `Next` > `Next` > `accept` > `Finish`

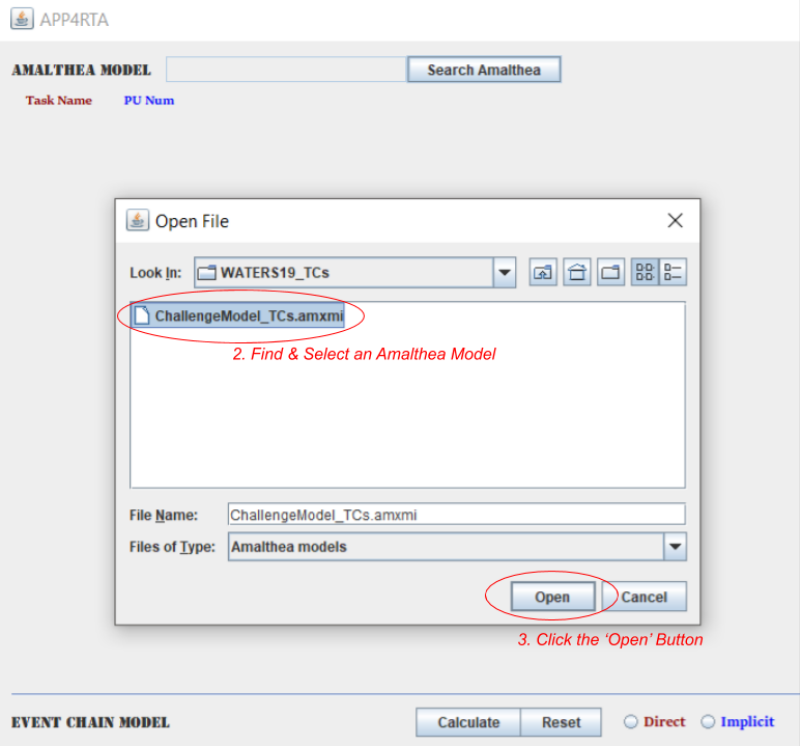
Search Amalthea



Run `APP4RTA.java` in `org.eclipse.app4mc.gsoc_rta.ui` package, then this window will show up. Based on the horizontal line on the middle, the upper part is for response time & mapping analysis, and the lower part is for end-to-end event-chain latency analysis. The first thing to do is deciding a target Amalthea model.

1. The window browser for searching Amalthea models shows up when the `Search Amalthea` button clicked.

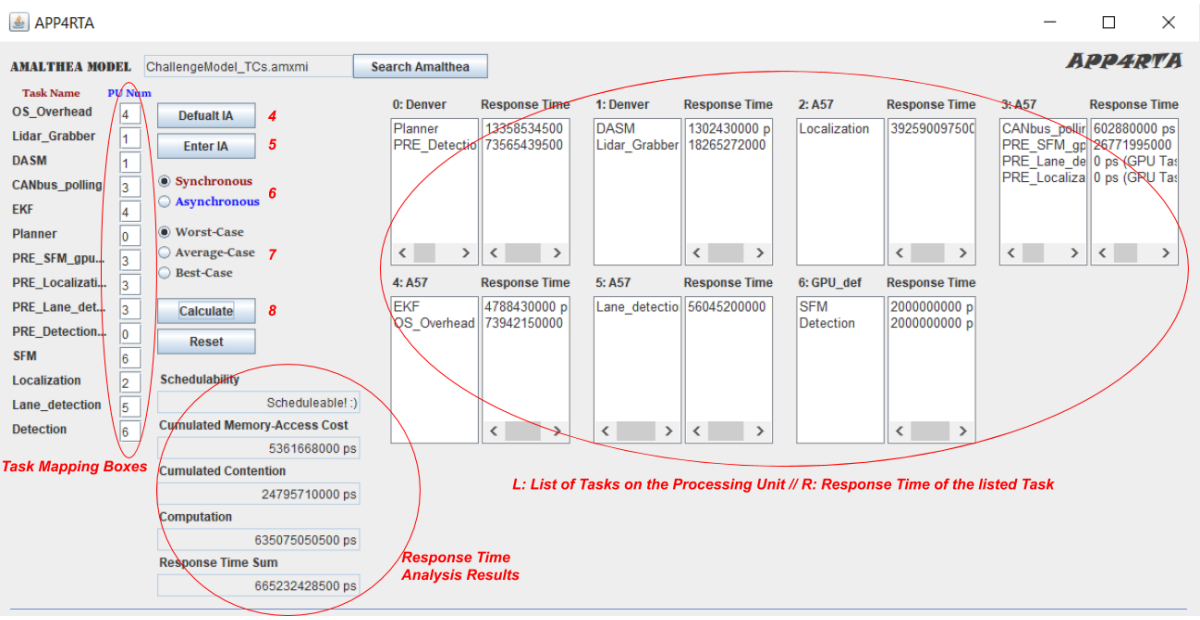
Direct & Select Amalthea



2. When the search browser shows up, direct to the path where the target Amalthea model file is located and select the model file.

3. Click the `Open` button.

UI Features (RTA)



Then the empty space will be filled with the the tasks and processing units of the selected model. On the left-hand side, tasks' names with empty boxes can be found. On the right-hand side, seven pairs of lists are seen (It means the selected model has seven processing units). The list on the left side of each pair is for listing names of the tasks which are mapped to the corresponding processing unit while one on the right side is for listing response times of the corresponding tasks. Basically, we can map the tasks with these boxes by entering the number of each processing unit which is stated on the top of the lists on the left-side.

4. The user can either manually type numbers for every box or simply click the `Default IA` button which would automatically fill up every box with the pre-defined integer array values.

5. Once every `PU Num` box is filled, click `Enter IA` button to assign tasks to processing units according to each integer value. Once this is done, the mapped tasks would appear on the left-side lists.

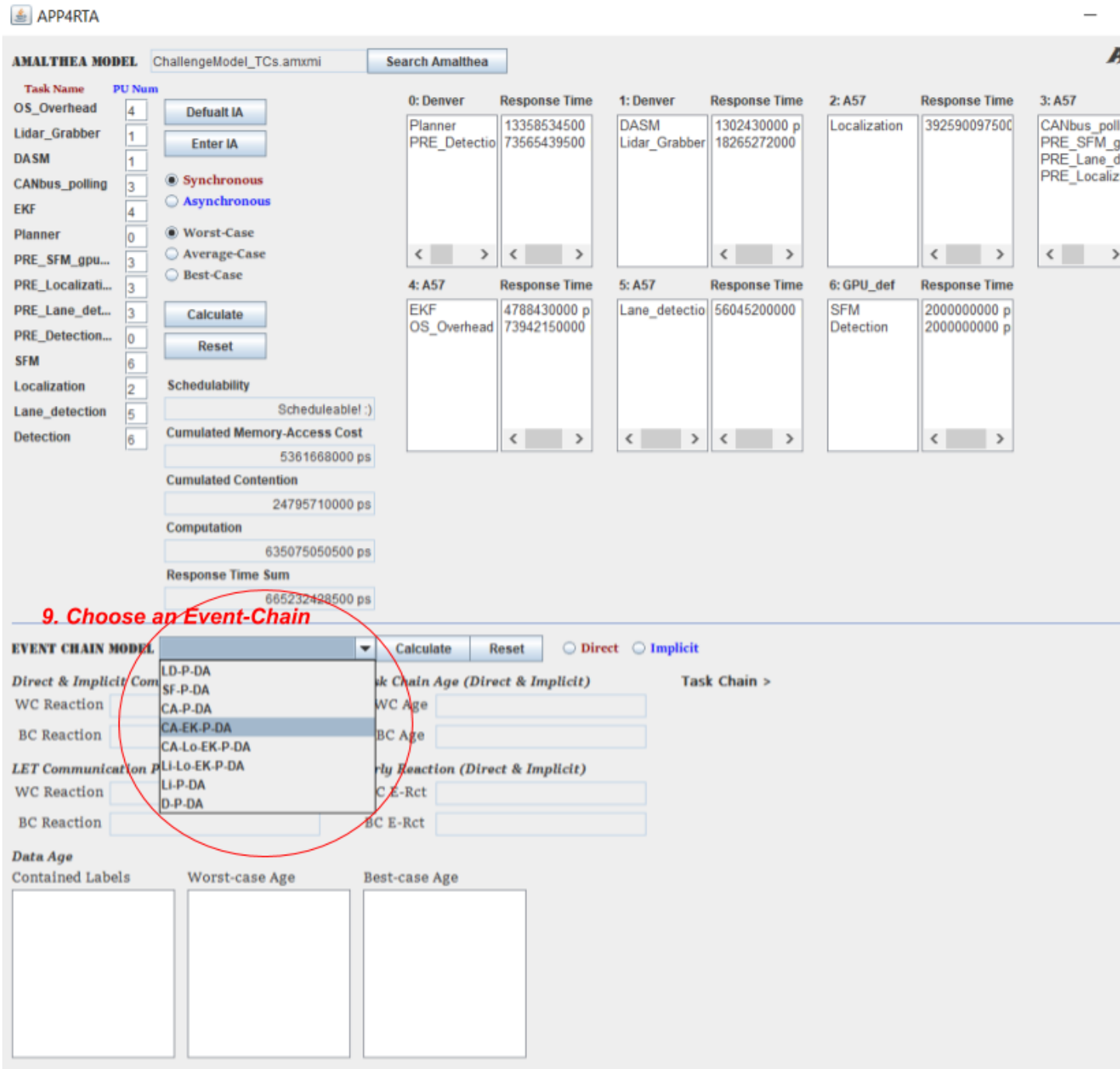
6. Choose the offloading mode between `Synchronous` case and `Asynchronous` case.

7. Choose the execution case between `Worst` case and `Average` case and `Best` case.

8. By clicking the `Calculate` button, all calculation results will be printed out on the text-fields (`Schedulability`, `Cumulated Memory-Access Cost`, `Cumulated Contention`, `Computation`).

For the implementation details, see CPURta-reference.

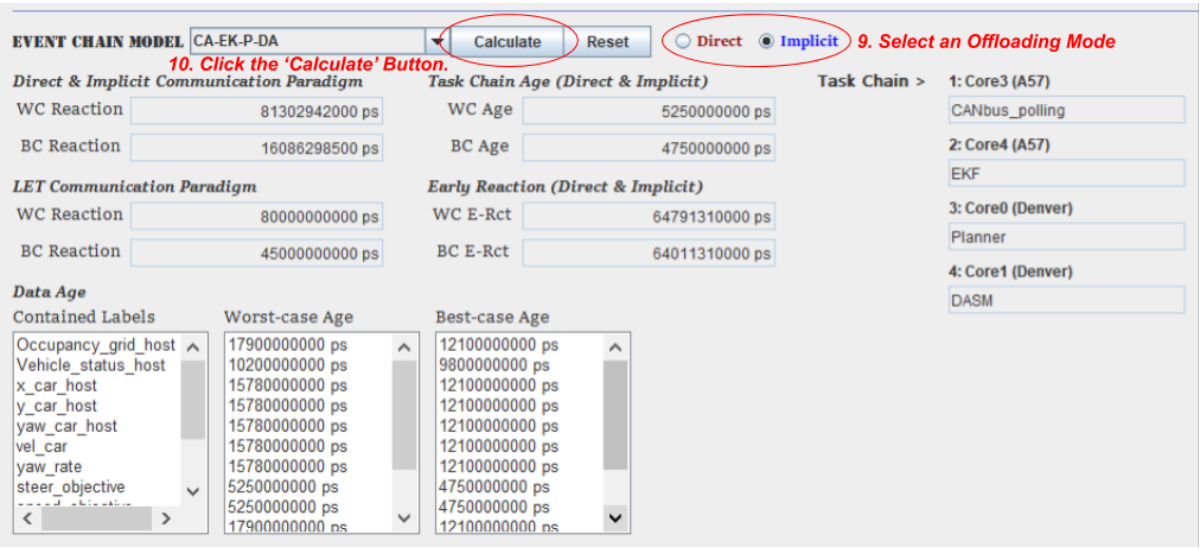
Select an Event-Chain



The event-chain combo-box becomes visible once the user clicks `Enter IA` to assign tasks to processing units according to each integer value in the boxes.

9. To analyze end-to-end event-chain latency, an event-chain in the combo-box should be selected first.

UI Features (E2ELatency)



10. Select the communication paradigm between direct Communication and implicit communication.

11. Finally, click the `Calculate` button.

Then all calculation results regarding reaction, age of data, task-chain in the worst and best cases will be printed out to the corresponding text fields or lists.

For the implementation details, see E2ELatency-reference.

Download `PDF` file to see offline.

1.1.7 Bibliography

[1] (GSoC 2019) CPU-GPU Response Time and Mapping Analysis (Junhyung Ki, 2019)

[2] AMALTHEA (-, 2014)

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[5] Scheduling Algorithms for Multiprogramming in a Hard-Real-Time Environment (C. L. Liu, James W. Layland, 1973)

[6] Earliest Deadline First scheduling (-, -)

[7] Model-based Task Chain Latency and Blocking Analysis for Automotive Software (Robert Höttger, The Bao Bui, Junhyung Ki, Burkhard Igel and Olaf Spinczyk, Not yet published)

[8] CPU-GPU Response Time and Mapping Analysis for High-Performance Automotive Systems (Höttger, Robert and Ki, Junhyung and Bui, Thebao and Igel, Burkhard and Spinczyk, Olaf, 2019)

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[10] Exact Best-Case Response Time Analysis of Fixed Priority Scheduled Tasks (Redell, Ola and Sanfridson, Martin, 2002)

[11] WATERS Industrial Challenge (-, 2019)

1.1.8 Repositories

1.1.9 Contact

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