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Simulation Performance for Scenario-based Testing in a Cloud Environment

Kensuke Araki[1)] Katsuya Tsuzuki[1)] Takashi Yamada[1)]

1) dSPACE Japan K.K 4-7-35 Kita-Shinagawa, Shinagawa, Tokyo 140-0001 Japan

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Model-based development (MBD) is a software development method that utilizes computer models in addition to real prototype components. The automotive industry is now at a turning point where development trend is toward electrification and autonomous driving. In particular, development of autonomous driving (AD) systems has become a trend in the automotive industry.

Scenario-based testing has been proposed as a method of AD development using MBD by the United Nations Economic Commission for Europe (UNECE) World Forum for Harmonization of Vehicle Regulations (WP 29). Scenario-based testing is a testing method that aims to intensively and efficiently validate components that require in-depth validation by automatically finding next test scenario and test parameters based on former test results.

At the Society of Automotive Engineers of Japan 2022 spring congress, we discussed challenges and countermeasures for scenario-based testing using Function Mock-up Unit (FMU) in a cloud environment.

In this study, we prepare on-premise private cloud environment (hereinafter referred to as "private cloud") that is similar to a public cloud environment, and measure execution time when tests are executed in parallel. Furthermore, we will also measure execution time of actual parallel computation when a FMU is integrated into the validation environment of an automated driving algorithm.

The plant models used for the simulations in this study consists of the following two models: dSPACE Automotive Simulation Models (ASM) and a model in which a FMU replaces a part of ASM and is linked to it. For the parallel computing environment for scenario-based testing, SIMPHERA version 22.4 from dSPACE was used. SIMPHERA is a parallel computing environment for software-in-the-loop (SIL) simulations developed using Kubernetes clusters.

In this study, simulations were performed in the following two cases to obtain results on computation time versus parallelism.

The first case is the result of the simulation of 20 scenario-based test jobs on SIMPHERA, a private cloud environment 1, by changing the degree of parallelism from 1 to 15 for each job (Figure 1). The computation time decreases inversely proportional to the degree of parallelism from 1 to 5. From 5 to 15, the computation time decreases in steps according to the degree of parallelism. Although overhead caused by communication between cores can be considered as a reason for the increase of execution time, it was confirmed that the overhead does not increase even if the degree of parallelism is increased, since the computation time does not increase with the overhead. From the results of this study, it can be expected that even if the number of jobs increases and the degree of parallelism is increased, we can expect a speedup corresponding to the degree of parallelism.

The second case is the result of the scenario-based test on SIMPHERA, a private cloud environment 2, which is different from the private cloud environment 1, with all the jobs calculated by changing the parallelism from 1 to 2 for each case (Figure 2). It can be confirmed that the computation time is almost the same between the model with ASM and FMU and the model with only ASM, and that the computation time is inversely proportional to the degree of parallelism and is almost halved when the degree of parallelism is increased from 1 to 2. In the case of the model in which ASM and FMU are linked, there may be overhead due to communication between cores and communication between ASM and FMU, but as in the result of Private Cloud Environment 1, the computation time for the overhead does not increase even if the degree of parallelism is increased. The results show that the overhead due to the degree of parallelism and the overhead due to the communication between ASM and FMU do not increase.

Since we have not yet conducted the parallel computation in a public cloud environment where computing resources can be flexibly changed, it remains to be seen whether the trend of the results is different between the two environments and whether the bottleneck changes or not.

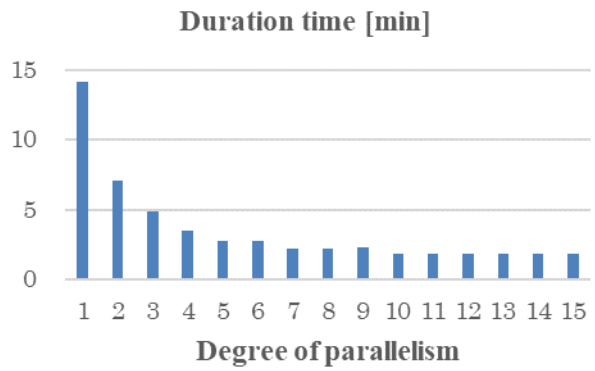

Figure 1 Duration time depending on the degree of parallelism.

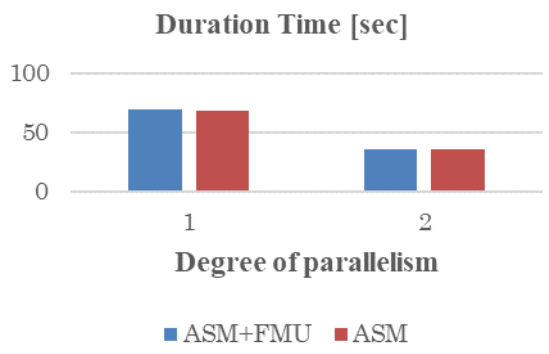

Figure 2 Duration time depending on the degree of parallelism.