Extension of Simulation Caching Framework for Large-scale Simulation*

Extended Abstract†

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ABSTRACT

Simulations running on HPC systems are driving the advanced innovations for academic and industrials. With the fast increasing power of HPC resources, it's looking forward to interactively steering the simulations in real time, which is known as interactive simulation. The interactive simulation methodology allows dynamic, fast, and flexible analysis to the simulation and avoid expensive data transfer and storage in this data expanding era. In order to overcome the inevitable network delay and jitter which will harm the real-time effectiveness of interaction, and help application users easily build their interactive remote simulation environment, there is a research project named Simulation Caching Framework. It utilizes a local server to give users quick response and keep accuracy in an acceptable range by cooperating with centralized remote server via data consistency control. However, there exists deficiencies in the current framework which make it insufficient to support large-scale simulations. This paper focuses on making this framework feasible for large-scale simulation, by extending the ability of using parallel computing on computing nodes of HPC system, which cannot be directly communicated from a remote network, without introducing security issues. Besides, parallel data compression and decompression are used to reduce the overhead of communication. This paper takes an open source electronic-magnetic simulation OpenFDTD [1] as the user application to investigate and demonstrate the effectiveness of extended framework.

CCS CONCEPTS

• **Computer systems organization** → *Cloud computing*; *Real-time system architecture*;

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KEYWORDS

Interactive Simulation, Simulation Caching Framework, Large-scale Simulation, Parallel Computing, Data Compression

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1 INTRODUCTION

Driven by the fast increasing abilities of computing resources, a great diversity of simulation have been used in various fields for academic research and industrial engineering. With the on-going developments in recent years, real-time simulation with interactions from users or machines is expected to give a dynamic, fast, and flexible steering of the simulation; meanwhile, this kind of interactive simulation can avoid expensive data storage and transfer in common batch processing and post analysis [2].

In order to overcome the inevitable network delay and jitter which will harm the real-time effectiveness of interactive simulation, there is a research named Simulation Caching Framework [3] devoting to build general-purpose framework for application users to realize interactive remote simulation. The strategy is to utilize a local server to hide network delay by duplicately performing limited area and/or lower resolution simulation on the local server to give a timely response. Since the remote server is assumed to keep a more accurate simulation result, the framework performs periodically synchronization which called data consistency control to renew the local simulation data.

The direction of Simulation Caching Framework is appealing, and indeed they have shown some interesting achievements in their paper evaluated using their in-house simulations. However, there exist some insufficiency to support large-scale simulation in practical environments.

(1) For large-scale computing: the framework should be able to support inter-node highly parallel computing to utilize the back-end computing resources in many nodes system.

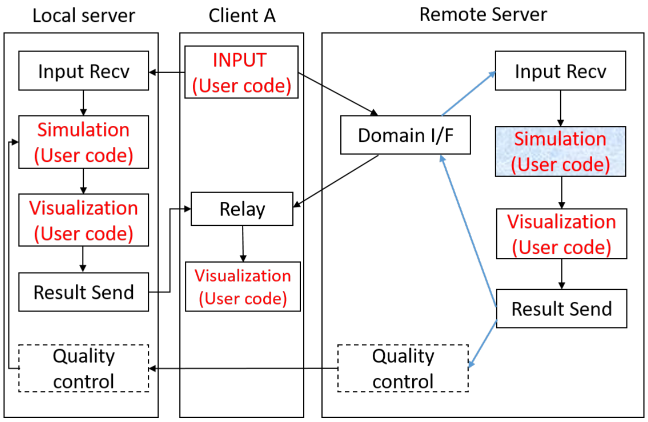

Figure 1: Overview of the original Simulation Caching Framework system

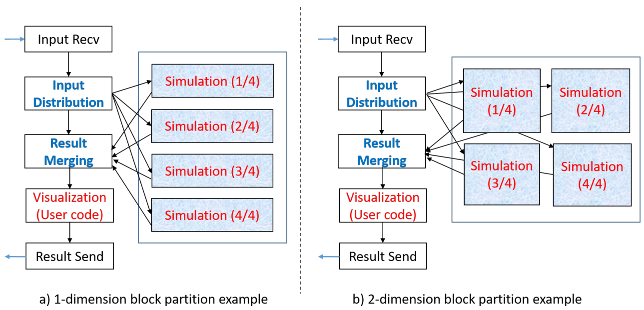

Figure 2: Extension of parallel computing for large scale simulation

(2) For large-scale data, the sie effects of large-scale data for communications such as consistency control has to be considered and optimized, otherwise the overhead may affect the real-time effectiveness.

By the way, as the assumption of this research, we assume that some nodes can be required in an interactive way, instead of the common batch processing of using HPC resources. And we assume that the back-end computing nodes can communicate with the login node, which remote user can access. The framework should utilize the computing nodes without introducing any security issues.

In order to make the framework applicable for most large-scale simulations in practical, this abstract extends the framework to endow the parallel computing ability without introducing security issue to computing nodes.

2 EXTENDED SYSTEM FOR LARGE-SCALE SIMULATION

Figure 1 shows the original system design, the red color means this part belongs to user applications, formerly all simulation work on remote server is computed on a single process.

Figure 2 illustrates this extension. In common HPC system, user can access a remote login node, where deployed the relay processes

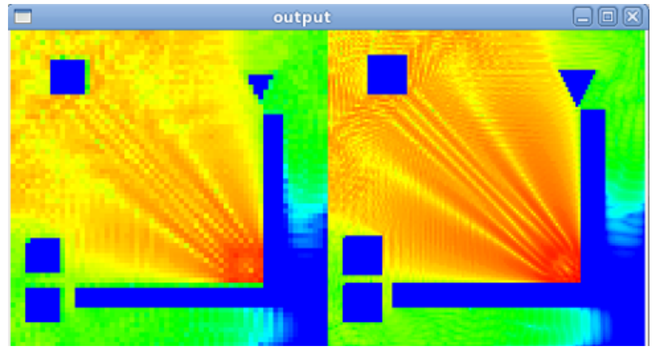

Figure 3: A snapshot of implemented OpenFDTD simulation. left) Local Simulation, right) Remote Simulation

(Domain I/F and Quality control process in the figure) that send input to computing process and results to local server. This abstract extends the framework to have the ability of parallel computing, by distributing input information to a group of MPI processes on computing nodes and then merge the gathered results from computing nodes. Between relay processes and input/result process inside login node, the extended framework use sockets rather than MPI to realize communication to connect two separate MPI world, making the whole system loosely coupled.

In order to realize the parallel computing and reduces application users' complexity, the distribution and merge processing for typical domain decomposition has to be considered. The extended framework implements the interface for data scattering and gathering for typical domain decomposition such as block, cyclic, block-cyclic partition to help users realize their parallelism on invisible computing nodes.

In order to reduce the overhead of communication, this abstract also utilizes parallel data compression/decompression to reduce the size of transferred data, by using Deflate algorithms provided in zlib. However, the compression makes the size of data changeable rather than fixed, which makes the communication by sockets difficult since sockets requires programmers specify how much data to be sent or received in advance. This abstract solves this problem by adding a defined header data structure to fill in the information of sent data. Instead of sending small message several times, data packing is also considered to be used to save communication time.

This abstract adopts a third-party open source electronic-magnetic simulation OpenFDTD developed by EEM company as a user study to investigate the effectiveness of the extended framework for large-scale simulation. Figure 3 shows a snapshot of the implemented system, we can see that the higher resolution result from the remote server is better on details so that it is expected to help improve the simulation on the local server via data consistency control.

3 CONCLUSIONS

As a general-purpose framework to help realize various interactive remote simulations, the Simulation Caching Framework has shown interesting and appealing effects of giving both real-time interaction and reasonable accuracy of simulation with the help of cluster cooperation. This paper shows a work-in-progress research to extend its ability of utilizing parallel computing on computing nodes of HPC system and reducing the large-scale data by compression. The contributions of this abstract are listed as follows.

(1) Application level: Demonstrate the implementation of applying a large-scale electronic-magnetic simulator OpenFDTD with extended Simulation Caching Framework, and investigate the issues of large-scale computing and data in simulations.
(2) System Architectural level: This abstract extends the framework to be able to utilize the power of parallel computing on many nodes system without introducing security issues to computing nodes which are usually inaccessible and being in private network.
(3) User Interface level: This abstract provides the interface for dynamically using parallel nodes and data scattering and gathering.
(4) Optimization level: To reduce the overhead of communication which cost heavily in remote network environment, this abstract utilize parallel data compression/decompression and some endeavors such as creating header data to send changeable size, and message packing to achieve the goal.

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