Remote Collaboration System Based on the Monitoring of Large Scale Simulation " SIMON" — A New Approach Enhancing Collaboration —*)

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In recent years, there has been a growing awareness that large scale simulation plays an important role in various science fields. To assist such simulation studies in which many collaborators working at geographically different places participate, we developed a unique remote collaboration system, referred to as SIMON (SImulation MONitoring) [A. Sugahara and Y. Kishimoto: J. Plasma Fusion Res. **84**, 51 (2008)]. This system is based on the *client-server model*, where the simulation (client) running on a supercomputer controls an external workstation (server) by sending various requests such as data transfer, analysis, visualization, updating website, etc. via network. Here, in order to increase the reliability of the network connection, we apply a method which establishes the login-shell of SSH automatically, and that ciphers the password by utilizing plural encodes. Furthermore, in order to provide an efficient environment for data analyses on the website, we introduced a method that stratifies the capability of visualization. By applying the system to a specific simulation project of laser-matter interaction, we confirmed that the system works well as a collaboration platform on which many collaborators work with each other.

Keywords: remote collaboration, client-server model, simulation monitoring, update processing, trigger method, network security, hierarchical visualization

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1. Introduction

Recently, computer simulation, which allows the study of various complex phenomena in high resolution, plays an important role in various scientific projects as well as in basic research. This is because the computer performance has improved significantly. However, such computer performance alone does not lead simulation research to success. In large scale experimental research, a lot of researchers and engineers participate. Similarly, success of simulation research depends not only on the ability of individual researcher, but also on that of whole research group. Namely, as the simulation becomes large scale and the problem becomes complex, in addition to the scientists directly managing the simulation, the participation and the contribution of many collaborators who play different roles are essential.

In order to assist such a simulation project, we have developed a unique remote collaboration system, referred to as SIMON (SImulation MONitoring) system. This system is based on a *client-server model* that the simulation running on a supercomputer controls an external workstation by sending various requests via network in parallel to the simulation [1, 2].

Here, we improved the SIMON system from two viewpoints. First, we improved the network security associated with the connection between client and server, which increases the system reliability. For this purpose, we developed a method of dynamic connection using SSH [3] and Expect commands, and that of ciphering the password utilizing plural encodes. Second, we improved visualization environment that increases the convenience of data analyses for collaborators. For this purpose, we introduced a method that stratifies the interactive capability of visualization software on the website depending on level of data analysis.

In Sec. 2, we describe the basic concept of the SIMON system. In Secs. 3 and 4, we explain the network security and visualization environment that we developed in this research, respectively. We provide an example in Sec. 5 and give concluding remarks in Sec. 6.

2. Concept of SIMON System

Figure 1 illustrates the schematic view of the SIMON system. This system is constructed as a *client-server model* that exchanges information between the supercomputer (client) on which a simulation is executed and an external workstation (server). The SIMON-client requests the server to perform data transfer and analysis, visualization, etc., during the simulation (Fig. 1: Trigger). According to the requests, the SIMON-server starts operation (Fig. 1:

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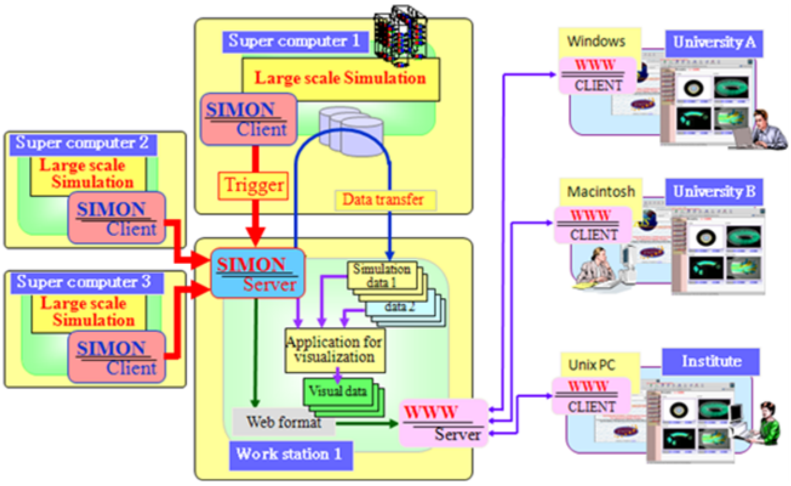

Fig. 1 Schematic view of flowchart of various operations and functions in SIMON system.

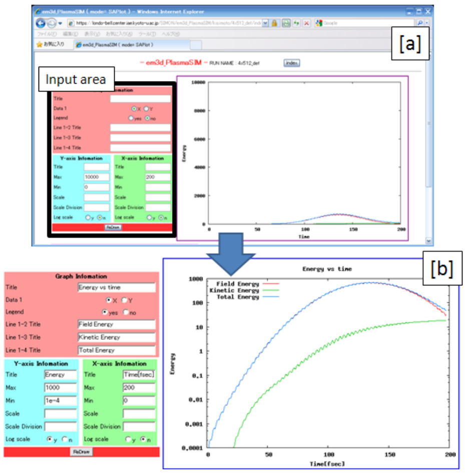

Fig. 2 Example of "Web analysis" in Hierarchical visualization method.

Data transfer) and sends the latest results to a website where collaborators can monitor the simulation result at any place in the world. This approach is different from that of post processing where data analysis is performed after the end of the simulation. This is also different from real time monitoring where graphic routines are directly inserted in the program and the results are simultaneously obtained during the simulation [4–6]. We refer to this concept as *update processing*. This latter is based on the idea that it is more important to know the latest results at appropriate time intervals depending on the time scale of simulation, namely, not necessary to be true "real time". For this purpose, we developed the *trigger method* [1]. In this method the time to send the request to the server is negligibly small, so that the simulation is not interfered by this procedure.

3. Security between Client and Server

As a method for trigger between SIMON-client and server, there is the method to use the SOCKET of TCP/IP. However, the usage of the related port depends on the security policy of each institution. In order to be free from such situation, we utilize SSH.

Since the client sends the request to the server through the internet, a method to automatically and dynamically connect between the client and server is necessary. In this case, ongoing a secure connection is of special importance. Here, we explored a method that establishes the login-shell of SSH automatically utilizing Expect command. In addition, we introduced a method that encrypts the password for the connection by combining the RSA code, random number, and substitution cipher. Using tests, we confirmed that there is no security hole in this method and system ensure with high reliability.

4. Hierarchical Visualization

Here, we categorize the analysis of simulation into three levels depending on the user's needs: *basic analysis*, *web analysis*, and *detail analysis*, and develop the SIMON system accordingly. We refer to this approach as *hierarchical visualization*.

As we discussed in Sec. 2, once the SIMON-server receives the trigger request for visualization from the SIMON-client, the server automatically performs the related tasks and show the results on the website. Note that the information of the visualization, e.g. the title of graphs, physical quantities in horizontal and vertical axes, max. / min. values, etc., has to be set in the request beforehand. For the axes, automatic scaling is generally used assuming that the result is not predicted before the simulation start. This level corresponds to the *basic analysis* in which collaborators can monitor the latest results equally through the website and grasp the status of the simulation.

On the other hand, in order for collaborators to flexibly analyze the data according to their interests, we introduced an interactive capability in the visualization software, which allows ones to directly handle (change) the

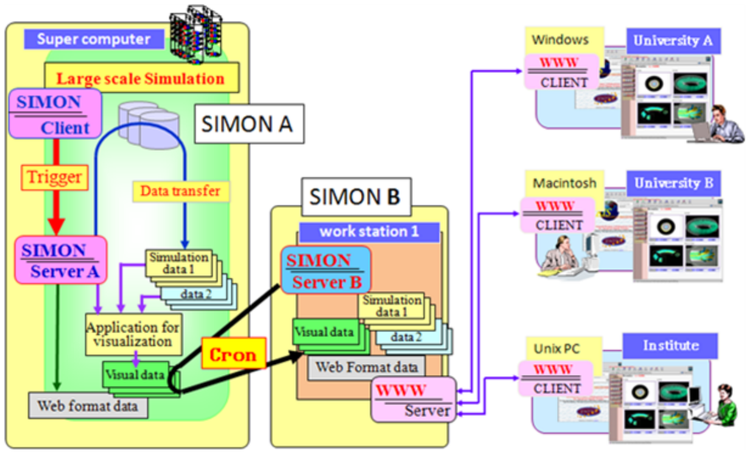

Fig. 3 Schematic view of flowchart in SIMON system (Case where trigger to outside or Web ability is not accepted).

graphs on the website. An example is shown in Figure 2. In this case, since the values on the vertical axis are not properly set (Fig. 2 [a]), one can change these values interactively through the web browser as shown (Fig. 2 [b]). This level corresponds to the *web analysis*.

Thus, the SIMON system serves these capabilities for the visualization. For more details analysis, a direct handle to raw data is necessary, which corresponds to the *detail analysis*. For that we can also utilize the SIMON system effectively for the transferring large data as discussed in Ref. [1].

5. Example Using SIMON System

We applied the SIMON system to a specific project for studying laser-matter interaction using the relativistic particle code EPIC3D, which includes atomic process [7–9]. We utilize the PS (Plasma Simulator) at NIFS (National Institute for Fusion Science) as SIMON-client and a Linux PC at Kyoto University, which are located in geographically different places, i.e. Toki and Uji in Japan, respectively.

However, as discussed in Sec. 3, the permission of automatic data transfer using the trigger in the SIMON system depends on the security policy the institution. To show the generality of the SIMON system, we assume a case where neither the trigger to the outside server nor the website capability are permitted to connect to the client. To apply the SIMON system to such a case, we introduced an alternative method as shown in Figure 3.

In this method, the SIMON system is applied as usual but only inside the LAN (local area network) in one institution. Namely, the SIMON-client and server are set at the same machine or different one, but inside the same LAN so that the automatic data transfer by the trigger between SIMON-client and server is permitted. We refer to this system inside the LAN as SIMON-A (Fig. 3). Additionally, we introduce another server, SIMON-B, besides SIMON-A. The SIMON-B accesses the SIMON-A at regular intervals. If the data provided by the SIMON-A is updated, the SIMON-B acquires mirroring. In this method, it is necessary to set an adequate interval for SIMON-B to check whether a data update is available by from SIMON-A.

According to the above procedure, we performed an EPIC3D simulation on the PS, linked with the SIMON system above to study the ionization dynamics of a solid carbon film irradiated by a high power laser (wavelength: 820 nm, pulse width: 40 fsec, peak intensity: 5.1×10^{19} W/cm^2) [10]. The system size $(x, y) = (5, 656)$ nm with the mesh number of (4,512) and 100 particles per cell are used. Simulation is followed by 100 fsec, which takes about 4 hours using 32 CPUs of the PS.

Figure 4 shows the website page on which the latest results of the simulation are shown. The time history such as energy and density of electrons and ions with different charge state q, as well as electromagnetic energy are illustrated. Two dimensional graphs of electromagnetic energy and density distribution at each snapshot are also illustrated. These snapshots are updated every 30 minute, whereas the time histories every 5 minutes. The capability of hierarchical visualizations, specifically website analysis is incorporated.

The present mirroring method, where two SIMON systems are incorporated to offset the restriction for network connection is found to work well without causing any serious problem in the case where the trigger is permitted to connect the outside server.

6. Conclusion / Summary

In order to perform the study of large scale simulation efficiently, we have proposed a remote collaboration system, the SIMON system, by which many collaborators working at geographically different places can participate in the project. The collaborators can monitor the latest information the ongoing simulation via internet. The system is designed based on a client-server model using a trigger method, which is a key ingredient of the present system.

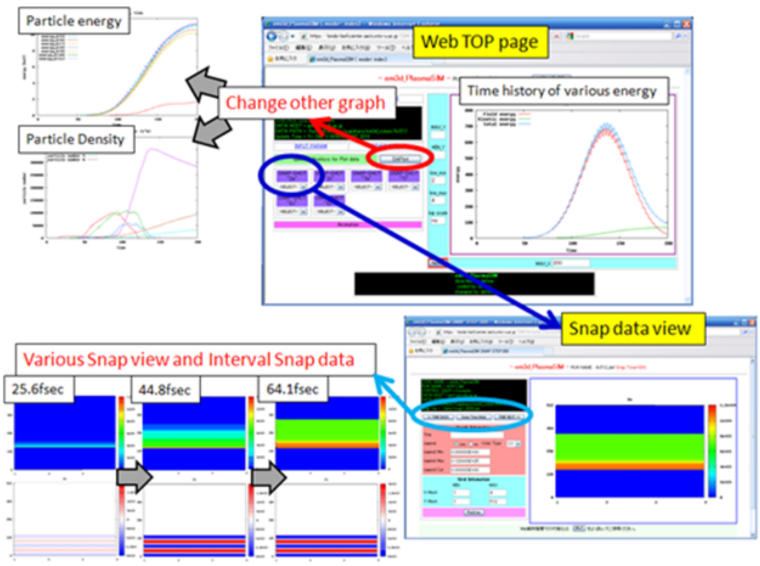

Fig. 4 Various information of simulation about of laser matter interaction on a web page using the SIMON system.

In this method, a simulation running on the supercomputer actively controls the timing of update processing by transferring the various requests to an external server, which performs the tasks parallel to the simulation.

In this paper, we improved the SIMON system from two viewpoints: network security and the visualization environment. Method that constructs the login-cell of SSH automatically and that encrypts the password for the connection between client and server by using plural encodes drastically increased the security level. Based the idea of hierarchical visualization, analysis, we introduced an interactive capability of visualization on a web browser, so that a wide range of collaborators can perform data analysis and visualization, efficiently and flexible depending on individual needs.

These implementations were done without using specialized hardware or software. Therefore, the SIMON system can be installed readily on standard computer environment. As a next step, we will develop a system by cooperating not only with simulation but also with experiment which widen the framework of scientific research.

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