10-3 Assembly Structure Analysis of Extra Large-Scale Nuclear Plants

—Grid-Based Extra Large-Scale Structural Analysis by a Part Oriented Approach—

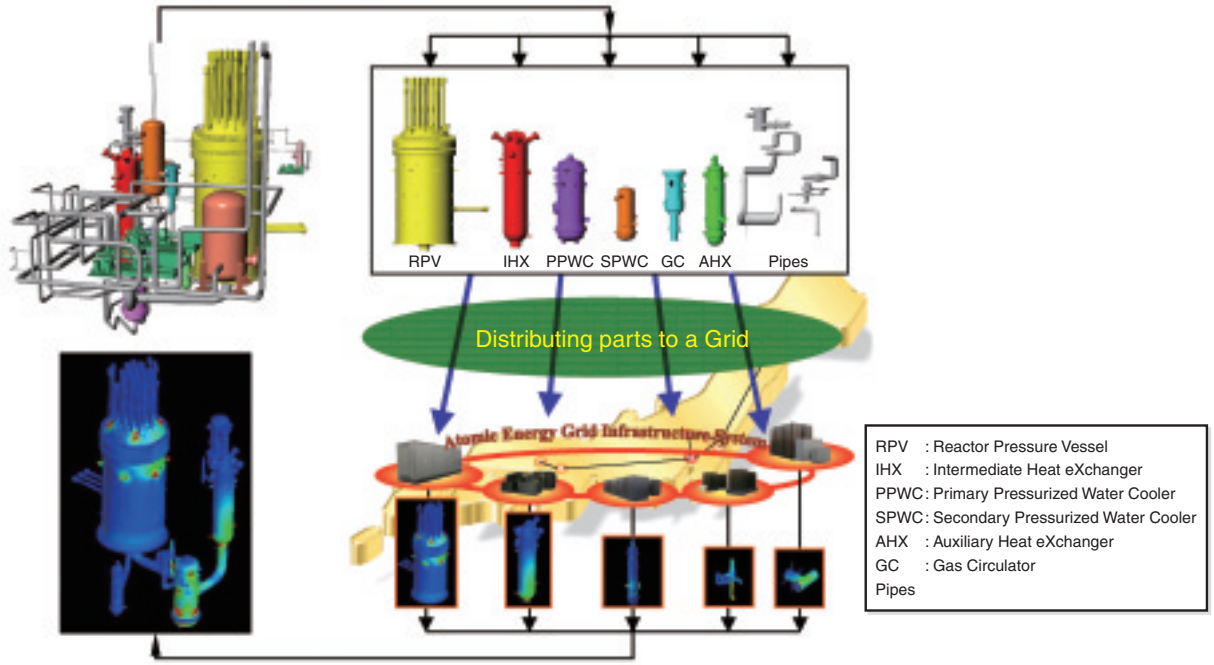

Fig.10-4 Summary of the proposed simulation framework
A framework for analyzing a whole nuclear plant consisting of over 10 million parts has been developed by preparing model data for each part, then distributing them to numerous supercomputers inter-connected by Grid, and finally simulate an entire by considering the connecting condition among the parts. Numerous supercomputers on the Grid are powerful enough to meet the demands on memory and disk capacities in visualization of gigantic analytics data. By distributing all the simulation processes such as the model data preparation, analysis execution, and the data visualization among multiple supercomputers located inside and outside of JAEA opens up the possibility of structural analysis of a whole extra large-scale nuclear plant.

The Center for Computational Science and E-systems of JAEA is conducting researches and developments for extra large-scale simulation technologies of whole nuclear plants using state-of-the-art computational and IT technologies. Specifically we focused on establishing a virtual plant vibration simulator on inter-connected supercomputers, for seismic response analysis of a whole nuclear plant. In order to achieve high accuracy simulation, we need to consider how connecting conditions affect the integrated behaviors (stresses and deformation etc.) of the parts of a plant. A nuclear plant is generally composed of a gigantic number of parts. The simulation of the whole plant becomes a very difficult task because an extremely large dataset must be processed which is too expensive to be carried out on a single supercomputer by the conventional simulation technique. To overcome this difficulty, we have established:

(1) a framework which allows model data preparation to be carried out in a part-wise manner, so that there is high scalability as the model size increases, and allows the connecting condition of the parts to be taken into consideration in the integrated simulation of the whole plant.

(2) a computing platform which enables extra large-scale whole nuclear plant simulation to be carried out on a Grid computing platform called Atomic Energy Grid InfraStructure(AEGIS) which is built by high-speed interconnection of dispersed heterogeneous supercomputers.

The simulation framework developed has been applied to an elasto-static analysis of the reactor pressure vessel and cooling systems of a nuclear research facility, the “High Temperature engineering Test Reactor (HTTR)” located at the Oarai R&D center of JAEA.

The simulation framework taking advantage of Grid distributed computing techniques showed early success in the extra large-scale simulation of the major parts of the nuclear plant, and opens a possibility of new simulation technologies for building a whole virtual nuclear plant in computers for virtual experiments. In SC05 held at Seattle, USA, one of the world largest international conferences on high performance computational technologies and sciences, our HPC Analytics Challenge contest entry giving these simulation results gained attention and was awarded “honorable mention” recognition.

Reference

Nishida, A., Wave Propagation Properties of Framed Structures based on the Timoshenko Beam Theory, Kozo Kogaku Ronbunshu, vol.52B, 2006, p.119-124 (in Japanese).