PetaFlow Project: A project towards an ultraparallel synergy Internet system for scientific applications

Cybermedia Center
Osaka University

Strategic Japanese-French Cooperative Program

Overview:

It is a reality that "contemporary society and science is faced with the challenge of dealing with increasing amounts of data." Today, continuous developments occur in measurement technologies and computational resources in various fields of science and society. They have facilitated the collection as well as generation of petascale data. High-performance computational (HPC) resources need to be made remotely accessible through long-distance, high-performance networking for the efficient generation or processing of petascale data. The PetaFlow project enables the representation of these data as an interactive scientific visualization. Consequently, the emergence of adequate "information and communication technologies (ICTs)" has been beneficial for the generation and processing of petascale data with respect to high-performance computing-networking visualization and their mutual "awareness."

We organize our project into three functions; PetaFlow Application, PetaFlow Visualization, and PetaFlow Network and Middleware as follows.

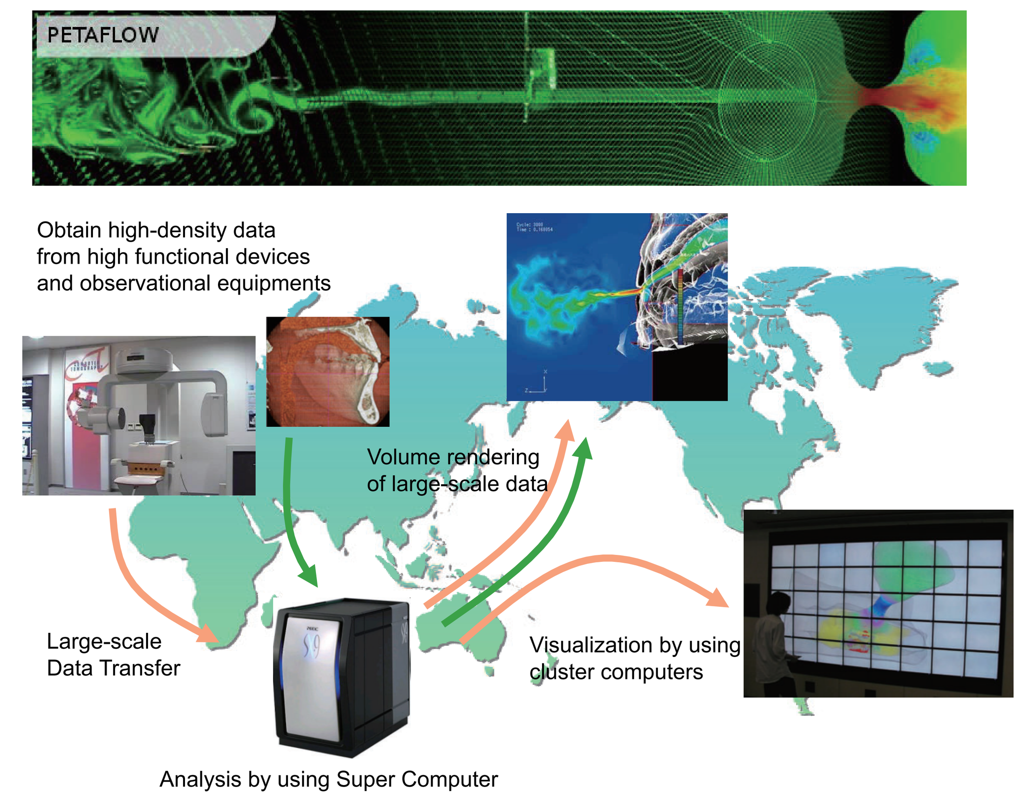

Figure 1: Overview of PetaFlow scheme.

PetaFlow Application:

Interactive super computing helps oral practitioners (dentists) to demonstrate a predictive orthodontic surgery or fabrication of dentures that enable patients to know the change of pronunciation before his operation, such as tooth movements. To do this, appropriate HPC packaging is necessary, so as to avoid strange movements due to the losing frames, because the package includes heavy simulations, CFD etc. Smooth and useful computational oral therapies required the profluent information flow by using the advancing internet technologies (see Fig. 2).

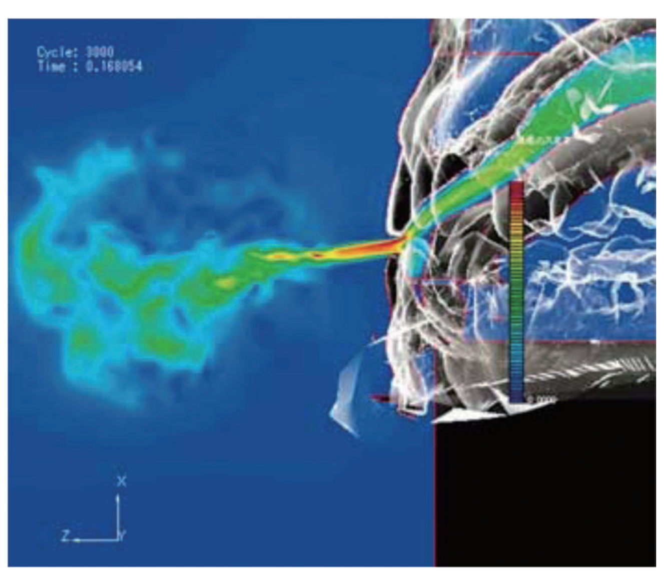

Figure 2: Application example.

PetaFlow Visualization:

We utilize the FlowVR library to visualize computing results in world-wide large-scale visualization. The FlowVR library provides users with the necessary tools to develop and run high performance interactive applications on PC clusters and Grids. The main target applications include virtual reality and scientific visualization. FlowVR enforces a modular programming that leverages software engineering issues, while enabling high performance executions on distribued and parallel architectures. The FlowVR software suite has today three main components; FlowVR, FlowVR Render, and VTK FlowVR (see Fig. 3).

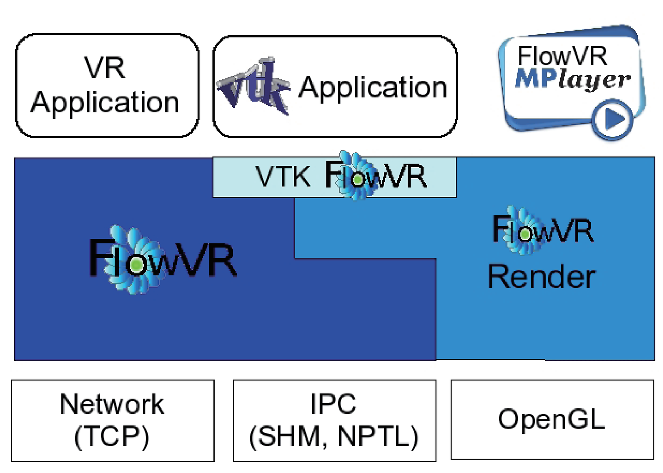

Figure 3: Architecture of FlowVR.

We also utilize Particle-based volume rendering (PBVR). PBVR is one of the effective rendering techniques applicable to huge volumes of data. It is based on Sabella' s density emitter model, in which the scalar field is characterized as a cloud of opaque and self-emitting particles with single-level scattering. PBVR, being different from the ray-casting method, does not require sorting of elements, and thus, it facilitates handling of huge amounts of data, which could be of the magnitude of several gigabyte. We show an example in Fig. 4, where oral flow sound simulation results in higher-level complexities of 3D phenomena and huge volume datasets on Tiled Display Wall in Fig. 4.

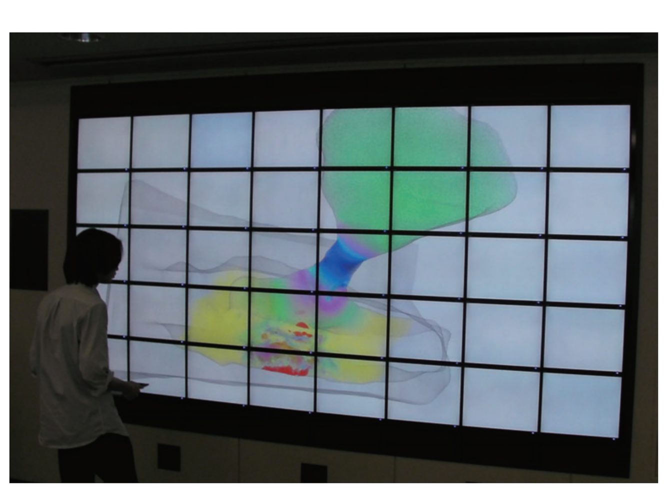

Figure 4: Particle-based volume rendering (PBVR) on tiled display wall (TDW).

PetaFlow Network and Middleware:

The PetaFlow network testbed is a layer-2 virtual private network (VPN). It has been developed from the NAREGI-Grid5000 network testbed (2006–2009) and constructed through a collaboration among SINET, JGN-X, RENATER, GEANT, and MAN LAN. Figure 5 shows the topology of the PetaFlow network testbed. On the Japanese side, the network is composed of SINET and JGN-X networks, which are connected at Tokyo. The NII and Kyoto University connect with SINET, and Osaka University connects with JGN-X. The international network operated by SINET is used to connect the Japanese research foothold with Grid5000, and this network extends to MAN LAN (New York, USA) via GEANT (Europe). The Grid5000 backbone network is provided by RENATER.

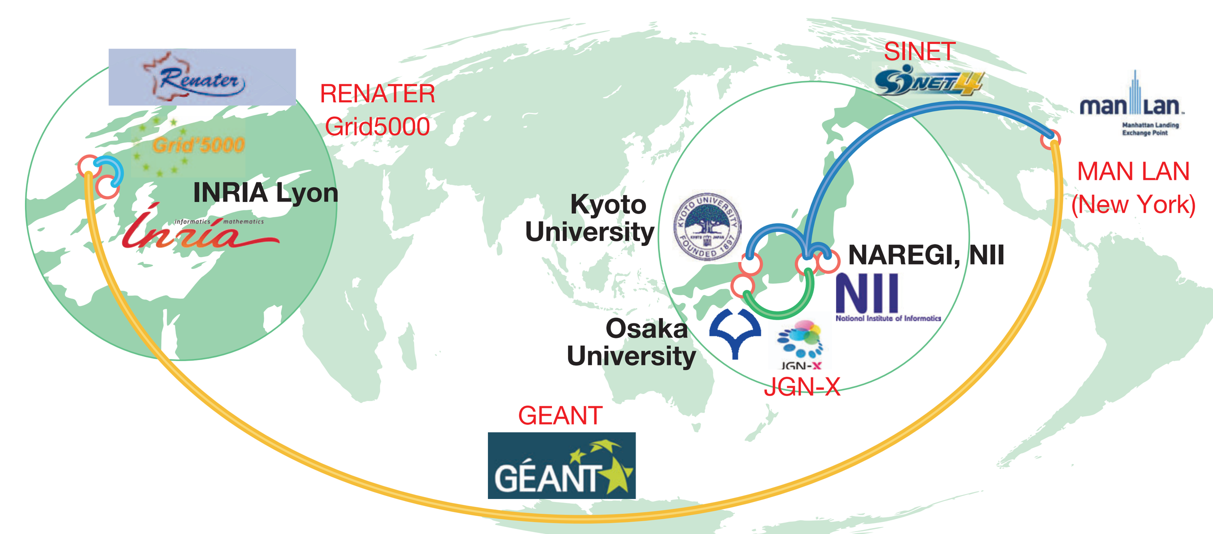

Figure 5: Network topology in PetaFlow testbed.

RESO (ENS Lyon, INRIA Grenoble) is focused on metrology equipment synchronization. We develop a synchronized distributed packet capture system which is a software-hardware based solution yielding a good compromise between accuracy and affordability [Collaboration with SyncLab from the University of Melbourne, Australia]. The metrology equipment that will be connected at INRIA Grenoble and Osaka University, consist of two servers that each have Endace DAG7.5G2 network monitoring card installed over one 10 Gbps interconnection Grid5000 (France) and NAREGI (Japan) and one 1Gbps cluster at Osaka University. Endace DAG card provides a synchronized sub-10 nanosecond timestamp capability over 2Gbps capture and inspection. For synchronization and accuracy of network traffic, we are using two Trimble Acutime Gold GPS smart antenna mounted at both locations. Acutime Gold GPS system is set with L1 frequency, C/A code (SPS), continuous tracking receiver, static overdetermined clock mode, Update Rate of 1Hz, Event Update maximum of 5 Hz/second and External Event Capture of 455 nanoseconds.

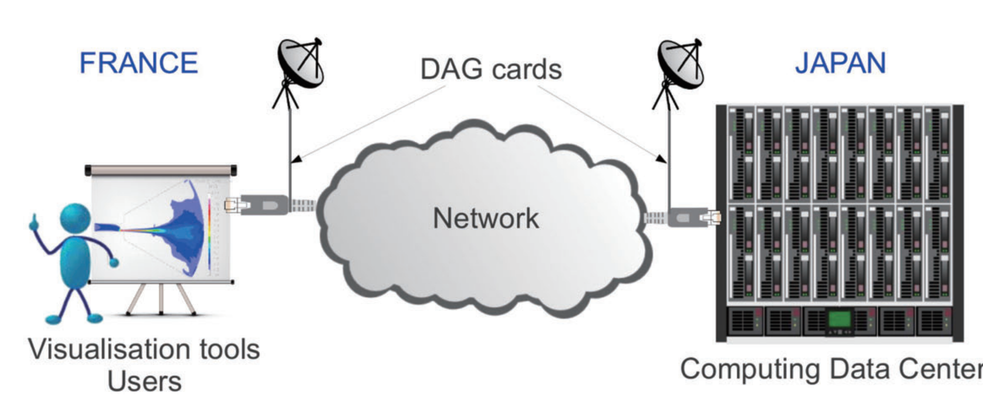

Figure 6: Network monitoring system by packet capture.

Osaka University also develops a traffic control method in long distance high-speed networks. We focus on fairness among high-speed transport protocols. So we control traffic at the router or switch in the network based on windowsizes of high-speed transport protocols by traffic monitoring.

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Member of PetaFlow Project

Shinji Shimojo: Leader and Network (Osaka University, JAPAN)
Ken-ichi Baba: Network (Osaka University, JAPAN)
Yuya Hasegawa: Network (Osaka University, JAPAN)
Kohji Koyamada: Visualization (Kyoto University, JAPAN)
Allan Lorant: Visualization (Kyoto University, JAPAN)
Takamichi Nishijima: Network (Osaka University, JAPAN)
Kazunori Nozaki: Application (Osaka University, JAPAN)
Hiroyuki Ohsaki: Network (Osaka University, JAPAN)
Naohisa Sakamoto: Visualization (Kyoto University, JAPAN)
Eisaku Sakane: Network (NII, JAPAN)

Annemie van Hirtum: Leader and Application (Gipsa-lab, CNRS, FRANCE)
Alexandre Ancel: Visualization (INRIA, Grenoble University, FRANCE)
Yo Fujiso: Application (Gipsa-lab, CNRS, FRANCE)
Paulo Goncalves: Network (ENS Lyon, INRIA, FRANCE)
Matthieu Imbert: Network (ENS Lyon, INRIA, FRANCE)
Pierre Neyron: Visualization (CNRS, Grenoble University, FRANCE)
Anne-Cecile Orgerie: Network (Irisa, CNRS, FRANCE)
Xavier Pelorson: Application (Gipsa-lab, CNRS, FRANCE)
Bruno Raffin: Visualization (INRIA, Grenoble University, FRANCE)

Contact: PetaFlow Project **E-mail: petaflow@ispl.jp**