Osaka University

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PetaFlow Project

A project towards an ultraparallel synergy Internet system for scientific applications

Ken-ichi Baba

Cybermedia Center, Osaka University

baba@cmc.osaka-u.ac.jp

November 13, 2012

NII National Institute of Informatics

NICT

KYOTO UNIVERSITY FOUNDED 1897 KYOTO JAPAN

cnrs

informatics mathematics

ENS DE LYON

Outline of PetaFlow Project

- JST in Japan and ANR in France
  Strategic Japanese-French Cooperative Program on "Information and Communications Technology Including Computer Sciences"
- Theme:
  Peta-scale computing with transnational high-speed networking: application to upper airway flow
- Duration: Five years from 2009 to 2013
- Leader:
  Prof. Shinji Shimojo (Japan)
  and Dr. Annemie Van Hirtum (France)

Project Member and Role

- **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)

Background: Reaching Peta-Scale Data

The amount of information handled and the speed of information processing/transmission are reaching **peta-scale**.

- In large-scale numerical computations and large-scale simulations, **the number of objects** and **the amount of data** generated are reaching peta-scale.
- Similarly, the maximum communication speed of a single optical fiber reaches several tens of tera-bit/s, and **the bandwidth-delay product** of a wide-area optical network exceeds several peta-bits.

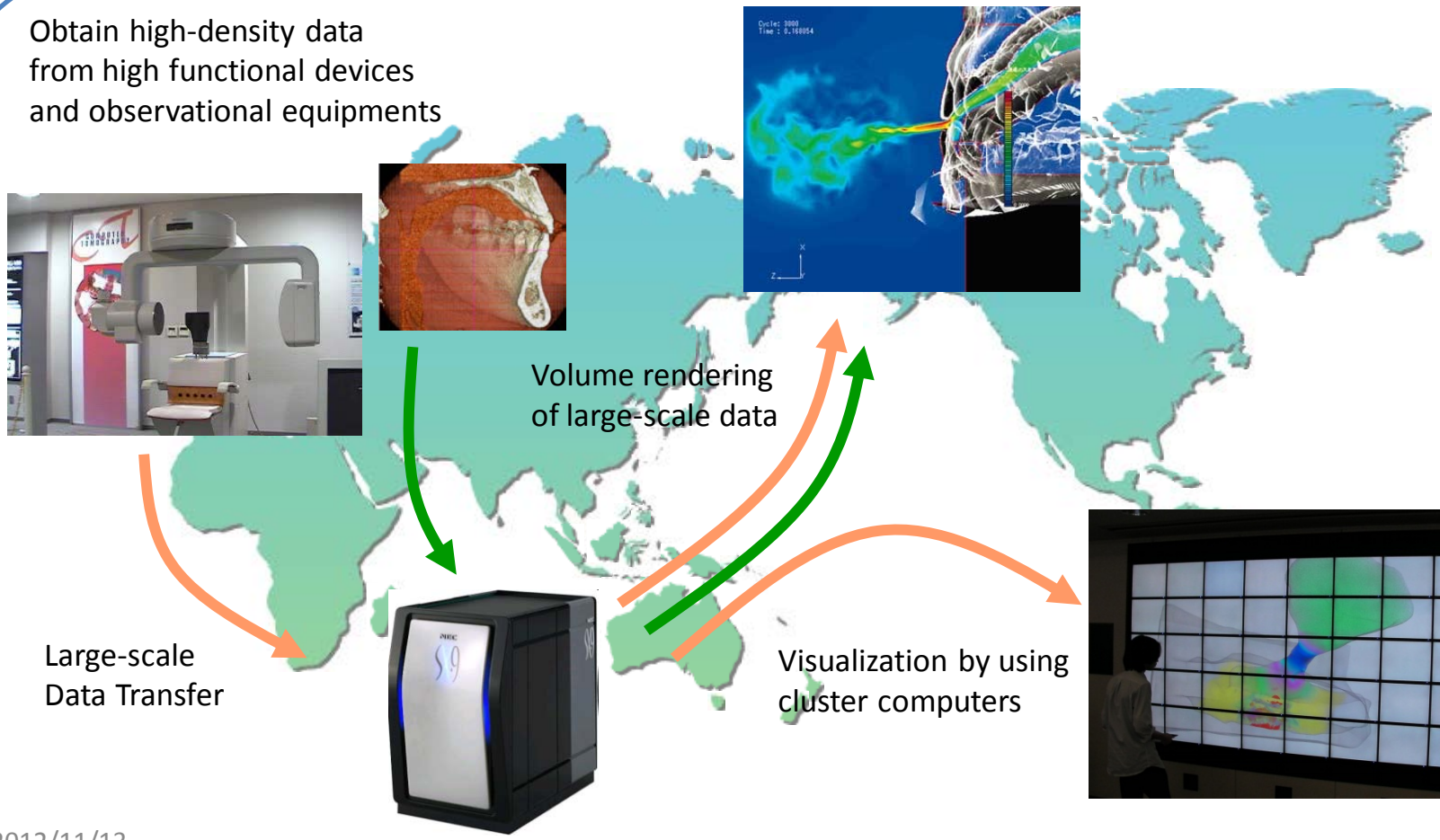
Background: Toward Synergetic Integration

To realize peta-scale computing, networking, and visualizing technologies, individual research and development in each technological field should not suffice.

- Instead, a new ICT paradigm **peta-flow computing**, which enables peta-scale information processing and communication by **synergetic integration of three technological fields**, is desired.

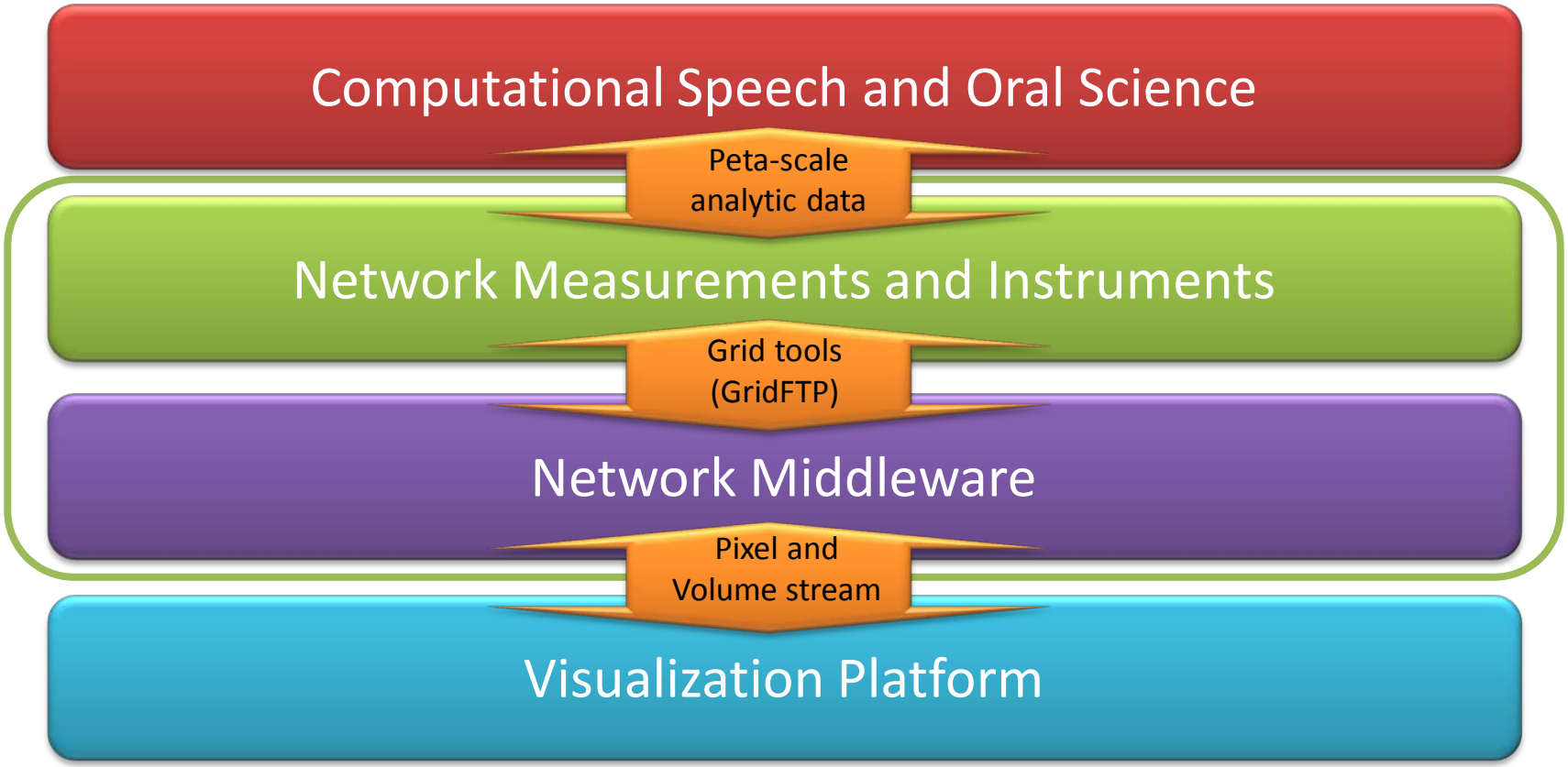
Our Goal Image

- A project towards an ultraparallel synergy Internet system for scientific applications



Our aims

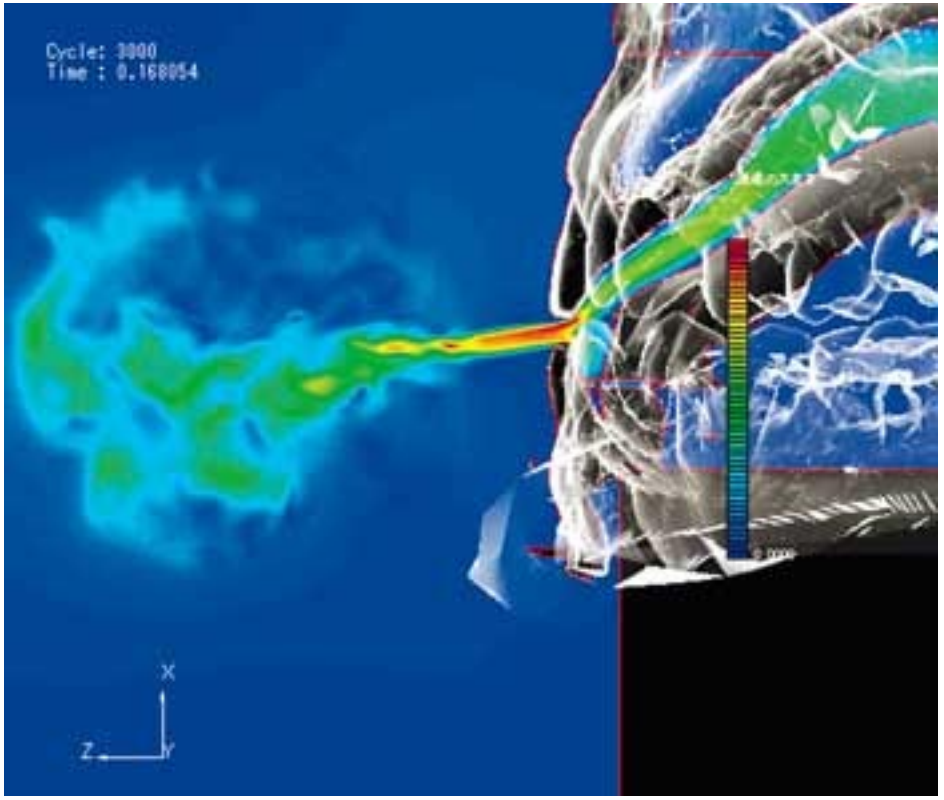
- A project towards an ultraparallel synergy Internet system for scientific applications



PetaFlow Application

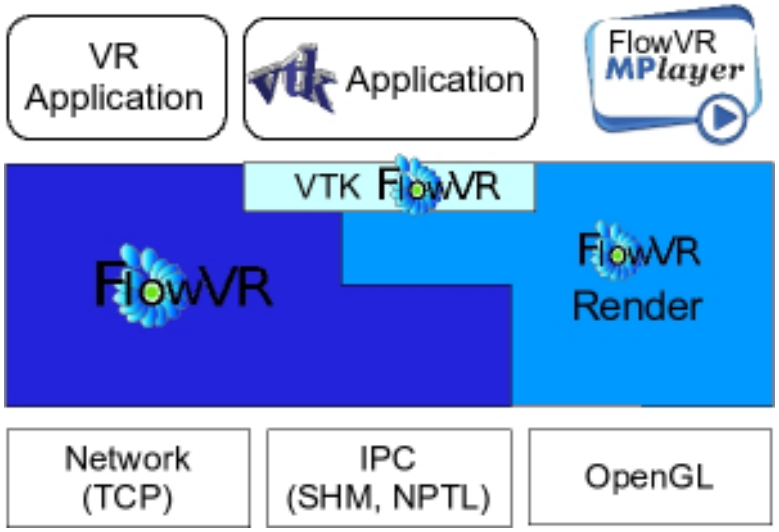
Interactive super computing helps oral practitioners (dentists) to demonstrate a predictive orthodontic surgery or fabrication of dentures that enable patients to know the change of pronunciation before his operation, such as tooth movements.

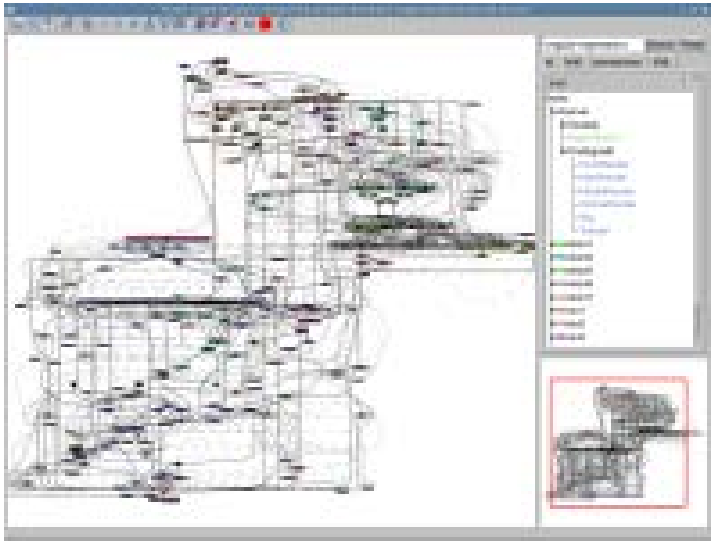
To do this, appropriate HPC packaging is necessarily so as to avoid strange movements due to losing frames, because the package includes heavy simulations, CFD etc. Smooth and useful computational oral therapies required the profluent information flow by using the advancing internet technologies



PetaFlow Visualization (1/3)

- FlowVR
  - Software environment to allow the user to develop and run high performance interactive application on distributed computing environment

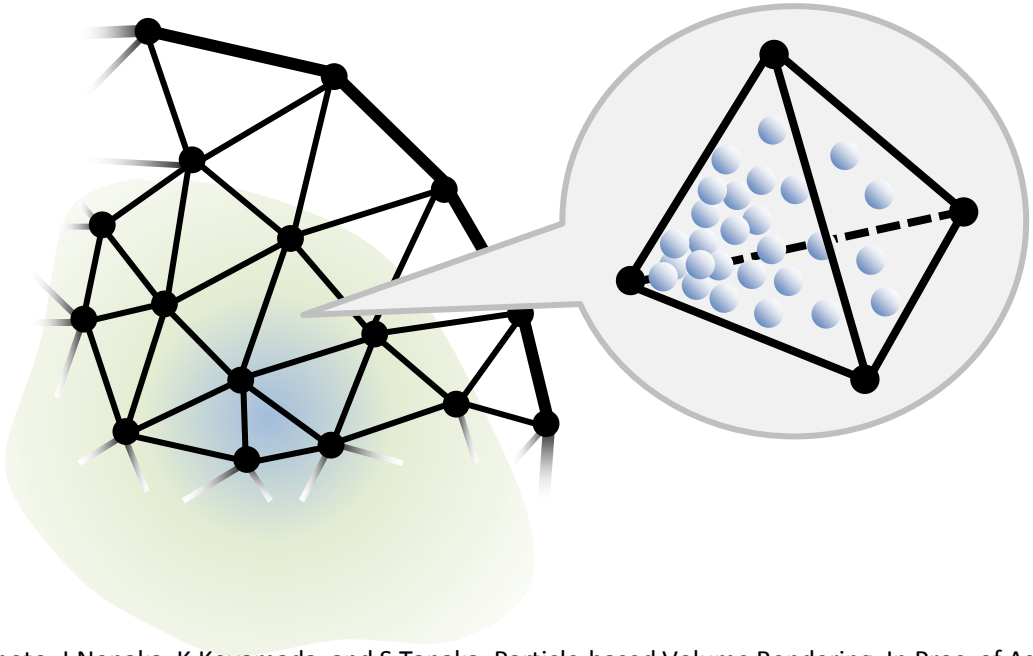




J.Allard, V.Gouranton, L.Lecointre, S.Limet, E.Melin, B.Raffin and S.Robert, “FlowVR: a Middleware for Large Scale Virtual Reality Applications”, Euro-Par'04, 2004

PetaFlow Visualization (2/3)

- Particle-based Volume Rendering
  - Suitable for large and complex volume datasets
  - Volume data is represented as particles
  - Visibility sorting is not required



$$\rho = \frac{-\log(1-\alpha)}{\pi r^2 \Delta t}$$

Opacity

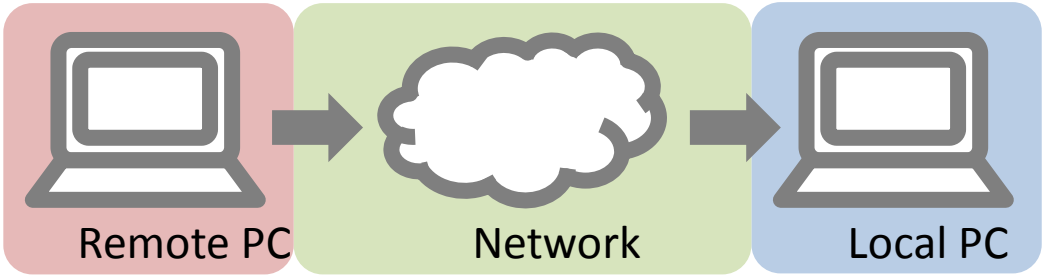
Particle density

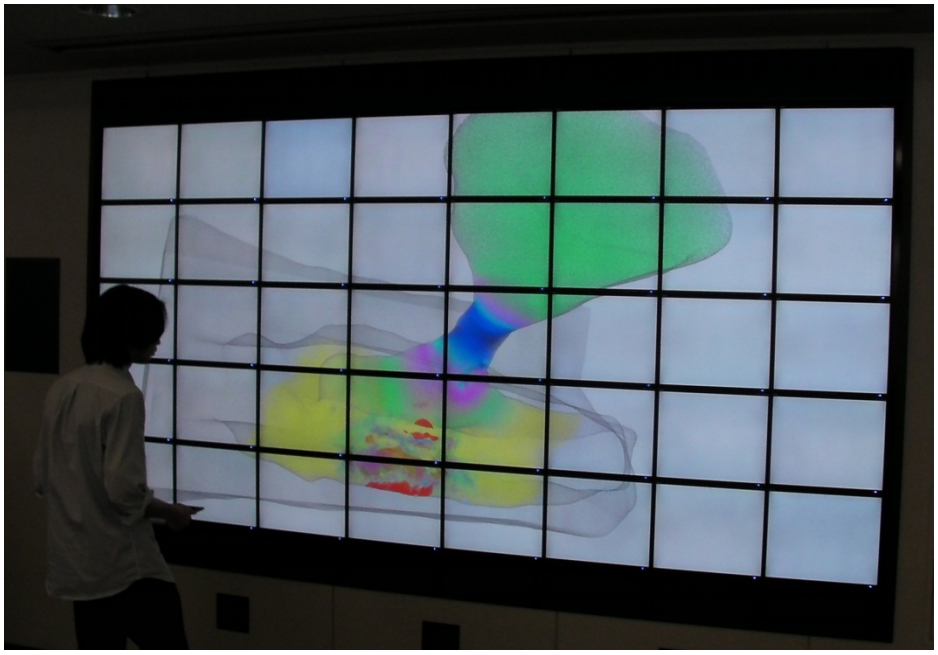
(Num. of particles within a unit volume)

N.Sakamoto, J.Nonaka, K.Koyamada, and S.Tanaka, Particle-based Volume Rendering, In Proc. of Asia- Pacific Symposium on Visualization 2007, pp.141-144, 2007

PetaFlow Visualization (3/3)

- Remote visualization system
  - Large-scale visualization with **Particle-based Volume Rendering** technique
  - PC cluster / Grid application development with **FlowVR**



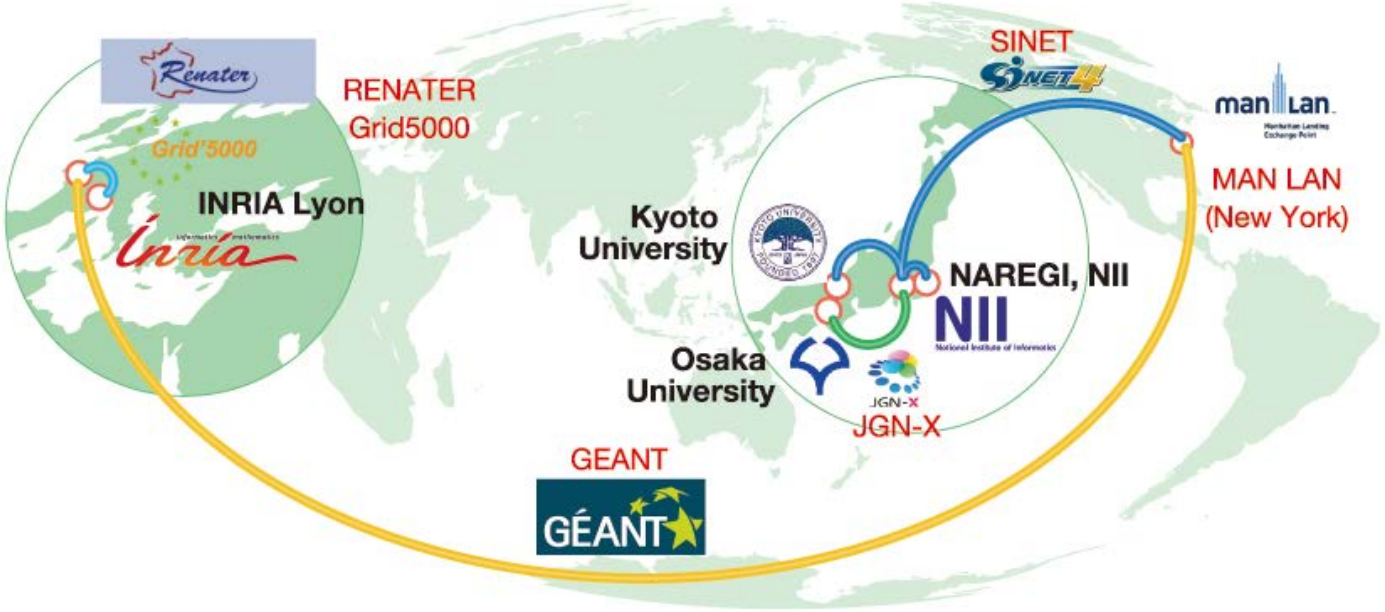


PetaFlow Networking (1/6)

- Network design and construction on Testbed network
- Network measurement and monitoring
- Traffic control in long-distance broadband network

PetaFlow Networking (2/6)

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 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.



PetaFlow Networking (3/6)

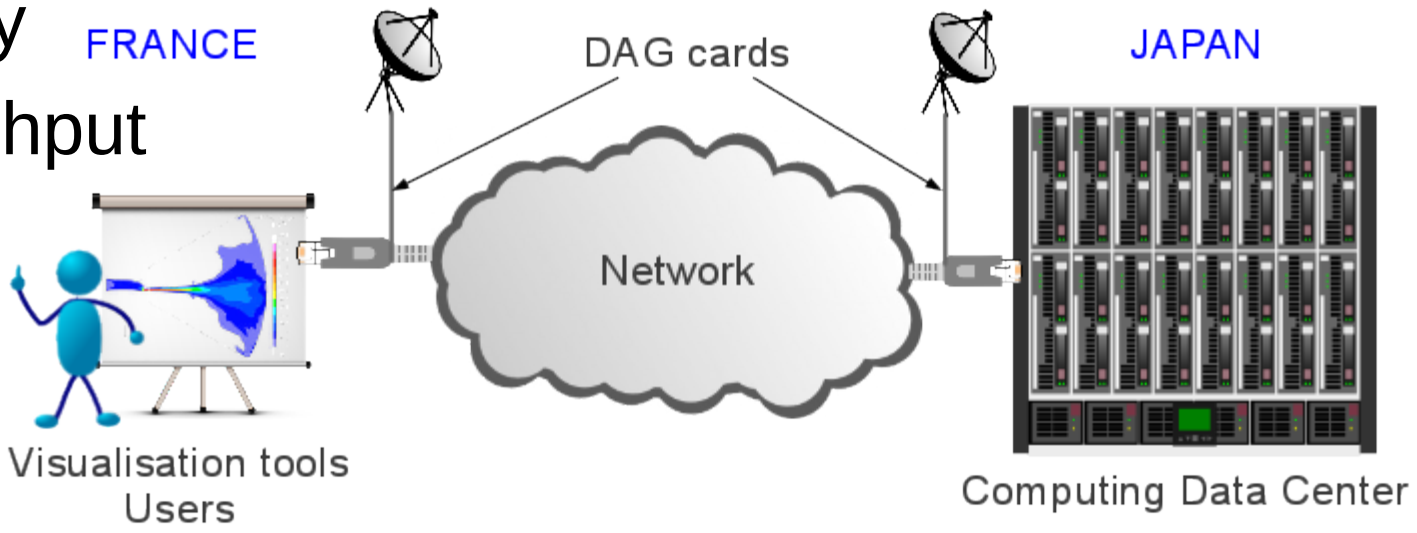
RESO team within PetaFlow

Aim: to guarantee the reliability of the communications and data file transfers

→ Bandwidth provisioning tools to ensure Quality of Service for real-time applications

→ Metrology platform to control the quality of the link and in particular end-to-end:

- latency
- throughput
- jitter



PetaFlow Networking (4/6)

Collaboration with the University of Melbourne

Design a packet capture facility which provides:

- accurate timestamps
- easy deployment
- low cost

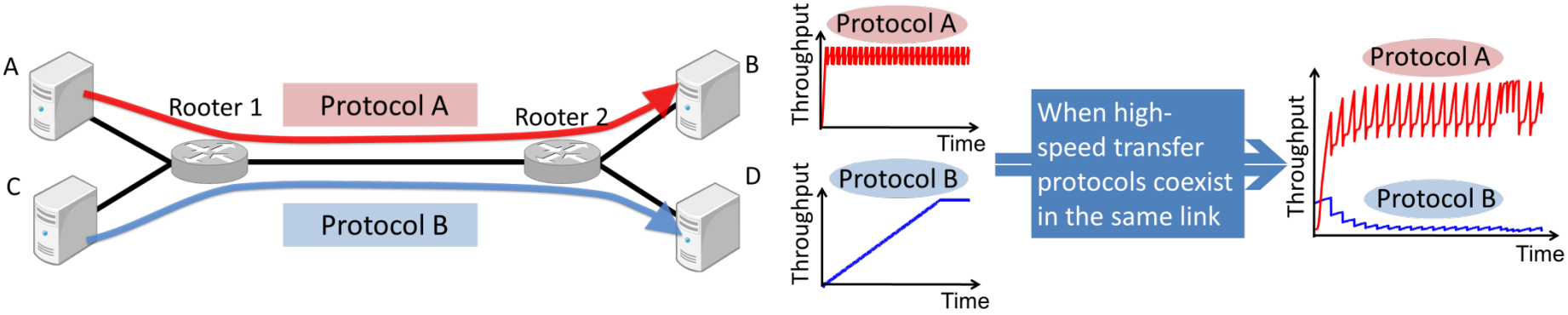
in comparison with current solutions (DAG+GPS, NIC+NTP, …)

Evaluation of this solution on the PetaFlow test-bed to compare its performance against the DAG cards in a transcontinental context

PetaFlow Networking (5/6)

A Bandwidth Control Method with Fairness

- High-speed transport protocol
  - In long-distance broadband network
- Contention problem:
  - Flows with High-speed transport protocol share same link
  - Sum of throughput for each flow sometimes decreases
  - A particular flow occupies bandwidth and another flow decreases bandwidth



PetaFlow Networking (6/6)

A Bandwidth Control Method with Fairness

- We control at the switch in network
- Proposed control method
  1. Estimation of the window size
  2. Determination of dropped packets
- We can achieve the high value of fairness index of our proposed method

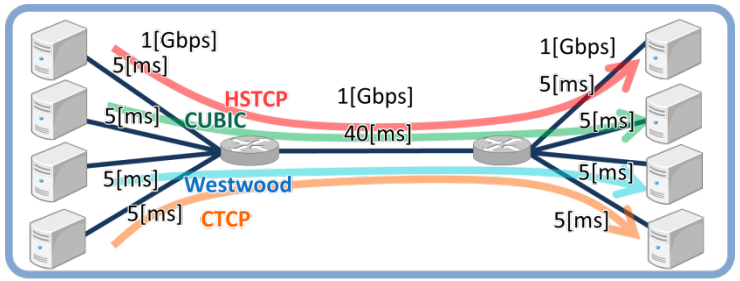
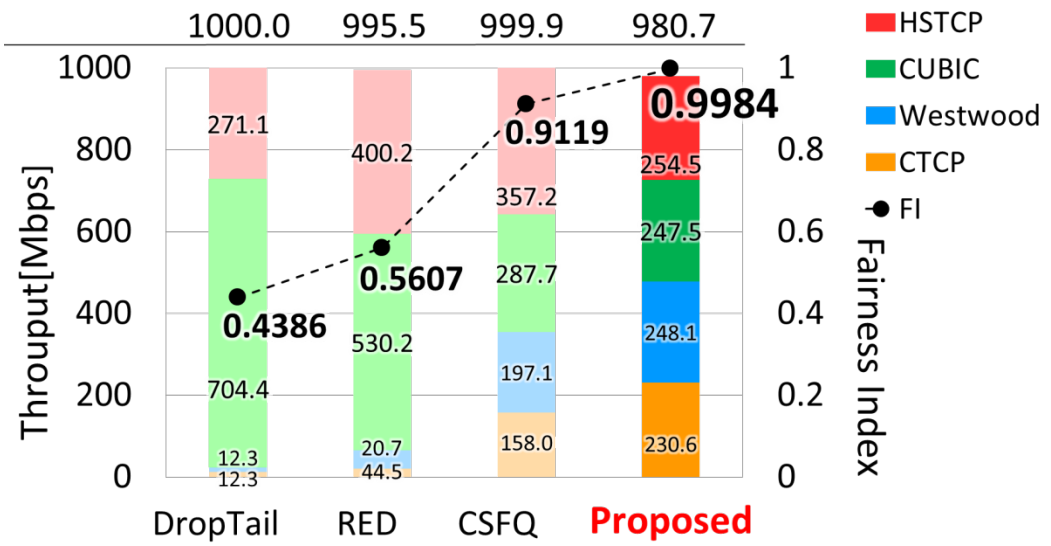


Figure 1 Simulation environment



Conclusion and Future Work

- We need to provide world-wide computing environment
- We need collaborative work among application, visualization and networking for such PetaScale computing.
- We researched and developed technologies on each layer: application, visualization and networking

- Establishment of fundamental technologies for peta-flow computing such as
  - Networking-aware computing
  - Visualizing-aware computing
  - Networking-aware visualizing
- Combine these technologies, then ultimately creation of a new communication paradigm

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Our Presentation at SC12

- Osaka University
  - Booth #1837
  - PetaFlow Project and Research on Network
- Kyoto University
  - Booth #3830
  - Visualization by PBVR
- NICT
  - Booth #4018
  - Testbed Network Activity
- INRIA
  - Booth #1209

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Thank you very much for your kind attention.

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