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SC10 Booth No.2051

Handheld User Interface for GPU-Accelerated Large-scale Volume Visualization

Cybermedia Center, Osaka University, Japan

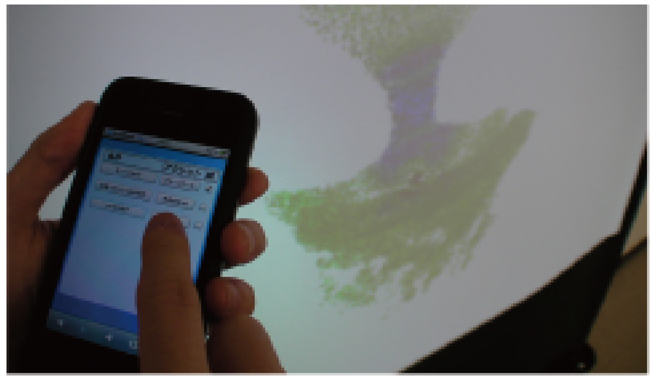

Figure 1 : Prototype System

Introduction

The ever-increasing sizes of the volumetric data sets acquired by a variety of scientific studies represent a formidable challenge for subsequent real-time large-scale volume visualization and analysis. While steady advances in graphics hardware have enabled faster rendering, real-time rendering of large-scale volume data still remains a tough problem. Unlike polygonal data, visualization of volume data requires assignment of transparency to internal voxels, which necessitates time-consuming voxel sorting with conventional volume rendering algorithms.

Such large-scale volume visualization must also take into account interactive transfer function control for data mining and scientific discovery. A high-resolution, large screen is often used for displaying large-scale volume data, and so conventional input devices such as a mouse and a keyboard are not practical.

This poster presents ongoing work on an interactive large-scale volume visualization system incorporating a handheld device for interactive control and a GPU-accelerated particle-based algorithm for volume rendering (see Figure 1).

Particle-based Volume Rendering

Our visualization system employs a particle-based volume rendering algorithm developed at Kyoto University. The algorithm generates a set of tiny opaque particles from a given 3D scalar field. The final image is then generated by projecting these particles onto an image plane. Semi-transparency is realized by sub-pixel processing and averaging, thus doing away with the need for voxel sorting. This algorithm is further accelerated by GPU programming.

Interactive Transfer Function Control

For assisting data mining and scientific discovery, a handheld device is provided to control the transfer function in detail in real-time. Our visualization system consists of a server that renders volume data and the client handheld device (i.e., an iPad), which are connected to each other via WiFi or Bluetooth (see Figure 2). The hardware specifications for our system is summarized in Table 1.

The GPU-based rendering algorithm was carefully modified to accept user input for controlling a variety of visualization parameters with negligible performance degradation.

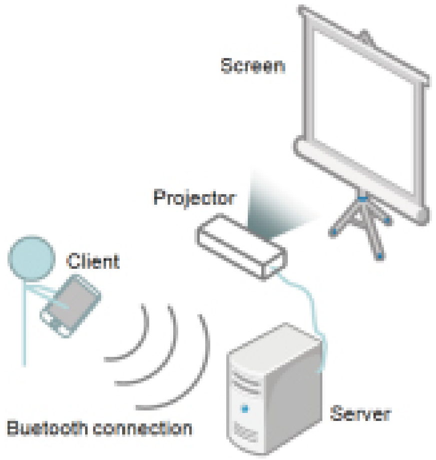

Figure 2 : System configuration

Table 1 : Specification

Server	Client
CPU : AMD Opteron 2350 2.0GHz RAM : 32GB GPU : NVIDIA Quadro FX 4800 OS : Ubuntu 8.10 (64bit)	Multi-touch Display : 9.7 in Resolution : 768 x 1024

A set of graphical user interfaces (GUI) are under development (see Figure 3) for the handheld device. A user will be able to control the visualization parameters interactively. Example interactions implemented are as follows:

- Color curve editing. Mapping between a scalar value of voxel data and its rendered color can be changed simply by deforming the color curves.
- Particle filtering. Particles with specified values can be hidden or highlighted.

Any change in visualization parameters will be immediately reflecced in the rendering result.

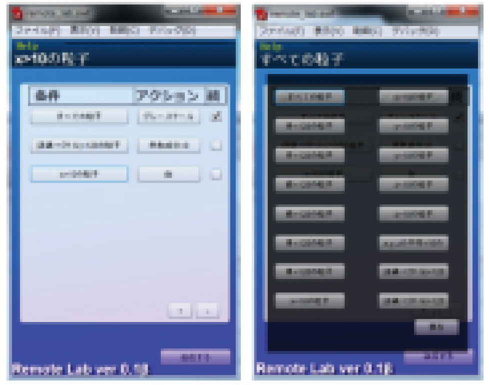

Figure 3 : User Interface

Conclusion

An interactive visualization system for large-scale volume data is proposed. Large-scale volume visualization can be realized with GPU-accelerated particle-based volume rendering. Interactive transfer function control can be realized with a dedicated graphical user interface on a handheld device.

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Handheld User Interface for GPU-Accelerated Large-scale Volume Visualization

GPU-based Pedestrian Crowd Simulation and its Application to an Evacuation Scenario in a Large-scale Underground Shopping Mall

Cybermedia Center, Osaka University, Japan

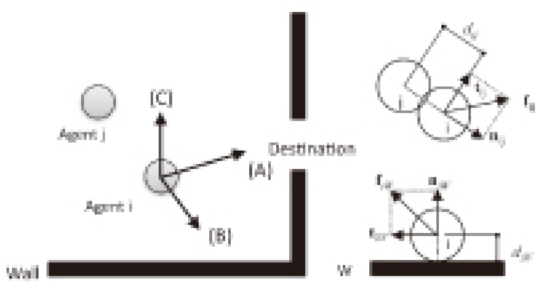
Introduction

Pedestrian crowd simulations are designed and used for verifying the evacuation safety of buildings and urban environments. Agent-based simulations are particularly suitable for pedestrian crowd behavior derived from a set of simple individual rules. However, computing and visualizing crowd behavior in real time is a computationally intensive task largely because most algorithms for calculating the interactions among all the agents have $O(n^2)$ complexity. In relevant previous works, this complexity was reduced by using special data structures such as grids. In addition, researchers have demonstrated significantly increased computational speed after adapting existing CPU-oriented algorithms to parallel processing architectures. Furthermore, modern graphics processing units (GPUs) have many cores, and offer the performance benefits of parallel processing at low cost. In 2007, NVIDIA released the CUDA parallel-processing architecture for their next-generation GPUs, which allows programmers to use a version of C to code algorithms for execution on the GPU. Hence, it is now easier to design agent-based simulations that can be executed on GPUs.

In this study, we present an agent-based pedestrian crowd simulation implementation for a GPU and apply it to an evacuation scenario for a large-scale underground shopping mall.

Implememtation

We used the social force model for pedestrian crowd behavior. In this model, an agent is represented by a moving disc (Figure 1) that has mass and a constant radius and is subjected to forces exerted by other agents, obstacles, and the destination. All operations were executed on a GPU using CUDA (Figure 2). The computational power available when parallel processing on GPUs with many cores is huge; this computational power is sufficient for updating the behavior of massive pedestrian crowds in real time.



$$m_i \frac{dv_i}{dt} = m_i \frac{v_i^0(t)e_i^0(t) - v_i(t)}{\tau_i} + \sum_{j(\neq i)} f_{ij} + \sum_W f_{iW}$$

$$f_{ij} = \{A_i \exp[(r_{ij} - d_{ij})/B_i] + kg(r_{ij} - d_{ij})\} n_{ij} + \kappa g(r_{ij} - d_{ij}) \Delta v_{ji}^t t_{ij}$$

$$f_{iW} = \{A_i \exp[(r_i - d_{iW})/B_i] + kg(r_i - d_{iW})\} n_{iW} - \kappa g(r_i - d_{iW})(v_i \cdot t_{iW}) t_{iW}$$

Figure 1. Social Force Model

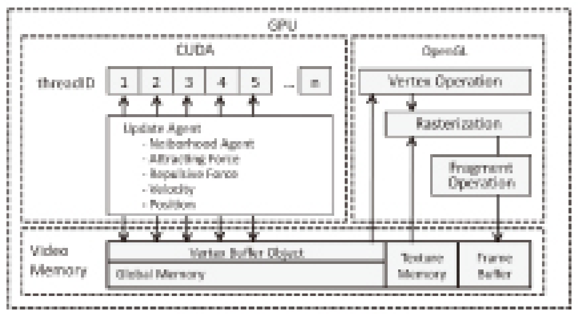


Figure 2. Operations on GPU

Case study and performance

As a case study of pedestrian crowd simulation, we configured an evacuation scenario in a large-scale underground shopping mall in Osaka, Japan (in Figure 3). For performance testing, we evaluated two versions of the simulation. The first was executed on a GPU, and the second was executed on a CPU. In both cases the same algorithm and data structures were used; these tests were performed on an Intel Core i7 930 2.80 GHz CPU and an NVIDIA GeForce GTX 460 GPU. Figure 4 shows the average time required to compute the social force of all agents in the absence of the rendering process. The tests were executed for each implementation type by varying only the number of agents, which ranged between 1000 and 10,000. It was found that the GPU version had better scalability than the CPU version. For example, at 10,000 agents, the GPU version was approximately seven times faster than the CPU version. Moreover, it could be clearly observed that the performance of the GPU version was sufficient to sustain interactive frame rates for rendering complex models of agents and buildings.

Figure 3. Application to Large-scale Underground Shopping Mall

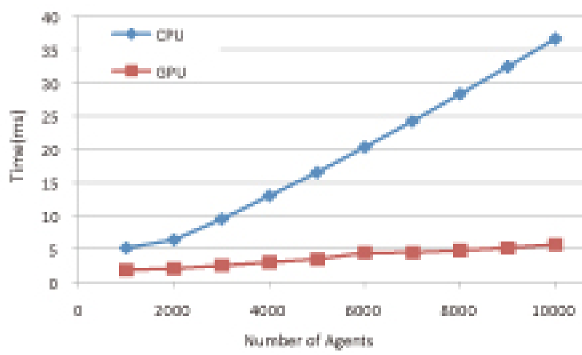


Figure 4. Performance Result of CPU and GPU

Conclusion

In this study, we developed an agent-based pedestrian crowd simulation implementation for a GPU and applied it to an evacuation scenario in a large-scale underground shopping mall. We demonstrated that the GPU-based implementation was capable of supporting up to 10,000 agents at an interactive frame rate using current graphics hardware and CUDA technology.

GPU-based Pedestrian Crowd Simulation and its Application to an Evacuation Scenario in a Large-scale Underground Shopping Mall

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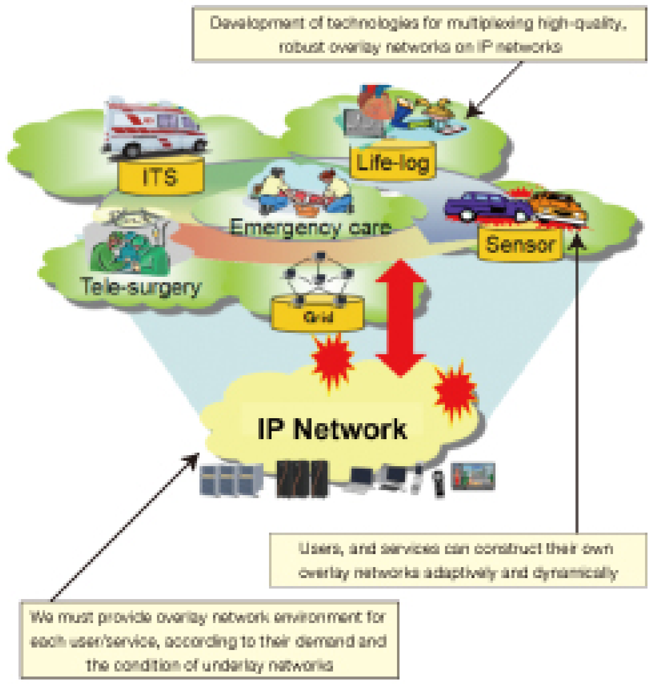
Management of Overlay Network Performance: End-to-end Network Measurement Strategy and Quick Failure Recovery

Cybermedia Center, Osaka University, Japan

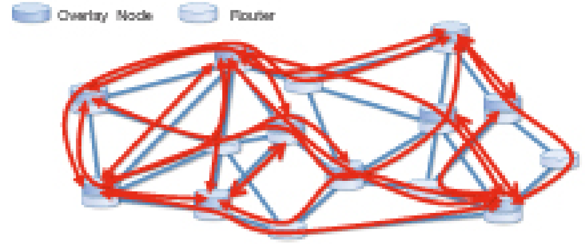
Joint works of Osaka University and NEC Corporation, Japan, supported in part by the National Institute of Information and Communications Technology (NICT) of Japan

Overlay Networks

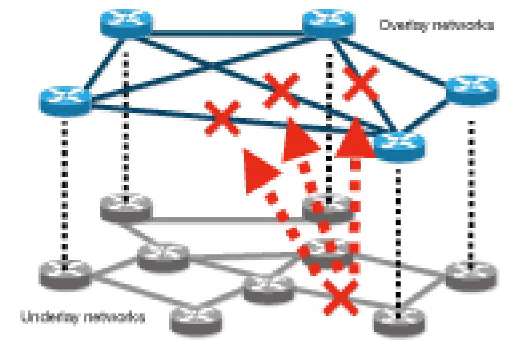


Management of overlay networks

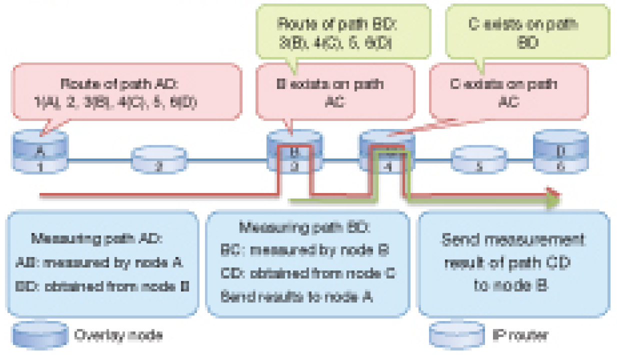
Network measurements: Simple full-mesh measurement has the $O(N^2)$ overhead. So, we need simple, lightweight, and scalable measurement method.



Failure recovery: Since overlay networks share underlay network equipments, a single network failure would bring multiple, simultaneous failures in overlay networks. So, we need failure recovery method from simultaneous failures in overlay networks.



Measurement strategies for overlay networks



-Each overlay node conduct traceroute commands to other overlay nodes

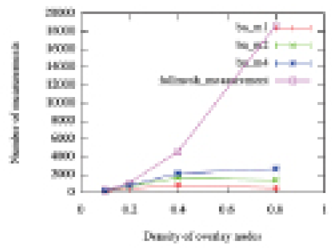
-Intermediate overlay nodes capture them and record src/dst nodes' IP addresses

-All overlay nodes understand path overlapping status

-Measurement of longer path will be omitted and measurement result is estimated from results of shorter paths

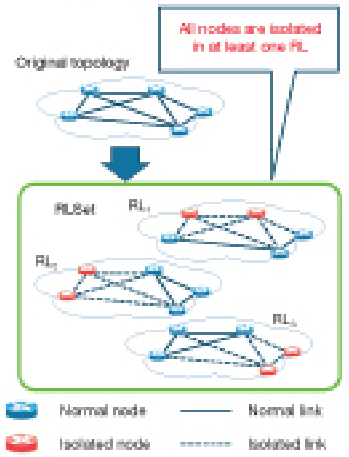
-- Delay: D=d1+d2, bandwidth: B=min(b1, b2)

-- Packet loss ratio: P=1-(1-p1)(1-p2)



We can decrease the number of required measurement paths to 1/30 – 1/50, regardless of the underlay network topologies and the number of overlay nodes.

Proactive recovery method for overlay networks

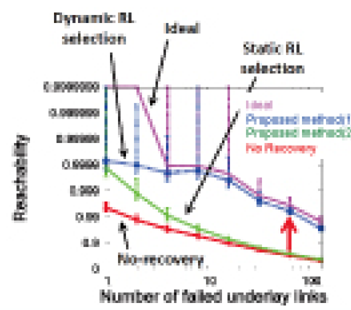


-We construct multiple topologies for failure recovery from the original topology

-Each topology has isolated nodes. When a node failure occurs, we utilize the topology which isolates the failed nodes

-Multiple simultaneous node failures can be recovered, when such nodes isolated in one topology

We can improve reachability of the overlay network from 69% to 93%, when 5% links in the underlay network fail simultaneously.



Management of Overlay Network Performance: End-to-end Network Measurement Strategy and Quick Failure Recovery

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A Virtual Cluster over Multiple Physical Clusters Using P2P Overlay Network

Cybermedia Center, Osaka University, Japan

Introduction

Recently, virtual cluster technology, which allows scientists to build their private computational environments that can be customized as they like, has attracted attention. However, although it is becoming relatively easy to build a virtual cluster on a single physical cluster, building and managing a virtual cluster spanned over multiple physical clusters on multiple sites is hard despite that it is expected to be useful for parameter-study research observed in various computational scientific fields.

A reason can be explained from the fact that each physical node composing the virtual cluster can be, in general, isolated by the Firewall or NAT deployed based on organizational administrative policies. Also, it causes the situation that virtual machines deployed on different physical nodes cannot be connected directly with each other.

From the point of view above, we are working on a solution that allows scientists to build a virtual cluster spanned over multiple physical clusters easily, by seamlessly integrating virtual machine technology and overlay network technology. In this poster, we will report our work-in-progress activities related to this research.

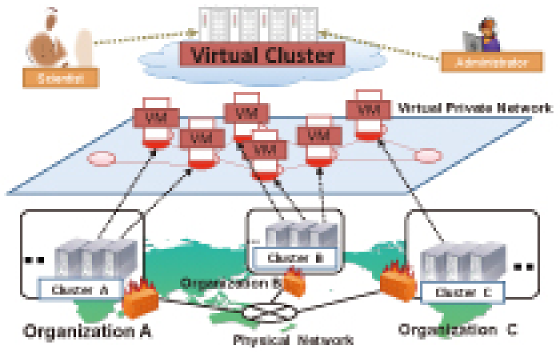

Figure 1 : Concept of our virtual cluster

Features of Our Virtual Cluster Solution

Dynamic network connection among virtual machines composing a virtual cluster :

In our solution, each virtual machine composing our virtual cluster automatically establishes an overlay network for dedicated and secure use of it, irrespective of the underlying physical network structure. For the functionality of overlay network, N2N, which provides an encrypted L2 virtual network solution, is utilized. Leveraging N2N, we are now developing a mechanism that automatically establishes an overlay network among virtual machines.

Seamless integration with Rocks cluster toolkit :

Rocks cluster toolkit is a toolkit that facilitates researchers to build a cluster system composed of multiple computational resources. Furthermore researchers are able to easily build a virtual cluster system on a Rocks-based physical cluster system with it. For our virtual cluster solution, we are developing the functionality of building a virtual cluster on multiple physical cluster systems for the Rocks toolkit, by integrating the mechanism that automatically establishes an overlay network with it.

Development of Our Virtual Cluster

Our virtual cluster is deployed on multiple Rocks-based physical clusters which are ready to accommodate virtual machines composing a virtual cluster. An overlay network is established by N2N among virtual machines composing the virtual cluster. To realize our virtual cluster, we are developing four modules that allow researchers to build a virtual cluster over multiple physical clusters.

Bridge module:

This module establishes a bridge network between a network device of a virtual machine and an N2N virtual network device on a vm-container. A connection between virtual machines and one N2N overlay network is established as a result.

Resource Management module:

Rocks utilizes a Database (DB) for managing computational resources composing a Rocks cluster but there is no data schema for computational resources at remote site. This module provides the Rocks with the management of remote nodes and manages virtual machines composing virtual clusters spanned over multiple physical clusters.

Overlay Network Setup module:

This module sets up an N2N overlay network for our virtual clusters. This launches N2N virtual network devices on each virtual machine composing a virtual cluster, communicating and this instructs Bridge modules to establish an overlay network among vm-containers. Finally, virtual machines running on the vm-containers can be on the same overlay network.

Virtual Machine (VM) Management module:

Virtual machines at remote physical cluster cannot be deployed with the original Rocks functionality. This module enhances Rocks with the functionality of deploying virtual machines at remote sites, communicating with other VM Management module at remote sites.

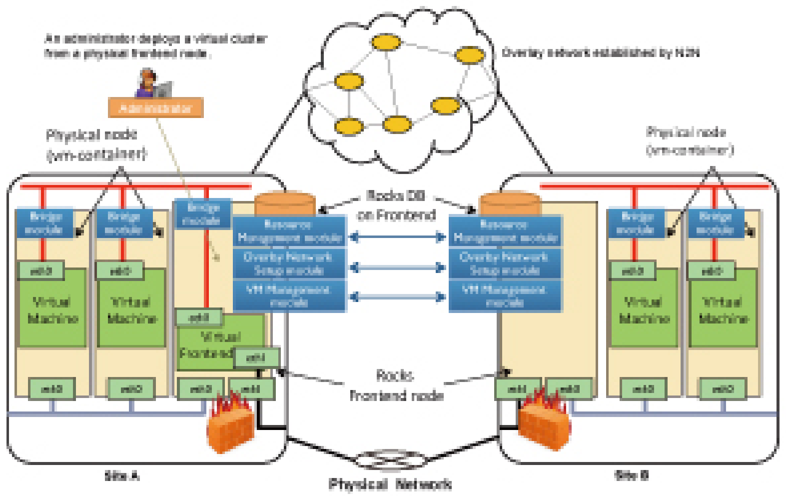

Figure 2 : Detail design of our proposed virtual cluster

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A Virtual Cluster over Multiple Physical Clusters Using P2P Overlay Network

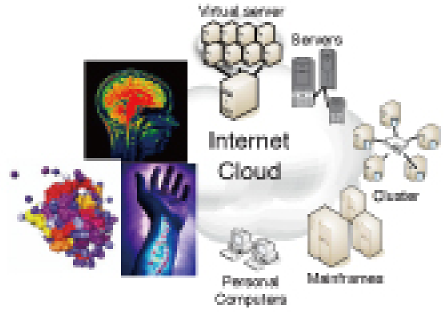
Improving the Accuracy of Throughput Prediction over the Internet

Cybermedia Center, Osaka University, Japan

Motivation

Applications in the grid environment must share large distributed blocks of data across multiple sites.
Network throughput affects total processing time as well as the task processing.

The predicted network throughput would be a useful parameter in scheduling tasks to improve the total processing performance.

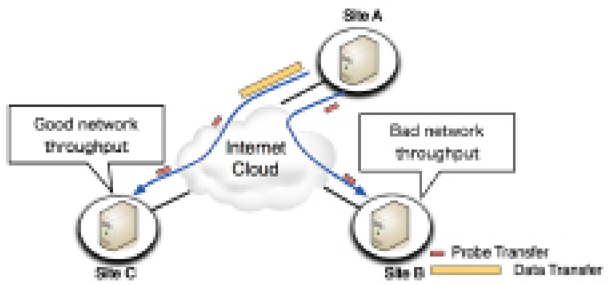


Purpose of our research

Improving precision of the throughput prediction method called "Network Weather Service" [1].
Adapting the prediction method to virtualized hosting environment, which shows anomalous behavior more frequently than physical nodes.

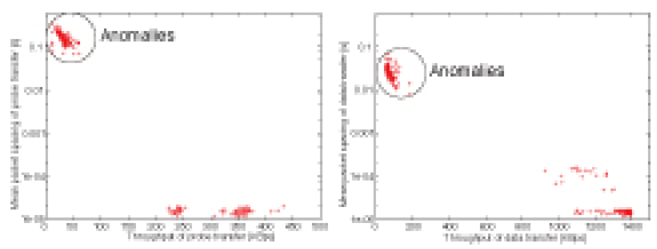
Connection pair

Network throughput prediction is challenging because of the dynamics of network traffic and the lack of guaranteed bandwidth.
Connection pair uses a probe transfer to predict the throughput of a large data transfer.
In previous work [1], the restricted sets of pairs of probe and data size were examined in a limited network environment.



Traffic anomalies

The evaluation results were affected by oversize packet spacings, which are caused by CPU scheduling latency.
Packet spacings larger than the TCP transmission period result in severe throughput anomalies[2].



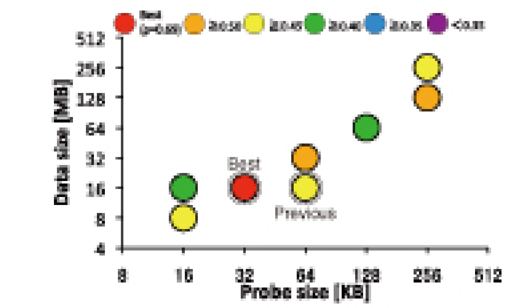
< Mean packet spacing and throughput under the best conditions>

Experiments

We used PlanetLab nodes, equipped with a virtualization mechanism called V-Server (http://www.linux-vserver.org).
Various sizes of both probe and data were used.
Correlation between both probes is evaluated by Spearman' s rank correlation coefficient, a non-parametric metrics.

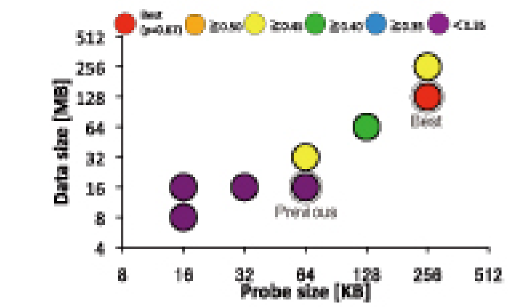
Original result

Smaller probes had better conditions than larger probes.



Results without anomalous cases

We re-evaluated the results without the anomalies, and found that larger probes are required for improved predictability.
If throughput is decreased by the anomalies, we should carefully review measurement results.



Conclusion and future work

Anomalies from virtualized hosting environment have a great impact on the prediction results.
We re-evaluated the results without the anomalies, and found that larger probes are required for improved predictability.
Future work includes measurement of throughput with various probe sizes and development of an anomaly estimation method.

References

[1] M. Swany and R. Wolski, Multivariate Resource Performance Forecasting in the Network Weather Service, in Proceedings of IEEE/ACM Conference on *High-Performance Computing and Networking*, pp 1-10, November 2002.
[2] C. Lee, H. Abe, T. Hirotsu, and kyoji Umemura, "Analysis of anomalies on a virtualized network testbed," in *Proceedings of the 10th IEEE International Conference on Computer and Information Technology*, pp. 297–304, June 2010.

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Improving the Accuracy of Throughput Prediction over the Internet

PetaFlow Project: A Project towards an Ultraparallel Synergy Internet System for Scientific Applications

Strategic Japanese-French Cooperative Program

Background

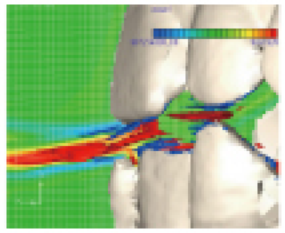

Figure 1. Oral flow sound simulation for pronunciation of "/s/."

It is a reality that "contemporary society and science is faced with the challenge of dealing with increasing amounts of data." Today, continuous developments occurring in measurement technologies and computational resources in various fields of science and society 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."

The aim is to develop and validate such ICT solutions with the help of a transnational high-speed research network between Japan and France that connects "Grid5000" (France) to the "NAREGI" (Japan) testbed. It is intended to validate data transfer protocols on the data obtained for a real scientific problem involving petascale data. For reasons of medical relevance as well as basic scientific interest, petascale data are obtained from HPC computational fluid dynamics (CFD) simulations on a vector supercomputer (NEC SX9, Japan) with the intention of predicting the airflow through the upper airways. In addition, results of the CFD simulation are used as an input for aero-acoustic computations (CAA) to predict noise production. Besides the international transfer of the generated petascale data, scientific visualization of petascale data is intended on a single PC as well as on a tiled display wall (TDW) for 3D interactive reconstruction of the flow and noise data. In summary, the PetaFlow project aims to contribute to state-of-the art HPC, networking, scientific visualization, and their mutual interactions for petascale data. At the same time, it contributes to basic research in the fields of CFD and CAA, applied to flow through the upper airways.

PetaFlow Network

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, JGN2plus, RENATER, GEANT, and MAN LAN. Figure 2 shows the topology of the PetaFlow network testbed. On the Japanese side, the network is composed of SINET and JGN2plus networks, which are connected at Tokyo. The NII and Kyoto University connect with SINET, and Osaka University connects with JGN2plus. 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.

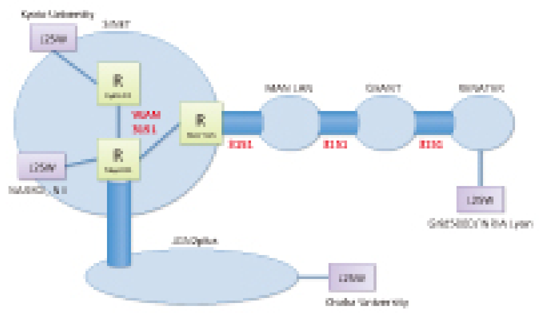

Figure 2. PetaFlow network.

PetaFlow Cloud

Many kinds of applications involve numerical simulations; examples of such applications include the Virtual Physiological Human (VPH), real-time Space Weather Simulator, numerical weather simulation, nuclear fusion simulations, aerodynamic research for next-generation supersonic transport, and numerical simulation for Tsunami disaster prevention. An increased number of computational resources are required to implement these applications. However, it has not been possible to perform numerical simulations for these applications, owing to insufficient computational resources. This problem arises from a structure in which each individual researcher or group owns their own computational resources. This structure of the scientific society proves to be inefficient in several aspects. To solve this problem, we hereby propose the "PetaFlow cloud," which enables researchers or groups to obtain solutions for their concrete objects. These solutions are needed in several numerical simulation codes. The PetaFlow cloud has three main components: "Petascale networking-storage," "Petascale computing," and "Petascale visualization" (see Figure 3).

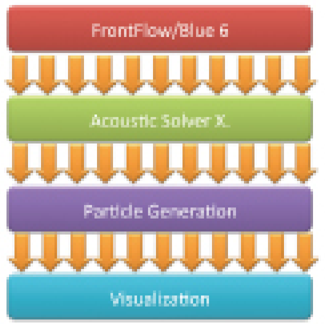

Figure 3. Vision of PetaFlow.

Petascale Visualization

Oral flow sound simulation results in higher-level complexities of 3D phenomena and huge volume datasets. Visualization of huge data often requires the use of high-resolution displays so that fine, important structures are not missed. This is so because the number of elements forming the huge volume of data exceeds the resolutions of the normal LCD displays. Particle-based volume rendering (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 gigabytes (see Figure 4).

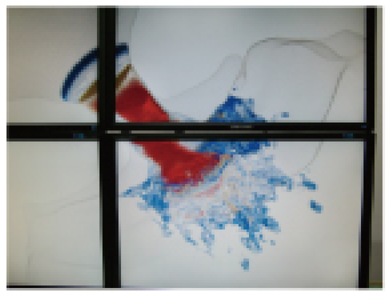

Figure 4. Particle-based volume rendering (PBVR) on tiled display wall (TDW).

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PetaFlow Project: A Project towards an Ultraparallel Synergy Internet System for Scientific Applications

Application for Finding Broken Sensor Nodes by Using Satellite Data

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Introduction

Public weather forecast services mainly use satellite image data in order to know the current weather information and predict the future weather information. In order to use these satellite image data, we should know what the raw digital values from the satellite image mean by the data at many reference points on the ground. But it is difficult to measure the data of the straggling reference points frequently. On the other hand, recently, many people set the low cost weather sensors and open their data on the internet. We use both data and develop the application for calibrating the satellite data and finding the broken sensor nodes.

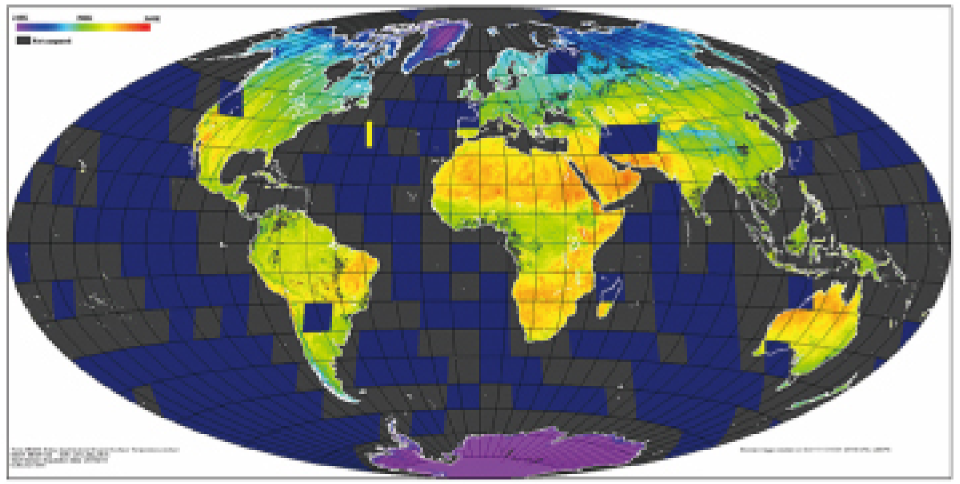

Figure 1: The example of satellite image data

Figure 2: The example of weather sensor map

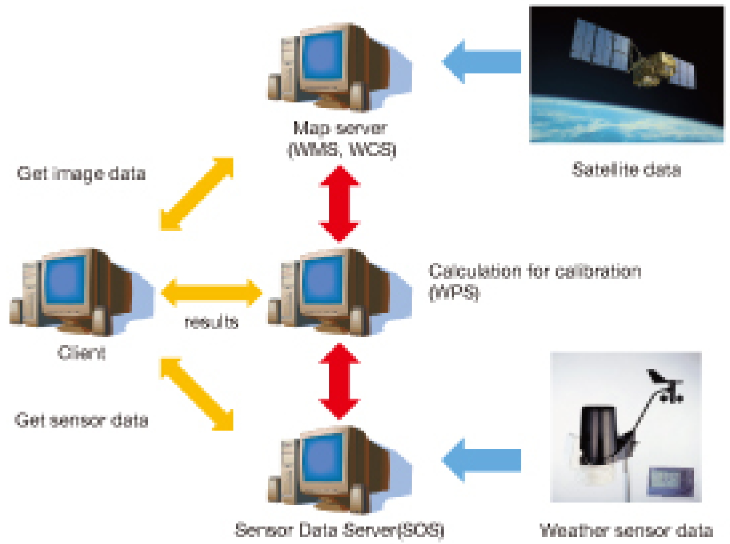

Figure 3: System overview

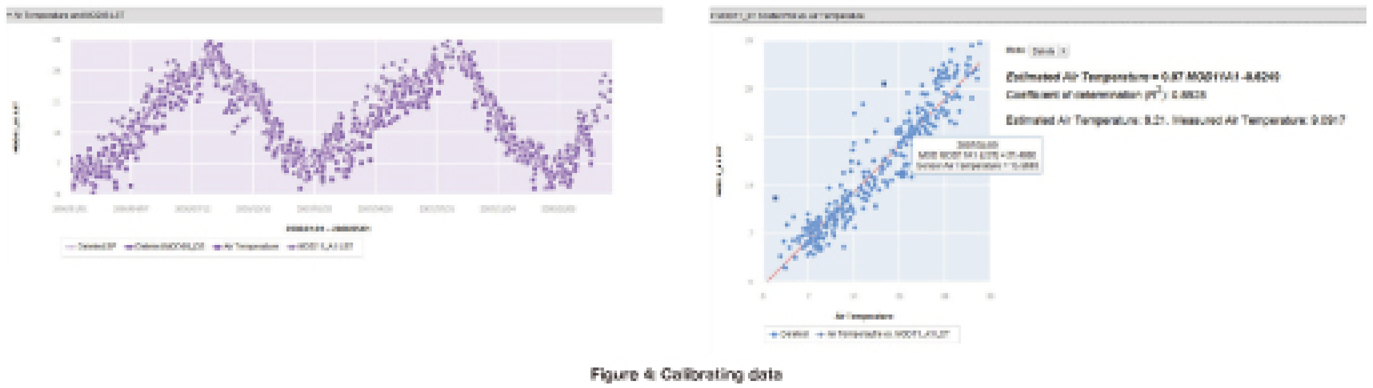

Figure 4: Calibrating data

System and Application

Figure 3 shows our system outline. We use OGC (Open Geospatial Consortium) web services in order to get the satellite image and weather sensor data. It is possible to get each satellite image and weather sensor data in addition to calibrating data. After getting the results of calibrating, we find the broken sensor node on the same window by finding the data of separating from calibration line.

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Application for Finding Broken Sensor Nodes by Using Satellite Data

About Us: Cybermedia Center, Osaka University, Japan

In April 1969, the Computation Center (CC) was established at Osaka University as a laboratory that provides indispensible computation and information processing services to researchers of universities and other institutes. The CC forms part of a grand-scale endeavor by the Japanese government to found seven such supercomputing centers across the nation in accordance with the suggestion of the Japan Science Council to facilitate collaborative use of information technology in research.

In April 2000, Osaka University expanded and reorganized the CC to form its branch of the Information Infrastructure Center, which was named the Cybermedia Center (CMC). During the expansion, the Education Center for Information Processing and a part of the university library were merged into CMC. While the CC continues to provide computers for advanced scientific techniques and media services, the Education Center for Information Processing contributes by promoting education in information processing and the university library, by providing digital contents.

Information Infrastructure Center

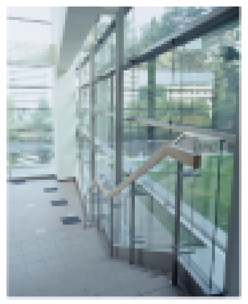
HPC System

The aim of the CMC is to achieve remarkable evolution in information and computing infrastructure by complementarily and systematically integrating functions of computing technology-related organizations, as well as to provide an advanced infrastructure for the accumulation and the dissemination of digital content and for efficient high-level utilization.

The CMC provides a powerful high-performance computing environment for university researchers across Japan. It acts as the nation's hub for teaching and disseminating advanced information technology. In addition, the center assumes the responsibility of facilitating campus IT infrastructure and promoting its effective use. The CMC also provides facilities for advanced education to Osaka University students. It operates an Information Education system and Computer Assisted Language Learning (CALL) system. The center offers a consistent information education curriculum, covering areas from basic usage of e-mail communication and the Internet to advanced computing technologies such as programming, as well as provides foreign language and cultural education support on various levels through a comprehensive application of multimedia techniques.

As a long-term goal, the CMC supports educational and research activities by making comprehensive use of computer-related technology. Specifically, the CMC develops various electronic and multimedia functions to improve the efficiency of educational activities. For research activities, the CMC provides facilities to improve scalability. In next-generation computer applications, it will be necessary to effectively "digitalize" the ideas of researchers, meaning that the CMC will need to deal with every stage of the research process, including information input, retrieval and collection, reports and discussion, analysis and modeling, and finally visualization.

Supercomputing Contest for High School Students (co-hosted by Tokyo Institute of Technology)



Research Divisions

Informedia Education Division develops an advanced environment for information processing education; offers educational programs on information processing and information ethics; and also conducts educational research, including faculty development programs for teaching staffs in information processing.

Multimedia Language Education Division develops an environment for language education using multimedia and provides assistance in the development of multimedia-based language education materials, such as for internationalized education using networks and foreign language programs as common subjects in Osaka University.

Large-Scale Computational Science Division supports the operation of CMC's supercomputer system, disseminates technology for visualization of computational results, and facilitates advanced utilization technology for large-scale computing systems. This division also offers educational programs and studies on computing science and related subjects.

Computer Assisted Science Division supports the operation of general-purpose computer systems; hosts faculty development programs to improve efficient computer applications for setting up and solving scientific problems; also offers educational programs and conducts research on subjects related to learning processes for setting up and solving scientific problems.

Cybercommunity Division supports the planning and operation of SCS-based distance learning, plans and operates distance training in the field of advanced technology, and studies the operation and promotion of cybercommunity plans.

Advanced Network Environment Division supports the operation and utilization of ODINS (Osaka Daigaku Information Network System) to introduce new network technologies such as high-speed networks and mobile computing environments, to facilitate the utilization technologies of large-scale wide-area computer networks, and to carry out research on network-related education.

Applied Information Systems Division develops and provides education on utilization technology for large-scale information systems; digitalizes libraries; supports the management of various databases; implements education on information systems and multimedia systems; and undertakes education on information explorer. Furthermore,

Communication Network Analysis, NTT DOCOMO Collaborative Research Division, was founded this year in collaboration with the largest mobile communications operator in Japan.

About Us: Cybermedia Center, Osaka University, Japan

Osaka University is a national university in Japan, founded in 1931.
***"Live Locally, Grow Globally,"* Osaka University grapples with challenges in education and research.**