Cybermedia Center

Osaka University, Japan

TCP Symbiosis: bio-inspired congestion control mechanism for high-speed and long-distance networks

Virtual Cluster on Wide-Area Distributed Environment Using Overlay Network

Development of Evacuation Simulation Framework For High-Performance Computing

3D User Interfaces for Ultra-Scale Visualization with Tiled Display Wall

SuperCon2009 for High School Students

Observation system for Transient Phenomena and Weather Forecast on Sensor Network

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SC2009 Booth No.907

3D User Interfaces for Ultra-Scale Visualization on Tiled Display Wall

Cybermedia Center
Osaka University

Cybermedia Center, Osaka University, Japan

3D User Interfaces for Ultra-Scale Visualization on Tiled Display Wall

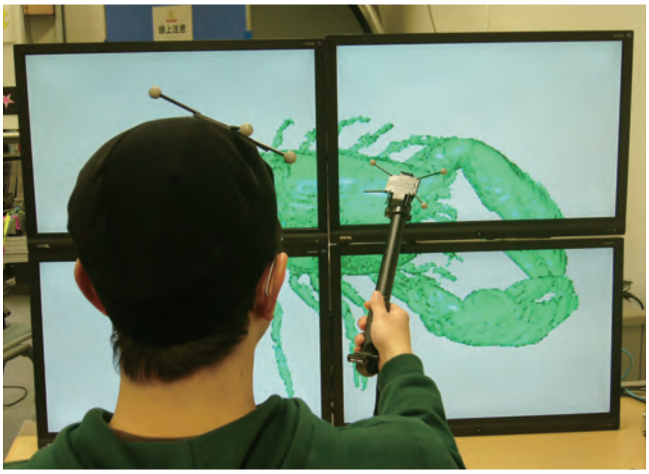


Figure 1: Prototype System

Introduction

Volume data generated from advanced simulations by using supercomputers and high-end measurement equipment in the field of medicine, for example, MRI system, has a tendency to become ultra-scaled and complicated. Therefore, many researchers in various fields find it difficult to detect and analyze the considerable amount of valuable knowledge contained in these volume data. In order to solve this issue, new techniques are required to interactively detect the knowledge by high-resolution display of these volume data on a large-sized screen. However, an effective 3D user interface has not been hitherto developed.

In the past, volume rendering, tiled display wall applications, and 3D-user-interface techniques have been studied individually. We integrated them to visualize large and complicated data with intuitive 3D interfaces. Concretely, we implemented the following technologies:

- Particle-based volume Rendering (for visualization of ultra-scale volume data)
- Tiled display wall (for high resolution representation)
- 3D user interfaces (for intuitive manipulation)

Particle-based Volume Rendering

Volume-rendering has become popular as the method for visualization of volume data in various research fields. However, the research and development on a practical visualization system for large-scale and complex volume data has not been conducted. Particle-based Volume Rendering, proposed by Kyoto University, is a method that could be used for this purpose. However, it is also difficult to render data precisely in real time, and this is a challenge for implementing 3D user interfaces. More details are exhibited in booth 2796.

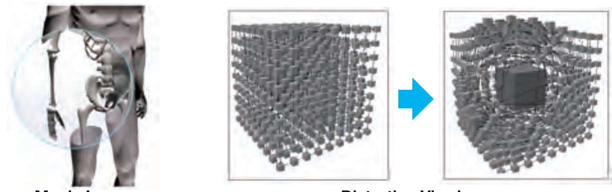
Tiled Display Wall

In this technology, a high-resolution image is displayed on large-scale display with two or more LCD panels in order to construct an effective wide-screen system. We constructed a tiled display wall environment that consists of one master node, two display nodes, and four LCD panels. We applied SAGE to delivery streaming pixel data with a virtual high-resolution frame buffer having a number of graphical sources for the tiled display wall.

3D User Interfaces

In the case of the 3D-user-interface technique, the following methods are proposed:

- 3D magic lenses (Figure 2-left)
- distortion viewing using the probe (Figure 2-right)



Magic Lense — Viega et al. 1996, Ropinski et al., 2004

Distortion Viewing — Sheelagh et al., 1996

Figure 2: Proposed 3D User Interfaces

The 3D magic-lenses method is a technique that changes the rendering method inside a region, forming a virtual lens. For example, in Figure 2-left, the body is rendered outside the region behind the lens, while the bones are rendered inside the region behind the lens. This image shows that the lens enables us to see through bodies. On the other hand, the distortion-viewing method enables us to show data in various ways. The simplest application is to magnify regions of interest (Figure 2-right). This method distorts only a part of the model. This enables us to understand the relationship between the entire model and the distorted region and also enables us to observe the region of interest in detail.

The distortion-viewing technique seems to be suitable for complicated volume data. In addition, the extraction of the interesting region is a basic but useful method; therefore, we implemented these two 3D user interfaces using OptiTrack, which is a 3D tracker system. Figure 3 shows the configuration of the prototype system. Table 1 lists the specifications of the prototype system.

Table 1: Specifications of the Prototype System

Each Master Node and Display Node	AMD Opteron 2350 2.0GHz, RAM 32GB nVIDIA Quadro FX 4600 Ubuntu 8.10 (64bit)
3D Tracker	NaturalPoint OptiTrack FLEX:v100

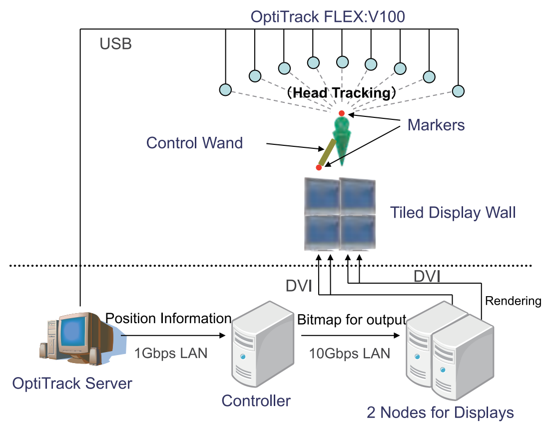


Figure 3: Prototype system configuration

Conclusion

We proposed an integrated system with an intuitive 3D user interface for ultra-scale volume data that are displayed on a wide area and at a high resolution by particle-based volume rendering and tiled display wall. In future, we will improve the interface and evaluate the integrated system.

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Development of Evacuation Simulation Framework for High-Performance Computing

Cybermedia Center, Osaka University, Japan

Development of Evacuation Simulation Framework for High-Performance Computing

Abstract

This research aims to develop an evacuation simulation framework using a multi-agent system that is applicable to high-performance computing. This framework enables us to compare a number of evacuation behavior models on the same system. In this study, we compared the social force model and the RVO model. The evacuation time of the RVO model is shorter than that of the social force model since the RVO model exhibits an optimized collision-avoidance behavior that affects the flow of the exit. Moreover, we visualized the evacuation situation on a high-definition immersive projection display in order to give the user a disaster evacuation experience.

Introduction

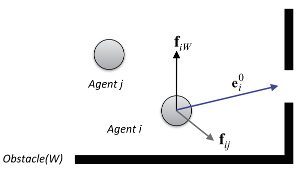
In the field of disaster prevention planning, evacuation simulations have been carried out on a multi-agent system that has pedestrians as agents. For the study of human behavior, a number of models have been studied. The social force model, which is one of the human behavior models, was used to simulate escape panic; this model determined a relation between social psychology and physical force. In the field of computer graphics, research was carried out for a crowd simulation model. For example, the reciprocal velocity obstacle (RVO) model was used for simulating evacuation from a building. The visualization of such an evacuation situation in a VR environment is effective in providing awareness training.

This research aims to (1) develop an evacuation simulation framework by using a multi-agent system and (2) implement the social force model and RVO model for the same purpose. Moreover, we visualized an evacuation situation on a high-definition immersive projection display in order to give the user an evacuation experience.

Method

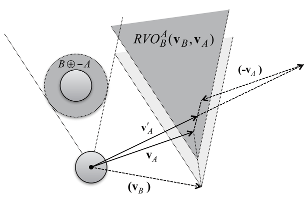
Evacuation Behavior Model

Using evacuation simulation framework, we implemented two human behavior models, namely, the social force model and the RVO model. The social force model solves the motion equation of an agent, which is represented by a moving disc. An agent that has mass and a constant radius is subjected to a force exerted by other agents and obstacles and exit position. On the other hand, the RVO model is an expanded model of velocity obstacles for crowd simulation. Velocity obstacles are used in the velocity selection algorithm for collision avoidance between moving objects in the field of robotics. The agents evacuate from the building, updating the walking velocity calculated using one of the evacuation models.



$$m_i \frac{d\mathbf{v}_i}{dt} = m_i \frac{v_i^0(t)\mathbf{e}_i^0(t) - \mathbf{v}_i(t)}{\tau_i} + \sum_{j(\neq i)} \mathbf{f}_{ij} + \sum_W \mathbf{f}_{iW}$$

Fig.1 Social Force Model



$$RVO_B^A(\mathbf{v}_B,\mathbf{v}_A) = \{\mathbf{v}'_A \mid 2\mathbf{v}'_A - \mathbf{v}_A \in VO_B^A(\mathbf{v}_B)\}.$$

Fig.2 RVO Model

Results and Discussion

Evacuation Time

We simulated evacuation from an office building, as shown in Figure 3. Figure 4 shows the results of the evacuation time. Each graph represents the evacuation and floor evacuation times for three rooms (one meeting room, two office rooms). We observed a difference between the social force model and RVO model; the room evacuation and floor evacuation times of the RVO model were shorter than those of the social force model. This is because the RVO model exhibits an optimized collision-avoidance behavior that affects the flow of the exit. A characteristic of the graphs shown in Figure 4 is that in both models, the first evacuee escaped after several seconds. After that, a certain number of evacuees escaped per unit time because the exit to the staircase was the bottleneck.

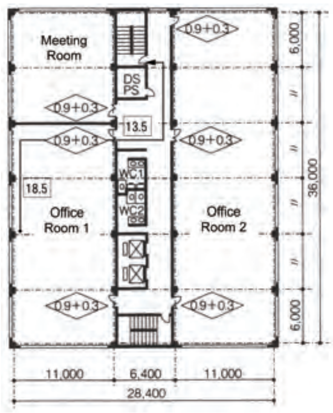


Fig.3 Office Plan

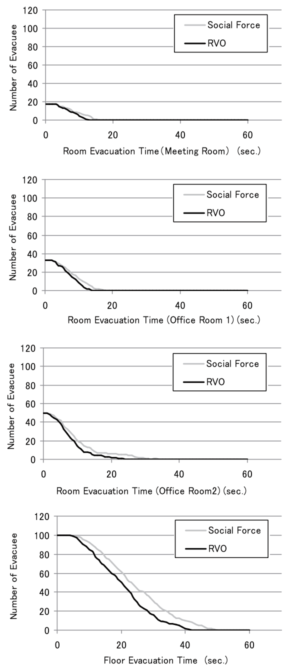


Fig.5 Simulation Image

Fig.4 Evacuation Time

Visualization

We visualized the evacuation simulation on a high-definition immersive projection display (CAVE), which contains a cluster of high-performance graphics PCs and high-definition projectors in order to give the user an evacuation experience.

Fig.6 Visualization on CAVE

Conclusion

We developed an evacuation simulation framework, which implements the social force model and the RVO model. The evacuation times of the RVO model are shorter than those of the social force model because the RVO model exhibits an optimized collision-avoidance behavior that affects the flow of the exit.

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SuperCon2009 for High School Students

Cybermedia Center, Osaka University, Japan

Outline

Supercomputing Contest (SuperCon) is a team-based programming competition for high-school students. It is hosted by the Global Scientific Information and Computing Center (GSIC), Tokyo Institute of Technology (Tokyo Tech), and Cybermedia Center (CMC), Osaka University (OU). SuperCon was initiated in 1995, and the newly introduced Clay C916 Supercomputer was used in this contest. The contests held every year from 1995 to 2005 were hosted solely by GSIC, Tokyo Tech, and, the recent four contests from 2006 to 2009 were co-hosted by CMC, OU. In 2004, 4 international teams from China, Korea, Singapore, and Thailand participated in the 10th anniversary of SuperCon in 2004. In 2009, 23 high schools and 36 teams from all over Japan participated in a preliminary contest, and 20 teams advanced to the SuperCon 2009 Finals.

SuperCon2009 for High School Students

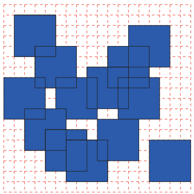
SuperCon uniquely provides high-school students with the opportunity to use supercomputers like TSUBAME Grid Cluster of GSIC, Tokyo Tech, and NEC SX-9 of CMC, OU. The long duration of the competition is another feature of SuperCon. It starts with seminars on supercomputing with vectorization and parallel processing. Students would be staying at Tokyo or Osaka for 5 days (August 3-7, 2009). They would be asked to develop a program that solves high-level problems. SuperCon provides participants with an opportunity to interact with students from all over the country. The contest fosters creativity, teamwork, and innovation in developing new software programs. Some participants are winners of the International Mathematical Olympiad and International Olympiad in Informatics. After the Contest, some students actively participated in other programming contests for university students like the ACM International Collegiate Programming Contest.

Visit the booth #1155 of GSIC, Tokyo Tech shows the SuperCon2008 poster.

SuperCon2009 preliminaries problem:

Area Counting

Write a program that computes the area of the union of the given axis-parallel unit squares in the plane. For the figure on the right, the answer is 172.



Problem for SuperCon 2009 finals:

Rescue in Space

Story:

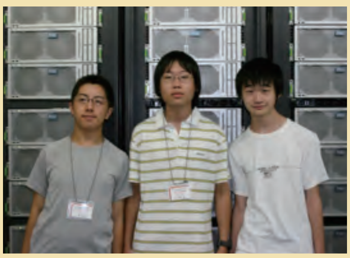
On clear nights, we can see many stars. Ancient people looked up at the stars and imagined fictitious objects by connecting stars; these objects are called constellations. A constellation consist of stars which appear near to each other when we see them from the earth, but in real space, they are not necessarily near each other. For example, although Aldebaran and the Pleiades belong to Taurus, the former is 60 light years from the earth, while the latter is 410 light years from the earth. In the distant future, when the human race find its way outside the solar system, they would be able to see stars from an outer planet far from the earth. Many stars would still be visible from this outer planet, but their arrangements would be different from the ones observed from the earth. Therefore, the constellations also would be quite different. That is, given a photograph of stars, we should be able to determine the star from where the photograph was taken if the coordinates of every star in the universe are given. The Problem of the the SuperCon 2009 finals is to determine the star to rescue a crash-landed spaceship which sent us the photograph of the stars taken from another star.

Problem:

Given an arbitrary number (N) of a fixed star in space, and 1000 pieces of the "all-sky photographs" (defined below Fig 3-1) taken from an arbitrary star among N stars, write a program that determines the stars from where the all-sky photographs were taken. The team that gives the most number of correct answers in the shortest period wins.

The winner: team "zatoriku"

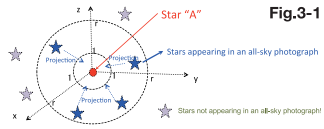
Masaki Hara Riku Yoshizato Shinichiro Kawai



Glossary:

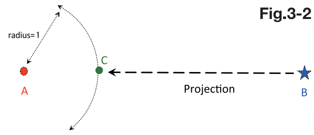
1. All-sky photograph: An all-sky photograph consists of three-dimensional "projection coordinates" (defined below) of n stars within a distance r from a star (called star "A") where the photograph is taken (Fig. 3-1). Stars farther than r that are away from the star "A" do not appear on the all-sky photograph.

Fig.3-1



2. Projection: Let "A" be the star from where the all-sky photograph is taken, and B1,..., Bn denote the n stars that are located within a distance r from the star "A." Then, "projection" is defined as an intersection point "Ci" of a line segment "A" to "Bi" (or its extension in some cases) and a spherical surface whose center is "A" and radius is unity (Fig.3-2).

Fig.3-2



3. Projection coordinate: Projection coordinates C1',..., Cn' are the rotation of C1, ... ,Cn so that the coordinates Bi (any of the n stars) are mapped onto Ci'(0,0,1) on the coordinates where "A" is the origin. The star Ci' is called "standard" (Fig.3-3).

Fig.3-3

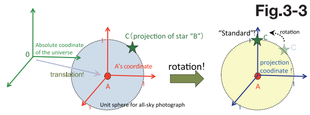


Fig.3-4

Input:

1. Coordinates of stars in the universe:

1-1. Coordinates of stars in the universe are given as 3-dimensional real-valued coordinates (x, y, z) and -3000 <= x, y, z <= 3000 (Fig.3-4).

1-2. N: the number of stars in the universe. For the semifinals, N = 100,000 and for the finals, N = 500,000 or 1,000,000.

2. All-sky photograph data:

2-1. All-sky photograph data consists of n sets of projection coordinates C'i (x'i, y'i, z'i) (i=1,2,...,n). In definition, x'i^2 + y'i^2 + z'i^2 = 1 because every C' is on a unity spherical surface.

2-2. Shooting range: Stars within a distance r from the center star "A" appear on the all-sky photograph. Note that the value r varies from photograph to photograph. The value of r is a real number and 50 <= r <= 51.

2-3. The number of stars, n, appearing on an all-sky photograph is limited in the range 50 <= n <= 10,000. Stars containing less than 50 or more than 10,000 stars in its shooting range r may be eliminated, but the number of such stars are not many.

2-4. The first coordinate C'1(x'1,y'1,z'1) of the n sets of the projection coordinates C1',...,Cn' is called "standard" and is therefore (0, 0, 1).

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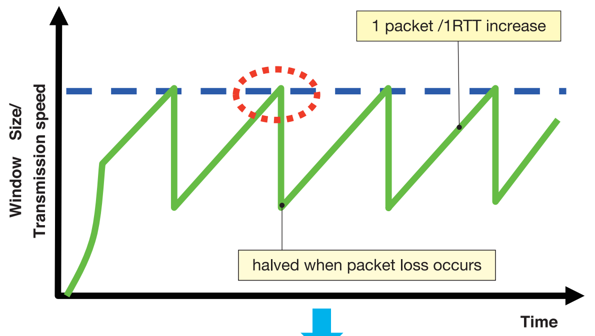
SuperCon2009 for High School Students

TCP Symbiosis: Bio-Inspired Congestion Control Mechanism for High-Speed and Long-Distance Networks

Cybermedia Center, Osaka University, Japan

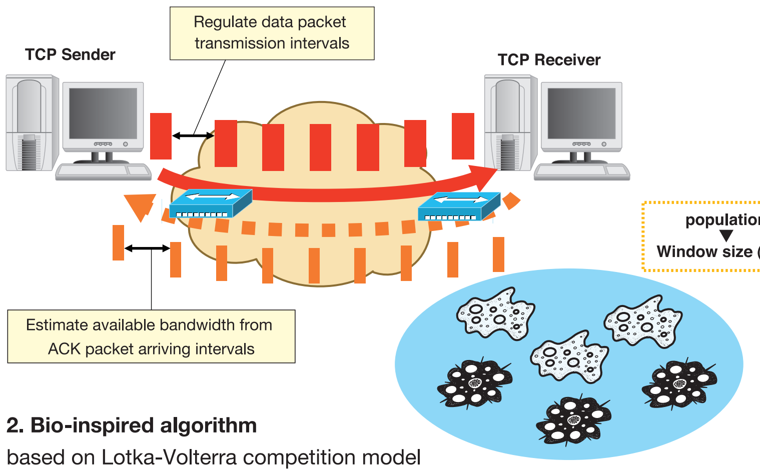
Conventional TCP Reno

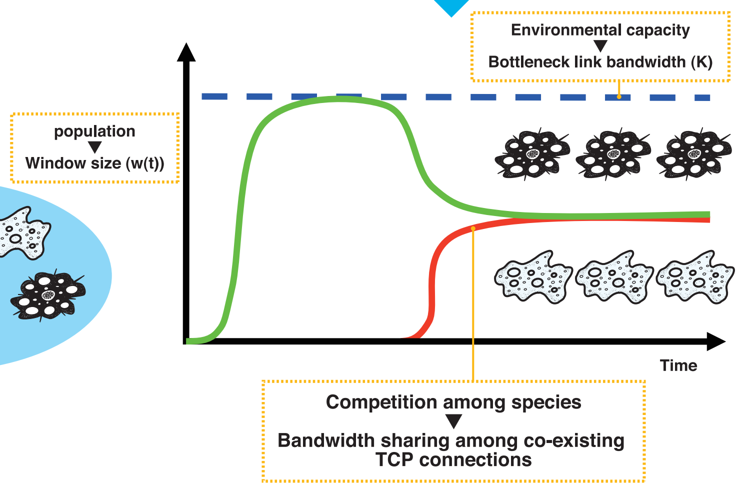
- Activates congestion control only when detecting packet losses
  —Cannot avoid periodical packet losses even when it behaves ideally
- Fixed parameters for increasing/decreasing transmission speed
  —Very low throughput in high-speed and long-distance networks



Our method: TCP Symbiosis

1. Inline bandwidth measurement





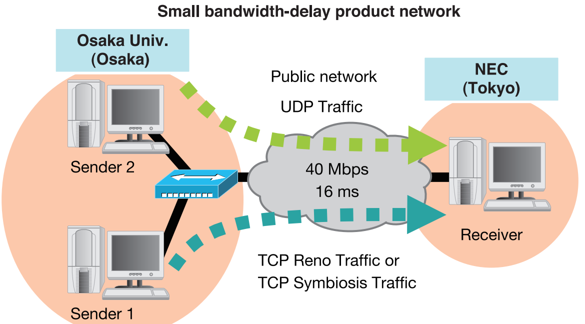
2. Bio-inspired algorithm

based on Lotka-Volterra competition model

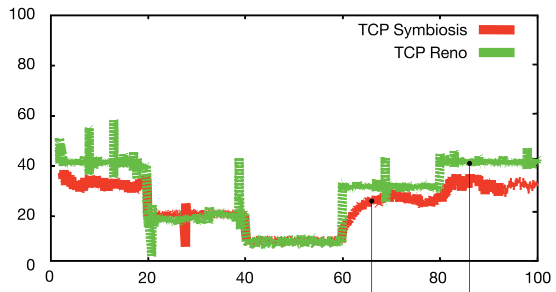
$$\frac{d}{dt} w_i(t) = \varepsilon \left(1 - \frac{w_i(t) + \gamma (K - A_i) \tau_i}{K \tau_i} \right) w_i(t)$$

Results in actual networks

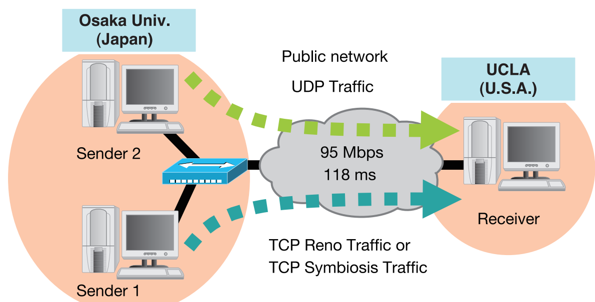
Small bandwidth-delay product network



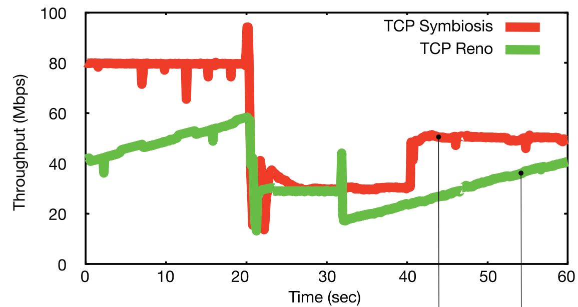
Time (sec)	0-20	20-40	40-60	60-80	80-100
Sender 2	0 Mbps	20 Mbps	30 Mbps	10 Mbps	0 Mbps
Available bandwidth	40 Mbps	20 Mbps	10 Mbps	30 Mbps	40 Mbps



Large bandwidth-delay product network



Time (sec)	0-20	20-40	40-60
Sender 2	15 Mbps	65 Mbps	45 Mbps
Available bandwidth	80 Mbps	30 Mbps	50 Mbps



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TCP Symbiosis: Bio-Inspired Congestion Control Mechanism for High-Speed and Long-Distance Networks

A Virtual Cluster Solution Using Overlay Network on Wide-Area Distributed Environment

Cybermedia Center, Osaka University, Japan

Applied Information System Division aims for the development of information technology useful for scientific users. For the purpose we have been researching elemental technology such as high-speed networking and Grid from a point of scientific application building view. A recent achievement in the Applied Information System Division is virtual cluster solution.

Concept and Architecture of our Virtual Cluster Solution

Grid technology has grown as a means to efficiently and effectively utilize computational resources among multiple organizations and it is highly required in scientific and business fields. However, the current Grid technology does not always provide the computational environment enough to satisfy users' requirements because users cannot setup or configure computational environment of the Grid as they like.

To solve this problem, we have been developing virtual cluster solution using overlay network. The virtual cluster is composed of virtual computational resources by Xen as a virtualization technology on top of an overlay network realized by PIAX as an overlay networking technology. With our solution, scientific users can build their own private virtual cluster, by dynamically aggregating computational resources on the Internet.

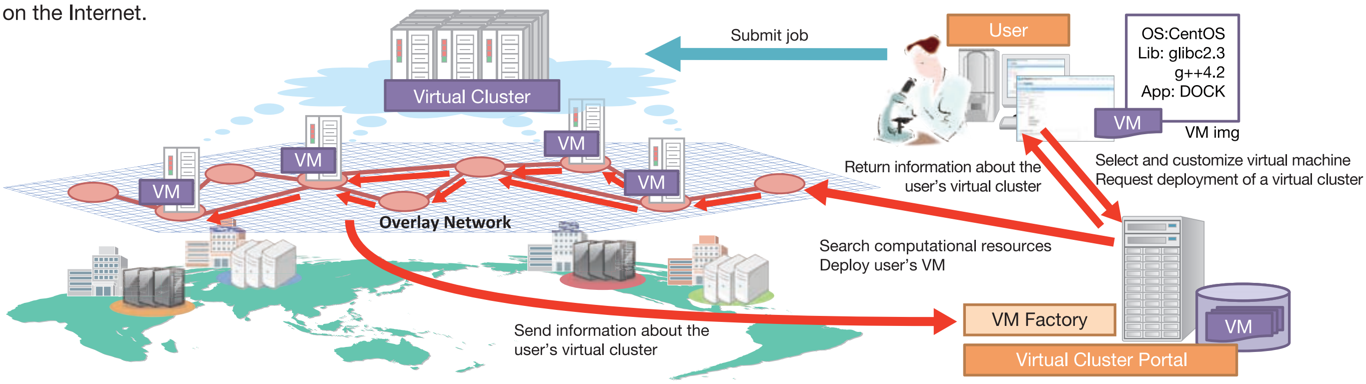

Fig.1 Concept of our virtual cluster solution

Our virtual cluster is built as follows. First, a user accesses to the Virtual Cluster portal and requests deployment of a virtual cluster. The request is sent to a resource discovery agent on the overlay network. The resource discovery agent finds appropriate computational resources which can host the requested virtual machines. After that, the virtual machines are deployed on selected computational resources and establish end-to end IP communication among them and organize a virtual cluster. Finally, the portal returns the information necessary for access to the cluster.

The communication relay mechanism plays a role of relaying IP communication between virtual machines composing the virtual cluster on the overlay network. The mechanism performs this function by encapsulating IP packet into PIAX message frame exchanged on the overlay network. By leveraging this mechanism, scientific users can execute their own scientific applications without any modification on the virtual cluster.

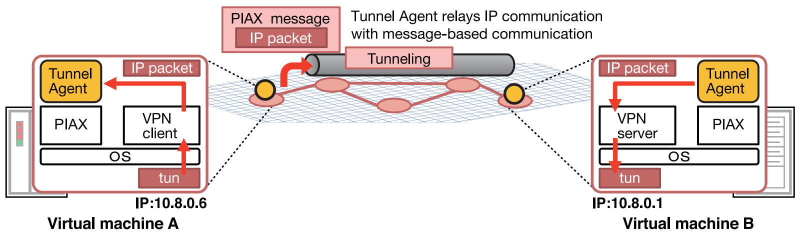

Fig.2 A Communication Relay Mechanism

Application Example: Docking Simulation

DOCK

DOCK is a simulation software for drug discovery. Bio scientists often use DOCK to investigate which chemical compound can bind to a target protein and so be a drug candidate. After simulation, the bio scientists experimentally test with the chemical compound ranked high of the chemical compounds. Usually, in the simulation, it is necessary to repeat multimillion combinations of chemical compounds and the target protein. For the reason, the recent high-performance computing technology such as PC cluster and Grid Computing is heavily required.

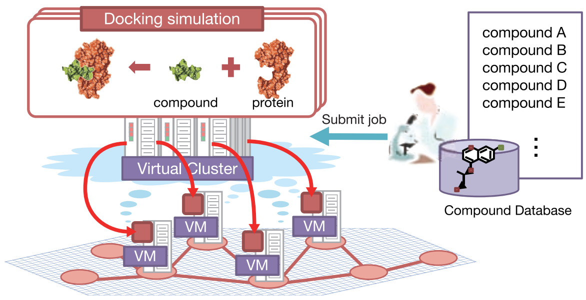

Fig.3 Execution of docking simulation on the virtual cluster

Performance

We measured the execution time of DOCK simulation on a physical cluster and a virtual cluster for investigating computational performance difference between them. In the measurement experiment, the total execution time of completing docking simulation between a target protein and 30 chemical compounds was measured on each cluster. The result shown in Fig. 4 indicates that the computational overhead on the virtual cluster is quite small compared with the physical cluster irrespective of the number of cluster node. Also, it shows our virtual cluster could be useful and effectively work for computationally intensive applications such as DOCK.

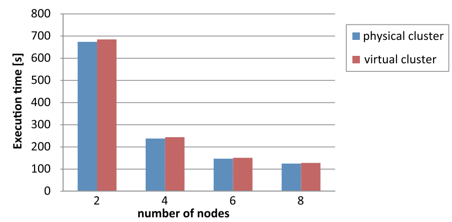

Fig.4 Execution time on physical cluster and virtual cluster

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A Virtual Cluster Solution Using Overlay Network on Wide-Area Distributed Environment

Observation System for Transient Phenomena and Weather Forecast on Sensor Network

Cybermedia Center
Osaka University

Hyogo University of Health Sciences, Japan

Observation System for Transient Phenomena and Weather Forecast on Sensor Network

Introduction

Transient phenomena such as super novae and gamma-ray bursts often occur in our universe. However, it is difficult to get the first few minutes of data because we cannot predict when these phenomena occur. On the other hand, small telescopes are in widespread use and these phenomena can be observed by these telescopes because these phenomena are bright enough to observe.

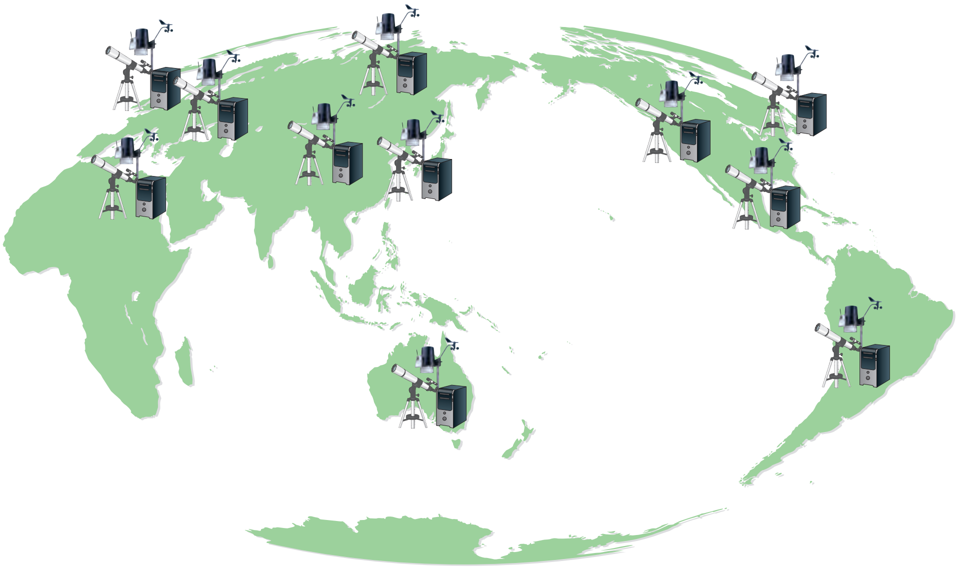
We present a cooperative observation system for these phenomena by using P2P infrastructure and a weather forecasting system for scheduling the observation.

P2P platform

We adopt the P2P architecture as our application platform for controlling many telescopes, images and weather sensor data.

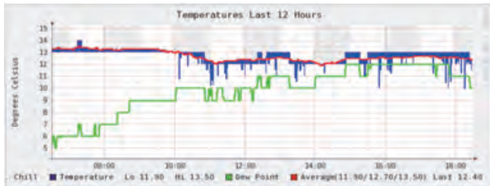
In general, discovering the data effectively is difficult.

We use PIAX (P2P InteractiveAgent eXtensions, http://www.piax.org/) as a platform. PIAX, which is developed by Osaka University, can search and get data on the basis of its location information effectively by DHT and LL-Net.



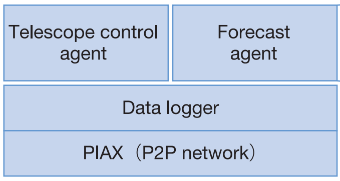
Observation and weather forecasting system

We built a system for controlling the telescopes and imaging devices and forecasting the local weather by weather sensor data. In order to schedule observations, knowing the local weather information is necessary.
But the local weather changes during 10 minutes order. So we use not only public information but also the local weather sensor data.
We collect the weather data by a mobile agent implemented by PIAX and predict the local weather by AR (auto-regressive) model and interpolate the data at certain points. We schedule the observation by these information and get the image data of the phenomena.

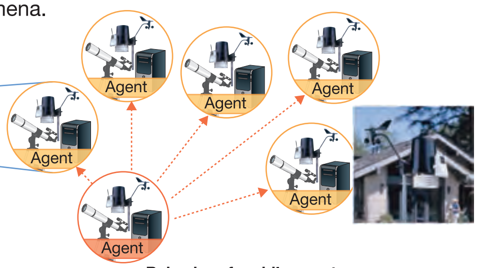


Example: multiple weather sensor data

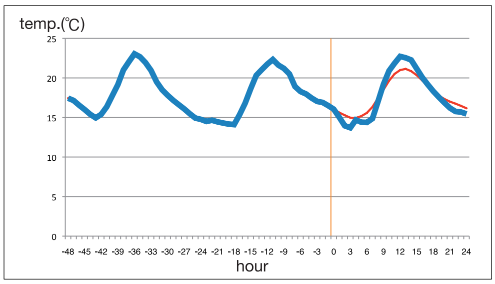
Data collection by P2P agent
The agent predicts the weather
by using the historical data



Software architecture of each peer

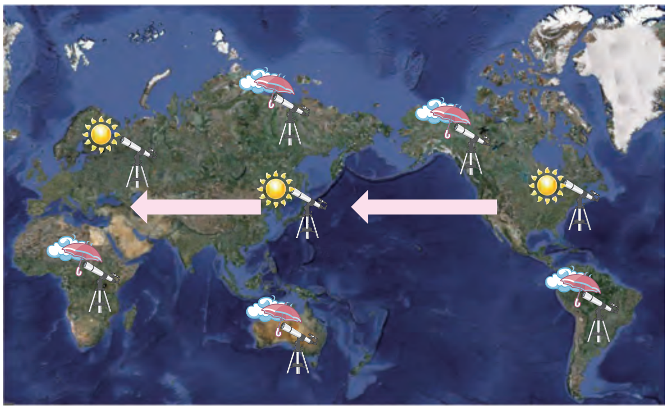


Behavior of mobile agent



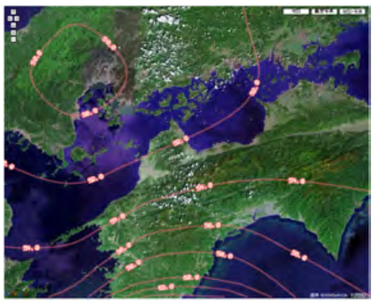
Blue: original data Red: predicted data

Get forecast information at
the any point by interpolation



Case: 24 hours cooperative observation network

Decision of Observation schedule in accordance with the weather forecast information



Interpolated map of weather data

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Application Control Module for SAGE

Cybermedia Center
Osaka University

Cybermedia Center, Osaka University, Japan

Background and Motivation

Scalable Adaptive Graphics Environment (SAGE) is a graphics streaming middleware for supporting collaborative scientific visualization environments that allow scientists to easily build a tiled display wall (TDW) composed of multiple computers and monitors. Furthermore, it allows scientists to share scientific images and videos stored or generated on local or remote computers through the use of network streaming techniques. Recently, SAGE has attracted increasing interest in the scientific community because it can potentially help scientists collaborate for a common scientific goal through the visualization on the TDW. However, the original SAGE does not provide any functions and methods for allowing applications to obtain user inputs from its user interface, SAGE UI, although scientists as users can manipulate operations related to window management. Therefore, there exists a major operational issue in SAGE-based TDW that may hinder its practical use.

Our solution

The principle of our solution to the operational problem of SAGE is to build a module that enables scientists to control application events as well as window management events in SAGE UI. Based on this principle, we have succeeded in developing a built-in application control module for SAGE. Our module offers transparency and usability in operation to SAGE users wherever SAGE-enabled application nodes are.

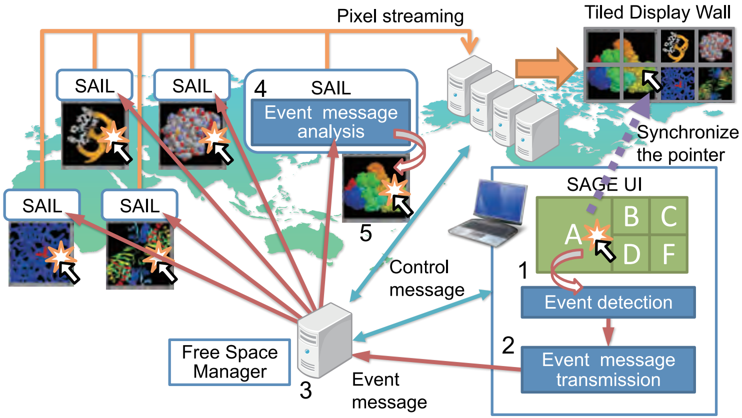
Features

- Unified, seamless, and transparent control of application and window management events in SAGE UI.
- X11-based visualization tools can easily adopt the application control module as a plug-in.
- The application control module allows users to manipulate multiple applications simultaneously.

How it works

Our built-in application control module provides three major functions: event detection, event message transmission, and event analysis. First, a user's request to an application is detected as an event (1). Then, a corresponding event message is generated and transmitted to the Free Space Manager, which manages information for applications running in SAGE (2).

The Free Space Manager transfers the received message to the target application (3). The SAGE Application Interface Library (SAIL) in the application analyzes the received event message and then converts it to an X-based event message for the target application (4). Finally, the target application responds with the delivered event (5).



OSAKA UNIVERSITY

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Application Control Module for SAGE

Uncompressed HDTV on Tiled Display Wall

Cybermedia Center
Osaka University

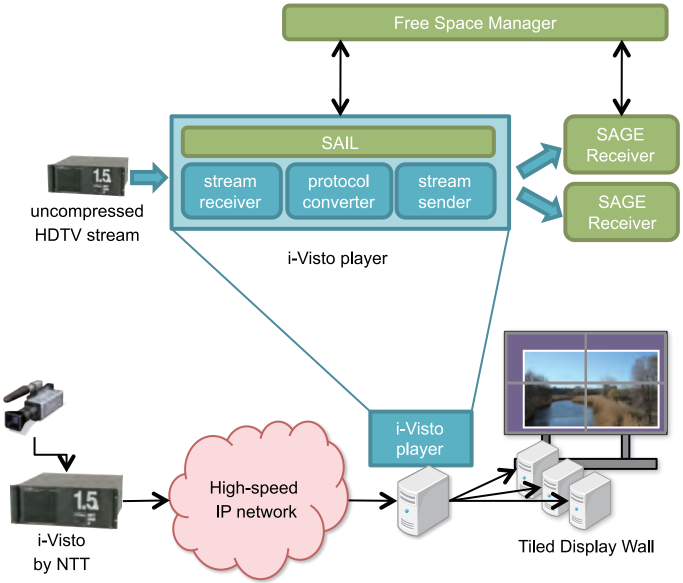
NTT Network Innovation Laboratories and Cybermedia Center, Osaka University

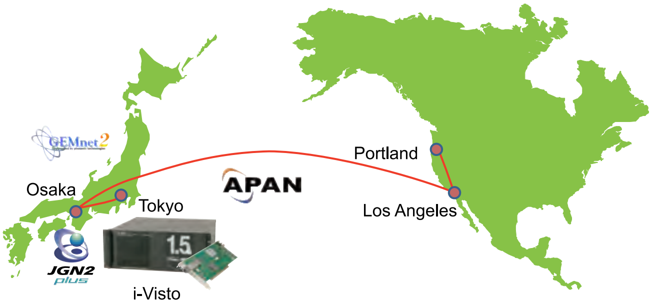
Uncompressed HDTV on Tiled Display Wall

The advancement of networking technology allows transmission of uncompressed High Definition video over the Internet.

Osaka University and NTT have developed an uncompressed HDTV streaming system for SAGE, i-Visto player, that allows HD streaming video to be displayed in real-time on a SAGE-based TDW. The system can receive HDTV streams from the NTT i-Visto system.

In this booth, we demonstrate the display of i-Visto stream on TDW. The stream is sent from Tokyo to Portland via Osaka.





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Uncompressed HDTV on Tiled Display Wall