5-3 Space Weather Information Network on JGNⅡ

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The space weather covers information over a vast area such as the Sun, interplanetary space, magnetosphere, and ionosphere. It is a problem how to handle distributed databases of various data and how to communicate among distributed researchers. This report introduces one attempt to use high-speed network JGNⅡ.

Keywords
Space weather, Visualization of 4-dimension data, Grid,
Electronic Geophysical Year (eGY)

1 Introduction

The growth of the Internet is changing styles of research in the field of space science, particularly in the provision of near-real-time observation data obtained by satellites and on the ground. Nevertheless, space weather deals with phenomena ranging from the Sun to the upper atmosphere of the Earth, covering a vast range of research fields (e.g. the Sun, interplanetary space, magnetosphere, and ionosphere) and a diverse array of researchers. Thus, in analysis combining ground and satellite observation data or in a comparison of actual and simulation data, a major challenge arises in determining how to integrate these distributed databases and disparate researchers in the most efficient manner.

This article discusses space-weather applications of JGNⅡ, including information-sharing in the visualization of three-dimensional data, integrated analysis of large amounts of mutually exchanged observation data, transmission of analysis results, and real-time exchange of information on space weather and the space environment via video conferencing.

2 Examples of experiments using JGNⅡ

As shown in Fig.1, six space-weather-related institutions are experimentally linked to JGNⅡ: the Solar-Terrestrial Environment Laboratory of Nagoya University, the Data Analysis Center for Geomagnetism and Space Magnetism of Kyoto University, the Center for Information Technology of Ehime University, the Space Environment Research Center of Kyushu University, the Yamanashi Prefectural Science Center, and NICT.

2.1 Experiments with the Yamanashi Prefectural Science Center

In the context of various educational activities dealing with space weather, an interactive lecture entitled “What is space-weather forecasting? From the Sun to Auroras” was held on July 2, 2005. In this lecture, the Yamanashi Prefectural Science Center, the Center for Information Technology of Ehime University,

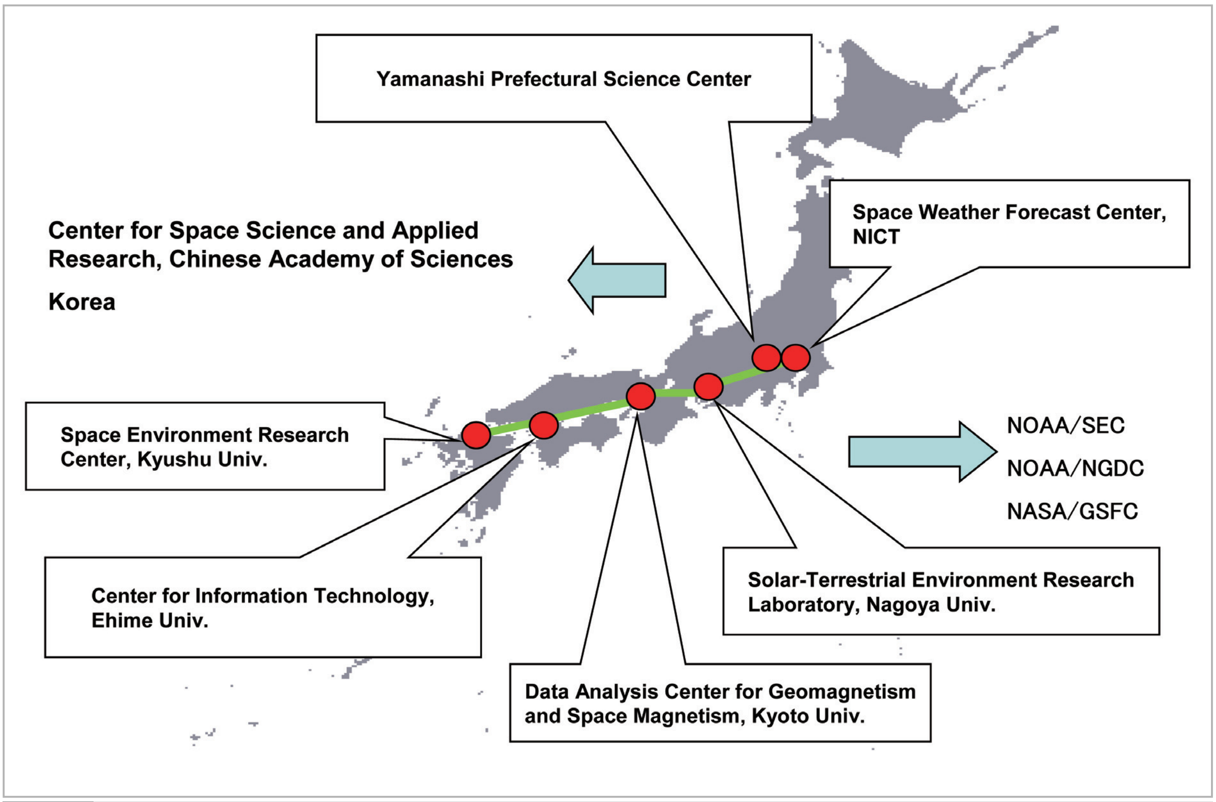

Fig.1 *Space-weather-related institutes connected to JGNII*

and the NICT Space-Weather Forecast Center were all linked to JGNII. The event brought together approximately 100 people, mainly consisting of high-school and university students. The event included the lecture itself as well as an experiment involving the distribution of a space-weather forecast, delivered by a space-weather forecaster. Figure 2 shows the configuration of the system used in the event. The lecture and the space-weather forecast demonstration were streamed using the XVD codec[1] at a high compression ratio. The experiment involved the placement of multipoint connection unit (MCU) at NICT and made use of an H.323-compatible video conferencing system to construct an environment enabling an interactive lecture between the three sites: NICT, the Yamanashi Prefectural Science Center, and the Center for Information Technology of Ehime University. Distribution via XVD offers the advantage of a high compression ratio but features the disadvantage of a time lag of 1 to 1.5 seconds due to the encoding and decoding involved. Nevertheless, higher-quality images could be transmitted with XVD relative to an H.323-compatible video conferencing system. Figure 3 shows scenes from the event.

2.2 Experiments at the Solar-Terrestrial Environment Data Analysis Workshop

NICT, Kyushu University, and the Solar-Terrestrial Environment Laboratory of Nagoya University host a Solar-Terrestrial Environment Data Analysis Workshop twice a year. This workshop looks at space-weather phe-

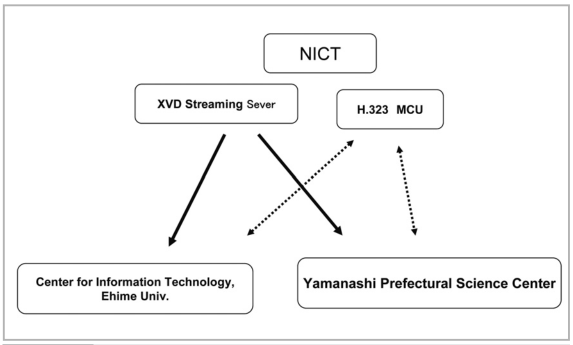

Fig.2 *Connection diagram for the event*

Fig.3 *Scenes from the event: Yamanashi Prefectural Science Center (upper left), Center for Information Technology of Ehime University (upper right), and NICT Space Weather Forecast Center (bottom)*

nomena occurring in the previous six months from a variety of viewpoints, with reference to a range of data involving the Sun, interplanetary space, the magnetosphere, and the ionosphere, as shown in Table 1. The experiment performed at the FY2005's First Solar-Terrestrial Environment Data Analysis Workshop held on August 3, 2005 at NICT involved the connection of five institutes: the Solar-Terrestrial Environment Laboratory of Nagoya University, the Data Analysis Center for Geomagnetism and Space Magnetism of Kyoto University, the Center for Information Technology of Ehime University, and the Space Environment Research Center of Kyushu University. As shown in Fig.4, this experiment involved the placement of multipoint connection unit (MCU) at NICT and connection of the remaining institutes via an H.323-compatible video conferencing system. These workshops handle many types of data, from information on the Sun to data on the upper atmosphere of the Earth, as shown in Table 1, and discussions proceeded with reference to these data. Consequently, it became clear that a system based on the MCU configuration is not completely satisfactory, as it becomes difficult to view the data with an increasing number of screen divisions. This demonstration in particular showed the need to consider the future incorporation of remote presentation support functions within the access grid.

3 Future plans

3.1 Visualization of four-dimensional data

Visualization of four-dimensional data, consisting of spatial three-dimensional data and a time axis, is expected to provide new knowledge within a high-speed network environment that will allow researchers to analyze data in collaboration, sharing three-dimensional views within this environment. In particular, given the importance in interpreting calculation results in simulations, three-dimensional visualization has evolved into an important analytical tool, allowing researchers to view calculation results from a variety of angles. Visualization of four-dimensional data is also important in terms of

Table 1 *Data presented at the Solar-Terrestrial Environment Data Analysis Workshop*

Region	Observation	Institute
Sun	sunspots, Hα, corona, magnetic field	NAOJ Hida Observatory, Kyoto Univ.
	solar radio	Nobeyama Solar Radio Observatory, NAOJ
Interplanetary Space	interplanetary scintillation	STE Lab., Nagoya Univ.
	cosmic rays	STE Lab., Nagoya Univ. Shinshu Univ.
Magnetosphere	magnetic field pulsation	Kakioka Observatory, Japan Metrological Agency NICT Onagawa Observatory, Tohoku Univ. Tokai Univ.
	geomagnetic index	Data Analysis Center for Geomagnetism and Space Magnetism, Kyoto Univ.
Ionosphere	ionosonde	NICT
	HF doppler	University of Electro-Communications Doshisha Univ.
	TEC	Research Institute for Sustainable Humanosphere, Kyoto Univ. NICT
	airglow	STE Lab., Nagoya Univ.

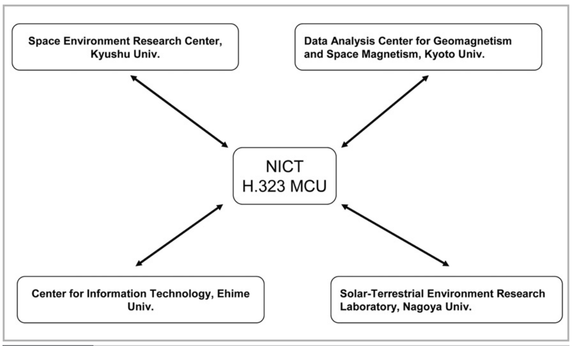

Fig.4 *Connection diagram for the Solar-Terrestrial Environment Data Analysis Workshop*

scientific education, as this helps to communicate a range of results to the general public in an easy-to-understand way. To date, NICT has displayed the three-dimensional distribution of electron density in the upper atmosphere using the International Reference Ionosphere (IRI) model and a three-dimensional display based on polarized light[2]. Additionally, in the field of astronomy, the National Astronomical Observatory of Japan has led the "Four-Dimensional Digital Universe Project"[3], attempting the visualization of four-dimensional data for celestial objects and phenomena using observed data and simulation results. Today, NICT performs real-time three-dimensional magnetohydrodynamic (MHD) simulations of the magnetosphere using supercomputers and applies the results to its space-weather forecasts[4][5]. Meanwhile, the Center for Information Technology of Ehime University collaborates with NICT in studies on the visualization of three-dimensional data using various simulation results[6][7]. In terms of space weather, real-time distribution of three-dimensional visualization results via high-speed networks, as indicated in Fig.5[6][7], is expected to help researchers understand conditions in the continuously changing magnetosphere in even greater detail.

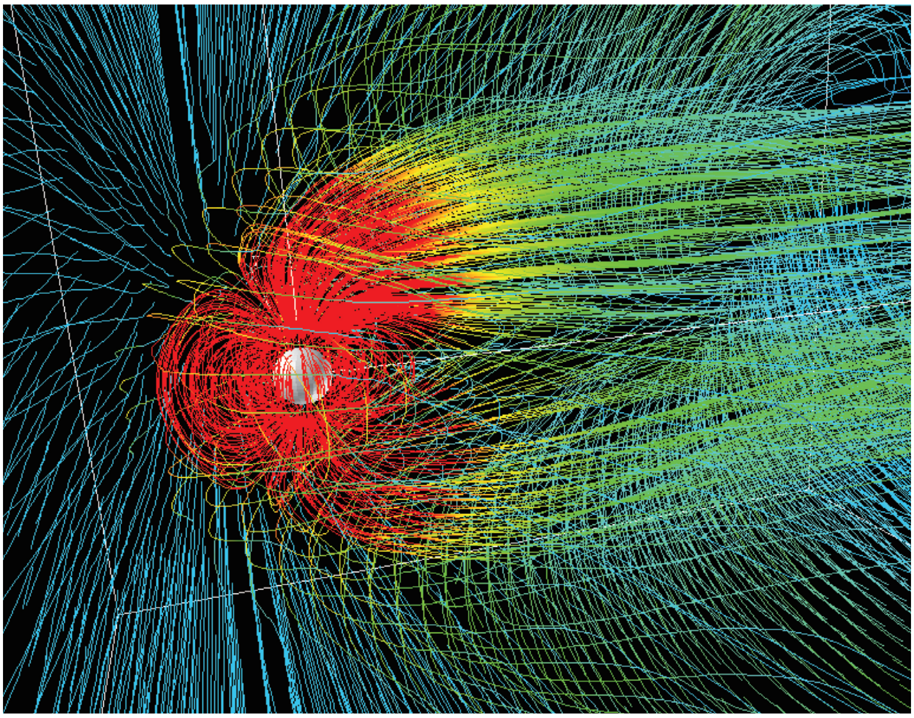

Fig.5 *Example of three-dimensional visualization of magnetospheric simulation results* [6] [7]

3.2 Grid technology

Grid technology allows flexible network access to diverse computer resources located on this network[8] [9]. In particular, so-called "data grid technology" links distributed storage resources via high-speed networks, treating these resources as a single enormous storage unit, or links two or more databases with different structures, handling them as a single virtual database. As space weather covers a wide range of fields from the Sun to the upper atmosphere, the introduction of this technology is expected to increase the efficiency of data retrieval and consequently of the research itself. In this context, we are now seeing progress in the "Virtual Observatory" astronomy project, which is designed to link all of the world's astronomy databases through standardization of the applicable database protocol. This project is expected to yield new discoveries from the abundant observation data accumulated in the past[10].

The "Access Grid" project, initiated by Argonne National Laboratory in the U.S., is aimed at the expansion of video conferencing systems and the facilitation of file and application sharing[8] [9]. This project makes use of IP multi-casting and wideband backbones for maximum scalability. As shown in Fig.6, the H.323 standard, adopted in many video conferencing systems, is the standard for one-to-one video conferencing. This standard requires multipoint connection unit (MCU) when connecting three or more sites, and the MCU node controls the image editing. On the other hand, Access Grid technology makes use of IP multi-casting, which allows for image editing at each node. The Access Grid also provides a number of functions to support remote presentations, such as simultaneous distribution of a presentation to multiple locations using Distributed PowerPoint (DPPT) and web-browser control using Shared Browser. We hope that these techniques will continue to be used to promote organized collaboration among distributed researchers in the space-weather field.

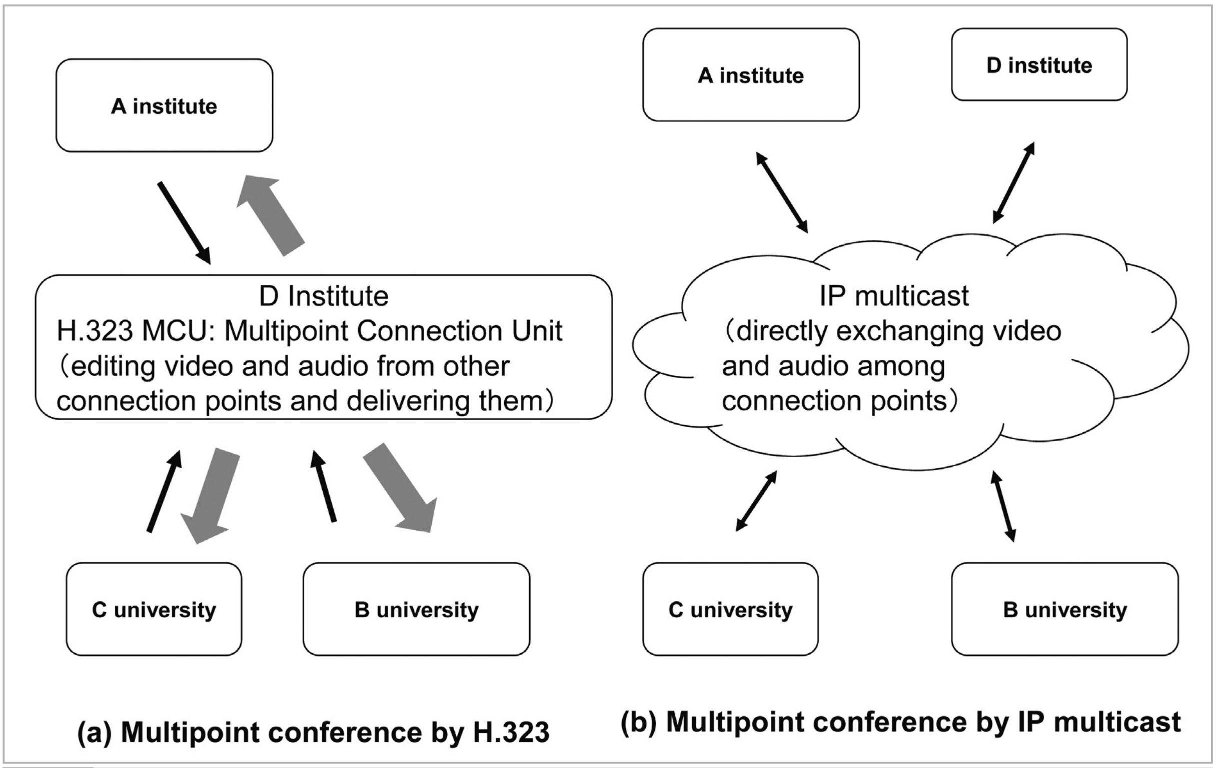

Fig.6 Differences between multipoint connection by H.323 and via Access Grid

3.3 International e-science space-weather campaign

From 1957 to 1958, the International Geophysical Year (IGY) international observation campaign took place, which involved observation networks being set up to measure the geomagnetic field, cosmic rays, and so on, and data centers being set up to archive and provide users with such data on request. At that time, the International Space Environment Information Service (ISES), consisting of the international network shown in Fig.7, provided support in the relevant exchange, contributing to the success of these joint international observations. However, no high-speed networks were available at the time; instead the necessary parameters were read from observed data, encoded into URSIGRAM codes, and exchanged via telex network.

Various international campaigns are scheduled to commemorate the 50th anniversary of the IGY, as shown in Table 2. In particular, the International Union of Geodesy and Geophysics (IUGG) is planning a campaign referred to as the Electronic Geophysical Year (eGY)[11]. One of the aims of this campaign is to make new discoveries by taking advantage of the significant advances in information and communication technology (ICT) that have taken place over the past 50 years. For example, one project involves the construction of a data-retrieval system that can instantaneously locate and identify data wherever it may be found (Fig.8). Other plans include the creation of metadata and digitalization of analog data collected in the past. Among the e-science campaigns shown in Table 2, the space-weather-information network using JGNII is expected to make a significant contribution to these aims.

4 Conclusions

High-speed network environments have yet to be employed in the field of space weather as widely as they are in astronomy. Accordingly, we hope that our activities will help promote the use of high-speed networks in the space-weather domain.

Fig.7 ISES space-weather forecast centers

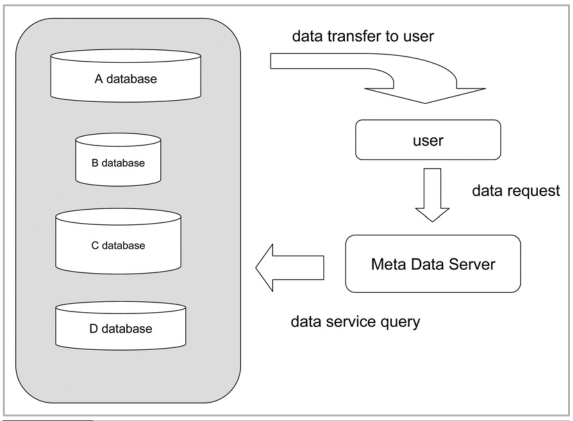

Fig.8 Conceptual diagram of the Electronic Geophysical Year (eGY)

Table 2 Campaigns commemorating the 50th anniversary of the International Geophysical Year (IGY)

Name of international campaign	Year
The Electronic Geophysical Year (eGY)	2007-2008
International Heliophysical Year (IHY)	2007
International Polar Year (IPY)	2007-2008
International Year of the Planet Earth	2005-2007

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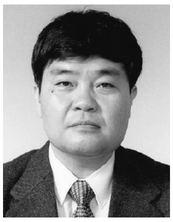

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