

# Development of “TVcation” Visual Communication System for Manufacturing Industry

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As broadband Internet services become more widespread, visual communications especially video conferencing are becoming more popular. With an aim of improving the efficiency of business in industry sectors, the authors have developed visual communication system software named “TVcation” as a solution to more efficient manufacturing. When dealing with information related to manufacturing business, the processing of still images and photographs is particularly important. TVcation supports for the JPEG2000 image compression algorithm and provides scalability, and therefore the quality of received image data can be freely selected even in an environment where the networks of different band widths intermingled.

## 1. Introduction

Recently, as the Internet becomes widespread and faster, visual communication technology as typified by videoconferencing is receiving widespread attention. Especially in business enterprises, there are demands for the introduction of video or web conference for the purposes of reducing business trip expenditures, travel times, carbon-dioxide emissions, and decision making times.

The authors have developed a prototype of a visual communication system (hereafter called “TVcation”) which aims at providing environment-friendly IT solution for raising business efficiency. This paper outlines the main functions of TVcation and describes the experimental use cases in the Sumitomo Electric Group’s member companies.

## 2. Overview

Although conventional videoconference is mainly based on communication through images and sound, as the processing speeds of computers increase, sharing of data such as presentation documents in videoconferences has become more common (Fig. 1).

One of the trends in the videoconference market is the use of high-definition (HD) video as in many telepresence systems. In telepresence, broadband transmission of high-quality image and sound data allows attendees to feel as if they are all in the same room. However, this type of videoconference device is costly, costing millions of yen or more (Fig. 2). Cost is an obstacle to the widespread use of telepresence in many businesses.

TVcation is the software program that runs on personal computers to transmit and receive still images, sound, video, and electronic documents for providing smooth communications between remote places. TVcation is used with personal computers that are increasingly faster in performance and lower in price. TVcation also supports other optional peripherals such

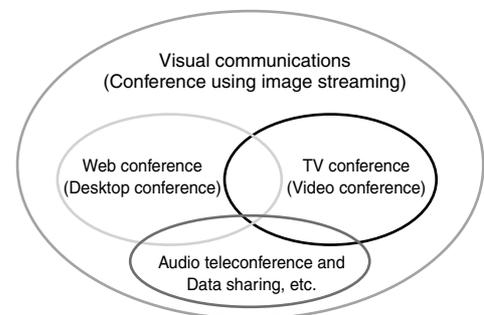


Fig. 1. Concept of visual communications

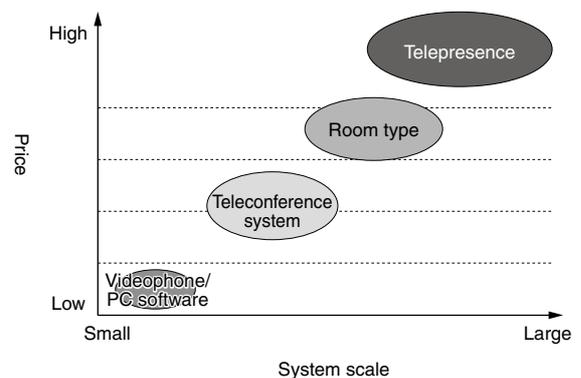


Fig. 2. Price range and system scale of videoconferencing systems

as whiteboards and projectors to provide a system that is easy to install and use.

When exchanging information in business, still picture information is very important as well as a person’s expression and gestures. In many cases, a lot of meeting time is spent on looking at whiteboard writings or meeting materials which are still picture information.

The videoconference system using TVcation can be used for technical meetings and conferences typical of the manufacturing sector, as well as production support of factories. In addition to live video pictures of attendees, which are already provided by conventional videoconferences, TVcation allows transmission of image information of facilities, equipment, parts, etc. as well as still images, electronic documents, and presentation materials. TVcation is aimed at daily meeting use as well as production support.

In the case of desktop videoconference, many functions can be carried out on a computer. Many desktop videoconference products come with complicated user interfaces and lack specialized functions. These become the problem because in actual uses, operations differ vastly among users, as some users may want to use the systems for holding presentation-like meetings, while others may want to provide equipment maintenance information and other technical helps to production lines.

Moreover, although broadband is common in Japan, there are many regions in the world where communication infrastructures are poor. In such narrow-band regions, network communications are of low quality and transmissions are slow. Therefore, it is necessary to have a system that can support a wide data transmission rate; from narrowband to broadband.

To provide the visual communication system that allows smooth information transmission from narrowband to broadband at a low investment cost, TVcation is built on peer-to-peer data transmission technology and JPEG 2000 image compression technology.

### 3. Technological Background

#### 3-1 P2P (Peer-to-peer connection)

Peer-to-peer (P2P), as shown in Fig. 3, is a network transmission architecture in which computers directly send and receive data between each other. In contrast to the server-type architecture, P2P does not need the server for communications.

In TVcation, the authentication and session initiation between computers are done via a server; afterward,

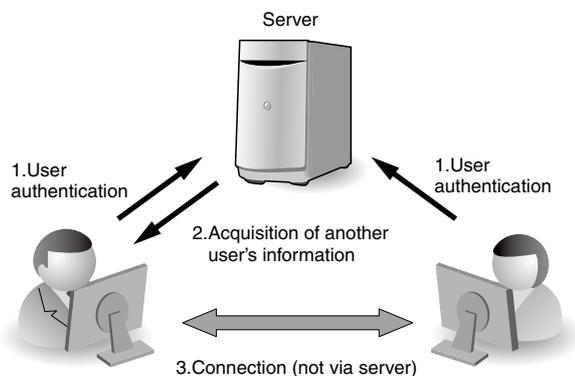


Fig. 3. TVcation connection method (P2P)

the sending and receiving of data such as video, sound, and still images are carried out directly between computers. Because computers exchange IP address information via a server, users do not need to know other computers' IP addresses to make a connection.

Figure 4 shows the connection diagrams and advantages/disadvantages of the P2P-type and server-type connection types. In P2P-type connection, the load on the server is small even if a large number of users use the system at the same time; this is because computers send and receive data directly to each others. Therefore, the advantage of P2P-type connection is that the service can be provided stably at a relatively low cost. On the other hand, when many computers are connected to the network, the network topology becomes a star-like topology and the volume of data greatly increases. As a result, high performance computers and wide network bandwidth are required in such cases.

However, it is generally said that there are less than six connections per videoconference in 80% of the cases of daily videoconferences. Moreover, overall data trans-

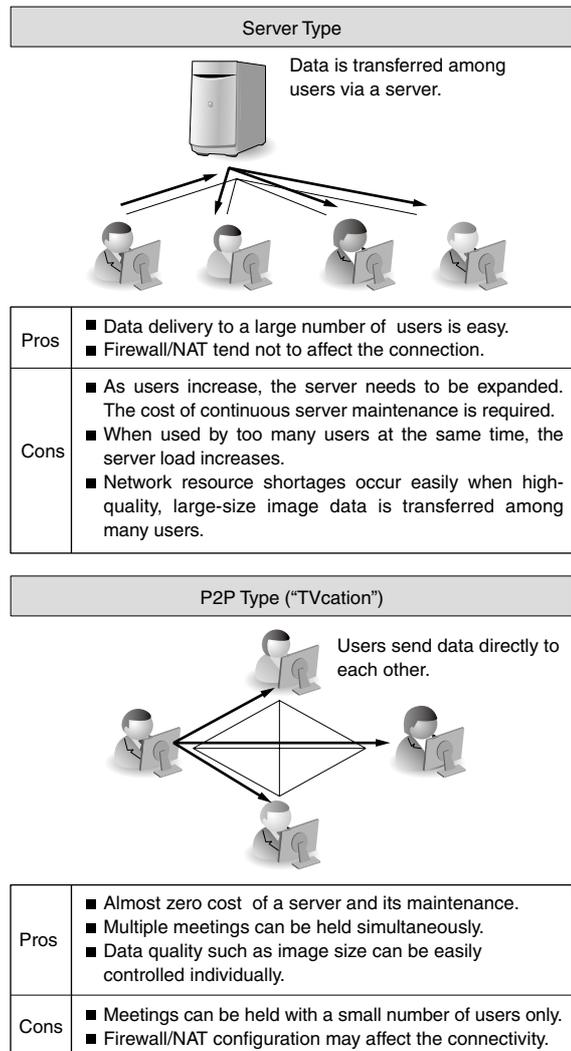


Fig. 4. Difference between server type and P2P type

mission rate can be suppressed by handling still images instead of video, as well as dynamically controlling video quality according to the network. From these observations, the authors have developed a system targeted at the use in videoconferences where the number of connections is less than six and the main use is the exchange of still picture information.

### 3-2 JPEG 2000 (Image compression technology)

TVcation uses JPEG 2000 video and image codec technology. JPEG 2000 can compress a still image at a high compression rate and form a high resolution image. This technology is best suited for handling the images of equipment and machine parts, as well as electronic documents. JPEG 2000 was standardized by the Joint Photographic Experts Group (JPEG) in 2001. Compared to the conventional JPEG format, the JPEG 2000 image compression/decompression format has a higher image quality and a higher compression rate. JPEG 2000 is applied to video data as well; it is selected as the recommended technological specification by Hollywood's Digital Cinema Initiative (DCI). **Table 1** shows the features of JPEG 2000.

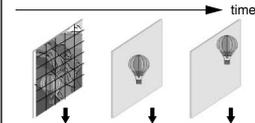
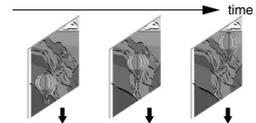
**Table 1.** JPEG2000 features

International standard	Made an international standard by the Joint Photographic Experts Group in 2001.
Still image compression	Images that have higher resolution than high-definition images can be compressed at a high compression rate.
Scalability	Images with different image quality, resolution and frame rate can be extracted from a single compressed image data.
Lossless compression	No image quality degradation after compression and decompression.
Recommended compression format for digital cinema	Selected as a recommended technology by the Digital Cinema Initiative (DCI), a consortium of Hollywood studios, in July 2005.

The conventional JPEG method uses discrete cosine transform (DCT) quantization/encoding by which an image is divided into small blocks and then the frequency components are analyzed. The JPEG 2000 method uses wavelet transform encoding by which the entire image is divided using wavelet function and each frequency component is quantized. As a result, block noises that appear when encoded by JPEG at high compression ratios (i.e. low image quality) do not occur in compression by JPEG 2000. In addition, JPEG 2000 provides loss-less compression that enables decoding without any loss of original image data.

MPEG and H.264 shown in **Table 2** are generally used for video compression. Because MPEG and H.264 use information such as difference between frames for motion prediction and other features, compression ratio is extremely high for video with slow or little motion. H.264 is also the standard for video compression used by Blu-ray discs, which gives H.264 a name "culmination of DCT encoding method." It is said that

**Table 2.** Comparison with H.264/MPEG-4 AVC

	H.264/MPEG-4 AVC	JPEG 2000
Compression format	 <p>Discrete cosine transform Compression is applied separately to 8x8 blocks.</p> <p>Compression is applied only to differences between multiple frames, extracted by motion prediction and other techniques.</p>	 <p>Wavelet transform Compression is applied to each frequency component.</p> <p>Compression is applied to one frame at a time.</p>
Compression ratio	<ul style="list-style-type: none"> <li>Still image: Low (about JPEG level)</li> <li>Streaming image: High</li> </ul>	<ul style="list-style-type: none"> <li>Still image: High</li> <li>Streaming image: Low compared to H.264</li> </ul>
Editing	<ul style="list-style-type: none"> <li>Extracting an arbitrary frame image is difficult</li> </ul>	<ul style="list-style-type: none"> <li>Extracting an arbitrary frame image is easy</li> </ul>
Standard	<ul style="list-style-type: none"> <li>Blu-ray and other DVD formats</li> </ul>	<ul style="list-style-type: none"> <li>Digital Cinema</li> </ul>

no other video encoding methods exceeding H.264 is expected to appear for the time being. However, H.264 is said to have poor performance in dealing with video that has large difference between frames, such as fast motion video.

One of alternative video compression methods is Motion JPEG 2000 based on JPEG 2000. JPEG 2000 produces video by continuously reproducing every frame. Although H.264 has better compression ratio, it is easier to extract a single frame from a JPEG 2000 format. In addition, since every frame is compressed in JPEG 2000, sequences with fast motion are not affected.

Other notable feature in JPEG 2000 is scalability, which allows an image of arbitrary quality to be extracted from a compressed image data. With scalability, multiple images with different image quality and resolution (image size) can be extracted from one compressed image.

### 3-3 Application of Scalability

With the globalization of corporate management, remote conferencing is not limited within a country. More conferences are being held globally between two remote places in regions such as Europe, North America, and Asia. Moreover, as mobile communications become widespread, it has become common for a business person to do work-related tasks during business travels or hold meetings with office members while being outside the office by using wireless LAN or mobile card.

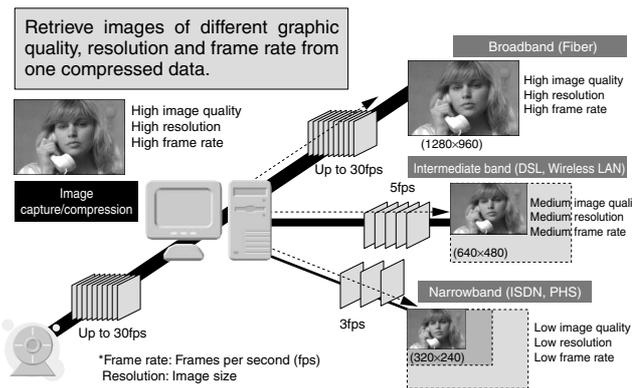
In these surroundings, it needs to be noted that unlike Japan where fiber-based broadband is becoming popular, there are many regions in the world where narrowband, private lines and dialup with phone lines, is the common Internet connection. Especially in the cases of offshore factories or construction sites, not only the connection is narrowband but also the network quality is poor. When places with different connection speeds and network quality are connected with each other, communications may become unstable with past videoconference systems. Problems such as low image quality due to narrowband connection or noises in images due to poor network quality may also arise.

TVcation uses the scalability function of JPEG 2000

for P2P data transmission between remote hosts with different network speeds. Image quality is changed according to network capacity: It is lowered in a narrowband environment and maximized in a broadband environment. Also, according to the usage purpose and conditions, image quality such as (1) graphic quality, (2) resolution, and (3) frame rate can be freely changed from the receiving side using the scalability function.

For instance, in the case of a remote conference involving Tokyo, Osaka, and Shanghai, attendees in Tokyo and Osaka may receive high quality images through broadband while those in Shanghai who use narrowband connection normally obtain images which quality and resolution are set to low. When attendees in Shanghai wish to see accurate images, like the facial expressions of attendees in Tokyo/Osaka or the small details of a product's prototype, image quality and resolution may be improved by reducing video's frame rate. **Figure 5** shows the conceptual outline of image transmission using scalability.

In summary, TVcation can be used under a situation with different network speeds and made remote conference possible in an environment that uses both broadband and narrowband connections.



**Fig. 5.** Image transmission using scalability

## 4. Design of Visual Communication System

### 4-1 Functions

In daily business affairs, conferences and meetings are held for various purposes. Some of the examples are following: presentations at board member meetings, intra-departmental business report meetings based on production and sales plans, R&D design reviews using product prototypes and design sheets, technical discussion meetings, in-factory technical guidance, and client meetings. Information exchanged is different in each case but there are three types of information exchange which are common in all the cases: (1) Presenting documents and drawings created by PowerPoint, Excel or CAD, (2) writing or drawing on a whiteboard, and (3) visually displaying product samples, equipments, facilities, etc. Auxiliary actions taken before and after meetings include handing out documents, taking minutes and keeping records.

### Basic Requirements for Conferences and Meetings

1. Presenting documents and graphics.
2. Writing on a whiteboard.
3. Showing equipment and parts.
4. Passing out conference materials and minutes.
5. Making notes and doing the minutes.

**Fig. 6.** Basic requirements for conferences and meetings

ties, etc. Auxiliary actions taken before and after meetings include handing out documents, taking minutes and keeping records.

TVcation is designed to have functions specializing in smoothly performing these tasks related to conferences and meetings. **Table 3** shows the main functions of TVcation.

**Table 3.** TVcation Main Functions

		Function
1	Presentation	Present documents
		Present the contents displayed on a computer screen
2	Whiteboard	Write on a whiteboard
3	Snapshot	Visually present equipment and parts
4	File transfer	Pass out meeting materials and minutes
5	Image saving/management	Make notes and do the minutes of the meeting
6	Video/audio conference	Visual and audio communications

### (1) Presentation

PowerPoint presentations are commonly used at conferences and meetings for giving information to the other parties. With TVcation, presentation materials displayed on a computer screen are transmitted to the other attendees for viewing. Besides PowerPoint presentations, information such as design specifications and 3D CAD images need to be shared during technological discussions; TVcation allows interactive sharing of screen contents.

### (2) Whiteboard

There are increasing numbers of interactive whiteboards which can be used at videoconferences. As shown in **Table 4**, interactive whiteboards can be classified into roughly two kinds: One is the retrofitting into an existing normal whiteboard and the other is the dedicated interactive whiteboard. Furthermore, the latter interactive whiteboard breaks down to several types: Large panel type, widescreen flat-panel TV screen type, and liquid crystal pen tablet type. TVcation can be linked to these interactive whiteboards to allow data written on a whiteboard to be shared among attendees during a remote conferencing.

### (3) Snapshot

Recent web cameras on the market are increasingly

**Table 4.** Major types of interactive whiteboards

Type		Description
Sensor terminal retrofit to existing whiteboard		A sensor terminal to be retrofitted to an existing whiteboard. The sensor detects information written by a standard whiteboard pen on a whiteboard and transfers this information to a computer.
Interactive whiteboard	Large panel type	A special pen is used for writing/drawing on the panel. The actual writings/drawings are displayed using a projector.
	Widescreen flat-panel TV screen type	A touch panel placed on a widescreen flat-panel TV screen (plasma or liquid crystal) that enables both display of computer screen contents and writing/drawing on the screen.
	Liquid crystal pen tablet	A liquid crystal display with pen tablet capability.

high performance and can be purchased at around several thousand yen. There are cameras with resolutions exceeding two million pixels, and some products allow recording of eight-million pixel still images.

Using such commercially-available web cameras, TVcation achieves recording of still images with a high resolution (QUXGA: 3200 by 2400 pixels), which is about three times that of high-definition television (HDTV) images. As for image quality, by using lossless JPEG 2000 compression, it is made possible to share high-definition image data (such as images of product samples and component part defects) at remote conferences without losing any of original image data quality. When more than one camera is connected, images of not only attendees but sample products or equipment as well can be displayed by switching cameras.

(4) File Transfer

TVcation uses P2P to transfer data directly to and from other computers. This makes it possible to send large-size data file which cannot be sent as e-mail attachment.

(5) Image Storage/Management

Video and still image data used in this system can

be saved in JPEG 2000 format as still-image snap shots. Stored images are managed in an integrated fashion by a special software program called Library, and can be reused. Moreover, it has a function to convert various electronic files into JPEG 2000 images.

(6) Videoconference/Audio Teleconference

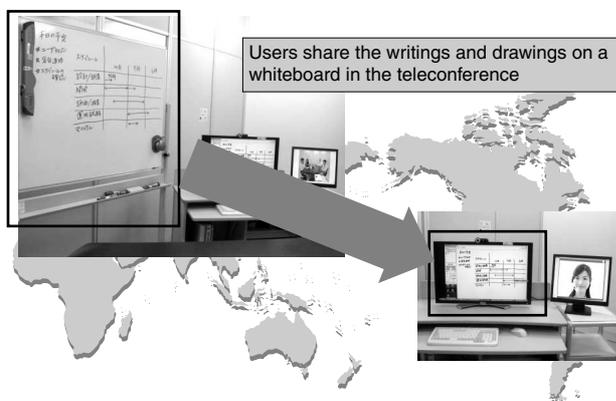
Videoconferences and audio teleconferences can be conducted by using the video and voice transmission function of TVcation. The prototype allows multipoint videoconferences connecting up to six sites. Frame rate (images per second) can be arbitrarily changed in a range between a maximum rate of 30 frm/sec and a minimum of one frame per 10 seconds. In a test using the prototype, it was verified that use between two portable wireless LAN terminals is possible by reducing the frame rate.

**4-2 Composition**

TVcation is a software program that works on a personal computer running Windows and allows use of various peripherals. **Table 5** shows the basic configuration with optional peripherals. The minimum configuration requires a computer and a display. In this configuration, it is possible to construct a data sharing environment by adding a phone or an audio teleconference/videoconference system.

**Table 5.** Main peripherals

Basic	Personal computer	
	Display monitor (can be more than one)	
Optional	Input device	Interactive whiteboard
		Camera / Video (can be more than one)
		Microphone / Audio
		Pen tablet
		Scanner
	Output device	Projector
		Speaker
		Printer



**Fig. 7.** Teleconference using whiteboard

**4-3 Multi-Display Function**

Recent computers allow two or more displays to be connected. TVcation supports the multi-display function and show different images on each display.

**Figure 8** is an example of a configuration with two displays. The image of the other party and the presentation material are displayed on separate screens. This configuration consists of a computer, a display, a microphone, a speaker and a web camera and assumes use in conference rooms.

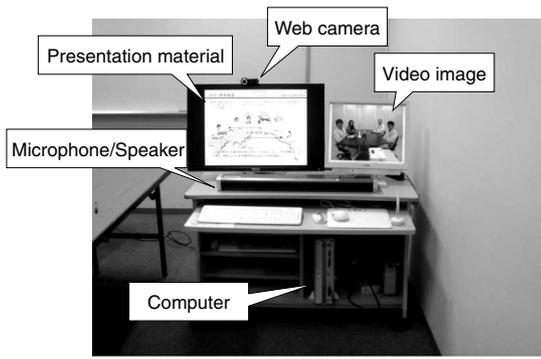


Fig. 8. Example for system configuration in meeting room

## 5. Case Example

### 5-1 Factory Support

At Toyokuni Electric Cable Co. Ltd. that has manufacturing bases all over Japan, there are many cases where one production engineer is responsible for more than one factory. Therefore, whenever production line trouble occurs, frequent business trips are made that cause high expenses. The other problem is that the production line stops until the production engineer arrives. In order to find a solution to these problems, the authors, in cooperation with Toyokuni Electric Cable, are conducting a study on the application of TVcation for providing guidance for technical issues and emergency facility restoration from remote location. The following is an example of the case where a production line trouble was remotely solved by giving instructions for emergency restoration measures.

As shown in Fig. 9, the person at the factory used TVcation on a handheld computer with built-in wireless LAN. A handheld computer was selected for easy maneuvering in confined spaces between machinery. The person at the factory explained the problem to the production engineer in remote location, showing the live image of machinery.

The production engineer then found the fault location in machinery by viewing the live image and talking with the person at the factory. In this case, there was similar machinery set on the production engineer side, and the production engineer instructed the emergency

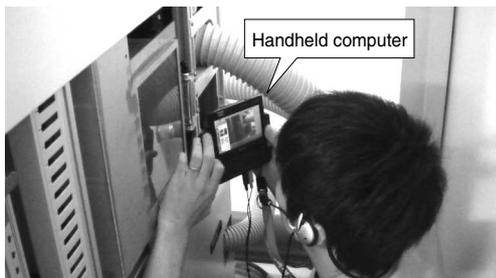


Fig. 9. Use of handheld mobile computer with built-in wireless LAN

recovery procedure using the image of this machinery. The image was shared by both sides using the image transfer and sharing function of TVcation. The recovery instructions were efficiently given in real time, and the person at the factory was able to follow the instruction while viewing the machinery's live image.

As shown in the above example, TVcation offers high-resolution image and clear voice quality, and is suitable for use not only in conference rooms but also in points of production such as fields and factories.

Moreover, TVcation is currently used experimentally for business performance reporting between factories for the purpose of replacing business trips with video-conferences to save both expense and time.

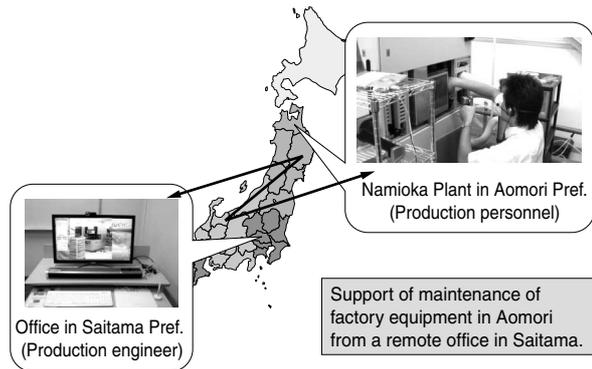


Fig. 10. Use for factory support

### 5-2 Conference

In the R&D Group of Sumitomo Electric, TVcation is being experimentally used to link the facilities in Yokohama, Osaka and Itami via a virtual private network (VPN) over the Internet (Fig. 11). In an Internet VPN environment, all data is encrypted before being transmitted so that two or more remote networks are connected like a single LAN and provides safe network access. Since it uses the Internet as a backbone network, the operational cost of an Internet VPN is much lower compare to an exclusive leased line.

Currently it is used mainly by the Analysis Technology Research Center in monthly reporting sessions and meetings to communicate images, audio and

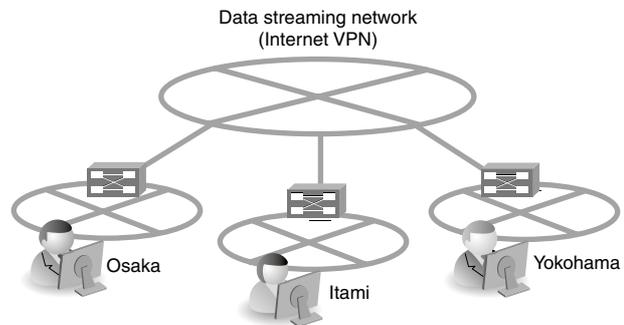


Fig. 11. Evaluation streaming network

PowerPoint presentations with remote locations. **Figure 12** shows the photo of a videoconference using TVcation.

In addition, because the size of data can be reduced without losing the quality of information, it reduces the need for energy-consuming transportation and lowers the impact on the environment.



**Fig. 12.** Use in videoconferencing

## 6. Conclusion

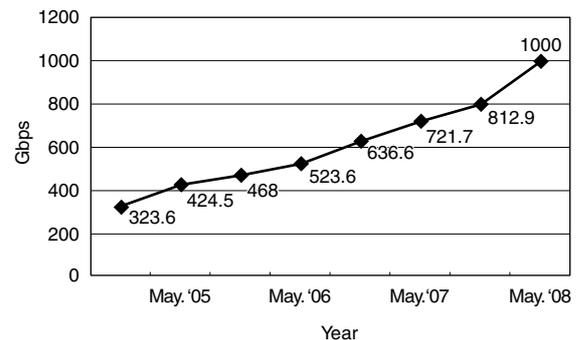
For providing support for raising work efficiency in the manufacturing industry, the authors have developed the TVcation visual communication system that uses the JPEG 2000 image compression format and peer-to-peer network connection. Through experimental use in the Sumitomo Electric Industries Group, it was confirmed that TVcation is effective in supporting business in the field of manufacturing. By using JPEG 2000 scalability, even in a network with different network speeds, the receiving side can freely select the quality of image data in terms of combination of (1) graphic quality, (2) resolution and (3) frame rate. This technology enables use in low-speed networks.

The authors aim to provide in the future more advanced and user-friendly visual communication systems. These systems will have customizable user interfaces to correspond with various user demands and provide digital watermarking and personal authentication for higher security.

The spread of broadband has enabled high-volume data to be transmitted from information terminals. This has exposed the problem of environmental impact of telecommunication technologies. The power consumed by IT equipment including information terminals presently accounts for 5% of Japan's total power consumption, and is said to quintuple by 2025. **Figure 13** shows the past increase of Internet traffic in Japan. As a result, it is becoming important to develop low-power, high-density telecommunication technologies such as a technology for saving energy in data center servers.

Using visual communications is effective in reducing the consumption of energy for transportation. By taking an approach different from those in the past, the authors aim to design a system that not only transmits

large-volume data but also reduces data size without affecting quality, and thus contributes reducing environmental impact.



Source: MIC (Ministry of Internal Affairs and Communications)

**Fig. 13.** Transition of Internet traffic in Japan

## Glossary

### \*1 Discrete Cosine Transform (DCT)

DCT is one of the orthogonal transformation which converts data such as images and voices into a frequency element. It is used in the image compression technologies such as MPEG and JPEG as well as in the audio compression technologies such as MP3.

In the image compression, the orthogonal transformation is done by DCT with a small block unit (e.g. 8×8 pixels) of the image and the frequency element is obtained. The obtained frequency element is then quantized and encoded for the compression. By allocating few or no encoding bits for the image area with less information, high compression rate is realized.

### \*2 MPEG

MPEG is one of compression methods for image data. Moving Picture Experts Group, the standardization body set up by ISO (International Organization for Standardization), is used as the name of the compression method.

Standards from MPEG-1 to MPEG-4 are provided; examples are MPEG-2 for DVDs and MPEG-4 for the video streaming.

### \*3 H.264

H.264 is one of compression encoding methods for video data. It was recommended by ITU (International Telecommunication Union) in 2003. It was also recommended by ISO as part of MPEG-4 (MPEG-4 Part 10 Advanced Video Coding), thus it is generally described both in parallel like "H.264/MPEG-4 AVC".

\*Windows, Excel, and PowerPoint are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

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