R&D Spirits

Toward Innovation in Broadcasting through IP Technology

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Internet protocol (IP) technology is expected to generate much innovation in the world of broadcasting. One example is NTT's Internet video studio system called "i-Visto" that can transmit uncompressed HDTV (high-definition television) at broadband speeds of 1.5 Gbit/s. How will i-Visto and its peripheral systems cause broadcasting studios to evolve? Will innovative systems such as these influence fields outside broadcasting? We put these questions to senior research engineer, supervisor, Mitsuru Maruyama, a group leader in NTT Network Innovation Laboratories.

Application of IP to uncompressed HDTV for the broadcasting field

—Dr. Maruyama, could you outline your current R&D work for us?

We are developing an Internet-based HDTV (high-definition television) video studio system called i-Visto (Internet video studio system for HDTV production) as part of our research into high-speed protocol processing technology. The i-Visto system was designed to enable IP technology to be applied to broadcast stations and other video-production studios. Its outstanding feature is the ability to handle uncompressed HDTV at 1.5 Gbit/s (**Fig. 1**). Existing transmission systems for broadcast use are based on electrical signals and coaxial cables, which limit transmission distance to 100 m. The i-Visto system, in contrast, can send signals to the other side of the world over an IP network. It also uses packet/multiplexing technology, which enables it to synchronize and send multiple video and audio signals along a single fiber in compressed or uncompressed format, thereby negating the need for fixed, large-capacity circuits. And as a service that only IP can provide, i-Visto enables realtime distributed control of video streaming using the IP switching network. The i-Visto system is also based on personal computers (PCs), which enables considerable cost savings.

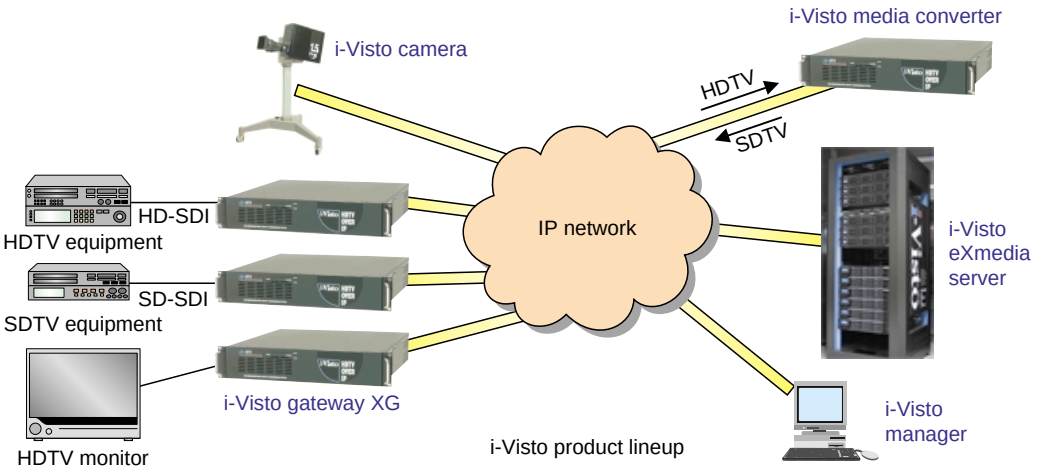
At the same time, we are developing a streaming server to support uncompressed HDTV. Based on a PC cluster, this server can store and deliver ten 1.5-Gbit/s broadband video streams. Servers that can directly handle uncompressed broadband video in this manner have yet to appear elsewhere in the world.

—What are some of the key technical points of this research?

In the past, high-speed transmission at the 1.5-Gbit/s level was difficult to implement due to performance limitations in central processing units (CPUs) and bus bandwidth. We were able to perform high-speed protocol processing in 2001 through the use of long 64-KB packets in MAPOS (multiple access protocol over SONET/SDH[*1]), an NTT technology. This

*1 SONET/SDH: both synchronous optical network and synchronous digital hierarchy

- Transmits/stores/delivers uncompressed HDTV streams in real time (press release Oct. 2001)
- Easy integration with common IP-based systems such as WWW, database, computing resources
- Low-delay (less than the time taken to display one HDTV video frame)
- PC-based cost-effective system
- Many field tests in cooperation with broadcasting stations (NAB and JGN II)



SDTV: standard-definition television

Fig. 1. Overview of i-Visto.

is probably the most significant point in this research. Another important point is NTT's in-house development of a streaming-oriented video interface card applying telecommunication-card technology. We developed this card because no video interface boards specifically for transmission purposes existed, and every time we used a commercially available board we always got a big processing delay no matter how hard we tried. To get what we needed, we developed this card from scratch, and as a result, we were successful in reducing the delay from around five frames to less than one frame.

In addition, the system that we developed was designed for broadcasting purposes from the outset. Our group has even been using it on a daily basis as a videoconferencing system connecting NTT's Musashino and Yokosuka R&D sites. This system has none of the delay common in existing videoconferencing systems and provides exceptionally smooth conferencing, even allowing the mutual interruptions that occur naturally in conversation. The video itself is also much better. Facial expressions of people at the other end are easy to make out and even text written on a white board is clear. All this contributes to a high-reality experience. Because of these great features, I sometimes feel that the system is more suitable for casual but highly interactive communication like brainstorming rather than formal communication as in meetings and presentations.

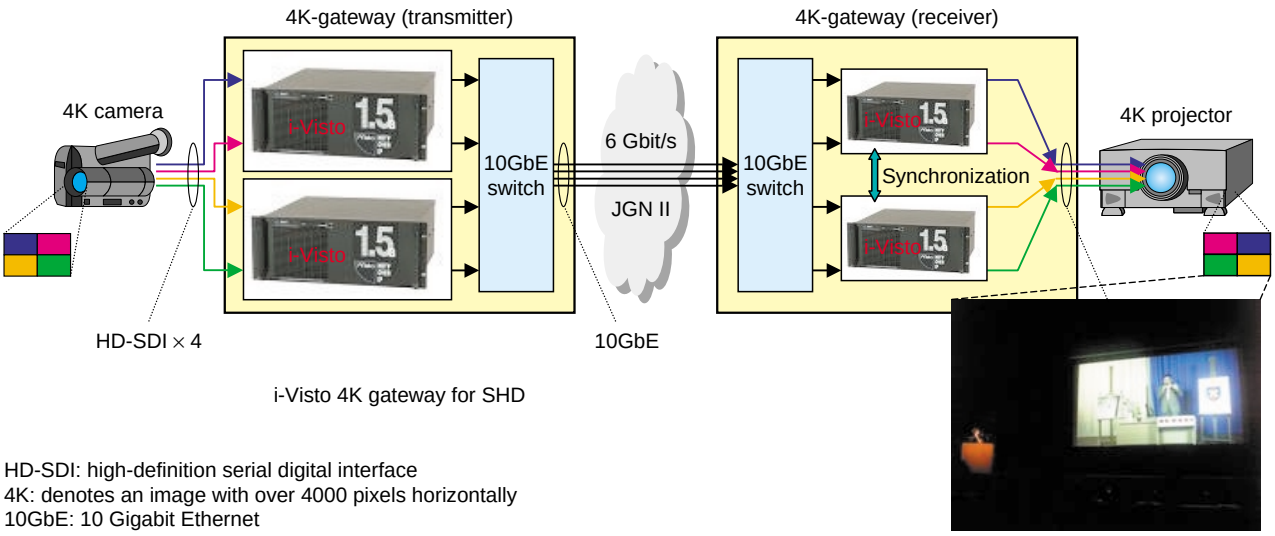
—What problems are you dealing with?

Well, since the i-Visto system is already in its implementation stage, the current problems are to work out the details and produce a product suitable for the open market. This task will be taken up mainly by NTT Network Service Systems Laboratories, whose mission within NTT is to turn the fruits of R&D into practical, working products. As a result, our group is now taking up "computing" as a new target in this field. In short, now that we have completed our work in transmission and storage, we would like to try our hands at achieving "stream computing[*2]" over an IP network. One other problem is the trend toward even higher resolution. In this regard, we are moving forward with research on video transmission at four times the definition of HDTV in collaboration with another group in NTT Laboratories (**Fig. 2**).

*2 Stream computing: distributed processing environment for streaming media

Jan. 2006: “i-Visto 4K gateway clusters” capable of handling a 6-Gbit/s uncompressed super-high-definition (SHD) stream (http://www.ntt.co.jp/news/news06/0601/060119.html)

The fastest uncompressed video transfer trial over an IP network except HD-SDI



HD-SDI: high-definition serial digital interface
4K: denotes an image with over 4000 pixels horizontally
10GbE: 10 Gigabit Ethernet

Fig. 2. JGN II Symposium in Sendai, Japan.

Making the world’s fastest PC-based system with an eye to international standardization

—Dr. Maruyama, could you tell us about R&D trends in high-quality video transmission in Japan and overseas?

Well, other than NTT, research on transmitting uncompressed data in a PC-based manner is now being conducted at the University of Washington and the University of Southern California (USC), but at present, I would have to say that our system is the fastest. The present situation, moreover, is such that the various research projects are going their own way, but the Asia-Pacific Advanced Network (APAN), an international organization, may hold discussions at upcoming meetings on establishing mutual interconnection between the various systems. Details have not yet been worked out, but it looks like some kind of standard is in the works.

—What kind of response have you received to your research achievements to date?

Over the last few years, we conducted various trials in Japan and elsewhere centered on broadcast stations and received high praise wherever we went. At the NAB2004 electronic media show, for example, we used i-Visto to establish a 15,000-km optical-fiber connection between the Las Vegas Convention Center and a broadcast station in Tokyo and had TV announcers at these sites converse with each other (**Fig. 3**). It is generally said that delay must not exceed 100 milliseconds if professional announcers at two sites are to have a natural, interactive dialog, but our system achieved a delay as low as 80 milliseconds. The participating announcers commented that “it was like the other person was right next to me.”

Back in Japan, we conducted a 10-Gbit/s network experiment between five points for the InterBEE2004 exhibition. And in 2005, we connected a broadcast station in Osaka with an exhibition hall at Aichi Expo 2005 in Nagoya and broadcast television programs to the hall every day for about half a year. In this trial, we also multiplexed camera control signals with the program signals and never lost a packet, demonstrating that the system is suitable for professional use.

—Are you engaged in any collaboration with other companies or research institutions?

We have often collaborated with broadcast stations to hold trials as I just mentioned, and in the world of academia, we are working on a joint project with Pro-

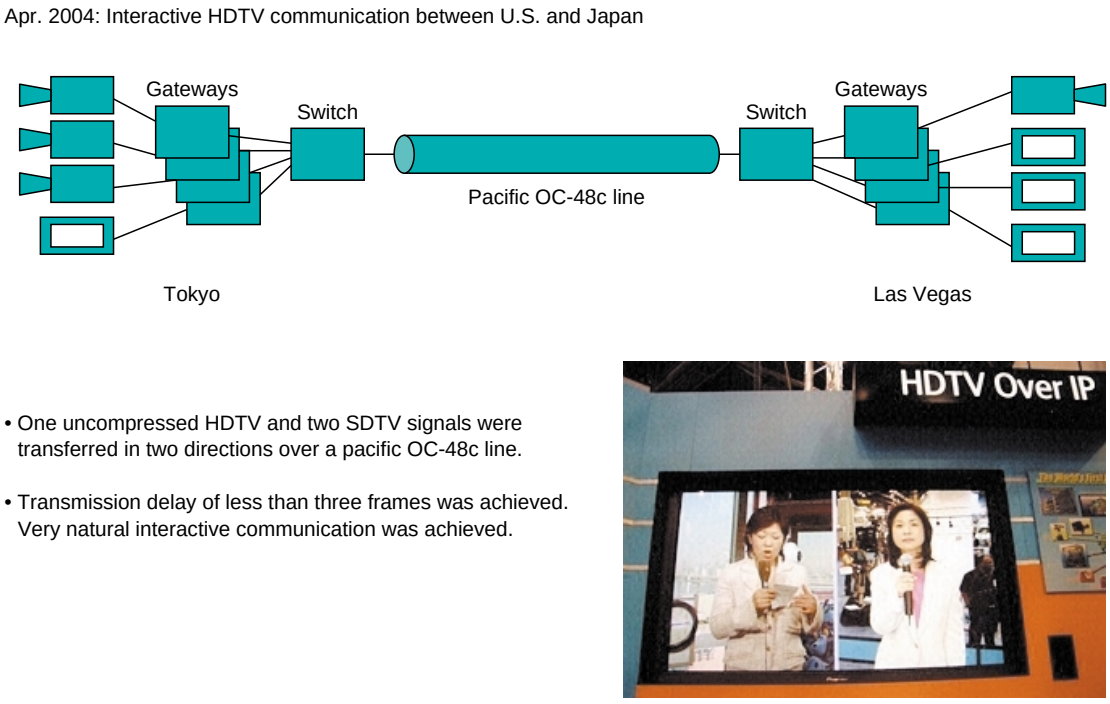


Fig. 3. NAB 2004.

fessor Jun Murai of Keio University to research applications for remote education. Professor Murai was deeply impressed with the low delay of the remote lecture system that we provided at the JGN II[*3] Symposium in January 2005. In this way, low delay is coming to be recognized as an important aspect of broadcast quality, and for this reason I think our system will attract more attention, which will in turn lead to more collaboration.

—On the other hand, are you faced with any competition at this time?

Product development that targets the multiplexed transmission of uncompressed video data in a PC-based system has just begun. The commercialization of transmission equipment in our system, for example, began only in 2005, and the server has yet to be put on the market. In addition, research sites that are targeting the broadcast field are themselves few in number, and I think it is safe to say that there is no substantial competition at this time. As the market begins to develop, however, I think there is a good chance that we'll begin competing with a number of companies, and for this reason, we have already submitted patent applications. At the same time, our main mission is to create new IP services that use the equipment that we develop. I believe that it is more important for us to spread the use of uncompressed, multiplexed transmission in society than to compete in the development of hardware.

Better communication with better systems

—What kind of research were you involved with in school?

My major was applied electronic engineering. The professor in charge of the research laboratory happened to be well versed in the UNIX operating system (OS), and his enthusiasm for programming rubbed off on me. As part of my graduate thesis, I actually created a realtime OS. And then, in the middle of the minicomputer age, I used that OS as a basis for building from scratch a personal computer using CP/M on my own. I was given the opportunity of presenting this computer at an academic society and the favorable reception that I received was a truly great experience for me at that time. Later, for my master's

*3 JGN II: Japan Gigabit Network II operated by NICT

thesis, I researched data flow here at the Musashino R&D Center while I was visiting NTT Laboratories along with several foreign students who were in the same research laboratory at the university. It was during those visits that I was first exposed to the amazing facilities and research environment at NTT, and I joined the company with that sense of awe.

—What research themes have you taken on at NTT Laboratories?

Soon after entering the company, I was assigned to the composite-switching research group, where I was engaged in the R&D of protocol processing for ATM-based high-definition videotex system and video-on-demand systems for more than 10 years (ATM: asynchronous transfer mode). After that, I moved over to what was then NTT Software Laboratories, and since then, I have been involved in the research of ultra-high-speed computer networks (MAPOS), i-Visto systems, and multi-agent systems. I have been here at Musashino the whole time. However, I have experienced organizational restructuring several times, and I have been involved with both core technology and application development, but it did, I admit, broaden my R&D experience.

—How did your current research begin?

With conventional video broadcast systems, broadcast content was delivered to customers' homes in compressed form, even though that video content was usually handled in uncompressed form within the studio. Audio and video were also handled separately, and as for switching, all video programs had to be stored at one place and centrally controlled. As a result, the assistant director at a broadcasting site would always have a good number of coaxial cables on hand and would forever be rearranging them as needed. If IP could be introduced, it was thought, then surely work of this sort could be done in a more efficient and economical manner. This type of thinking opened the door to my current research.

—What has been your main pursuit in your R&D work up to now?

My prime pursuit has been speed. Earlier I mentioned protocol processing in MAPOS. Here too, the emphasis is on ultrahigh-speed switching technology, and in my current research, the problem of how to go about achieving a high-presence or high-reality feeling is none other than the problem of how to increase processing speed and reduce delay. Why this obsession with speed? Because eliminating time lag is one sure way of broadening the scope of communication. In brainstorming, for example, where the atmosphere of the meeting and verbal exchanges are important, smooth interaction and realtime interpretation and translation should be able to overcome both language and distance barriers and facilitate immediate decision making. In this way, my pursuit of speed should not be confused with simply a desire to create something that is faster than anything that has come before. What has motivated me in my R&D work is to help provide a better means of communication through speed!

—What are your current objectives?

Since I obtained my doctorate through my research on high-speed protocol processing, one of my current objectives is to find out just how fast protocol processing can be taken. In particular, I would like to take protocol processing—which is more than simply a matter of transmission—from its current level of 10 Gbit/s to the 100-Gbit/s or even 1-Tbit/s level. Another of my objectives is to take up the subject of intelligence in the network. Some members in our group are currently researching an inter-AS (autonomous system) routing error diagnosis system called ENCORE. Today's Internet is not capable of managing inter-AS routing information, but ENCORE can automatically check and guarantee the flow of routing information by placing agents throughout the network. And still another objective is to combine high speed and intelligence in the network. We call this a "thinking network" that can automatically detect, diagnose, and repair faults and congestion in high-speed, broadband streaming communications.

Enthusiasm for one's work is the best motivation

—Dr. Maruyama, what do you envision for the near future?

To begin with, I would like to see the concepts of stream computing and a thinking network used to achieve a network backbone that can provide high-speed streaming services with no interruptions at all. Bringing research on this to the deployment stage within about five years is therefore one of my short-term objectives. And within ten years or so, I would

like to see all broadcast stations connected to the IP network. I can imagine, for example, the transfer of video data from a news-gathering site to the i-Visto system via a wireless connection. If that can be achieved, I think the face of broadcasting will change significantly. And once it has been achieved, it would be natural to extend such a system for mass use. Here, the 1.5-Gbit/s band that is currently being used in one clump could be divided up by a user to deliver personalized streaming content. One example would be communicating with grandparents in the country by high-reality audio and video streaming while also editing and sending a video of their grandchild in real time for their enjoyment.

I would like to have a good eye for the future with respect to our R&D efforts. But R&D in a corporate setting demands that feedback on achievements be continuously obtained lest we depart from the flow of the current era and get left behind. For this reason, our approach is to release products for every R&D milestone that we reach with the idea of advancing closer to our final objective while receiving feedback on developed technology. The i-Visto system is one such milestone.

—What would be your ultimate theme as a researcher?

I would love to construct a stream-oriented network processor. The handling of streaming data is entirely different from conventional data processing, which means that an entirely new form of architecture is needed. I don't even think that I could apply the concept of data flow that I myself researched earlier. Of course, software too will be needed, which means that a new compiler will have to be developed. Whether I can actually do this I'm not sure, but given the opportunity, I'd definitely like to try.

—What is it like working at NTT Laboratories for you personally?

NTT Network Innovation Laboratories that I currently belong to also conducts core technology development, and it allows new ideas to be actively tested. As for research style, it's a place with much freedom. In our group, for example, we advocate an "atelier" or workshop approach and construct much of our hardware ourselves. Of course, it might be much simpler to depend on manufacturers for this equipment, but we would miss the chance to gain new know-how. Attempting to build equipment on our own also deepens our understanding of any problems that arise. Nowadays, a lot of emphasis is being placed on efficiency in the R&D process, but thinking only of efficiency is hardly conducive to cultivating researchers that can discern the true nature of things. In this regard, I am grateful for the understanding that NTT Laboratories has of the research process, and at the same time, I think that our research tradition must be passed on to the younger generation of researchers.

—Dr. Maruyama, what would you like to say to young researchers?

Please find a research area that you can pursue with great enthusiasm. With research like that, you will apply the abilities that you have to the fullest, and those that you don't have you will supplement through study. That is how you will improve your research skills. And to maintain your identity as a researcher, you should not worry about your status within the organization or aim for high remuneration, but should instead engage in research that you yourself enjoy and that enables you to improve your abilities to the utmost.

Interviewee profile

■ Career highlights

Mitsuru Maruyama received the B.E. and M.E. degrees in electrical engineering and the Ph.D. degree in computer science from the University of Electro-Communications in 1983, 1985, and 1999, respectively. He joined NTT Laboratories in 1985 and has been engaged in R&D of a high-definition videotex system, video-on-demand systems, and an IP-based realtime video transmission and archiving system. He is a Group Leader in NTT Innovation Laboratories, where he is currently studying fast-protocol processing system architectures and multi-agent systems. He is a member of the IEEE Computer Society and Communications Society, the Association for Computing Machinery, the Institute of Electronics, Information and Communication Engineers of Japan, and the Information Processing Society of Japan.