An Overview of Research at NHK STRL on Technologies for Fusing Broadcasting and Communications

I describe the state of research and development at NHK Science and Technology Research Laboratories (STRL) on technologies for fusing broadcasting and communications. I will review past initiatives examining technologies for fusing broadcasting and communications, explain the basic approach to research, and introduce the current research being conducted at STRL on this topic, as well as technologies that use communications to support broadcasting.

1. R&D Background

NHK STRL began research on Integrated Services Digital Broadcasting (ISDB) in the 1980s. The research on this form of digital broadcasting had the goal of developing system for broadcasting of all kinds of digital data, which was not limited to video and audio. The ISDB was realized in the form of HDTV, surround sound and data broadcasts with the start of digital satellite broadcasting in 2000 and digital terrestrial broadcasting in 2003. It leads the improvement of the quality of video and sound, as well as usability. Of course, during the period of R&D on ISDB in the eighties and nineties, the main transmission media were considered to be satellite and terrestrial broadcasting networks. Even so, the digital broadcast receivers resulting from this development also incorporated a telephone modem or Ethernet interface for communications as a basic function. This communications function, in turn, can be used to realize a variety of two-way functions that will allow viewers to contribute their input to programs immediately. An example is how users can now participate in judging contestants on the Annual Year-end Grand Song Festival. The communications function also enables a diversity of data, which cannot be provided with broadcasting alone, to be provided over the network from servers in the form of Broadcast Markup Language (BML) documents. Such a service is provided as "NHK Data Online". Digital broadcasting is becoming more and more sophisticated through the use of communications in this way.

Besides developing digital broadcasting technologies, we at NHK STRL have conducted R&D on technologies for distributing broadcast content through communications channels. For example, in anticipation of the spread of broadband, we did research on a Program Request Service (PRS) system, which stores NHK broadcast programs on a server and allows their viewing over a communications network. This research involved experiments conducted in a closed environment on managing servers for distribution of HDTV content over the network, copyright

protection technologies, terminals for receiving[1], and other issues. Much of this research was completed at NHK STRL by emerged various problems that have to be resolved in order to realize actual services, such as content protection for copyrights. However, the concept was realized in the form of the catch-up service on NHK On-Demand, starting in December, 2008.

We also conducted research on a server-based broadcast system providing more diverse viewing options by using communications and storing broadcasts on a hard disk in the receiver[2,3]. In this research, we developed access control formats and techniques for using metadata. Technical materials compiled by the Association of Radio Industries and Businesses (ARIB)[4] describe technologies that handle not only low-volume files such as licensing and metadata, but also downloading and streaming of content data itself. The elemental technologies were later used in various video content distribution systems such as Internet Protocol TV (IPTV) in Japan.

2. Approaches to Research on Technologies Fusing Broadcasting and Communications

Digitalization has made broadcasting more compatible with communications and personal computers, and in the form of ISDB, it not only utilizes broadcast frequencies more efficiently, but extend its functionalities that were not possible in the analog system through use of communications. Here, I will summarize the progress of fusing broadcasting and communications, and its prospects for the future. The first stage was to use low-capacity communication lines to implement the bi-directional functionality. Through this functionality, viewers were able to provide information to the broadcaster, resulting in bi-directional programs. It also became possible for viewers to retrieve a variety of information, in addition to the broadcast, from a server in the form of on-demand.

In the past, HDTV content could only be provided through broadcasting. However, as communications-channel bandwidth increased, it became possible to provide HDTV content through Fiber-To-The-Home (FTTH). One of the new forms of this service is IPTV, which uses Internet Protocol (IP) as the communications protocol. This is the second stage of introducing communications functions into broadcasting services. IPTV not only enables IP broadcasts of programs produced in the usual way for broadcasting, but also makes Video On Demand (VOD) possible by exploiting the inherent on-demand characteristics of IP. In this way, this second
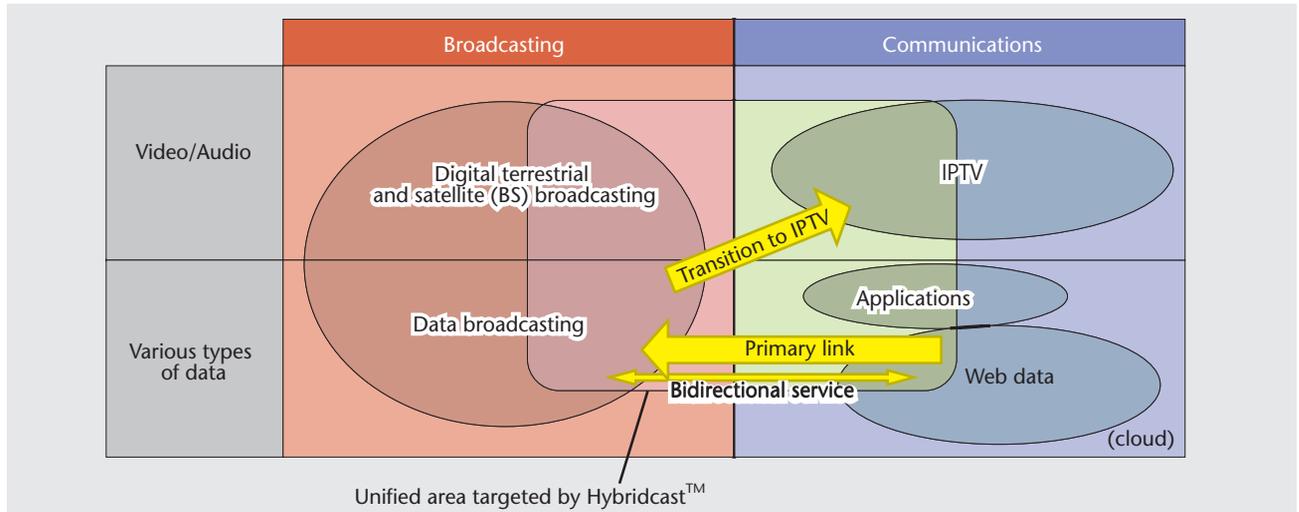
Figure 1: Services linking broadcasting and communications

stage can be considered as a unification of broadcasting and communications at the content level. This stage makes it possible to transit from data broadcasting to more functional links between communications and broadcasting in IPTV environments.

We expect that television receivers will have both a broadband connection and an RF antenna as the norm, and plan to continue to advance these developments into the future. This effort can be viewed as the third stage of development. At this stage, information linked to the broadcast and obtained through communications networks will be able to be used dynamically. In other words, individual viewers will have no particular awareness of whether the information came from the broadcast or through communications channels, and they will be able to use the content on the television or mobile terminal in a wide variety of ways. Also, from a business perspective, a wide range of content providers will be able to provide unified services. Hybridcast™ *1 system proposed by STRL is oriented toward building new environments for this stage. Figure 1 shows a schematic outline of services fusing broadcasting and communications.

A crucial point here is that as broadcasting and communications become more and more fused, the content and information being provided by NHK will grow in importance, and when they become completely unified, the value of this information will increase even further.

3. Systems Fusing Broadcasting and Communications

In the three-year NHK corporate plan starting in 2009, one of the nine policies set forth to increase contact with viewers is to "fulfill the role as a public broadcaster by offering new services in the coming era of the fusion of broadcasting and communications media". One of the

means for enacting this policy is to "promote research and development of technologies to guide the fusion of broadcasting and communications media". NHK STRL is now committed to pursuing such research.

At the 2010 NHK STRL Open House, NHK STRL unveiled plans for the Hybridcast system[5]. Hybridcast makes use of areas where broadcasting and communications complement each other to strengthen broadcast services and provide richer information tailored to the varying needs of each viewer. Hybridcast organically connects televisions, PCs, and mobile terminals to enhance broadcasting services with communications and cloud-computing technologies. These technologies promise to allow viewers from all generations to enjoy more and get more out of broadcast programming. One of the basic technologies of this system is a technology for playing content using both broadcasting and communications channels in a synchronized fashion[6]. The system also includes technologies that strengthen broadcasting and ensure its extensibility; for example there is an application that provides subtitles in multiple languages. Also, as one method for linking televisions with mobile terminals, we are developing a technology[7] that allows two dimensional bar codes (QR codes) to be produced by the TV receiver, and these can then be used by mobile terminals.

4. Security Technologies

NHK STRL contributed to making digital broadcasting practical by completing research and development on the BS Conditional Access Systems (B-CAS), which is the basic system for content protection and access control in the current digital broadcasting system in Japan. Yet, even more security technology will be needed in the era of fusing broadcasting and communications.

Broadcasting has its own dedicated transmission path, so it is more secure than communications. With communications, there is a danger that a malicious user could falsify or intercept data, or impersonate a user.

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*1 Hybridcast is a trademark of NHK Engineering Service Inc.

For a broadcaster, there are also several elements that must be reliably protected when using communications media; personal information and the content itself must be protected and there should be some control over what content is presented on a receiver device (e.g. priority should be given to urgent reports in times of emergency, etc.). When fusing broadcasting with communications, these types of issues must be considered in order for viewers to use content safely through communications channels.

It is also important to maintain ease-of-use in security systems for broadcasting. Normally, authentication is required when retrieving content through communications channels. With a system such as Hybridcast, which uses multiple transmission paths and multiple terminals, it is desirable to keep such troublesome procedures to a minimum. Since it is a service for individuals, it is also necessary maintain user safety, including protection of private information. One way to resolve these issues is by ID federation technologies[8].

We are advancing our research on encryption and authentication as basic technologies for governing links between broadcasting and communications. For example, we have been researching signature formats that are able to confirm that individuals are members of a group permitted to make a given content request, signature formats that can used to authenticate a provider (group signature[9], provider authentication[10]), and methods that can efficiently deliver CAS keys for the distribution of broadcast content and that allow unauthorized users to be tracked[11]. By using these technologies, users can temporarily belong to a particular group and authenticate themselves in anonymity. This creates an environment in which communications channels can be used, while maintaining the anonymous character of broadcasting. In the future, we are planning to implement an extensible encryption method, integrating multiple encryption methods. This will allow a single private key to be used for multiple services, and it is expected to ensure effective security for services linking broadcasting and communications. Encryption and authentication methods generally tend to require an increasing amount of computation, but the research being carried out at NHK STRL is oriented towards receivers for consumers; we are working on methods that are very safe, yet require less processing.

5. Multiplexing Technologies

Multiplexing is a very important technology supporting digital broadcasting today. MPEG-2 Systems, as currently specified, transmits fixed-length packets, while taking the broadcast transmission path characteristics into consideration, and it has a technology to adjust the presentation timing of the payload content. This structure enables the receiver to play back video and audio reliably. However, IP transmission has become more common and low cost, so there is a desire for new multiplexing methods that provide even more efficient and reliable transmission. For services fusing broadcasting and communications, it is also important for broadcasting systems to be able to handle IP packets, which are the norm in the communications world.

There are various methods for tying MPEG to IP. Encapsulating TS packets within IP packets is one way to do so, but it does not provide the best transmission efficiency. Thus, at NHK STRL, we developed the Type-Length-Value (TLV) multiplexing method[12] and standardized it in cooperation with MPEG, ITU-R[13], and ARIB[14]. With TLV multiplexing, the header information that is not needed for broadcast-style one-way transmissions is compressed, and the information required to decompress it is sent periodically in special packets. This allows for efficient, reliable transmission using IP packets. This method has been implemented in a download format for high-speed satellite broadcasting[15] and in a multimedia broadcast multiplexing format for VHF band[16].

6. Using Networks in Production

Production environments for broadcasting are rapidly moving to digital formats, and in line with this trend, the use of communications networks is growing. Making the technologies we have developed usable in the production environment is also an important research topic for us at NHK STRL.

Video content needed for program production and news reporting is gathered from various locations, and it is important to be able to transmit these materials to the broadcast station quickly, with low delay, and without degrading image quality. Till now, various dedicated channels have been used to transmit source video from around the world, including terrestrial radio networks, terrestrial wired networks, and satellite communications networks. Dedicated lines allow quality to be maintained, but channels and equipment are expensive, and there are limitations on the times and locations where they can be used.

On the other hand, the Internet has spread throughout the world, providing connections for communication almost everywhere. However, the Internet has a best effort character, because multiple users share the same channel. This means the Internet does not guarantee quality, so a method to transmit materials over the Internet efficiently and without distortion or interruption is needed to increase the flexibility of options for gathering production materials. For these reasons, we are also developing technologies for stable transmission of high-volume content such as video over the Internet. These technologies include switches to eliminate delay and jitter[17], wireless LAN equipment[18], and transmitters able to transmit HDTV video reliably over the Internet[19]. The HDTV transmission equipment works by estimating the available line bandwidth from information such as the packet loss rate, and then it dynamically adjusts the encoding rate so that no interruptions occur. This HDTV transmission equipment has already been in operation at the NHK Kushiro station.

Also, till now, tapes have commonly been used in news and program production and transmission environments, but along with recent advancements in ICT technologies, a transition to tapeless systems using networks and disks is taking place. At NHK STRL, we are working toward building an environment that will enable the effective use of content stored on various servers. This includes research on plug-and-play systems[20] that have various functions over the network, as well as versatile production systems[21]. In the future, these technologies will lead to a true tapeless system.

7. Conclusion

Television receivers that can receive and make use of both digital broadcasts and IPTV are already available in Japan. In that sense, IPTV and data broadcasting are already linked. Organizations in Europe and America are following the developments of IPTV and data broadcasting in Japan and are progressing with their own R&D and standardization on linking broadcasting and communications, with initiatives such as YouView[22] and HbbTV[23]. The main goal of developing such hybrid systems in various countries is to attract more viewers to television programming. At NHK STRL, we intend to continue to develop technology for fusing broadcasting and communications and would like to build cooperation with other organizations doing related work.

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