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ABU Technical Department

REPORT OF TOPIC CHAIRMAN
TRANSMISSION TOPIC AREA

Topic Chairman	**:**	**Kenichi MURAYAMA(NHK)**
Period of Report	**:**	**November 2019 to November 2020**
Date of Report	**:**	**23 November 2020**

Introduction
Transmission topic area comprises five projects. The matters concerning digital terrestrial television broadcasting, digital satellite broadcasting, Digital Sound Broadcasting and these frequency planning are studied or investigated by these projects. This topic area also covers research on IBB and OTT, including platforms and standards, etc.
This document has been submitted for this Technical Committee Annual meeting.

1. Frequency Planning for Digital Broadcasting(T/FPDB)

Project Manager: **Mr. Kazuhiro Kumamaru** (NHK, Japan)
Co-project Manager: **Mr. YUEN Man** (TVB, Hong Kong, China)
Mr. Rajeev Kumar (DDI, India)

Reports from the project managers and the contributor are as follows.
1.1 ITU-R text related to DTTB coverage and frequency planning
1.2 Latest ASO situations in the region
1.3 Latest topics over frequency policies in the world

The reports for T/FPDB are attached as Annex 1.

2. Next Generation Terrestrial Broadcasting (T/NGTB)

Project Manager: **Mr. Masahiro Okano** (NHK, Japan)
Co-project Manager: **Mr. LEE Jae Kwon** (KBS, Korea),
Mr. Chen Delin (ABS, China),
Mr. Halil Us (TRT, Turkey),
Mr. Özgür Cosar (TRT, Turkey),
Mr. Zhang Yu (ABS, China)
Mr. Xiao Jingting, ABS (ABS, China)

Reports from the project managers and the contributor are as follows.
2.1 Investigate efforts toward the realization of next-generation terrestrial broadcasting in Japan
2.2 4K-UHDTV field experiments in the Seoul metropolitan area for SFN optimization
2.3 Convergence of broadcasting and communication

The reports for T/NGTB are attached as Annex 2.

3. Integrated Broadcast-Broadband and OTT (T/IBBOTT)

Project Manager: **Dr. Go OHTAKE** (NHK, Japan)
Co-project Manager: **Mr. A. K. Mangalgi** (DDI, India)
Mr. Kazuhiro KUMAMARU (NHK, Japan)
Mr. Satoshi FUJITSU (NHK, Japan)
Mr. Kinji MATSUMURA (NHK, Japan)
Zhang Dingjing (ABS, China)
Zhang Yu (ABS, China)
Zhang Wei (ABS, China)
He Jing (ABS, China)
Wang Lei (ABS, China)

Reports from the project managers and the contributor are as follows.

3.1 Standardization of multimedia coding for UHDTV in Japan
3.2 Studies in ITU-R
3.3 Studies in ITU-T
3.4 Cyber Security on IoT devices in Japan
3.5 Content protection of China

The reports for T/IBBOTT are attached as Annex 3.

4. Satellite Broadcasting (T/SB)

Project Manager: **Dr. Masashi Kamei** (NHK, Japan)
Co-project Manager: **TBD** (TRT, Turkey)

Reports from the project managers and the contributor are as follows.

4.1 ITU-R documents related to satellite broadcasting systems
4.2 Latest topics on satellite broadcasting

The reports for T/SB are attached as Annex 4.

5. Digital Sound Broadcasting System (T/DSBS)

Project Manager: **TBD** (AIR, India?)
Co-project Manager: **TBD** (IRIB, Iran)
TBD (RRI, Indonesia)
TBD (TRT, Turkey)

Annex 1

Project: Frequency Planning for Digital Broadcasting(T/FPDB)

Project Manager: **Mr. Kazuhiro KUMAMARU** (NHK, Japan)
Co-project Manager: **Mr. YUEN Man** (TVB, Hong Kong, China)
Mr. Rajeev Kumar (DDI, India)

1.1 ITU-R text related to DTTB coverage and frequency planning

1.1.1 Recommendations (http://www.itu.int/rec/R-REC-BT/en)

BT.1306 "Error correction, data framing, modulation and emission methods for digital terrestrial television broadcasting"

BT.1368 "Planning criteria, including protection ratios, for digital terrestrial television services in the VHF/UHF bands"

BT.1877 "Error-correction, data framing, modulation and emission methods for second generation of digital terrestrial television broadcasting systems"

BT.1895 "Protection criteria for terrestrial broadcasting systems"

BT.2033 "Planning criteria, including protection ratios, for second generation of digital terrestrial television broadcasting systems in the VHF/UHF bands"

BT.2036 "Characteristics of a reference receiving system for frequency planning of digital terrestrial television systems"

1.1.2 Reports (http://www.itu.int/pub/R-REP-BT/en)

BT.2035 "Guidelines and techniques for the evaluation of digital terrestrial television broadcasting systems, including assessment of their coverage areas"

BT.2140 "Transition from analogue to digital terrestrial broadcasting"

BT.2209 "Calculation model for SFN reception and reference receiver characteristics of ISDB-T system"

BT.2265 "Guidelines for the assessment of interference into the broadcasting service"

BT.2294 "Construction technique of DTTB relay station network for ISDB-T"

BT.2295 "Digital terrestrial broadcasting systems"

BT.2302 "Spectrum requirements for terrestrial television broadcasting in the UHF frequency band in Region 1 and the Islamic Republic of Iran"

BT.2343 "Collection of field trials of UHDTV over DTT networks"

BT.2470 "Use of Monte Carlo simulation to model interference to DTTB"

1.1.3 Handbook (https://www.itu.int/pub/R-HDB-63)

"Handbook on Digital Terrestrial Television Broadcasting networks and systems implementation"

1.2. Latest ASO situations in the region

Hong Kong will switch off analogue television services (ASO) on November 30, 2020 (11.59pm). The spectrum currently being used for analogue TV broadcasting will be vacated to meet the increasing demand for high value-added mobile telecommunications services. A total of 160 MHz spectrum in the 600/700MHz bands will be assigned for indoor hotspots. This arrangement will help relieve congested traffic indoor mobile hotspots, such as MTR stations.

For those audiences that face financial difficulties to replace their aged analogue television set, the Government will subsidy eligible households to purchase a set-top box or basic model digital TV set through DTT Assistance Scheme.

After ASO, Hong Kong will have two SFN and one MFN for 10 terrestrial free television programme.

1.3 Latest topics over frequency policies in the world

1.3.1 5G spectrum auction results in Netherland

The Netherlands' Ministry of Economic Affairs & Climate Policy announced the completion of the country's 5G multi-band auction, allocating nationwide 700MHz, 1400MHz and 2100MHz spectrum under 20-year concessions to the three participants, incumbent mobile operators KPN, VodafoneZiggo, T-Mobile Netherlands, for respectively 416 million EUR, 416 million EUR and 400 million EUR.

Each operator won 2×10MHz in the 700MHz band and 2×20MHz in the 2100MHz band. In the 1400MHz band, KPN and VodafoneZiggo bought 1×15MHz each and T-Mobile acquired 1×10MHz.

Spectrum in the 700MHz and 1400MHz will become available immediately, the 2100MHz licences will be available from early 2021. Licences include coverage obligations of 98% geographic coverage of all domestic municipalities.

The 3.6 GHz auction is planned for 2022 as the band is currently used for satellite communications. Spectrum at 3400-3450 MHz and 3750-3800 MHz is intended to be made available for local use.

In late April, VodafoneZiggo announced the activation of its 5G network across more than half of the Netherlands. In partnership with Ericsson, the operator implemented 5G services via its existing antennas and Dynamic Spectrum Sharing (DSS) technology which allows operators to dynamically allocate some of their existing 4G LTE spectrum to 5G. Rival operators KPN and T-Mobile expect to launch its 5G network in the coming months.

Source: https://5gobservatory.eu/netherlands-multi-band-5g-auction-raises-1-23-billion-eur/

1.3.2 5G spectrum auction results in Austria

In September 2020, the Austrian regulator RTR finally completed the delayed multi-band 5G auction. RTR had to postpone the auction due to the Covid-19 outbreak. The second 5G auction in Austria awarded frequencies in the 700 MHz, 1,500 MHz and 2,100 MHz bands, raising 202 million EUR. In March 2019, 3.4- 3.8GHz spectrum was auctioned to seven successful bidders generating 188 million EUR.

27 blocks were up for sale, including six blocks in the 700MHz band, twelve in the 2100MHz range and nine in the 1500MHz band.

T-Mobile Austria paid 87 million EUR for 2×20MHz of 700MHz spectrum, 20MHz in the 1500MHz band and 2×15MHz of 2100MHz spectrum. A1 Telekom will pay 66 million EUR for 30MHz of frequencies in the 1500MHz band and 2×25MHz in the 2100MHz range. The incumbent player did not get 700 MHz spectrum. Hutchison Drei won 2×10MHz of 700MHz spectrum, 30MHz in the 1500MHz band and 2×20MHz of 2100MHz frequencies for a total of 50 million EUR.

The government aims to deploy 5G on main traffic routes by the end of 2023 and to reach "virtually nationwide" 5G coverage by the end of 2025. 700 MHz licences will include coverage of 80% of 2,100 underserved communities with download speeds of 30 Mbps and 3 Mbps for upload by 2027, and 90% of federal and state roads should get at least 10 Mbps for downloads and 1 Mbps for uploads.

Source: https://5gobservatory.eu/multi-band-700-1500-2100-mhz-auction-completed-in-austria/

1.3.3 5G spectrum auction results in Luxembourg

In the first Luxembourg auction for spectrum assignment, four out of the five bidders have acquired 5G frequencies in the 700MHz FDD and 3600MHz TDD spectrum auction, paying a total of 41.3 million EUR (Players' bids are not available). The 15+5 year-licenses include strict geographical coverage obligations for 700 MHz spectrum (50% geographical coverage by year-end 2022 and 90% by year-end 2024). In 3420-3750 MHz frequencies, players have to light up a minimum of 10 sites by ear-end 2020, 20 by year-end 2021, 40 by year-end 2022 and 80 by year-end 2024.

Orange, Post and Proximus were each awarded one of the three available lots of 2×10MHz in the 700MHz band.

In the 3600MHz band, Orange and Post each acquired 110MHz of frequencies, Proximus bought 100MHz and Luxembourg Online 10MHz. Eltrona participated in the auction but failed to secure spectrum rights.

Assignment rules published earlier in March 2020 included spectrum caps of 2×10 MHz in 700 MHz frequencies and of 130 MHz in 3.4-3.8 GHz frequencies.

Source: https://5gobservatory.eu/41-million-eur-raised-in-5g-multi-band-auction/

Annex 2

Project: Next Generation Terrestrial Broadcasting (T/NGTB)

Project Manager: **Mr. Masahiro Okano (NHK, Japan)**

Co-project Manager: **Mr. LEE Jae Kwon (KBS, Korea)**
Mr. Chen Delin (SARFT, China)
Mr. Halil US (TRT, Turkey)
Mr. Ozgur COŞAR (TRT, Turkey)
Mr. M S Duhan (DDI, India)

2.1 Investigate efforts toward the realization of next-generation terrestrial broadcasting in Japan

2.1.1. Introduction

Next-generation digital terrestrial television broadcasting will be dominated by UHDTV applications. UHDTV broadcasts consist of a huge amount of data and therefore require large-capacity transmission paths.

Japan is conducting research on large-capacity transmission technology for next-generation digital terrestrial broadcasting systems that will provide large-volume content services such as 8K. In order to transmit the 8K signal, which has a resolution 16 times greater than HDTV, it will be essential to utilize new technologies that expand transmission capacity, such as higher order modulation (4096-QAM), orthogonal frequency-division multiplexing (OFDM), and dual-polarized multiple-input multiple-output (MIMO).

This experiment establishes parameters for maximizing transmission capacity. However, in actual implementation, these parameters will have to be decided taking link budget, the transmission network, the receiving environment, and other factors into account.

2.1.2. 4K/8K-UHDTV field experiments with advanced system in urban area; Tokyo and Nagoya

2.1.2.1 Overview of advanced DTTB system

The objective of the advancement is to provide improved transmission performance compared to ISDB-T in terms of the increased transmission capacity and the reduced C/N required. The advanced system has been designed to inherit the feature of ISDB-T, i.e. it aims to provide a 4K or 8K UHDTV service for fixed reception and an HDTV service for mobile reception simultaneously by frequency division multiplexing (FDM) within a single channel. It also uses a frequency-segmented structure that allows partial reception. The bandwidth per segment is reduced to increase the number of segments from 13 (for ISDB-T) to 35, allowing for flexible bitrate distribution between layers such as the mobile reception layer and fixed reception layer. The advanced system allows a higher spectral efficiency and/or a transmission robustness with multiple-input multiple-output (MIMO).

A prototype modulator and demodulator for the advanced system were developed and their performances were confirmed through laboratory experiments. The feasibility of the system is being verified through large-scale field trials in urban areas.

2.1.2.2 Transmission parameters

Field experiments were conducted with the parameters listed in Table 2.1.1. The occupied bandwidth was expanded by about 5% compared to that of ISDB-T to increase transmission capacity. The 31 and 4 segments out of 35 segments were assigned for UHDTV and HDTV services, respectively. As for error-correcting code and carrier modulation, low density parity check (LDPC) code and NUCs were used for both UHDTV and HDTV services to enhance transmission robustness.

Table 2.1.1 Parameters for field experiments of hierarchical transmission in urban area (Tokyo and Nagoya)

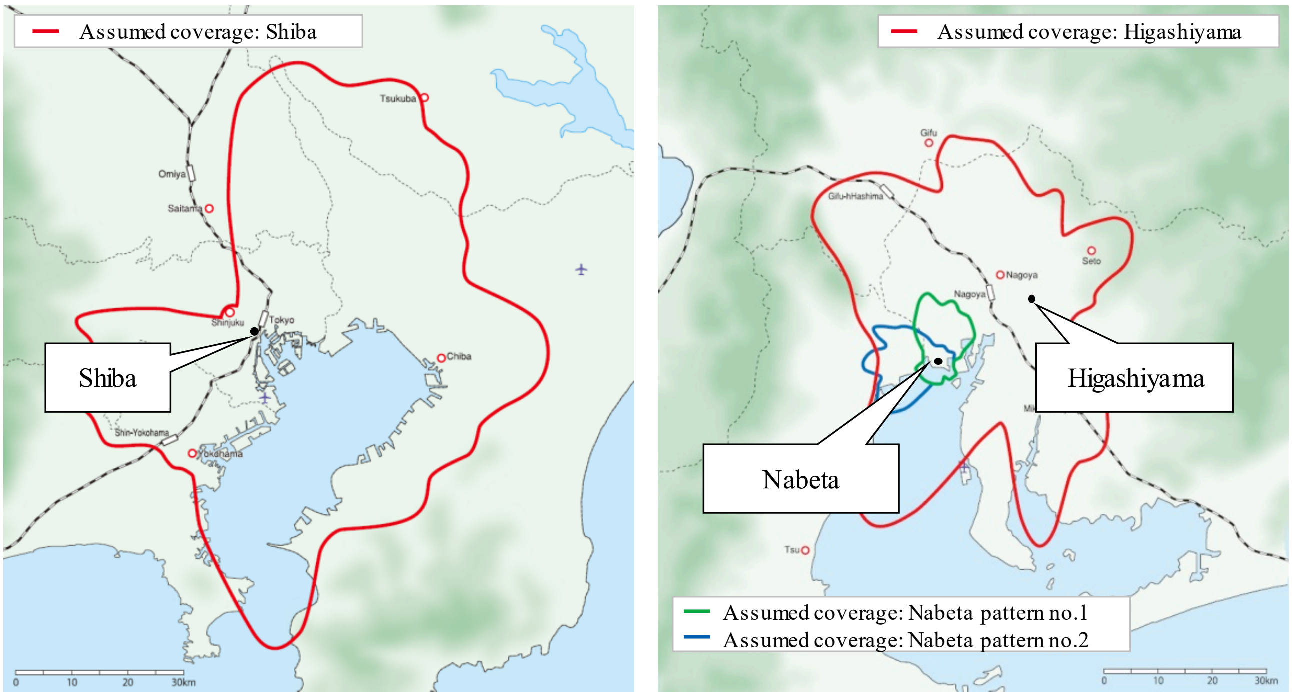
Modulation	OFDM	
Occupied bandwidth	5.83 MHz	
Reception scenario	Fixed (Rooftop)	Mobile (Car-mounted)
Number of segments	31	4
Carrier modulation	1024 NUC QAM	64 NUC QAM
FFT size (number of radiated carriers)	16k (15,121)	
Guard interval ratio (guard interval duration)	800/16384(126μs)	
Error-correcting code	Inner: LDPC, code rate = 11/16 Outer: BCH	Inner: LDPC, code rate = 7/16 Outer: BCH
Transmission capacity	31.4 Mb/s (SISO) 62.8 Mb/s (MIMO)	1.5 Mb/s (SISO) 3.0 Mb/s (MIMO)
Video coding	HEVC	
Video format	3840 ×2160/60/P (4K)	1920×1080/60/P (2K)

	7680 ×4320/60/P (8K)	
Video bit rate	SISO: 25 Mb/s (4K) SISO: 28 Mb/s (8K)* MIMO: 56 Mb/s (8K)*	SISO: 1.0 Mb/s (2K) MIMO: 1.0 Mb/s (2K)
Audio coding	MPEG-H 3D Audio LC level 4	
Audio bit rate	768 kb/s (22.2ch + 3 objects)	192 kb/s (2ch)

* Pre-processed before encoding by MPEG-H HEVC with a state-of-the-art software encoder offline taking plenty of time.

2.1.2.3 Field measurements

To evaluate the performance of the advanced system in different propagation environments, large-scale experimental environments were constructed. Two locations (in the Tokyo and Nagoya areas) were selected to have the same scale as the main stations currently used for terrestrial broadcasting. Figure 2.1.1 shows the transmitter sites and assumed coverage areas for the experimental parameters in Table 2.1.1. Table 2.1.2 lists the specifications of the transmission stations. Each transmission station is equipped with two transmitters and two antennas for horizontally and vertically polarized waves. The directional patterns of transmitting antennas at Nabeta relay station are designed to be selectable.



a) Tokyo area b) Nagoya area

Figure 2.1.1 Experimental environments

Table 2.1.2 Specifications of transmission stations

	Tokyo area	**Nagoya area**	
Transmitter site	Shiba (main station) (Minato Ward, Tokyo)	Higashiyama (main station) (Showa Ward, Nagoya, Aichi)	Nabeta (relay station) (Yatomi, Aichi)
Transmission frequency	563.143 MHz	605.143 MHz	
Polarization	Horizontal, Vertical		
Transmission power	Horizontal: 1 kW Vertical: 1 kW	Horizontal: 1 kW Vertical: 1 kW	Horizontal: 10 W Vertical: 10 W
Transmitting antenna height	280 m above sea level	203 m above sea level	42.5 m above sea level

Transmission experiments were conducted in the two experimental urban areas. Experiments were launched in November and December 2018 in the Nagoya and Tokyo areas, respectively.

The experiments involved field trials of hierarchical transmission of UHDTV/HDTV using a single channel based on the advanced DTTB system. The UHDTV (4K or 8K) content for fixed reception and HDTV (2K) content for mobile reception shown in Table 2.1.1 were recorded in advance in a player, and the video and audio streams were played back at the experimental stations. The block diagram of transmitting and receiving system is shown in Figure 2.1.2. UHDTV and HDTV streams from the player are multiplexed by the remultiplexer (remux) into a single IP stream and input to the advanced DTTB modulator. The frequency of two output signals from the modulator are converted and power-amplified by the transmitter. The audio of UHDTV was an object-based audio that transmitted a 22.2 channel audio encoded by MPEG-H 3D Audio and three narration objects in Japanese, English, and French. For the HDTV content, the video was encoded by HEVC and the stereo audio signals were encoded by MPEG-4 AAC.

Figure 2.1.3 shows the locations of the transmitting and receiving points in the Tokyo area. The NHK Science and Technology Research Laboratories (NHK-STRL), which is approximately 12 km away from the Shiba station, was selected as the receiving point. On the receiving side, the received spectrum was observed by a spectrum analyser, and the delay profile was confirmed by a signal analyser. The UHDTV signal output from the demodulator was decoded in real time by the HEVC decoder and displayed on a 4K/8K LCD monitor. The 22.2 channel audio was decoded in real-time by MPEG-H 3D Audio decoder, converted to 7.1 channel audio, and reproduced using a commercially available sound bar. The HDTV signal was converted from multicast to unicast, then transmitted via WiFi router, and decoded by an MMT player installed on a tablet or smartphone. Figure 2.1.4 shows the spectrum of the received signals. Figures 2.1.5 and 2.1.6 show the delay profile and constellation of the received signal of SISO transmission using horizontal polarized wave. As for the delay profile, almost no reflected waves were confirmed as shown in Fig. 2.1.5 In this experiment, it was demonstrated that UHDTV and HDTV contents can be successfully received with the advanced DTTB system.

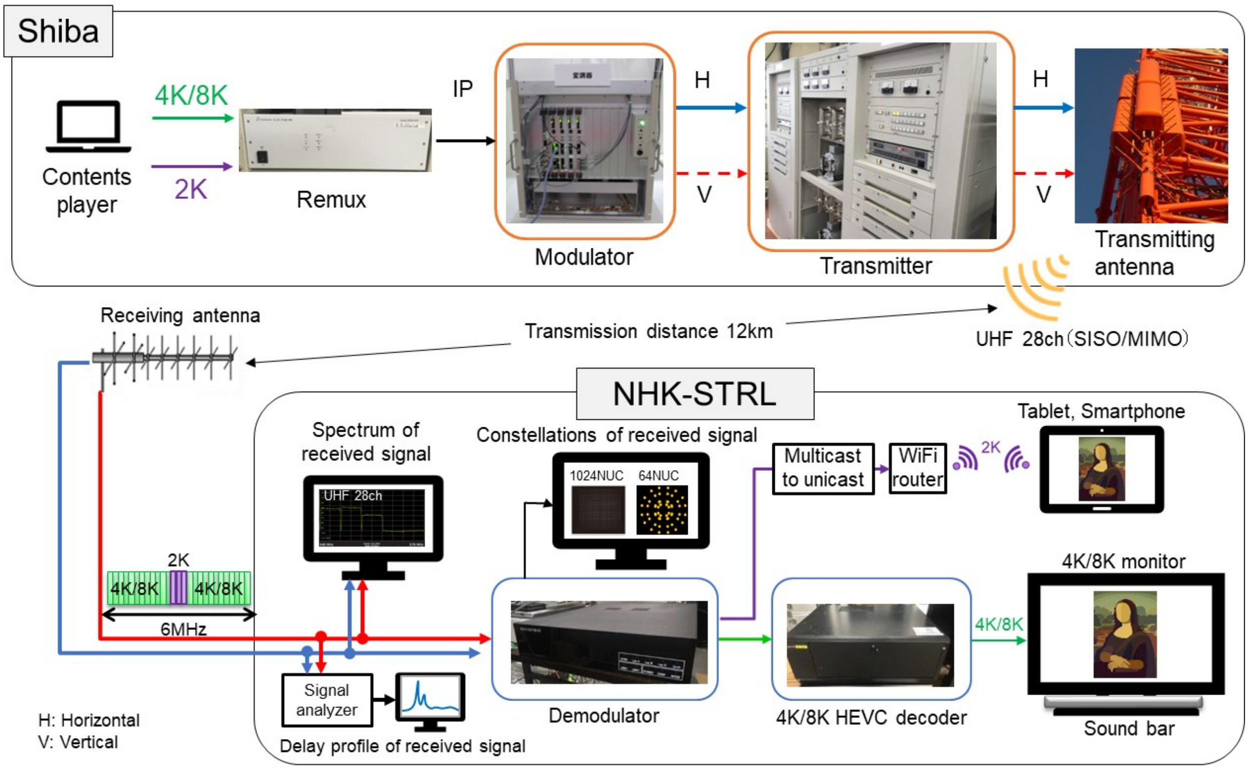


Figure 2.1.2 Block diagram of transmitting and receiving system in Tokyo

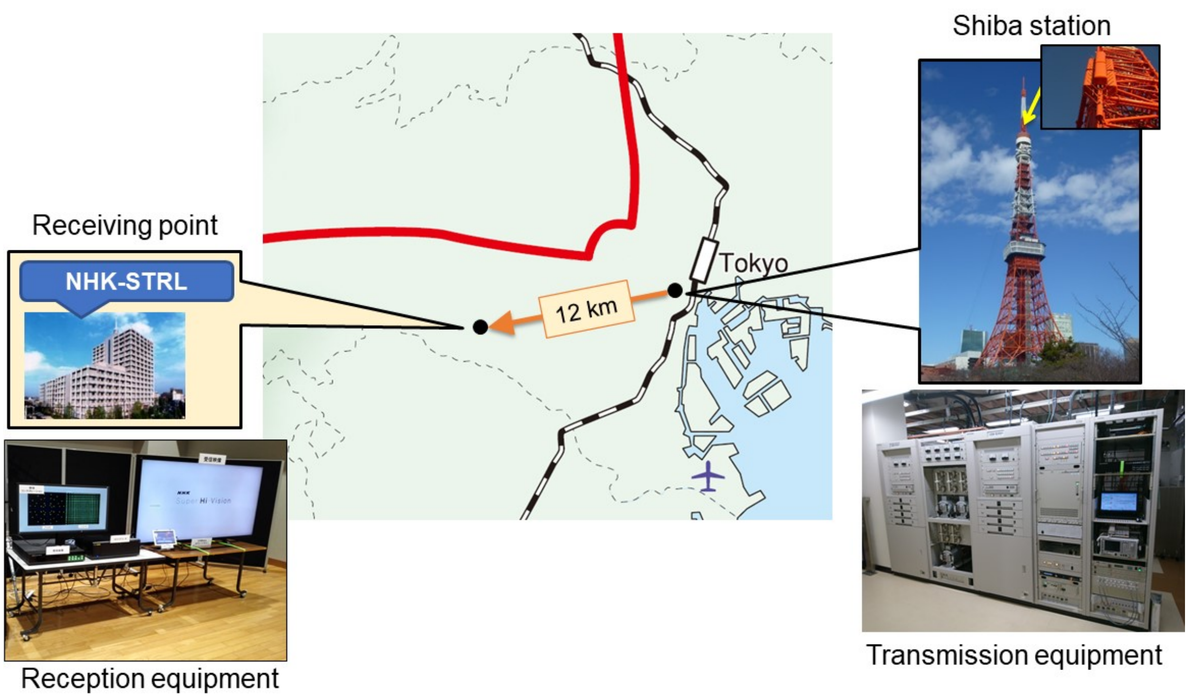


Figure 2.1.3 Locations of transmitting and receiving points in Tokyo

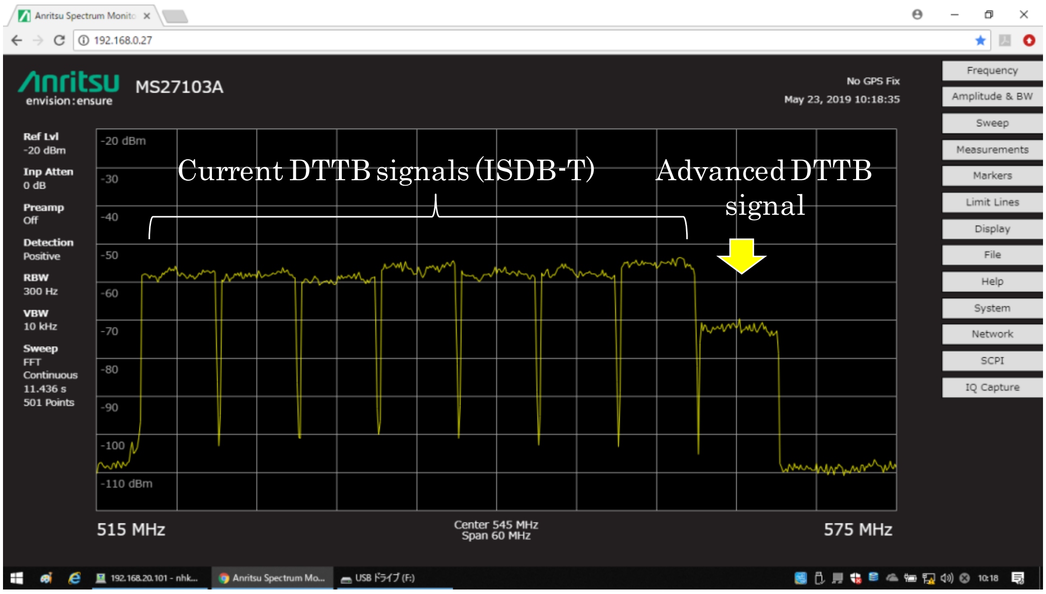


FIGURE 2.1.4 Spectrum of received signal at NHK-STRL (SISO)

Note: The advanced DTTB signal was allocated upper-adjacent to the current DTTB signals. The difference in the received power between the advanced DTTB signal and the current DTTB signals is due to the different transmitting power and the transmitting points.

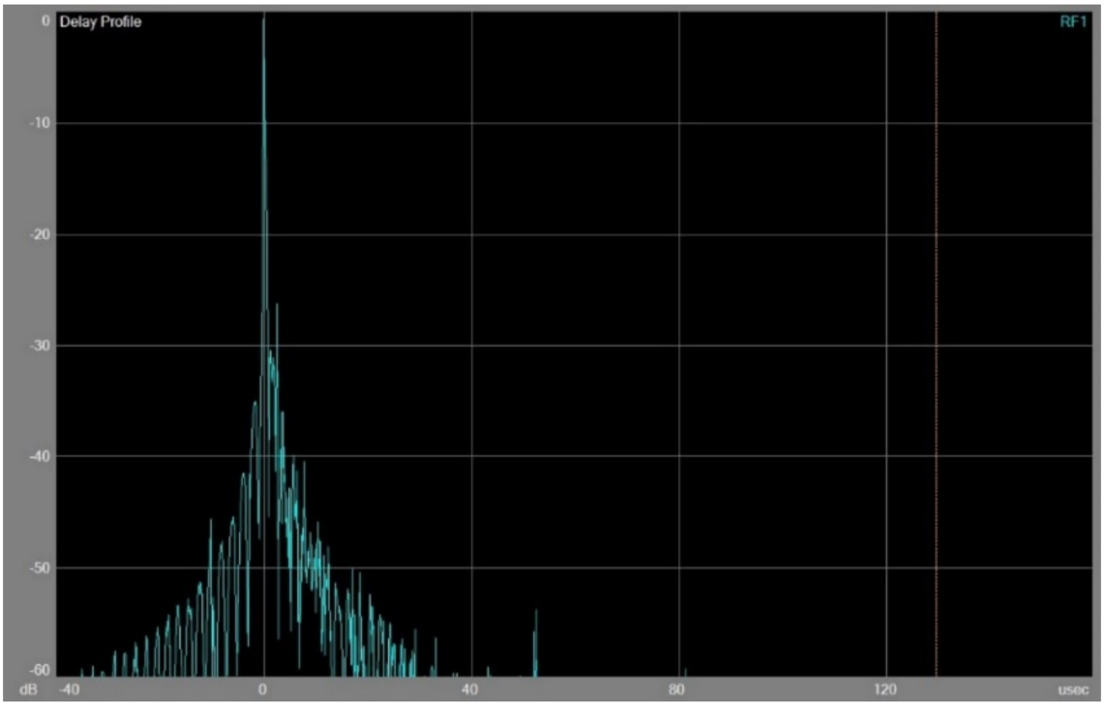
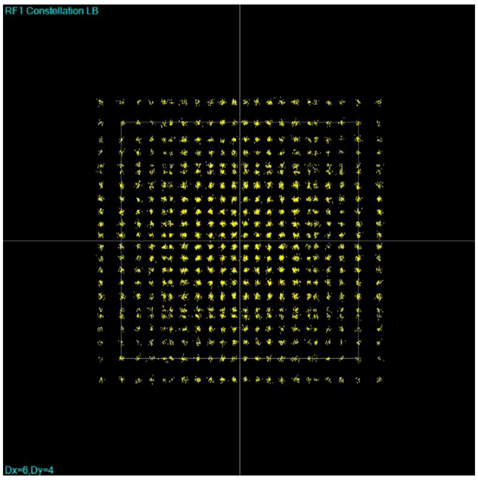


Figure2.1.5 Delay profile of received signal at NHK-STRL (SISO)

(a) 1024 NUC QAM for UHDTV **(b) 64 NUC QAM for HDTV**



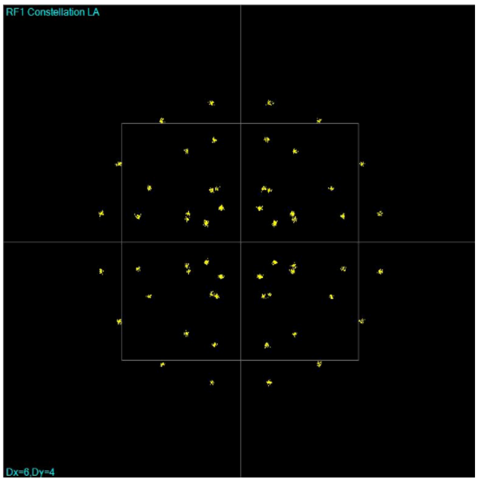


Figure2.1.6 Constellations of received signal at NHK-STRL (SISO)

The block diagram of transmitting and receiving system in Nagoya is shown in Fig. 2.1.7. Figure 2.1.8 shows the locations of the transmitting and receiving points in the Nagoya area. As a receiving point, the Nagoya port building, which is approximately halfway between the Higashiyama and Nabeta experimental stations, was selected. The remultiplexer was installed at the Higashiyama station and the IP packet was sent to the two modulators installed at the Higashiyama and the Nabeta stations. A 200 Mbit/s bandwidth secured line was used as the IP line between the Higashiyama and Nabeta stations. The radio waves were emitted from the two stations to carry out the transmission experiments in a SFN environment. The modulated signals were generated at each transmission timing.

At the receiving point (the Nagoya port building), the receiving antenna was installed facing the Nabeta station. Additionally, the transmission power of the Higashiyama station was adjusted to demonstrate severe SFN reception conditions. As an example, the desired-to-undesired signal ratio (DUR) of 3.2 dB and 1.9 dB for horizontal polarization and vertical polarization between the Nabeta station (D) and the Higashiyama station (U) was demonstrated with the reduction in the transmission power of the Higashiyama station by 5 dB for both polarizations. Regarding the delay setting of the remultiplexer, the transmitting timings of the Higashiyama and the Nabeta stations were aligned at the same time. As the Higashiyama station is geographically 500 m closer to the reception point than the Nabeta station, it was expected that the transmitted signals from the Higashiyama station would arrive 1.6 μs earlier than the signals from the Nabeta station. However, it was confirmed that the signals from the Higashiyama station arrived about 2 μs later than the signals from the Nabeta station. The delay was caused by a feedback compensation circuit installed in the transmitters at the Higashiyama station.

Figures 2.1.9, 2.1.10 and 2.1.11 show examples of the spectrum, delay profiles, and reception constellations of the received signals for MIMO transmission using horizontal and vertical polarizations. For the reception spectrum, ripples caused by the undesired signals from the Higashiyama station were confirmed. For delay profiles, horizontal to horizontal, horizontal to vertical, vertical to horizontal and vertical to vertical components are shown in blue, green, yellow and pink, respectively. The Higashiyama station is located in the direction opposite to the main lobe of the receiving antenna; therefore, many reflected signals transmitted by the Higashiyama station were observed. The demonstration of UHDTV/HDTV reception with the advanced DTTB system in the SFN environment was presented to the press. It was confirmed that even under severe SFN reception conditions, the UHDTV/HDTV video and audio could be received without any transmission errors.

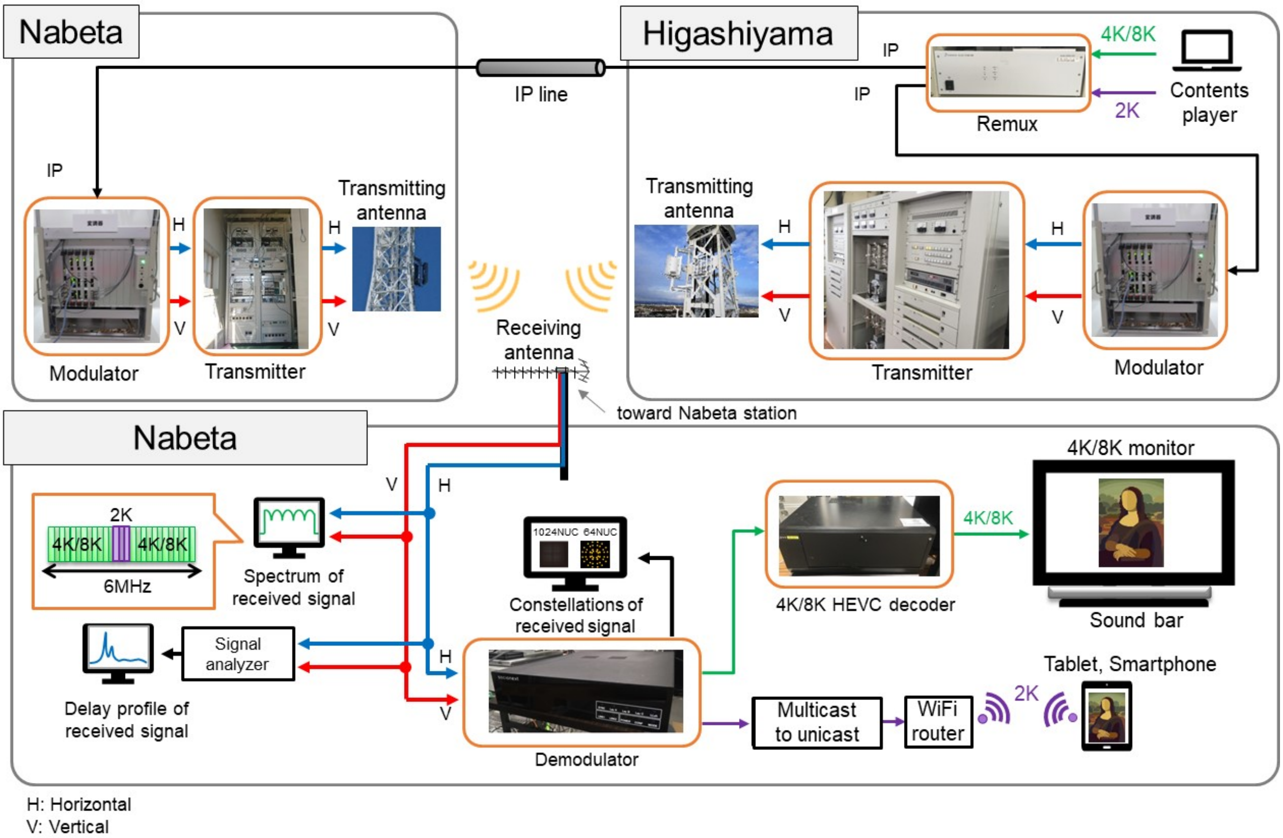


Figure 2.1.7 Block diagram of transmitting and receiving system in Nagoya

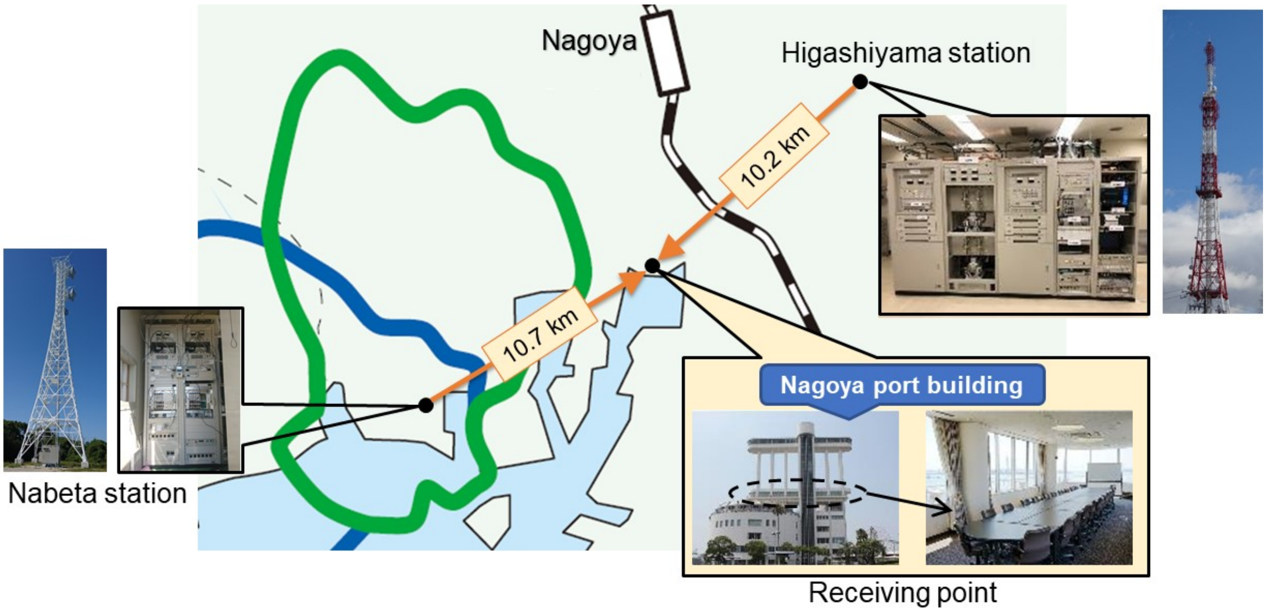


Figure 2.1.8 Locations of transmitting and receiving points in Nagoya

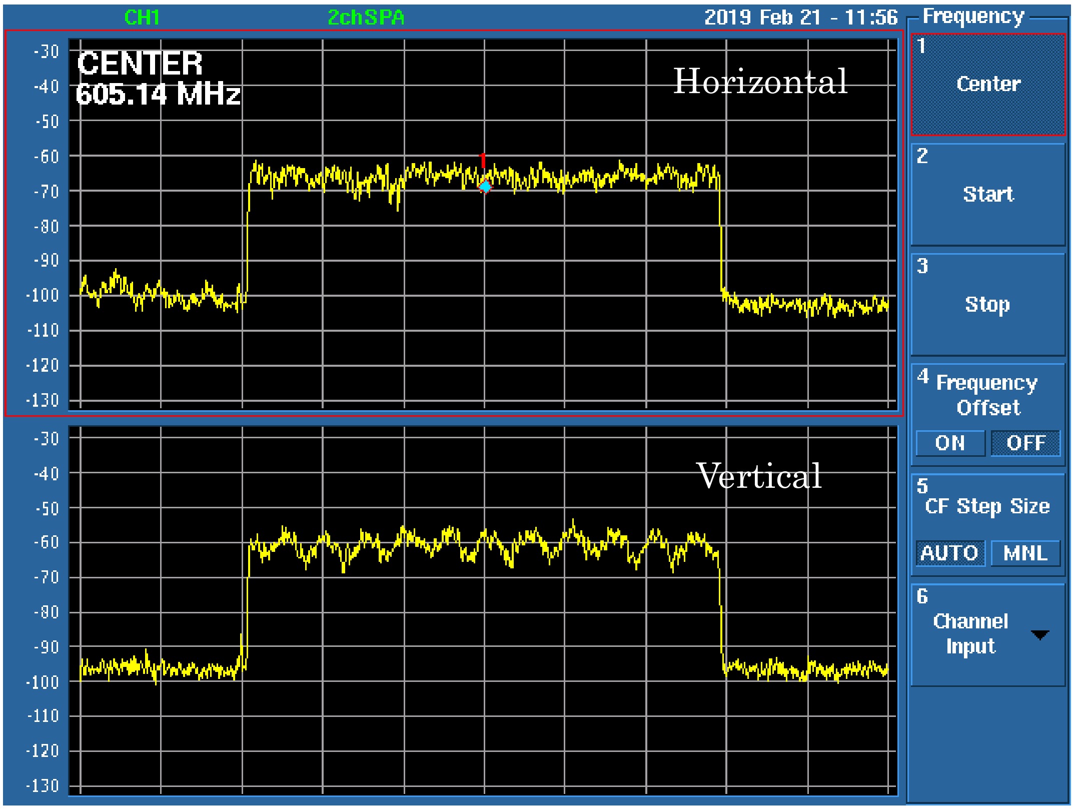


Figure 2.1.9 Spectrum of received signals at Nagoya port building (MIMO)

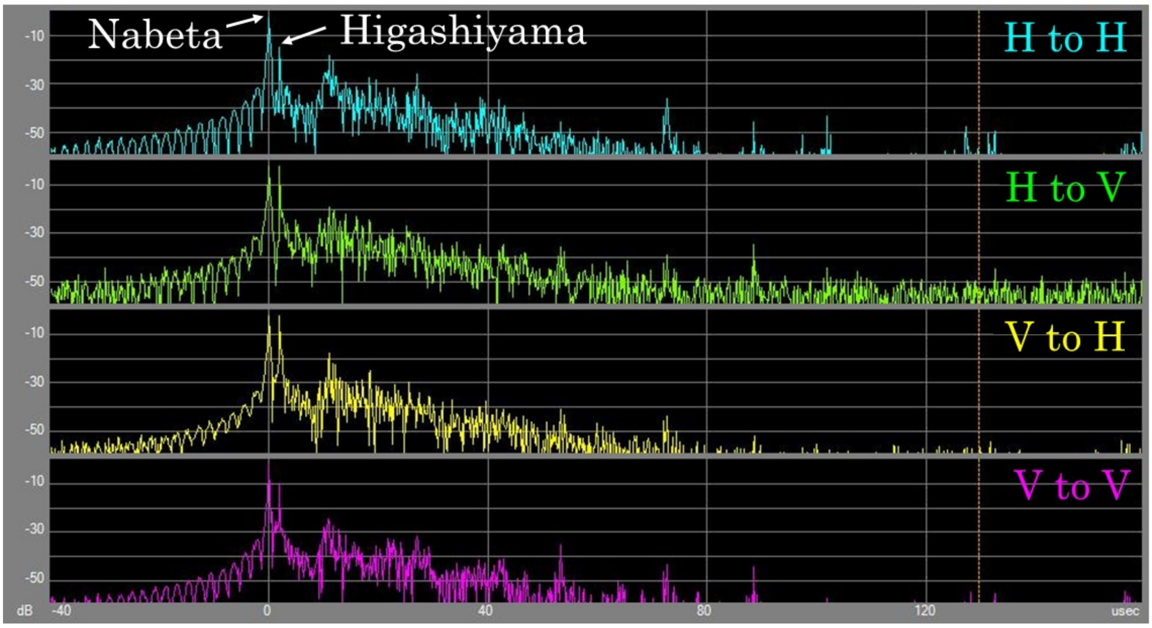
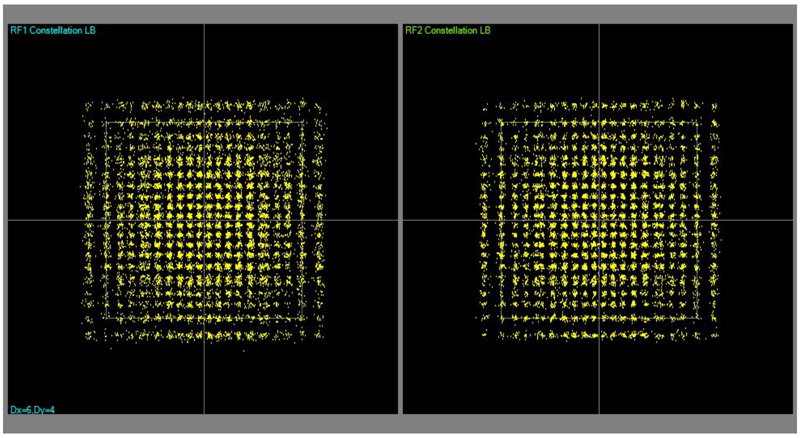


Figure 2.1.10 Delay profile of received signals at Nagoya port building (MIMO)

(a) 1024 NUC QAM for UHDTV (Horizontal) **(b) 1024 NUC QAM for UHDTV (Vertical)**



(c) 64 NUC QAM for HDTV (Horizontal) **(d) 64 NUC QAM for HDTV (Vertical)**

Figure 2.1.11 Constellations of received signals at Nagoya port building (MIMO)

Transmission performance of the advanced system is being verified assuming a fixed rooftop reception with a reception antenna at a height of 10 metres and a mobile reception with vehicular external aerials at a height of 2 metres in the Tokyo and Nagoya areas.

The plan is to evaluate the transmission characteristics not only of single-input single-output (SISO), but also MIMO to confirm the gain in the capacity and required C/N achieved with the advanced system in actual urban reception environments.

2.1.6. Summary

In the field of broadcasting, 8K-UHDTV has the potential to succeed HDTV.

Japan has launched an R&D project aiming at developing an advanced DTTB system and evaluating its performance through field trials in large-scale experimental environments constructed in urban areas.

These field experiments will show the feasibility of terrestrial 8K-UHDTV transmission using several key technologies, including dual-polarized MIMO, 4096-QAM carrier modulation, LDPC code, the 2 × 2 MIMO STC-SFN method, and NUC. The 8K-UHDTV system to be used in Japan will be selected on the basis of further consideration and examination of various technical possibilities and future trends.

More information such as transmission parameters, experimental results was described in the Rep. ITU-R BT.2343-4. (http://www.itu.int/pub/R-REP-BT.2343)

2.2. 4K-UHDTV field experiments in the Seoul metropolitan area for SFN optimization

2.2.1. Introduction

The next-generation terrestrial broadcasting standard, also known as ATSC 3.0 standard, can support high-throughput services in a fixed rooftop environment and robust-reception services in a mobile environment, simultaneously in a single radio channel. The terrestrial broadcasters of the Republic of Korea launched the ATSC 3.0-based commercial 4K-UHDTV broadcasting service in May 2017 and have been deploying the transmitters to expand the broadcasting coverage nationwide.

From a 4K-UHDTV network configuration point of view, an SFN deployment has been considered in the terrestrial broadcasting network to increase the spectrum utilization efficiency. However, it is required to optimize the SFN deployment for minimizing the unwanted self-interference.

This report briefly describes ATSC 3.0-based 4K-UHDTV network optimization planning and shows the field experiments in the Seoul metropolitan area for SFN optimization.

2.2.2. ATSC 3.0-based 4K-UHDTV network optimization planning

In the SFN deployment, all the transmitters broadcast the same information simultaneously at the same frequency. However, a long-delayed signal can arrive from a distant transmitter in the large SFN deployment. If the signal delay is longer than the guard interval, unwanted self-interference from a distant transmitter may inevitably cause performance degradation in the ATSC 3.0 receiver. In order to assist in resolving these problems, the transmitter identification (TxID) technique has been introduced in the ATSC 3.0 standard.

The TxID technique's objective is to obtain the channel impulse response (CIR) independently to support the adjustment of the delay offset of individual transmitters. By controlling each transmitter's delay offset, the unwanted self-interference can be easily avoided, and so that 4K-UHDTV network planning quality and efficiency can be improved.

Figure 2.2.1 shows the example of the simulation results of the 4K-UHDTV network planning optimization and non-optimization. As shown in Figure 2.2.1, the bad reception area of 4K-UHDTV service can be reduced by controlling each transmitter's delay offset so that all the transmitted signals lie within the guard interval.

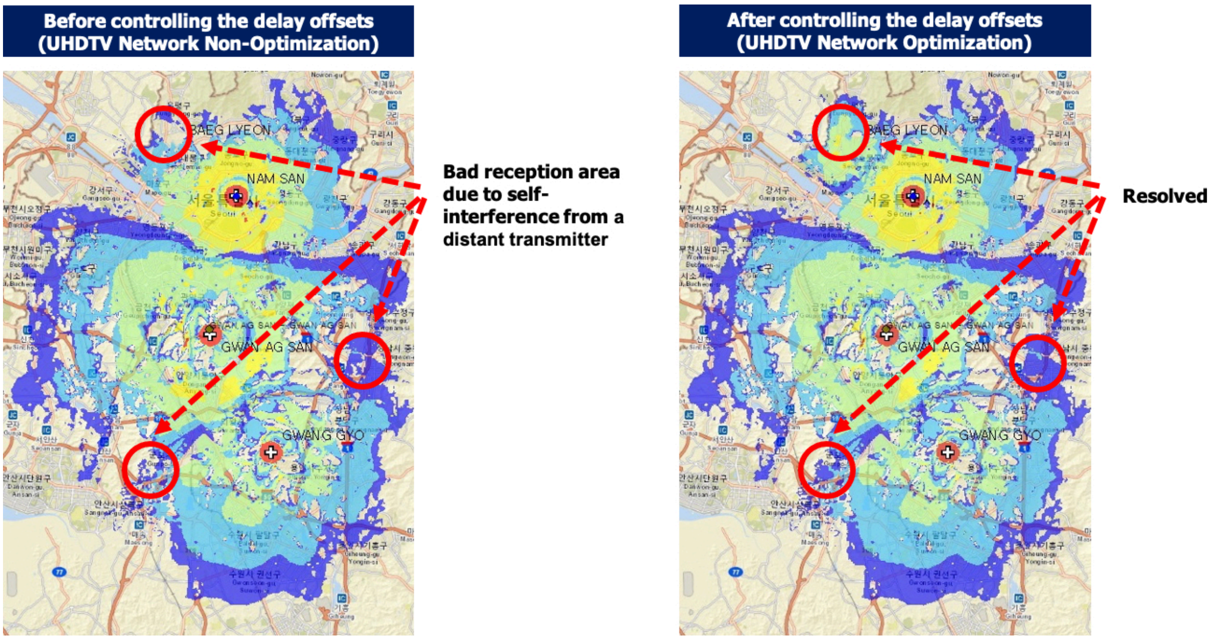


Figure 2.2.1 Simulation results of the 4K-UHDTV network planning optimization and non-optimization

2.2.3. 4K-UHDTV field experiments in Seoul metropolitan area

From 2017 to 2019, the Republic of Korea has installed ten 4K-UHDTV transmitting stations in the Seoul metropolitan area. Figure 2.2.2 shows the geo-location of 4K-UHDTV transmitting stations and their facility.

Figure 2.2.2 The geo-location of 4K-UHDTV transmitting stations and their facility

In order to estimate the CIR from each transmitter to a receiver independently, the ATSC 3.0 broadcast gateway system assigns different TxID addresses to all transmitters during the field experiments. The ATSC 3.0 exciter system generates the TxID signal, and it is embedded into the ATSC 3.0 host signal.

Figure 2.2.3 shows the example of the ATSC 3.0 broadcast gateway and exciter system configurations. Here, the red-box explains the setup information for the specified TxID address.

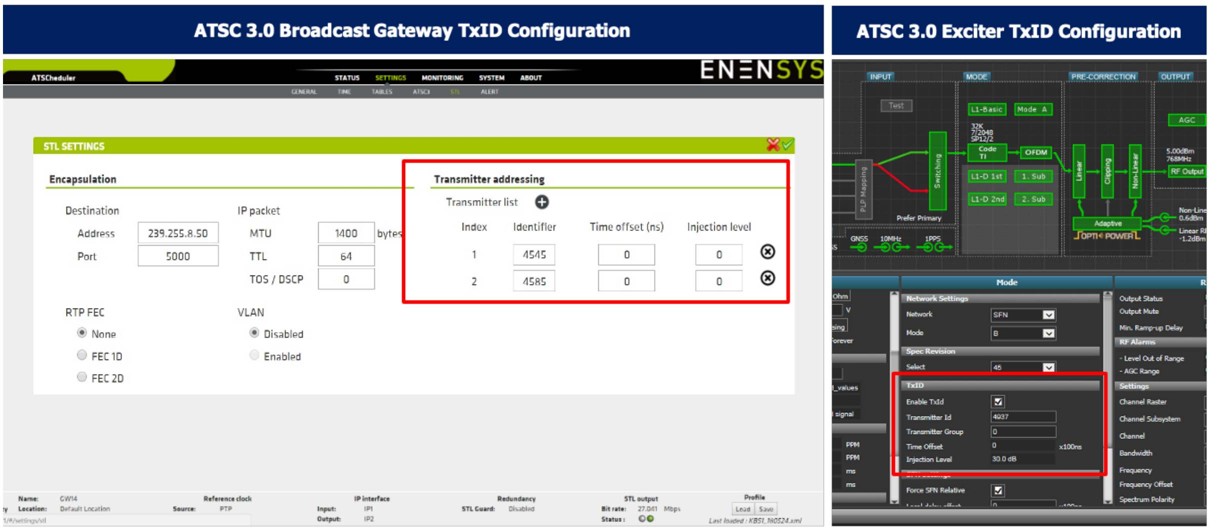


Figure 2.2.3 The geo-location of 4K-UHDTV transmitting stations and their facility

Figure 2.2.4 shows the example of the TxID signal detection results. In this case, four transmitted signals which use the same frequency and information but different TxID addresses, are overlapped in time-domain. Also, each TxID signal detection result has a different position of the maximum amplitude level, which means that each transmitter's appropriate delay offset can be extracted efficiently from these detection results.

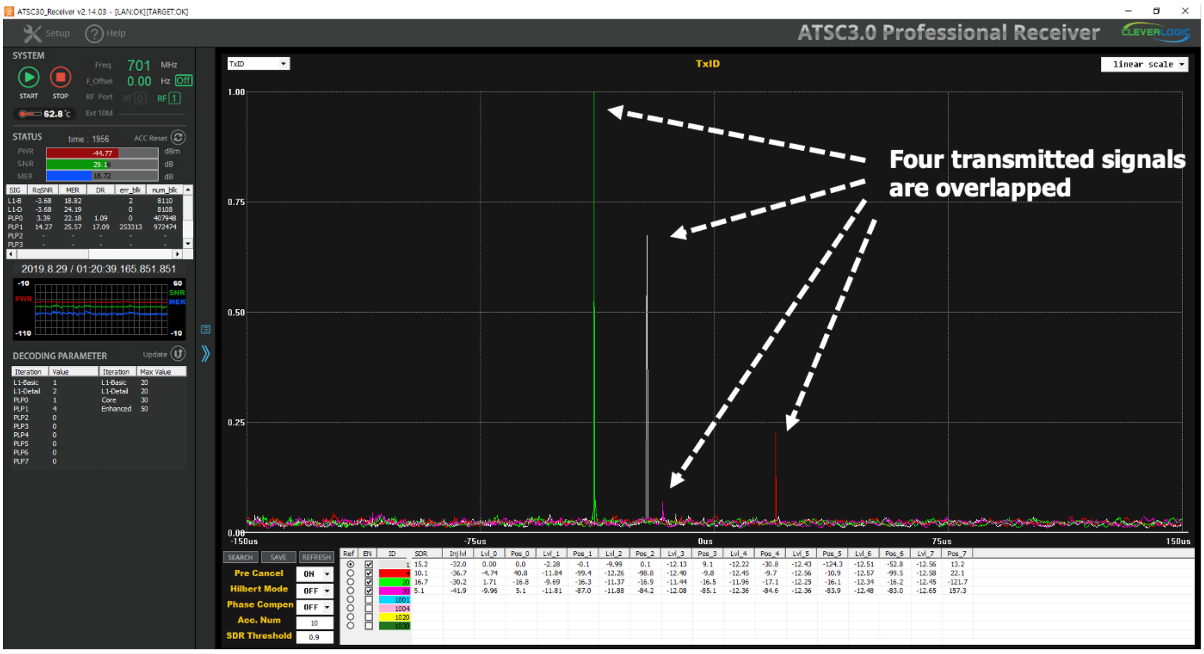


Figure 2.2.4 The geo-location of 4K-UHDTV transmitting stations and their facility

2.2.4. Summary

Since the beginning of the commercial terrestrial 4K-UHDTV service in May 2017, KBS has been conducted many field experiments to design effective 4K-UHDTV network planning. In this report, we have briefly explained the major drawback of SFN deployment and analyzed the effect of SFN optimization through network planning simulations. Also, this report contains the test results of TxID signal detection results in the Seoul metropolitan area. It shows that the TxID technique can assist choose the most appropriate delay offset of each transmitter in SFN environments.

From these results, the designed 4K-UHDTV network can be optimized by controlling each transmitter's reasonable delay offset to minimize the unwanted self-interference.

2.3. Convergence of broadcasting and communication

2.3.1. Service Requirement: Convergence of broadcasting and communication

By adopting bi-directional, point-to-point (PTP) link and cellular structure, mobile communication network is suitable to transmit personalized content or provide interactive service, while the coverage is smaller when comparing with broadcast network and the transmission efficiency is low when it is used to provide multicast/broadcast services. Broadcast network adopts uni-directional, large coverage (usually with high transmission power) and point-to-multipoint (PTM) or multicast/broadcasting mode, which is suitable to the transmission of public media service (PMS), however, it does not have uplink return channel, which can not realize personalized and interactive services such as Video-on-Demand (VoD), Virtual Reality (VR) and conversational video.

With the development trend of video content to ultra-high definition (UHD), multi-dimensional (3D or VR) and conversational, network video will bring more and more traffic to the network. In the communication network, when a lot of users watch video programs at the same time, the limited spectrum resources and transmission capacity will not be able to withstand the high traffic load and high concurrent level requirements. Therefore, it is necessary to aggregate the same video stream and transmit it by multicast/broadcast, which will greatly reduce the traffic load, save bandwidth and release spectrum resources of network.

With the convergence of broadcast and communication, video content can be transmitted to the mobile terminal in a way compatible with the underlying technology of mobile communication. One modem chip can not only send/receive communication signals, but also receive broadcast signals. Users can watch broadcast TV programs anytime and anywhere without generating any data traffic cost. Broadcast and communication converged network not only can provide common content and public services with broadcast mode, provide personalized and interactive services with communication mode, but also can schedule content and handover user between the two modes, and optimize the use of transmission resources according to the content favorite degree, user mobility and network coverage.

2.3.2 Service Requirement: Emergency Broadcast

5G communication network cannot effectively deal with the risks brought by natural disasters and provide emergency communication services. Due to the high construction density of 5G base stations and the small coverage of the base stations, natural disasters such as earthquakes and floods will seriously affect the external communication services of the disaster area, and the property losses will also be huge. In order to improve the disaster resistance of the communication network and reduce the construction cost, 5G broadcast can have much longer inter-site distance or larger coverage. The 5G broadcast adjacent to the disaster area can cover part of the disaster area and provide broadcast services uninterruptedly and will play an important role in public warning system and emergency communications.

2.3.3 Solution: High Power High Tower broadcast based on 3GPP Release 16 "5G Broadcast"

3GPP Release 16 set up a work item (WI) named "LTE-based Terrestrial 5G Broadcast" which is usually called "5G Broadcast". This project is fininshed together with 3GPP release 16 which is evaluated and adopted by ITU-R as IMT-2020/5G standard in July 2020. 5G Broadcast supports Sub-carrier Space (SCS) equal to 0.37, 1.25 and 2.5kHz thus has longer Cyclic Prefix (CP) equal to 300, 200 and 100us which can provide more protection for Inter-symbol Interference (ISI) then support Inter-site Distance (ISD) to 100, 60 and 30km. It can support High Power High Tower (HPHT) broadcast and can meet broadcaster's requirements.

It is noticed that 3GPP also set up two work items (WIs) "5G Multicast Broadcast Service" (Acronym: FS_5MBS) in Service and Architecture aspect (SA), "NR Multicast Broadcast Service" (Acronym: NR_MBS) in Radio Access Network (RAN). Till Dec. 2020, FS_5MBS will output a report TR 23.757 and the specifications will be made based on the solutions provided in this report during the first half of 2021. NR_MBS will be frozen in Dec. 2021, which is said to be postponed by 9 months.

The working mechanism of NR_MBS is as same as that of Single-Cell Point-to-Multipoint (SC-PTM) in 3GPP Release 13. It setup multicast group based on bi-directional communication link of each participating User Equipment (UE). In release 17, NR_MBS does not support narrow SCS such as 1.25kHz, does not support Free-to-Air (FTA) and Receive Only Mode (ROM), does not support Multicast Broadcast Single Frequency Network (MBSFN). Essentially it enable a kind of mobile communication service and is not for broadcasting service.

Annex 3

Project: Integrated Broadcast-Broadband and OTT (T/IBBOTT)

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He Jing (ABS/RTPRC, China)
Wang Lei (ABS/RTPRC, China)

3. Status report

This clause describes recent updates on IBB and OTT standards and related technologies identified and studied by this project. And it describes also recent update on standards and technologies of information security for broadcasting services and cyber security in broadcasting industry for protecting the broadcasting systems.

3.1 Standardization of Integrated Broadcast-Broadband System in Japan

IPTV Forum Japan standardizes specifications of Hybridcast in Japan. Technical specification of Hybridcast is composed of two technical standards and an operational guideline listed below and the latest versions are published in November 2020.

- IPTVFJ STD-0010 'Integrated Broadcast-Broadband System Specification', version 2.3
- IPTVFJ STD-0011 'HTML5 Browser Specification', version 2.6
- IPTVFJ STD-0013 'Hybridcast Operational Guideline', version 2.9

In the revision in November 2020 several new features were added to the Hybridcast technical specifications. Major updates are as follows:

- Addition of the new application type named "Broadcast-independent managed application"
  An application of this type runs in the state that no broadcast channel is being tuned so that service providers can offer application services regardless of their broadcasting area.
- Enhancement to the streaming video playback function
  The CMAF*1 is added as a supported container format of streaming video, including low-latency playback features. Support for stream event delivery mechanisms such as an 'event message' (emsg) box and an 'Event' XML element of MPEG DASH*2 are also added.

- Enhancement to the companion device function
  UHDTV broadcasting services, i.e. 4K and 8K satellite broadcasting in Japan, are added to the available channels for tuning from a companion device.
- Addition of the three-dimensional audio codec support
  The enhanced AC-3[*3] is added to the available audio codecs for video streaming.

*1 ISO/IEC 23000-19 "Multimedia application format (MPEG-A) — Part 19: Common media application format (CMAF) for segmented media".
*2 ISO/IEC 23009-1 "Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats".
*3 ETSI TS 102 366 "Digital Audio Compression (AC-3, Enhanced AC-3) Standard".

3.2 Studies in ITU-R

ITU-R WP6B is working for the study on IBB systems. The working party is now studying on harmonization of IBB systems by making comparison of Hybridcast2.0 (Japan), HbbTV2.0 (Europe), TOPSmedia (South Korea) and Ginga (Brazil).
At the meeting held in April 2019 in Geneva, the working party developed the comparison of application life-cycle and application transition of the IBB systems, and revised Report ITU-R BT.2267 "Integrated broadcast-broadband systems" to add a new part on the harmonization of Integrated Broadcast-Broadband (IBB) systems' applications. To allow the exchange of services covered by the IBB systems and to deploy these services in an area where other systems are used, it is important to harmonize the IBB systems, to ensure compatibility with the IBB applications and interoperability across systems.
At the meeting, the working party revised Report ITU-R BT.2342 to replace information on TTML Text and Image Profiles for Internet Media Subtitles and Captions 1.0 (IMSC1.0) with the updated IMSC1.1 and to update a list of current EBU specifications pertinent to the content of the Report.

At the meeting held in July 2019 in Geneva, the working party revised Report BT.2267 to add the companion application to execute the application on a receiver. The working party also developed the new use cases of IBB system which provides object-based sound services via MPEG-DASH streams.
The working party also developed the global platform. The working party revised Report ITU-R BT.2400 "Usage scenarios, requirements and technical elements of a global platform for the broadcasting service" to add the specific reference to the ATSC 3.0 standard and some examples to show its Internet Protocol-based capabilities to integrate broadcast and broadband services. New digital terrestrial transmission standards such as the ATSC 3.0 system can help effectuate a converged broadcast and broadband platform, which is an important aspect of a global platform for broadcasting services.

At the meeting held in October 2020, the working party revised Recommendation ITU-R BT.2075 to update an application execution mechanism of Hybridcast, with which a companion device sends a command to a receiver to tune to a designated channel and launch a Hybridcast application.

3.3 Studies in ITU-T

ITU-T SG9 is also working for the study on IBB system applied to Cable Digital TV. At the meeting held in November 2018 in Bogota, Colombia, the Study Group started the work to revise IBB system Recommendation (ITU-T Recommendation J.207 "Specification for integrated broadcast and broadband digital television application control framework") to add the function of device collaboration with companion devices in Hybridcast. Recommendation J.207 is a twin of IBB system Recommendations in ITU; Recommendation ITU-R BT.2075 is another twin on this topic. So, the Study Group continue to work to revise the Recommendation according to revision of Recommendation ITU-R BT.2075. The Study Group is studying the work of smart TV operating system for hybrid cable Digital TV services including IBB DTV service provided by cable television operators and third-party providers. At the Bogota meeting, the study group make progress the work of the architecture of smart TV operating system. The study group consent the Recommendation of "The functional requirements of smart TV operating system" as ITU-T Recommendation J.1201.

At the meeting held in June 2019 in Geneve, the study group consent Recommendation J.207 to add the function of device collaboration in Hybridcast. The study group also make progress the work of drafting new Recommendation "Harmonization of Integrated Broadcast-Broadband DTV application control framework". As for the smart TV operating system, the study group consent the Recommendation of "The architecture of smart TV operating system" as ITU-T Recommendation J.1202. In addition, making a new Recommendation for the specification of smart TV operating system was started in the study group.

3.4 Cyber Security on IoT devices in Japan

The Ministry of Internal Affairs and Communications (MIC) of Japan and the National Institute of Information and Communications Technology (NICT), in cooperation with telecommunications carriers, started the "NOTICE (National Operation Towards IoT Clean Environment" project on February 20, 2019, to survey vulnerable IoT devices and to alert users to the problem.

Outline of the "Notice Project" is as follows.

1) NICT surveys IoT devices on the Internet and identifies vulnerable devices, such as those with weak password settings.
2) NICT provides the information of the devices to the telecommunications carriers.
3) The telecommunications carriers identify the users of the devices and alert users to the problem.

In addition to NOTICE, MIC, NICT, and ICT-ISAC have been working on other initiatives to investigate devices that may be misused in cyberattacks and to alert users of such devices. In the "Issues to Be Immediately Addressed to Strengthen Japan's Cybersecurity (Urgent Recommendations)" released by MIC in January 2020, it was reported that it is necessary to promptly investigate whether IoT devices installed at important domestic facilities are placed in a condition that is subject to attack in addition to those efforts by NOTICE. This survey (Critical IoT Device Investigation) will be conducted by NTT Communications Corporation, Yokohama National University, and ICT-ISAC who can easily identify their operator names and uses from the Internet. They are expected to urge the owners and operator of the devices in question and other parties to take precautions and implement measures.

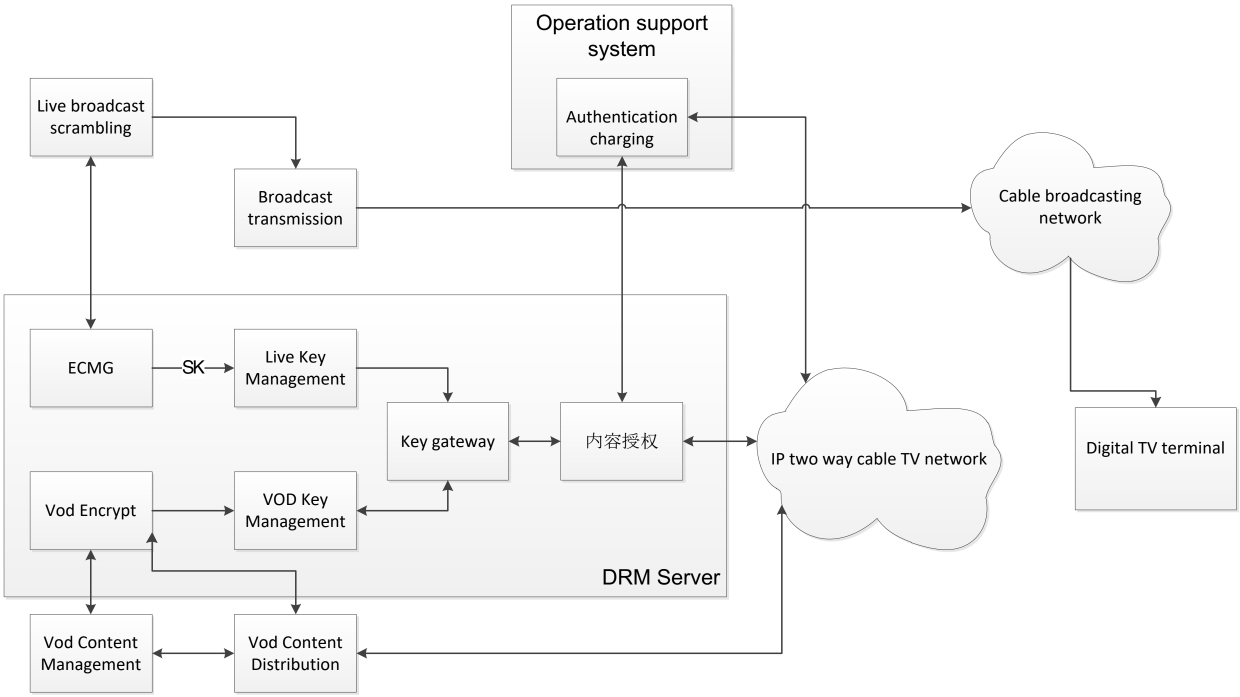
https://notice.go.jp/en/

3.5 Content protection of China

Currently, for content protection of IBB and OTT, DRM technology needs to ensure that in a variety of network modes, multiple file packaging formats and multiple encoding formats, the DRM technology can support content encryption under multiple technical architectures with the same technical architecture, can play with multiple different terminals, and have the same or similar experience. In addition, with the improvement of content quality, the requirements for content encryption are also gradually improved. These requirements include not only the performance improvement of content encryption, but also the improvement of security requirements for content protection. China has made technological attempts and innovations on several levels, issued DRM specifications[1] (ChinaDRM[2]), and has achieved certain industrial demonstration and verification.

3.5.1 The head-end system includes the key gateway, and the content key is synchronized in different network systems

In the IBB network model, for a high-quality content, the most important security guarantee is not to decrypt in the middle of the transmission link, but only to transfer the content key and code stream data safely, which can achieve the purpose of delivering high-quality content without disclosing the content key. The process is as follow:



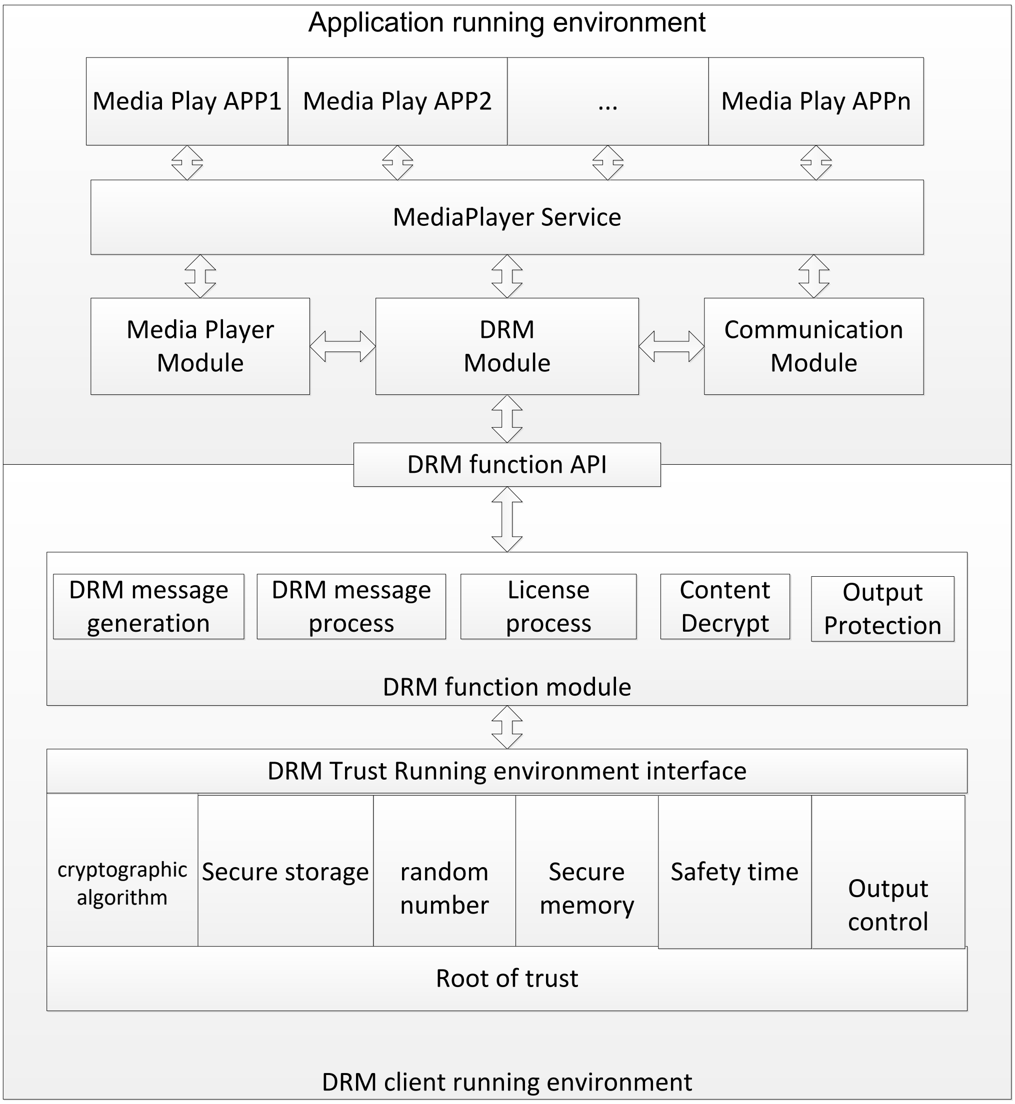
The transmission on the DRM service is guaranteed by the key gateway's isolation of content authorization and key management server. The DRM client doesn’t need to add additional business logic to support the key gateway.

3.5.2 Common encryption methods can be supported in a variety of stream formats as well as encoding codec

In the OTT network, the common formats are including HLS, DASH and other streaming media packaging, at the same time for broadcast networks to use TS packaging format, ChinaDRM described different encryption methods, and in accordance with international standards, the encryption characteristics of CENC is used in ChinaDRM, and other DRM business solutions in the industry can be achieved multi-encrypt technology.

3.5.3 Provide platform-independent DRM client SDK, which is open source components to fit multiple device scenarios

In the terminal market situation, the form of various types of terminals, hardware and software platforms are different, in order to ensure that a variety of terminal equipment, different chipset platforms can achieve the fit of the scheme, ChinaDRMLab[3] provides a platform-independent DRM client SDK, the SDK is open source to the certified members, its structure is as follows:



Huawei has completed the relevant fitting and deployment of mobile devices based on the ChinaDRM client SDK, enabling mass production of more than 20M devices.

3.5.4 Set three security level, meets the content providers' requirements

The DRM client defined by this standard is divided into three security levels: software security level, hardware security level, and enhanced hardware security level. Software security level refers to the implementation of some or all DRM client runtime based on software security mechanism; Hardware security level refers to the implementation of DRM client execution environment based on hardware security mechanism; Enhanced hardware security level refers to upon hardware security level DRM client execution environment should also have capabilities like side channel attack defense, forensics watermark, etc.

3.5.5 Security technology system of interoperability between server and client

ChinaDRM constructs a security technology system for client and server interoperability from the following aspects:

1. ChinaDRM standard defines the protocol and license format of interaction between client and server;

2. The client reference design is provided, which not only supports the terminal rapid integration, but also provides the security capability and interoperability compatibility with the server;
3. Establish the authentication system of client and server, control the security of server and classify the security of terminal;
4. Establish trust system based on trusted certification center to realize the trust construction between different vendors.

References:
[1] GY/T 277-2019 Technical specification of digital rights management for video audio content distribution

GYT277-2019
Technical specific

[2] ChinaDRM http://www.china-drm.net

[3] ChinaDRMLab http://www.chinadrmlab.org

Annex 4

Project: Satellite Broadcasting (T/SB)

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Co-project Manager: **TBD** (TRT, Turkey)

4.0 Objectives

This clause describes technologies on the latest satellite systems for UHDTV broadcasting and specifications of the latest satellite broadcasting systems. And it describes also the latest topics on advanced satellite broadcasting technologies using Ka-band, etc.

4.1 ITU-R documents related to satellite broadcasting systems

4.1.1 Radio Regulations

ARTICLE 23 Section 2 "Broadcasting-satellite services"

APPENDIX 30 "Provisions for all services and associated Plans and List for the broadcasting-satellite service in the frequency bands 11.7-12.2 GHz (in Region 3), 11.7-12.5GHz (in Region 1) and 12.2-12.7 GHz (in Region 2)

APPENDIX 30A "Provisions and associated Plans and List for feeder links for the broadcasting-satellite service (11.7-12.5GHz in Region 1, 12.2-12.7 GHz in Region 2 and 11.7-12.2 GHz in Region 3) in the frequency bands 14.5-14.8 GHz and 17.3-18.1 GHz in Regions 1 and 3, and 17.3-17.8 GHz in Region 2

RESOLUTION 506 "Use by space stations in the broadcasting-satellite service operating in the 12 GHz frequency bands allocated to the broadcasting-satellite service of the geostationary-satellite orbit and no other"

RESOLUTION 507 "Establishment of agreements and associated plans for the broadcasting-satellite service"

RESOLUTION 528 "Introduction of the broadcasting-satellite service (sound) systems and complementary terrestrial broadcasting in the frequency bands allocated to these services within the range 1-3 GHz."

RESOLUTION 536 "Operation of broadcasting satellites serving other countries."

RESOLUTION 548 "Application of the grouping concept in Appendices 30 and 30A in Regions 1 and 3"

RESOLUTION 552 "Long-term access to and development in the frequency band 21.4-22 GHz in Regions 1 and 3"

RESOLUTION 553 "Additional regulatory measures for broadcasting-satellite networks in the frequency band and 21.4-22 GHz in Regions 1 and 3 for the enhancement of equitable access to this frequency band"

RESOLUTION 554 "Application of pfd masks to coordination under No. 9.7 for broadcasting-satellite service networks in the band 21.4-22 GHz in Regions 1 and 3”

RESOLUTION 555 “Additional regulatory provisions for broadcasting-satellite service networks in the frequency band 21.4-22 GHz in Regions 1 and 3 for the enhancement of equitable access to this frequency band”

RESOLUTION 557 “Consideration of possible revision of Annex 7 to Appendix 30 of the Radio Regulations”

4.1.2 Recommendations (https://www.itu.int/rec/R-REC-BO/en)

BO.1213 “Reference receiving Earth station antenna pattern for the broadcasting-satellite service in the 11.7-12.75 GHz band”

BO.1408 “Transmission system for advanced multimedia services provided by integrated services digital broadcasting in a broadcasting-satellite channel”

BO.1516 “Digital multiprogramme television systems for use by satellites operating in the 11/12 GHz frequency range”

BO.1659 “Mitigation techniques for rain attenuation for broadcasting-satellite service systems in frequency bands between 17.3 GHz and 42.5 GHz”

BO.1696 “Methodologies for determining the availability performance for digital multi-programme BSS systems, and their associated feeder links operating in the planned bands”

BO.1724 “Interactive satellite broadcasting systems (television, sound and data)”

BO.1774 “Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief”

BO.1784 “Digital satellite broadcasting system with flexible configuration (television, sound and data)”

BO.1900 “Reference receive earth station antenna pattern for the broadcasting-satellite service in the band 21.4-22 GHz in Regions 1 and 3”

BO.2063 “Alternative BSS earth station antenna radiation pattern for 12 GHz BSS bands with effective apertures in the range 55-75 cm”

BO.2098 “Transmission system for UHDTV satellite broadcasting”

4.1.2 Reports (https://www.itu.int/pub/R-REP-BO/en)

BO.2007 “Considerations for the introduction of broadcasting-satellite service of high-definition television and ultra-high-definition television systems in the band 21.4-22 GHz”

BO.2071 “Broadcasting-satellite service system parameters between 17.3 GHz and 42.5 GHz and associated feeder links”

BO.2101 “Digital satellite broadcasting system (television, sound and data) with flexible configuration”

BO.2102 “Multiple-feed BSS receiving antennas”

BO.2397 “Satellite transmission for UHDTV satellite broadcasting”

4.2 Latest topics on satellite broadcasting

4.2.1 4K/8K Broadcasting in Japan

Japan has laid out a future vision for 4K/8K broadcasting roadmap and started providing 4K/8K programs via satellites, cable, IPTV. The launches of 4K/8K broadcasting via satellites are as follows;

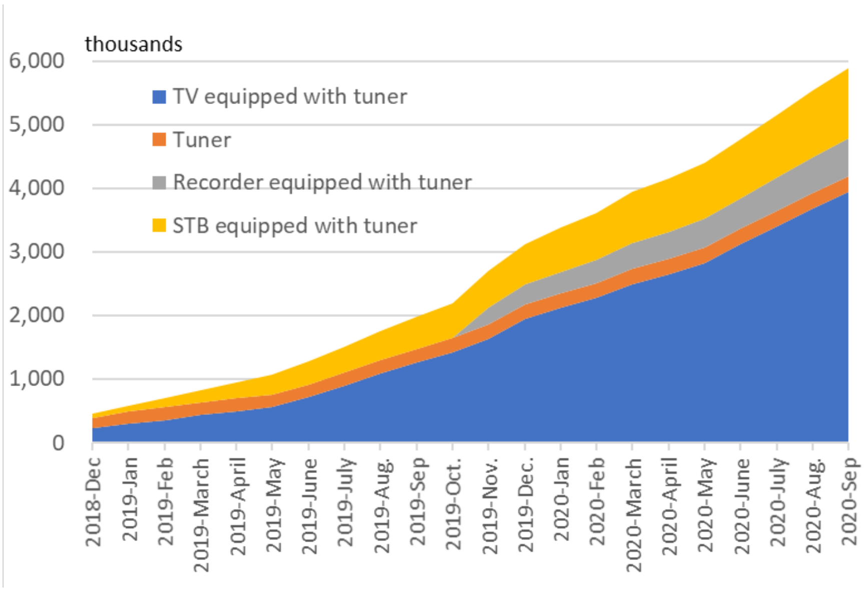
2014 June 4K test broadcasting via communication satellites of 124/128E
2015 March 4K full broadcasting via communication satellites of 124/128E
2016 August 4K/8K test broadcasting via broadcasting satellites of 110E
2018 December 4K/8K full broadcasting via broadcasting satellites of 110E

The technical specification of the transmission system called "ISDB-S3" for 4K/8K full broadcasting is shown in Rep. ITU-R BO.2397 as follows;

Technical specification of the transmission system for 4K/8K full broadcasting

Frequency	Uplink: 17GHz-band Downlink: 12GHz-band
Bandwidth	34.5 MHz
Symbol rate	33.7561 Mbaud
Roll-off factor	0.03
Modulation	16-APSK
Inner coding rate (LDPC)	7/9
Information bit rate	100.0 Mbps
Multiplexing	MMT
Video coding	H.265/HEVC
Audio coding	MPEG-4 AAC

4K/8K television ownership has been increasing. It reached to 7.8% in March 2019, 9.9% in July 2019,14.4% in May 2020, respectively. The number of the shipment of 4K/8K receivers has been increasing to about 6 million units as of September 2020.



Number of shipment of 4K/8K receivers in Japan