Ka-band Satellite Broadcasting System using Scalable Video technology

Seung Chul Kim[1], Dae Ig Chang[1]

요 약

본 논문에서는, 스케일러블 비디오 압축 기술을 이용한 Ka대역 HD 위성방송 시스템을 소개하고자 한다. 이미 알려진 바와 같이, Ka대역은 강우감쇠에 취약한 특성으로 인해 HD 위성방송 서비스를 제공함에 있어서 일정 수준 이상의 가용도가 보장되기 어렵다. 그러한 문제점을 극복하기 위한 방안으로서, 본 논문에서는 H.264 SVC 비디오 기술을 기반으로 한 계층형 방송 시스템의 개념과 그에 따른 몇 가지 형태의 시스템 시나리오를 제시하고, 각각에 대한 비교 분석을 통해 최적의 모델을 제시하고자 한다. 각 시나리오에는 DVB-S, DVB-S2 전송 규격이 포함되며, 변조 방식으로는 QPSK와 8PSK등이 고려되었다. 모든 경우에 대하여, 2 계층 공간 스케일러블 비디오 압축 방식이 적용되었다.

키워드 : 위성, 위성방송, Ka 대역, SVC, Scalable Video, H.264

ABSTRACT

In this paper, we propose an advanced Ka-band satellite HD broadcasting system using scalable video coding technology. As already known, it is not so easy to achieve reasonable link availability on Ka-band because of the rain-attenuation effect, and in case of HD broadcasting service it's more difficult. To overcome that problem, we propose an hierarchical broadcasting system based on H.264 SVC technology. In this paper, we suggest a few types of system scenario to realize the concept. Those scenarios are including DVB-S and DVB-S2 and spatially scalable video stream is the source stream in all cases.

Key Words : satellite, satellite broadcasting, Ka band, Scalable Video, H.264

I. Introduction

The ITU World Administrative Radio Conference(WARC '92) had allocated frequency bands in the 21 GHz range for Broadcasting Satellite Services for region 1, 3. The primary aim of this allocation was to open up the Ka-band satellite frequency range to potentially provide high quality HDTV services and powerful data services over satellite.

The Ka band can be useful for the broadband service like the HD class multi-channel satellite broadcasting. But, it is very sensitive to an affect by the atmospheric factor like rain attenuation which can cause the quality blazing or service outage. And this low link availability is critical in view of TV broadcasting service.

Fig 1 shows the rain attenuation distribution based on ITU-R P.618-8.

In this paper, to improve the link availability for the Ka band HD broadcasting, we propose the concept of the hierarchical broadcasting system based on scalable video coding technology (SVC) and present a few system scenarios based on the concept.

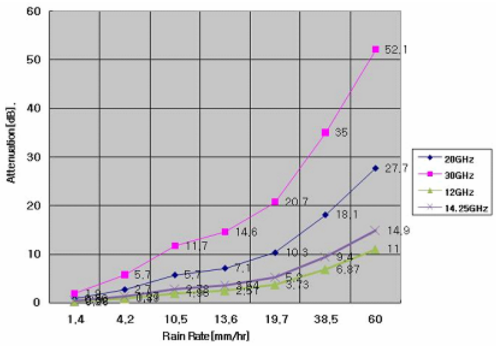

Figure 1: Rain Attenuation at 20GHz

* 1 Electronics and Telecommunications Research Institute 138 Gajeongno Yuseong-gu Daejeon. KOREA 305-700
Email: skimc@etri.re.kr

Overview of the proposed system is described in section 2. In section 3, H.264 SVC, the new emerging scalable video standard, is introduced. In section 4, several transmission system scenarios are presented.

2. Hierarchical broadcasting system

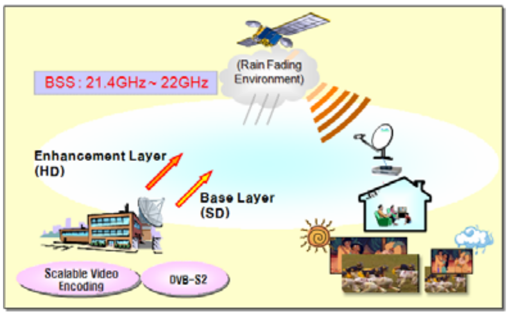

Figure 2: Hierarchical broadcasting over satellite

Figure 1 shows the overview of the proposed architecture of 21GHz hierarchical satellite HD broadcasting service. Prior to processing the video compression, high quality video source is down-sampled into low quality video sequence. The two video sources are fed into the SVC encoder and coded into layered bitstream. The Layered bitstream is separated and transmitted with different FEC rate or different transmission channel. In case of clear sky condition, high quality video can be received. On the contrary, low quality video is available in case of deteriorated channel condition. Consequently the link availability can be improved. This quality-selective service can be achieved by layering at both source level and transmission level as described above.

For the layering at the source level, the scalable video coding technology is applied. The key feature of scalable video coding (SVC) is that various representations of a video source with different resolutions, frame rates, and/or bitrates are provided inside a single bit-stream as shown at Figure 3.

The scalable extension of H.264/MPEG4-AVC, called as H.264 SVC, is a current standardization project of the Joint Video Team (JVT) of the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG).

Layering at the transmission level can be achieved with various techniques like hierarchical modulation, multiple physical channels and variable coded modulation(VCM).

As previously well known, DVB-S2 allows the use of hierarchical 8PSK modulation for backward compatibility and VCM to enhance the bandwidth efficiency. Using multiple channels depends on how much it costs to realize the system. With those techniques including svc, there can be several system scenarios for transmitting scalable video stream over Ka band satellite which are described in section 4.

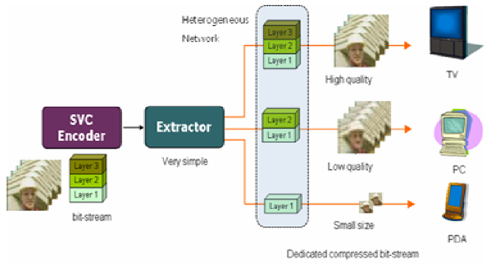

Figure 3 : Scalable video application

3. H.264 SVC

SVC has been an active research area since more than 15 years. However, former approaches and standards have been rarely used, since the additional scalability features came along with a significant coding efficiency loss and an increased decoder complexity. As an important feature of the H.264 SVC design, most components of highly efficient H.264/MPEG4-AVC are used as specified in the standard.

H.264 SVC provides spatial, temporal and SNR scalability. In contrast to older video coding standards as MPEG-2/4, the coding and display order of pictures is completely de-coupled in H.264/MPEG4-AVC and the temporal scalability is achieved by reorganizing the decoupled pictures into several groups. Spatial scalability is achieved by an oversampled pyramid approach. The pictures of different spatial layers are independently coded with layer specific motion parameters. SNR scalable coding is achieved using the concepts for spatial scalability. The only difference is that the up/down sampling and scaling operations of the inter-layer prediction mechanisms are omitted and that the general concept of re-quantization is used.

Base layer(layer1 in Figure 3) stream is completely compatible with H.264 AVC decoder. The efficiency drop of 10% around is shown than the single layer H.264 AVC coding. But, whereas the code efficiency is not so decreased, a complexity does not show the discriminative improvement.

Broadcasting system models presented in section 4 premised 2 layer Spatial Scalability. 2Mbps SD is allocated to the base layer, 6Mbps

HD is allocated to the enhancement layer.

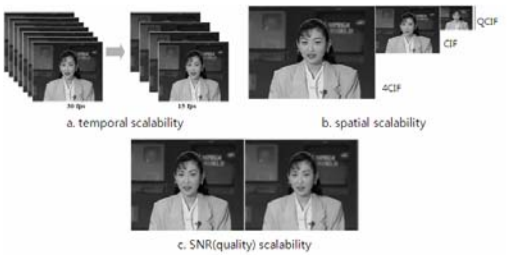

Figure 4 : Scalabilities of H.264 SVC

4. Transmission system scenarios

4-1. Scenario 1 : Dual(Ku/Ka) band

Ku band endures comparatively better than Ka band in rain attenuation. So, if stream can be separated into two parts and transmitted via both Ku and Ka, service link availability can be improved. In view of network, dual band acts like an heterogeneous network. The base layer part of svc stream is transmitted through the comparatively stable narrowband channel, and the enhancement layer part is transmitted through the unstable broadband channel.

Applying the SVC technology into the dual band transmission system, provides advantage of efficient frequency resource allocation for HD broadcast because it is possible to provide both one SD class service and one HD class service simultaneously with single stream.

In spite of the above advantages, the cost increase and there can be time delay disadvantage due to synchronism between the layers.

Figure 5 shows an overview of dual band hierarchical broadcasting system. DVB-S for base layer can be replaced by DVB-S2.

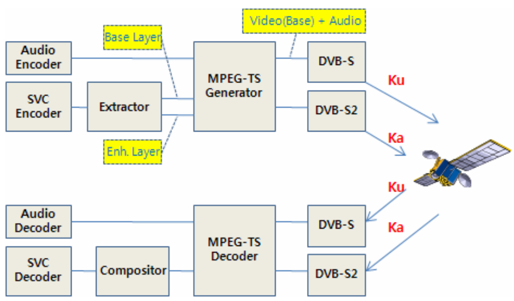

Figure 5: Dual-band hierarchical broadcasting

4-2. Scenario 2 : Hierarchical Modulation

DVB-S2 includes Hierarchical modulation technique(hier-8PSK) to provide backward compatibility. Figure 6 shows the system model modified from the DVB-S2 BC. Base layer and enhancement layer stream are assigned with the LP stream and HP stream and transmitted over Ka satellite.

In using hierarchical 8PSK, it is not quite differentiable in quality between LP and HP because the transmission capacity of LP is at most about 70% of HP's.

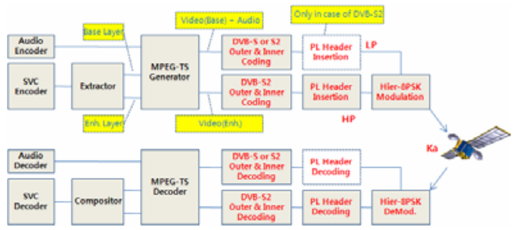

Figure 6: Hierarchical modulation broadcasting

With that reason, hierarchical modulation can not be the good approach for applying spatially scalable HD class stream. **

4-3. Scenario 3 : DVB-S2 VCM

The Dual channel transmission technique described in section 4.1 has the realistic problem like cost and time delay. In this section, the application of the VCM technique is presented to avoid those advantages.

In DVB-S2, each frame that is transmitted, contains information on how that frame is modulated and coded in its header. A VCM capable demodulator will read this information from the header of each frame and use it to demodulate and decode that frame. This allows varying the modulation and coding parameters of each transmitted frame within the DVB-S2 stream since decoding is done on a frame-by-frame basis. VCM is particularly powerful when different services do not need the same protection level. It is acceptable to lose a secondary channel in case of rain fade.

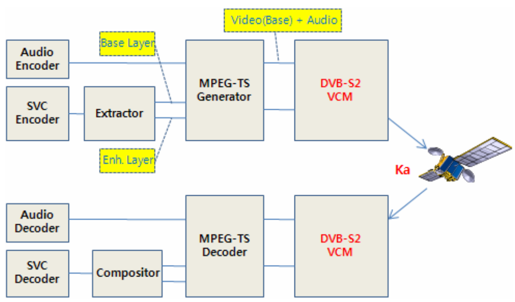

Figure 7: Dual-band hierarchical broadcasting

The variability of VCM conceptually very well matches with transmitting the layered SVC stream. But, in VCM, the PL frame length is changed according to a modulation, the FEC rate, and the appearance of the pilot symbol. That makes so difficult to implement receiver, more specifically to complete the synchronization. There can be two approaches to realize. One of them is not giving a change in modulation scheme, just giving a change in FEC rate. The other is giving changes both in modulation scheme and FEC rate. The length of the PL frame only changes according to the modulation scheme. For synchronizing the frame having the fixed modulation and the variable code rate, there is no difficulty.

Figure 8 shows the frame constitution which applies the QPSK 1/2 to the 2 Mbps base layer and applies QPSK 8/9 to the 6 Mbps enhancement layer.

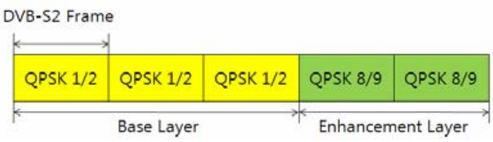

Figure 8: Frame structure : same modulation, different FEC rate

For synchronizing the frame having the fixed modulation and the variable code rate, a superframe structure can be a solution for minimizing the frame loss resulted from the synchronization failure. A receiver should be given in advance with information about the repetition cycle. But it takes more time to get locked during initial synchronization. And PLS decoding should be accomplished with phase-locking in the feedforward form or can be done right after frequency locking. The change of PL-length has an effect on the mean acquisition time and it means that the frame synchronization error-rate need to be adjusted. Figure 9 shows the structure of a super frame proposed. link budget can be obtained as shown Table 1.

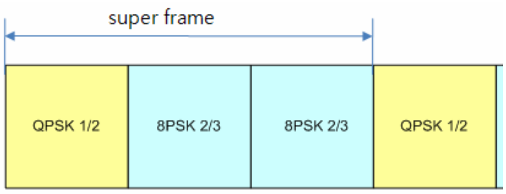

Figure 9: Frame structure : different modulation, different FEC rate

To satisfy the 99.7% link condition, the size of receiver side antenna should be bigger than 0.6m.

Table 1 : D Link budget for system scenario 3

Antenna	0.6m	0.7m	0.8m	0.9m	1m	1.1m
C/N for 99.7% availability	0	1.31	2.44	3.43	4.3	5.1
C/N for 99.9% availability	-4.56	-3.23	-2.08	-1.07	-0.16	0.65

5. Conclusions

Recently, HDTV seems to be becoming a new paradigm in both terrestrial and satellite digital broadcasting. As a method to compensate the degradation of link availability due to rainfall attenuation, we proposed several types of hierarchical broadcasting system based on DVB-S2 for HD service over Ka band satellite. They all have commonly layered architecture both at source and transmission level. High quality video can be received in case of clear sky condition and low quality video is available in case of deteriorated channel condition.

Dual-band transmission system described in section 4.1 can give more than estimated 99.85% link availability for receiving low quality video and estimated 99.7% for high quality video with 0.6m antenna. In case of using VCM, as described in section 4.3, it is possible to get estimated 99.9% with 0.9m antenna and to get estimated 99.7% with 0.6m antenna.

Acknowledgements

This work was partly supported by the IT R&D program of MIC/IITA[2007-S008-01, Development of 21GHz Band Satellite Transmission Technology]

Reference

[1] Heiko Schwarz, Detlev Marpe, and Thomas Wiegand, “Overview of the scalable H.264/MPEG-AVC extension”, IEEE Trans. On Circuits and Systems for video Technology, Vol. 17, no.9, Sept. 2007, pp. 1103-1120

[2] ITU-T Rec. & ISO/IEC 14496-10 AVC, “Advanced Video Coding for Generic Audiovisual Services,” version 3, 2005.

[3] Thomas Wiegand, et al “Scalable Video Coding – Joint Draft 10,” Joint Video Team, Doc. JVT-W201, Sanjose, USA, Apr. 2007

[4] H. Kaoth, A. Hashimoto, H. Matsumura, S. Yamazaki, O. Yamada, “A flexible

transmission technique for the satellite ISDB system", IEEE Trans. On Broadcasting, Vol.42, No.3, pp. 159-166.
[5] L.Combarel, E. Lavan, "HD-SAT(RACE 2075) : HDTV broadcasting over Ka-band satellite, cable and MMDS", International Broadcasting Convention, No.397, Sept. 1994, pp. 633-640

저 자

김 승 철(Seung-Chul Kim) 정회원

1996년 8월: 전남대학교 전자공학 학사
1999년 2월: 전남대학교 전자공학 석사
2000년 10월～현재: 한국전자통신연구원 선임연구원

<관심분야> 전자공학, 통신공학

장 대 익(Dae-Ig Chang) 정회원

1985년 2월: 한양대학교 전자통신공학과 학사
1989년 2월: 한양대학교 전자통신공학과 석사
1999년 2월: 충남대학교 전자공학과 박사
1990년 2월～현재: 한국전자통신연구원
광대역무선멀티미디어연구팀 팀장
1991년~1993년 캐나다 MPR Teltech 연구소 VSAT팀 연구원
2005년~현재 과학기술연합대학원대학교(UST) 이동통신 및 디지털방송공학전공 교수

<관심분야> 위성통신시스템,위성방송, 디지털통신, 디지털 변복조등