Comparison of the Physical-layer Performance between ATSC 3.0 and 5G Broadcast

Seok-Ki Ahn, *Member, IEEE* and Sung-Ik Park, *Fellow, IEEE*

***Abstract*—This paper compares the physical-layer performances of ATSC 3.0 and 5G broadcast in the scenario to provide mobile broadcasting services. The differences of physical-layer between ATSC 3.0 and 5G broadcast are discussed in terms of transmission efficiency, overheads, and BICM performance over mobile environments. Through the computer simulations, it is shown that ATSC 3.0 can provide more robust and enhanced physical-layer performance than 5G broadcast over mobile environments.**

***Index Terms*—ATSC 3.0, 5G broadcast, mobile broadcasting, physical-layer.**

I. Introduction

In 2016, the Advanced Television Systems Committee (ATSC) approved the physical layer standard of ATSC 3.0 systems, which support efficient and flexible delivery of broadcast services for both fixed and mobile receivers [1]. As a result, high quality broadcasting services such as three-dimensional and ultra-high definition (UHD) contents are possible over ATSC 3.0 thanks to its superior spectral efficiency, channel robustness, and flexible transmission. Since ATSC 1.0 was first standardized, many innovative physical-layer technologies have been evolved and applied to ATSC systems. For example, low-density parity-check (LDPC) codes and non-uniform constellation (NUC) are regarded as two representatives of the superiority of ATSC 3.0 physical layer.

On the other hand, in the 3rd generation partnership project (3GPP), a work item for LTE-based 5G terrestrial broadcast (referred to as 5G broadcast in this paper) is carried out during 3GPP release (Rel-) 16 and finished with some enhancements in 2019 [2], [3]. The major improvements of the 5G broadcast over the underlying technology further evolved multimedia broadcast multicast service (FeMBMS) is to support a large geographical area up to 100km inter-site distance (ISD) and high mobility up to 250km/h. Due to the above enhancements, 5G broadcast not only can meet the 5G terrestrial broadcast requirements but also becomes a competitive technology comparable to ATSC 3.0.

As the proportion of mobile terminals is increasing in terms of the receiving terminal for broadcasting services, the capability to provide services for mobile user equipment (UE) is becoming more and more important. For this reason, 5G broadcast has been drawing attention as a future terrestrial broadcasting solution. Recently, a Mark One smartphone has been released that enables ATSC 3.0 service in mobile terminals to facilitate the reception of ATSC 3.0 in a mobile environment. According to the trend of mobile broadcasting services, this paper comprehensively compares the capability of both technologies in terms of providing mobile broadcasting services.

TABLE I
Physical Layer Overhead of ATSC 3.0 and 5G Broadcast

	ATSC 3.0	5G broadcast
Guard band overhead (%)	2.8	10.0
Cyclic prefix overhead (%)	20.0	20.0
Pilot pattern overhead (%)	16.7	16.7
Total overhead (%)	35.2	40.0

II. Physical Layer Overview

To provide stable terrestrial broadcasting services over mobile environments, superior and robust physical-layer performance is essential, which can be expressed as transmission efficiency as the following formula:

$$\text{Efficiency} = SE(SNR)\times(1-OH_{SP})\times(1-OH_{GB})\times(1-OH_{CP}) \quad (1)$$

where OH_{SP} is the scattered pilot overhead of channel estimation, OH_{GB} is the overhead of guard band, and OH_{CP} is the overhead of the CP of an orthogonal frequency-division multiplexing (OFDM) symbol. In addition, SE(SNR) represents bit-interleaved coded modulation (BICM) spectral efficiency, which means the number of data bits per channel use that can be received successfully, depending on the received signal-to-noise power ratio (SNR). The main overheads in the physical layer of both systems are compared in Table I. For fair comparison, CP length and pilot pattern of ATSC 3.0 are chosen as closely as possible to those of 5G broadcast, although other parameters are permitted in ATSC

TABLE II
BICM Components of ATSC 3.0 and 5G Broadcast

	Channel codes	Constellation	T/F interleaver
ATSC 3.0	LDPC codes	NUC/QAM	Used
5G Broadcast	Turbo codes/ Convolutional codes	QAM	Not

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TABLE III
EVALUATION ASSUMPTIONS

	ATSC 3.0	5G broadcast
FFT size	8192	12288
Guard interval	222.22us	200us
OFDM duration	888.83us	800us
Subcarrier spacing	1.125kHz	1.25kHz
Center frequency	500Hz	
Bandwidth	8MHz	
Channel Model	India-Urban [5]	
UE Mobility	60km/h	
Channel estimation	LS estimation + Linear interpolation	

3.0 standard. As shown in Table I, the total overhead of 5G broadcast is slightly larger than that of ATSC 3.0.

The BICM spectral efficiency and robustness is mainly determined by the component technologies such are channel codes, signal constellation, and time/frequency (T/F) interleavers [4]. Since 5G broadcast is based on the LTE physical layer, which is first standardized in 3GPP Rel-8, there are limitations in the viewpoint of physical-layer performance. Table II summarizes them between ATSC 3.0 and 5G broadcast.

III. PERFORMANCE RESULTS

In this section, physical-layer performances of ATSC 3.0 and 5G broadcast are evaluated by computer simulations in terms of block error rate (BLER). Note that the Log-MAP algorithm with 8 iterations is used for turbo codes and sum-product algorithm with 50 iterations is used for LDPC codes. The BLER performances of the data channel of two systems are evaluated over additive white Gaussian noise (AWGN) channel and India-Urban channel [5] in Fig. 1 and Fig. 2, respectively, whose evaluation assumptions are given in Table III.

For ease of comparison, data rate of 5Mbps, 10Mbps, and 15Mbps are chosen for performance comparison. Thanks to the superiority of the LDPC codes in ATSC 3.0 compared to the turbo codes in 5G broadcast, the decoding performance of ATSC 3.0 is better than that of 5G broadcast over AWGN channel. In addition, in the case of 15Mbps, ATSC 3.0 provides strictly better performance than 5G broadcast due to the shaping gain of NUC under high-order modulations (HOMs).

The performance gain of ATSC 3.0 under mobile environment is evaluated over India-Urban channel in Fig. 2. As shown in Fig. 2, the performance gain is larger than that over AWGN channel due to the time interleaver. For this reason, the performance gain increase as the target BLER decreases because the BLER curves of ATSC 3.0 is steeper than that of 5G broadcast. As a result, SNR gain for achieving BLER = 10^{-4} reaches up to about 8.5dB, 9.0dB, and 12.5dB for 5Mbps, 10Mbps, and 15Mbps, respectively.

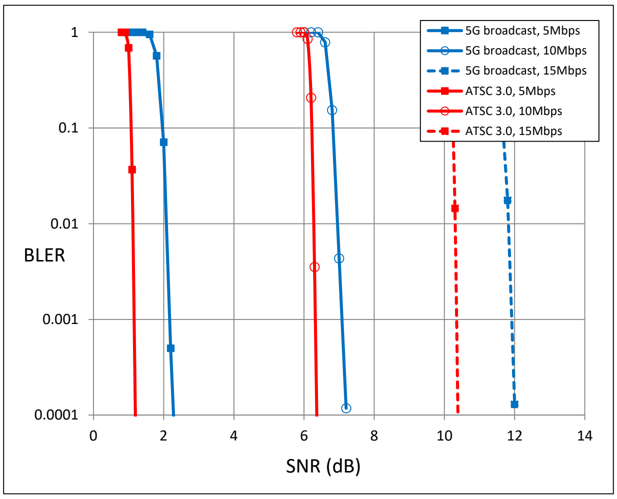

Fig. 1. BLER performance over AWGN channel

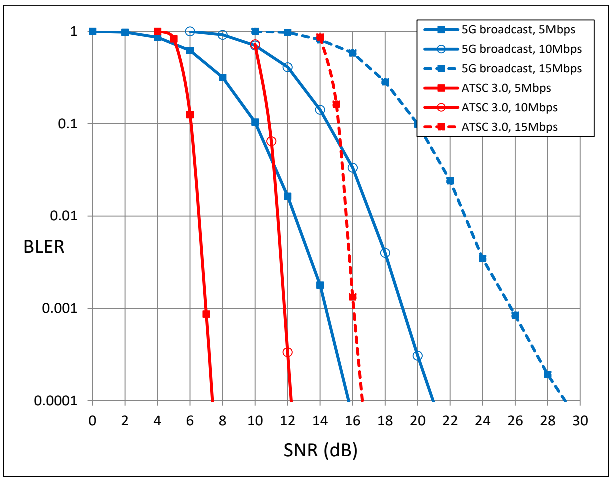

Fig. 2. BLER performance over India-Urban channel

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