Master's Thesis

Adaptive Logical Superposition Modulation and H.264 SVC based Video Streaming Multicast over WiMAX Network

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와이맥스 망에서 적응적 논리 중첩 변조와 H.264 SVC를 기반으로 한 동영상 스트리밍 멀티캐스트 시스템

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by

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The undersigned have examined this thesis and hereby certify that it is worthy of acceptance for a master's degree from POSTECH

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Abstract

In this paper, we present an adaptive logical superposition modulation system considering mobility and distribution of subscribers. Since existing logical superposition modulation systems transmit OFDM symbols to subscribers using fixed modulation schemes without considering time-varying channel condition of subscribers, it achieves a lower network throughput compared to adaptive modulation and coding scheme. The proposed adaptive logical superposition modulation accurately estimates time-varying wireless channel condition by using Kalman filter and Channel Quality Information of subscribers. According to the information, it dynamically chooses modulation schemes to maximize total network throughput of subscribers. And H.264 two-layer SVC video stream data are mapped to the proposed superposition modulation to improve streaming video quality. Finally experimental results are provided to show the performance of the proposed system.

Keywords: Video streaming multicast, Logical superposition modulation, Adaptive modulation, Kalman filter, H.264 SVC

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I. Introduction

The data throughput and requirement of multimedia service is increased due to the broadband networking and personal devices(e.g. smartphone, tablet PC) that provide various services. To satisfy these requirements, the cost issues are occurred expand infrastructure. For reducing cost and satisfying the requirement of subscribers, It needs multicast technique. The multicast transmits same data to many subscribers at same time without increasing overhead of sender or networks. Especially, If multi cast is used can overcome the limit on the number of subscribers. If multicast technique is adopted at video streaming system, this system provides the multimedia service for many subscribers as low cost. WiMAX(Worldwide interoperability for Microwave Access) network is one of strong candidate that supports video streaming multicast service. It is an appearing wireless access network that provides high data rates and guarantees individual QoS(Quality of Service) requirement of subscribers in wide service area. But WiMAX network has some issues that restricts supporting video streaming multicast service smoothly. Although WiMAX network provides high rates in the wireless environment, it is still poor and unstable compared to wired networks. Also It is important to provide satisfied quality of service to each subscribers using limited radio resources, but guarantee basic quality of service for every subscribers is also an important issue. SPCM (SuperPosition Coded Modulation) [1, 2, 3] and LSPM (Logical SuperPosition Modulation) [4, 5, 6] is proposed to handle these issues. SPCM is transmitted signal that superimposed two signal to one signal. For superposition modulation, it need to physical equipments both transmitter and receiver. It is weak point to apply this technique for existing infrastructure. LSPM(Logical SuperPosition Modulation) is need not physical equipments for superimposed signal. But LSPM is not considered subscribers' distribution and time-varying wireless channel condition, sometimes performance of LSPM is lower than performance of AMC(Adaptive Modulation and coding scheme). In this paper, we propose an effective adaptive LSPM and H.264 SVC-based video streaming multicast system. One of the unique features of the proposed system is that the proposed multicast system adaptively changes the modulation scheme like other state-of-art wireless networks and decomposed it into a combination of two sub-modulation schemes considering the distribution of subscribers in order to maximize overall network throughput. Consequently, better video streaming service can be provided to more subscribers.

II. Related Works

Modulation is the process of translating a data stream into a form suitable for transmission on the physical medium, and its performance is measured by the ability to preserve the accuracy of the encoded data. In mobile wireless networks, large-scale path loss, small-scale fading and multi-path, and interference cause random variations in the received SNR. Such variations increase the BER (bit error rate) because it is more difficult for the modulation scheme to decode the received signal in the case of the lower SNR. Since high rate schemes typically use denser modulation encodings, a tradeoff generally emerges between data rate and BER: the BER decreases with increasing SNR for each modulation scheme and an increase in data rate results in an increase in BER for a given SNR[7]. Recently, superposition modulation has been proposed to achieve higher channel capacity [1, 2, 3]. In this section, we briefly introduce SPCM (SuperPosition Coded Modulation), LSPM (Logical SuperPosition Modulation), H.264/SVC scheme[8, 9, 10].

2.1 SPCM and LSPM

SPCM is the modulation which makes a superimposed signal with two signal to transmit. As shown in Figure 1, The input video stream is encoded by base layer video data and enhancement layer video data using scalable video encoder at the transmitter. The encoded video data stream creates 2 different of modulation scheme signals as low priority in base layer and high priority in enhancement layer. The created signals transmit modulation scheme of low priority signal superimpose on modulation scheme of high priority. Received signal of SPCM carries out demodulation as modulation scheme of low priority at the receiver. At this time, demodulated signals is extracted a signal created by modulation scheme of low priority. And when you carry out SIC(Signal Interference Cancellation) at SPCM signal, it can be extracted modulation scheme of high priority from received signal of SPCM and the extracted signal. The extracted signals are demodulated base layer video stream and enhancement layer video stream. Each video streams is stored in buffers and play out a integrated video stream using video decoding.

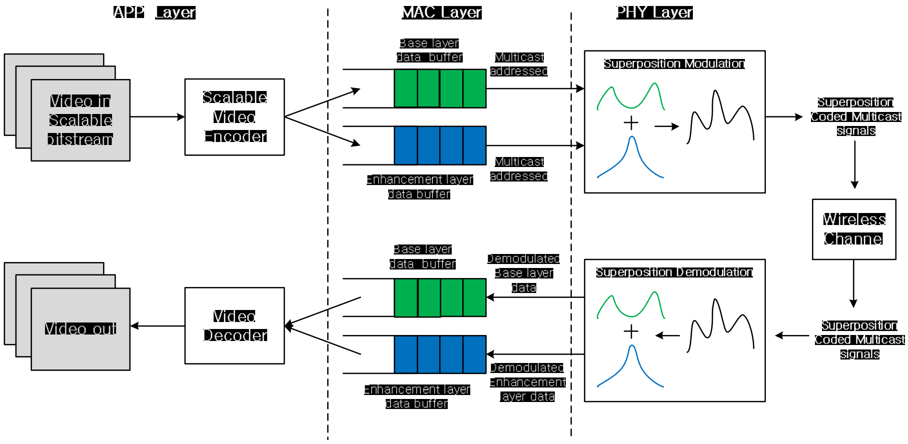


Figure 1. The structure of SPCM.

SPCM is needed physical equipments for the transmitter and the receiver. The transmitter need signal equipment to superimpose the created signal. And the receiver need SIC equipment to cancel the extracted signal in received signal. The traditional service providers don't prefer SPCM that needs new infrastructures demanding high costs. So, LSPM is proposed that modulation system considers this issues. As shown in Figure 2, LSPM is the modulation which logically makes a signal with a data stream consisting a data stream of two signals without physical equipments.

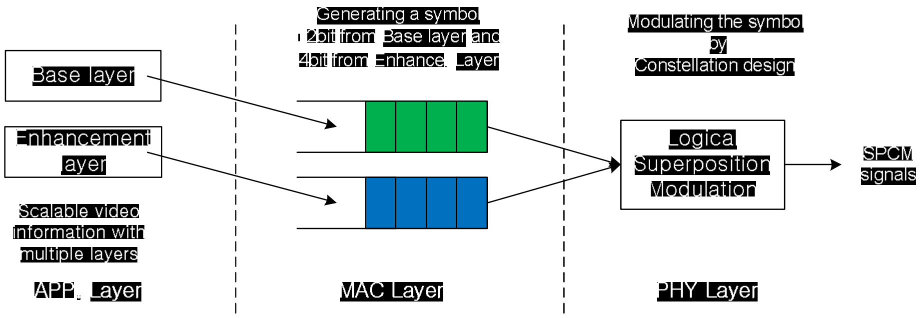
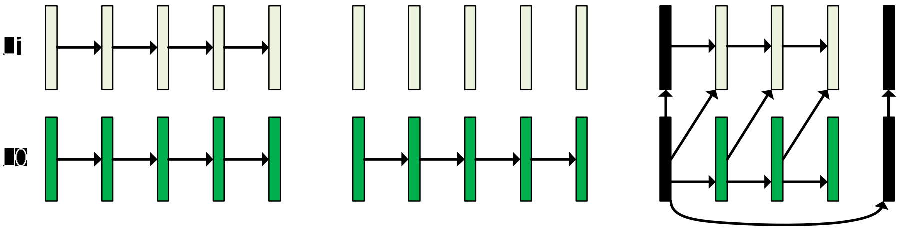


Figure 2. The structure of LSPM.

The encoded base layer and enhancement layer video data is stored in data streams of MAC layer for composition of OFDM symbol. The stored data generates OFDM symbols according to determined modulation scheme of base and enhancement layer by LSPM system. Then, generated OFDM symbols are transmitted to receiver. The received OFDM symbols is demodulated by integrated modulation scheme of base and enhancement layers. The demodulated data of OFDM symbols are stored data streams of base and enhancement layer splitting base layer data and enhancement layer data. If demodulation of OFDM symbols is failed due to weak wireless channel condition, The OFDM symbols are demodulated by modulation scheme of base layer to extract only base layer data. The extracted data is stored a base layer data stream. Each data streams is integrated video data by decoding. Then, this data provides video service to receivers. LSPM transmits a data stream that consists of base layer video data and enhancement layer video data. It is means that simultaneously consider two issues about guarantying a basic quality of video service and providing satisfied quality of service to each subscribers by using limited radio resources for every subscribers.

2.2 H.264 SVC Scheme

H.264/SVC is standardized to expand H.264/AVC for Scalable Video Coding schemes which are adopted a specific profile parts of the H.263 that is standardized by JVT(Joint Video Team) of ITU-T VCEG(Video Coding Experts Group) and ISO/IEC MPEG(Moving Picture Experts Group) [11]. H.264/SVC divides video data for base layer which is interoperable with H.264/AVC and enhancement layer by using layered video coding scheme. The base layer has encoding information which is minimum perceptible quality of video data. The enhancement layer has video information to improve video quality of base layer. At this time, the number of enhancement layer is more than one and each enhancement layers consists hierarchical architecture. These enhancement layers can employ spatial scalability about resolution of video, temporal scalability to improve video quality using frame rate of video, and SNR scalability that controls detailed video quality using quality refinement information of the base layer or the sub-enhancement layer. As shown Figure 3, coding schemes as Coarse Grain Scalability (CGS), Fine Grain Scalability (FGS), Medium Grain Scalability (MGS) are existed for SNR scalability.



(a) CGS (b) FGS (c) MGS

Figure 3. H.264/SVC SNR scalability granularity mode : (a) CGS, (b) FGS, (c) MGS.

CGS scheme has same structure of spatial scalability. Each layers predicts pictures individually. Each layers is encoded by same resolution and different quantization factor. It has weak point that if a degree of layer is increased, data of layer is exponentially increased. So, the density among high-ordered layers is decreased. FGS scheme employs an advanced bit-plane technique where different layers are responsible for transporting distinct subsets of bits corresponding to each data information. This scheme can provide improved video quality of layer by controlling output bit rate in relation to the real network bandwidth. Unlike CGS scheme, FGS scheme can increase a density among high-ordered layers. But FGS scheme also increases computational complexity. MGS scheme approaches to increase the number of extracted layers in CGS scheme using the prediction structure of FGS scheme. As shown Figure 3.(c), the MGS scheme increases efficiency by using a more flexible prediction module, where both types of layer can be referenced. But, this scheme induces a drafting effect if only the base layer is received. The MGS scheme uses a periodic key pictures to solve this issue, which immediately resynchronizes the prediction module. The MGS scheme is lower computational complexity than the FGS scheme and more increases density of high-ordered layers than the CGS scheme. The CGS and MGS schemes are standardized for supporting scalability considering low computational complexity and density of high-ordered layers in H.264/SVC[12, 13].

III. Proposed Video Streaming Multicast System

The goal of the proposed system is to support better video streaming multicast services to more subscribers over wireless network. Most of state-of-art wireless networks such as WLAN, WIMAX and LTE have functionality to adaptively change modulation scheme based on time-varying wireless channel condition to improve the throughput. Recently, IEEE 802.11 ac standard is trying to support up to 256 QAM to improve channel bandwidth. While, existing LPSM algorithms [5, 6, 7] use a fixed sub-modulation schemes regardless of time-varying wireless channel condition and node mobility. Now, the proposed system under consideration is presented in Figure 4. One of the unique features of the proposed system is that the modulation scheme in the proposed multicast system is adaptively changed like other state-of-art wireless networks and decomposed into a combination of two sub-modulation schemes considering the distribution of subscribers in order to maximize overall network throughput. In general, more combinations can be made for denser modulation schemes as shown in Table 1. In addition, LSPM is suitable for two-layer SVC (scalable video coding) video stream transmission (e.g. high priority modulation scheme for SVC and low priority modulation scheme for SVC enhancement layer).

Combination	md_{ad}	md_{HP}	md_{LP}
1	QPSK	QPSK	
2	16QAM	QPSK	QPSK
3	64QAM	QPSK	16QAM
4		16QAM	QPSK
5	256QAM	QPSK	64QAM
6		16QAM	16QAM
7		64QAM	QPSK

Table 1. Possible LSPM combinations of high priority sub-modulation scheme and low priority sub-modulation scheme.

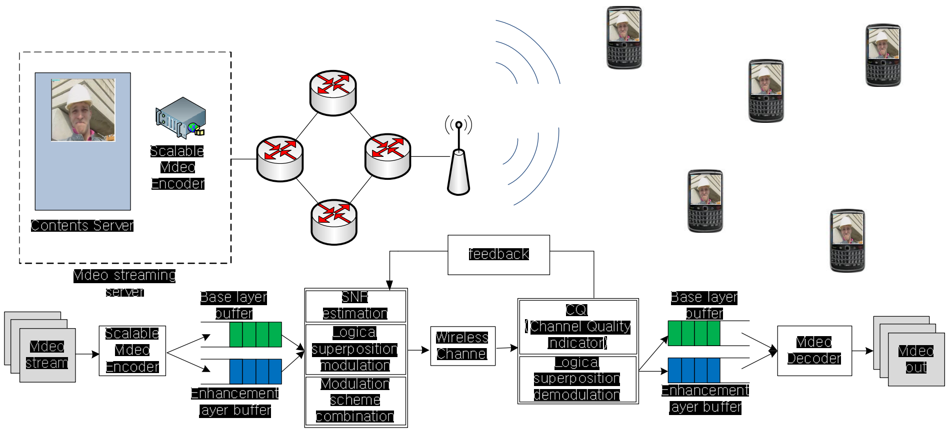


Figure 4. video streaming multicast system architecture under consideration.

In the proposed system, the video streaming server provides SVC video data of contents server to the BS, and the BS requests wireless channel conditions from subscribers for efficiently transmitting of provided SVC video data. Each subscriber replies the current wireless channel condition by using CQI (Channel Quality Indicator). BS estimates wireless channel condition using received CQI and predicts receivable modulation scheme at subscribers. Based on the information, BS determines the high priority sub-modulation scheme and the low priority sub-modulation scheme of LSPM system among the candidates of sub-modulation scheme combinations to maximize overall network throughput. Mainly, the base layer stream data and the enhancement layer stream data of SVC are mapped to the high priority sub-modulation scheme and the low priority sub-modulation scheme, respectively. Based on determined sub-modulation scheme combination, OFDM symbols are produced by logically superimposing the corresponding symbols for the base layer stream data and the enhancement layer stream data of SVC. Subscribers demodulate the received signal to obtain OFDM symbols. If the demodulation process is successfully performed, both base layer and enhancement layer video stream data are extracted based on these OFDM symbols. Otherwise (i.e. demodulation is failed), subscribers executes the demodulation process one more time to get only the high priority of modulation scheme. If it is successful, subscribers can have only the base layer video stream data. In this case, the video service of the minimum quality is still provided.

3.1 Problem Description

WiMAX, one of strong candidate that supports video streaming multicast, is considered in this paper. In WiMAX network, BPSK, QPSK, 16QAM, and 64QAM are supported (BPSK is used for only the uplink). The modulation scheme is dynamically adjusted according to wireless channel condition. In this paper, when available modulation schemes are determined, all possible modulation combinations of superposition modulation are examined to maximize the overall network throughput. Actually, it depends on the distribution of subscribers. Based on the information theory, the better video services can be provided with higher network throughput. In the followings, md denotes the modulation scheme of the downlink, and the high priority modulation scheme and the low priority modulation scheme of LSPM are denoted by md_{HP} and md_{LP}, respectively. As mentioned earlier, a dense modulation symbol set can be represented by a 2-dimensional convolution of two sparse sub-modulation symbol sets (i.e. $md_{ad} = md_{HP} * md_{LP}$). b_{md} is the number of bits included in an OFDM symbol, and $b_{md_{HP}}$ and $b_{md_{LP}}$ symbolize the numbers of bits included in a high priority sub-modulation symbol and a low priority sub-modulation symbol, respectively. When md_{ad} is expressed by $md_{HP} * md_{LP}$, the following equation is satisfied.

$$b_{md_{ad}} = b_{md_{HP}} + b_{md_{LP}} \tag{1}$$

Let E_{ad}, E_{HP} and E_{LP} mean the energy levels of md_{ad} md_{HP} and md_{LP}, respectively. Now the below equations are satisfied.

$$E_{ad} = E_{HP} + E_{LP} \tag{2}$$

$$E_{HP} = \alpha E_{ad} \tag{3}$$

$$E_{LP} = (1-\alpha) E_{ad} \tag{4}$$

In fact, the parameter α governs the relationship between E_{HP} and E_{LP}. When an equally- distant modulation symbol set is decomposed into two equally-distant sub-modulation symbol sets by using the above convolution, α should be fixed as shown in Table 2.

md_{ad}	md_{HP}	md_{LP}	α
16QAM	QPSK	QPSK	0.80
64QAM	QPSK	16QAM	0.7618
	16QAM	QPSK	0.9522

Table 2. The value of parameter α according to combination of modulation schemes.

The i_{th} subscriber demodulates OFDM symbols transmitted from BS. The expected demodulation failure probability [5] is denoted by $\mathrm{P}_{HP+LP}\left(SNR_i, md_{HP}, md_{LP}\right)$, where SNR_i is the signal-to-noise ratio over the estimated wireless channel condition between the i_{th} subscriber and BS. If demodulation is failed, the i_{th} subscriber is trying to demodulate OFDM symbols to get only the base layer stream data once more. In this case, the expected demodulation failure probability [5] is represented by $\mathrm{P}_{HP}\left(SNR_i, md_{HP}, md_{LP}\right)$. Now we can formulate the given research goal as follows.

Problem formulation: Determine md_{HP} and md_{LP} to maximize

$$\sum_{i=1}^{N_{ss}} \left\{ \begin{array}{l} \left(\left(1-\mathrm{P}_{HP+LP}\left(SNR_i, md_{HP}, md_{LP}\right)\right)\times\left(b_{md_{HP}}+b_{md_{LP}}\right)\right) \\ +\left(\mathrm{P}_{HP+LP}\left(SNR_i, md_{HP}, md_{LP}\right)\times\left(1-\mathrm{P}_{HP}\left(SNR_i, md_{HP}, md_{LP}\right)\right)\times b_{md_{HP}}\right) \end{array} \right\}, \quad (5)$$

$$\text{subject to } \; md_{HP} \leq md(SNR_{\min}), \quad (6)$$

where N_{ss} is number of subscribers participating in the multicast session, $md(SNR_{\min})$ is the modulation scheme determined based on the worst channel condition among subscribers.

3.2 Kalman Filter-based SNR Estimation

It is well-known that Kalman filter[14, 15] can provide the optimal solution for non-stationary random process. The Kalman filter supports estimations of past, presents, and even future states, and it can do so even when the precise nature of the modeled system is unknown. The process of kalman filter is divided by initialization, state prediction, and measurement updates. First, the initialization is proceeded. Then, the state prediction and measurement updates are recursively proceeded over a period of time. In the state prediction, the estimation value of present state is determined by the estimation value of previous state and matrixes of system state. In the measurement updates, the difference between measured value and estimated value is calculated. Then, matrices of system state are updated according to this difference. BS can know wireless channel condition based on the received CQI from subscribers. But It is not accurate because subscribers send wireless channel condition when previously receiving data. To transmit symbols without error, the wireless channel condition estimation is important. Kalman filter is adopted to estimate accurate wireless channel condition. $SNR_i(t)$ is estimated wireless channel condition at time t from BS to i_{th} subscriber, which is calculated as follows.

$$SNR_i(t) = A \cdot SNR_i(t-1) + K(t)\left(SNR_i(t-1) - H \cdot A \cdot SNR_i(t-1)\right) \tag{7}$$

where A is state transition matrix that is system state at time t using estimated system state at time $t\text{-}1$ and $K(t)$ is the Kalman gain matrix that is determined by considering stochastic nature of the process and measurement dynamics. and H is observation model that means the relationship between the previous measurement and the system state

3.3 Model based Determining Process of md_{HP} and md_{LP}

The proposed adaptive LSPM system determines the combination of md_{HP} and md_{LP} by the estimated channel conditions according to the distribution and mobility of subscribers.

Step 0 : Observe the current wireless channel condition of each subscriber and estimate next wireless channel condition based on the observation by using Kalman filter.

Step 1 : Calculate $\mathrm{P}_{HP+LP}\left(SNR_i, md_{HP}, md_{LP}\right)$ and $\mathrm{P}_{HP}\left(SNR_i, md_{HP}, md_{LP}\right)$ based on the estimated signal-to-noise ratio values SNR_i as follows.

At first,

$$P_{HP+LP}\left(SNR_i, md_{HP}, md_{LP}\right) = 1 - \frac{4}{2^{b_{md_{HP}}+b_{md_{LP}}}}\left(\sum_{j=0}^{\sqrt{2^{b_{md_{HP}}+b_{md_{LP}}-2}}-1} P_{HP+LP}\right)^2 \tag{8}$$

Where

$$P_{HP+LP} = \begin{cases} Q\left(\dfrac{2j-(z_1+z_2)}{\sqrt{\dfrac{2^{b_{md_{HP}}+b_{md_{LP}}}-1}{3\times SNR_i}}}\right) - Q\left(\dfrac{2(j+1)-(z_1+z_2)}{\sqrt{\dfrac{2^{b_{md_{HP}}+b_{md_{LP}}}-1}{3\times SNR_i}}}\right) & j = 0,1,2,\ldots,D_{outside}^{HP+LP}-1 \\ Q\left(\dfrac{2j-(z_1+z_2)}{\sqrt{\dfrac{2^{b_{md_{HP}}+b_{md_{LP}}}-1}{3\times SNR_i}}}\right) & j = D_{outside}^{HP+LP} \end{cases} \tag{9}$$

$$z_1 = \left(2\cdot\left\lfloor\frac{j}{\sqrt{2^{b_{md_{LP}}}}}\right\rfloor+1\right)\cdot\sqrt{\frac{\alpha\left(2^{b_{md_{HP}}+b_{md_{LP}}}-1\right)}{2^{b_{md_{HP}}}-1}} \tag{10}$$

$$z_2 = \left(2\cdot\left(j \bmod \sqrt{2^{b_{md_{LP}}}}\right)-\sqrt{2^{b_{md_{LP}}}}+1\right)\cdot\sqrt{\frac{(1-\alpha)\left(2^{b_{md_{HP}}+b_{md_{LP}}}-1\right)}{2^{b_{md_{HP}}}-1}} \tag{11}$$

$$D_{outside}^{HP+LP} = \sqrt{\frac{2^{b_{md_{HP}}+b_{md_{LP}}}}{4}}-1 \tag{12}$$

$$D_{inside}^{HP} = \sqrt{\frac{2^{b_{md_{HP}}+b_{md_{LP}}}}{4}}-\sqrt{2^{b_{md_{LP}}}}-1 \tag{13}$$

Second,

$$P_{HP}\left(SNR_i, md_{HP}, md_{LP}\right) = 1 - \frac{4}{2^{b_{md_{HP}}+b_{md_{LP}}}} \cdot \left(\sum_{j=0}^{\sqrt{2^{b_{md_{HP}}+b_{md_{LP}}-2}}-1} P_{HP} \right)^2 \tag{14}$$

$$P_{HP} = \begin{cases} Q\left(\dfrac{2\sqrt{2^{b_{md_{LP}}}} \cdot \left\lfloor \dfrac{j}{\sqrt{2^{b_{md_{LP}}}}} \right\rfloor - \left(z_1 + z_2\right)}{\sqrt{\dfrac{2^{b_{md_{HP}}+b_{md_{LP}}}-1}{3 \times SNR_i}}} \right) - Q\left(\dfrac{2\sqrt{2^{b_{md_{LP}}}} \cdot \left(\left\lfloor \dfrac{j}{\sqrt{2^{b_{md_{LP}}}}} \right\rfloor + 1 \right) - \left(z_1 + z_2\right)}{\sqrt{\dfrac{2^{b_{md_{HP}}+b_{md_{LP}}}-1}{3 \times SNR_i}}} \right) & \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad for\ j = 0, 1, 2, \cdots, D_{inside}^{HP} & \\ Q\left(\dfrac{2\sqrt{2^{b_{md_{LP}}}} \cdot \left\lfloor \dfrac{j}{\sqrt{2^{b_{md_{LP}}}}} \right\rfloor - \left(z_1 + z_2\right)}{\sqrt{\dfrac{2^{b_{md_{HP}}+b_{md_{LP}}}-1}{3 \times SNR_i}}} \right) & for\ j = D_{inside}^{HP} + 1, \cdots, D_{outside}^{HP+LP} \end{cases} \tag{15}$$

Step 2 : Search for all possible high priority sub-modulation scheme candidates considering $md(SNR_{\min})$.

Step 3 : Search for all possible combinations of high priority sub-modulation scheme candidates and the corresponding low priority sub-modulation scheme candidates.

Step 4 : Calculate Eq. (5) of above all possible combinations. And the combination with the highest value is selected as a solution.

3.4 Video Stream Allocation in Logical Superposition Modulation

As shown Figure 5, video data are encoded into two-layer SVC video streams (i.e. base layer video stream and enhancement layer video stream). The base layer video stream of the minimum quality should be transmitted by the sparsest sub-modulation scheme to support the multicast service as many subscribers as possible. Hence the encoding rate of base layer is set to the data rate of the sparsest sub-modulation scheme (i.e. QPSK in WiMAX network), and the encoding rate of enhancement layer is fixed to the data rate of the densest sub-modulation scheme (i.e. 64QAM in WiMAX network). To provide enhanced quality of video by using partial received data which is lost by mobility and wireless channel condition of subscribers, H.264 MGS coding scheme is adopted in the process of video encoding.

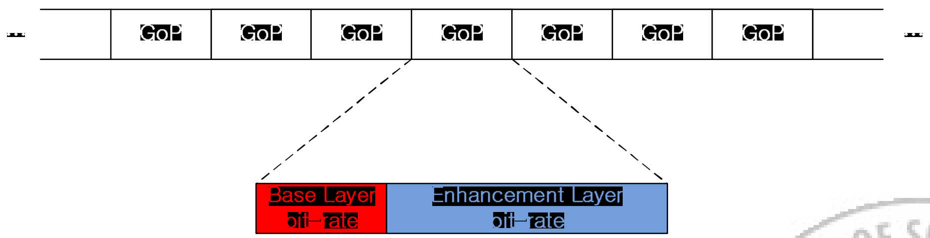


Figure 5. An example of video stream.

The encoded base layer and enhancement layer video streams which has fixed encoding rates are transmitted from video streaming multicast server to the BS. Because the data rate of modulation scheme is changed according to determining the combination of high priority sub-modulation scheme and low priority sub-modulation scheme, we need to solve this difference of the encoding rate and the data rate by using video stream allocation. In the BS, OFDM symbols of LSPM system are generated by using received video streams from video streaming multicast server according to determined combination of md_{HP} and md_{LP} as shown Figure 6.

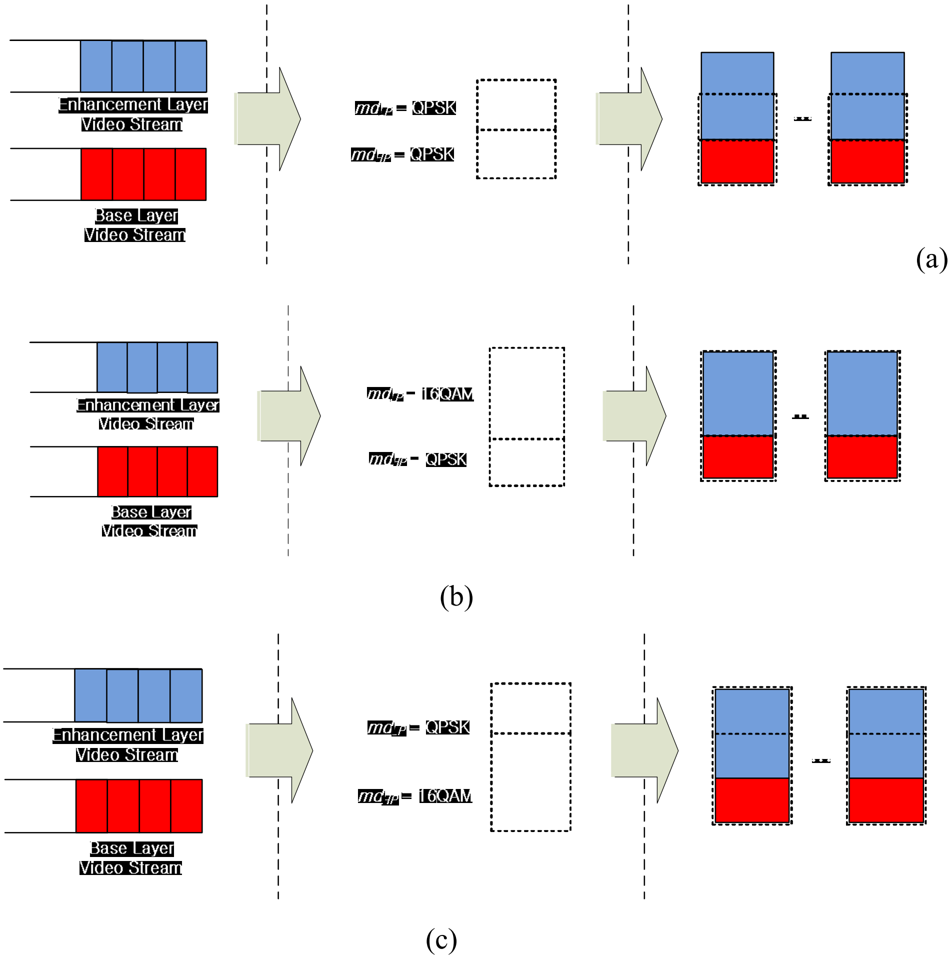


Figure 6. The OFDM symbol generation process in Base Station : (a) combination of (mdHP, mdLP) : (QPSK, QPSK), (b) combination of (mdHP, mdLP) : (QPSK, 16QAM), (c) combination of (mdHP, mdLP) : (16QAM, QPSK).

In Figure 6 (a), the determined combination of md_{HP} and md_{LP} is QPSK and QPSK. This case generates OFDM symbols by using the whole base layer video streams and a part of enhancement layer video streams. The base layer video streams are allocated data stream of the high priority sub-modulation scheme. Then, a part of enhancement layer video streams are allocated data stream of the low priority sub-modulation scheme. This case considers that every subscribers can not demodulate signals which is modulated 64QAM as bad channel condition of subscribers. In Figure 6 (b), the determined combination of md_{HP} and md_{LP} is QPSK and 16QAM. In this case, the each video streams of base layer and enhancement layer are allocated data stream of md_{HP} and md_{LP}. Then, OFDM symbols are generated these data streams. This case considers that the distribution of every subscribers is uniform in the same BS. This combination improves network throughputs considering channel condition of every subscribers. In Figure 6 (c), the determined combination of md_{HP} and md_{LP} is 16QAM and QPSK. In this case, the whole base layer and a part of enhancement layer video streams are allocated data stream of the md_{HP} and the other enhancement layer video streams are allocated data stream of the md_{LP}. This case considers that every subscribers can demodulate signals modulated 16QAM or more.

IV. Experiment results

NS-2 simulator[16] and H.264 JSVM (Joint Scalable Video Model)[17] is employed for this experiments. The network topology is considered as shown Figure 4. It assumed that the bandwidth between video streaming multicast head-end and BS is 1Gps and connects by wired network. The wireless channel model is employed AWGN(Additive White Gaussian Noise) model. Number of subscribers is 10 in the cell and the mobility model of subscribers is adopted the Random-way point model[18]. Each video streams is encoded at 30 frame per second. Test video sequences are CIF size City, Soccer, Foreman and encoded two layers according to video quality. The video rate of base layer is fixed data rate of sparsest modulation scheme as QPSK. The other experimental environment is set up as Table 3.

Parameters	Value
Topology	2000m X 2000m
Simulation time	300 sec
Mobility speed	10~20 m/s
Channel Bandwidth	10 MHz
FFT size	1024-FFT PUSC
Number of data subcarriers	720
Number of pilot subcarriers	120
Number of null and guardband subcarriers	184
Cyclic prefix or guard time	1/8
UL/DL boundary	5:11

Table 3. Parameter values used in experiments.

4.1. Performance Comparison between Kalman filter and ARMA model

The proposed Adaptive LSPM system should be determine sub-modulation scheme combination which improves network throughput using accurate estimation of wireless channel condition for system efficiency. The proposed system estimates accurate wireless channel condition at next time by using kalman filter and CQI information which is wireless channel conditions of subscribers at previous time.

We compare Kalman filter with ARMA(AutoRegressive Moving Average) model for comparison of wireless channel condition estimation performance.

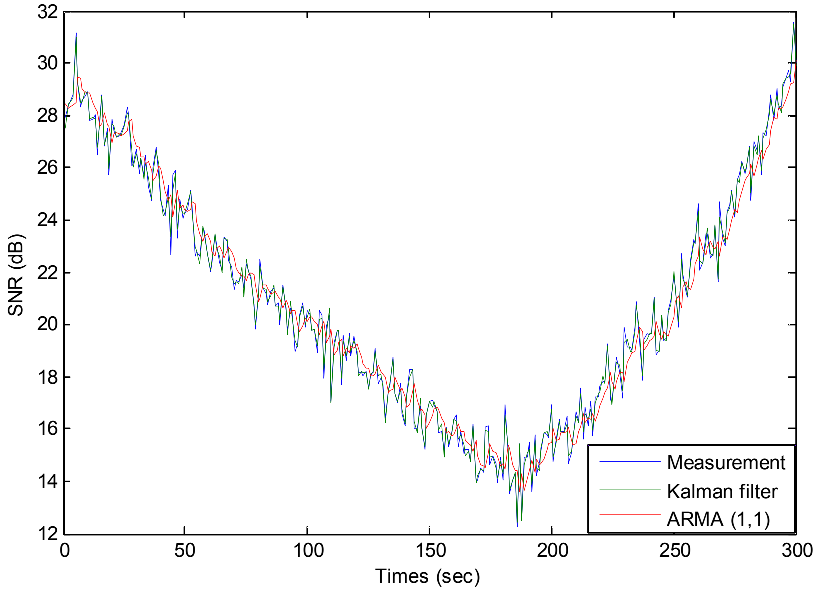


Figure 7. The estimated SNR comparison using Kalman filter, ARMA and measurements.

	The estimated SNR using Kalman filter	The estimated SNR using ARMA model
MSE	0.038707	0.885948

Table 4. MSE of estimated wireless channel condition using Kalman filter and ARMA model.

In Figure 7 and Table 4, the measured wireless channel condition and the estimated wireless channel condition which is estimated by Kalman filter and ARMA model is presented. The estimated value of wireless channel condition using Kalman filter is similar to the measured value of wireless channel condition despite wireless channel fluctuations. But, the estimated value of wireless channel condition using ARMA model fails to response channel fluctuation and roughly estimates wireless channel conditions. When the system uses the estimated value of ARMA model, the system degrades performances that demodulation failures and network throughputs. The estimated value of channel condition by using Kalman filter overcomes wireless channel fluctuations and decreasing network throughputs about demodulation failures. Based on this information, The proposed system determines sub-modulation scheme combination which maximizes network throughput of subscribers.

4.2. Performance Comparison according to Distribution and Mobility of Subscribers

We compare the performance between proposed system and other system according to distribution of subscribers as shown Figure 8 and Table 5. In this experiment, conventional LSPM system is a lower performance than the AMC system at the environment of Figure 8 (b). Because conventional LSPM system does not consider changes of channel condition for subscribers., subscribers can receive only base layer data when base layer and enhancement layer data is lost. Furthermore the AMC system determines more dense modulation scheme than modulation scheme of high priority sub-modulation scheme, the conventional LSPM system degrades a performance in comparison with the AMC system. But the proposed system can receive both base layer and enhancement layer data by controlling data of low priority sub-modulation scheme according to wireless channel condition. In addition, the proposed system is more stable than the AMC system about guaranteeing base layer data in channel fluctuations. When the channel fluctuation is occurred, the AMC system losses both base layer data and enhancement layer data. But, the proposed system perform demodulation for base layer data by using high priority sub-modulation scheme once more.

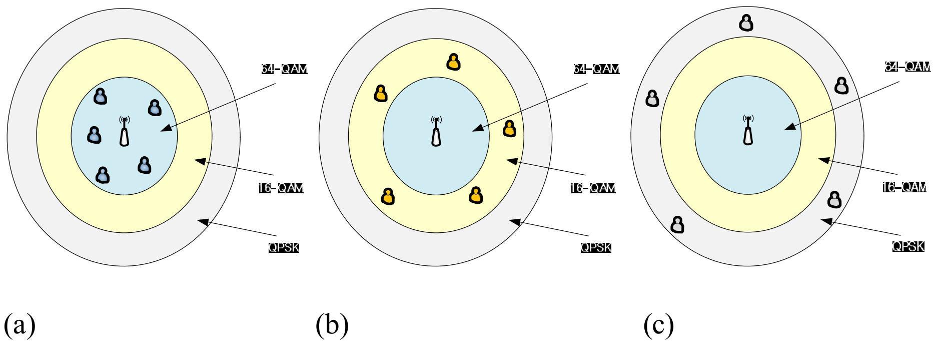


Figure 8. Subscriber distribution in Base Station : (a) Subscribers can receive 64QAM, (b) Subscribers can receive 16QAM, (c) Subscribers can receive QPSK.

Distribution type	**Conventional LSPM**	**AMC**	**Proposed Adaptive LSPM**
(a)	243139.05	243183.60	243183.60
(b)	80457.30	102420.15	113023.35
(c)	80457.30	81808.65	81808.65

Table 5. Network throughput according to subscriber distribution.

Then, we perform experiments considering mobility of subscribers for proposed video streaming multicast. In experiments, subscribers are moved 10 ~ 20 m/s by

Random-Way Point Model. Figure 9 is shown average network throughput of proposed system and others according to experiments.

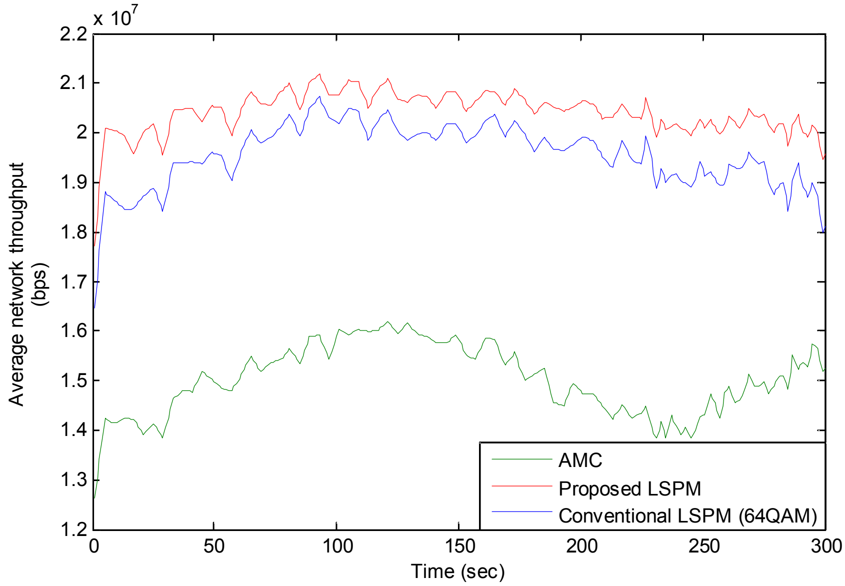


Figure 9. Average network throughput according to subscriber mobility.

The proposed system try to solve problem of conventional LSPM system by determining a combination of high priority and low priority sub-modulation schemes. In experiment of average network throughput according to mobility of subscribers, the proposed system is shown the higher performance than both conventional LSPM system and AMC system. The average network throughput of

AMC system is lower than the conventional LSPM system because modulation scheme of AMC system is determined by the worst channel condition among subscribers.

4.3. Objective and Subjective Video Quality Comparison

The symbol which logically superimposed by determined sub-modulation scheme combination is occurred symbol error by demodulation failure. When a symbol error is occurred, AMC system is lost SVC encoding data both base layer and enhancement layer. But, The adaptive LSPM system and conventional LSPM system are lost only enhancement layer data that encoded by SVC. Then, systems perform demodulation of LSPM symbol about base layer data once more. When the demodulation about base layer data is failed, the adaptive LSPM system and conventional LSPM system are also lost base layer data. In figure 10, It presents the error probability of SVC base layer data.

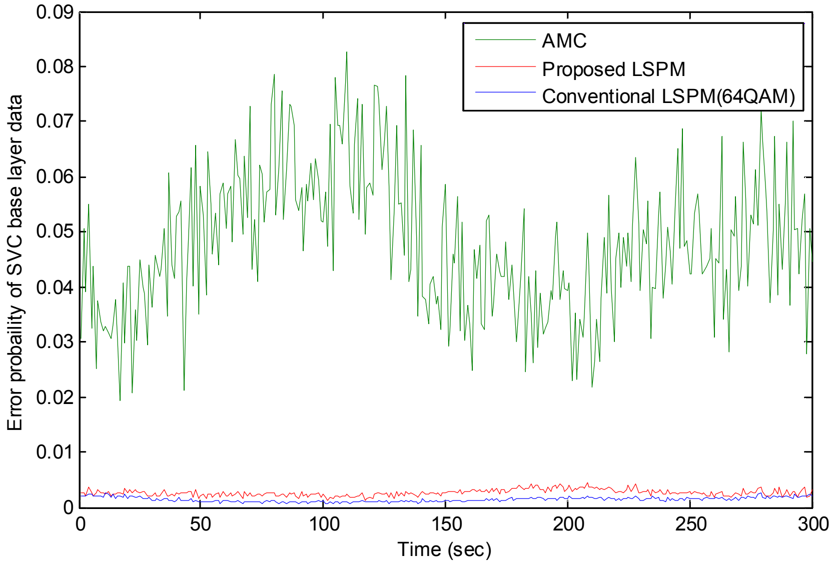


Figure 10. Error probability of SVC base layer data.

The error probability of the proposed system is similar to the error probability of the conventional LSPM system which is employed a fixed high priority sub-modulation scheme as QPSK. When comparing with AMC system, the proposed system has lower error probability. Because the proposed system and the conventional LSPM system extract base layer data with much higher probability through second chances of demodulation, the proposed system and the conventional LSPM system decrease an error probability than the AMC system. The proposed system determines sub-modulation scheme combination to maximize network throughput although increasing error probability of some subscribers. Hence, the error probability of the proposed system is more increased than the conventional LSPM system. In Figure 11, It presents the error probability of SVC enhancement layer data.

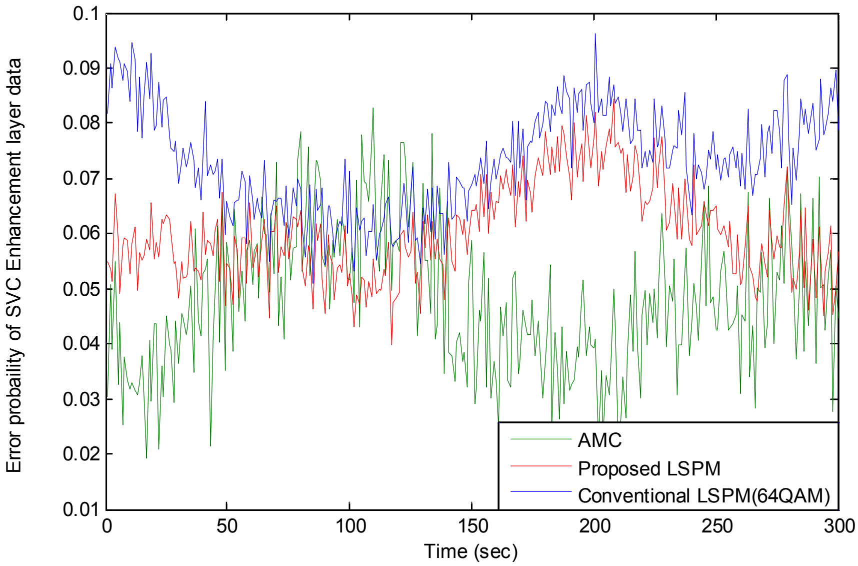


Figure 11. Figure 11. Error probability of SVC enhancement layer data.

The proposed system has a lower error probability of SVC enhancement layer data than the conventional LSPM system. But the proposed system has a higher error probability than the AMC system. When wireless channel is low condition or fluctuation, the conventional LSPM system has a high error probability of SVC enhancement layer data demodulation. The proposed system and AMC system transmit signals to change modulation schemes according to wireless channel condition of subscribers. Because the purpose of proposed system is high network throughput, the proposed system determines modulation scheme which maximizes network throughput although increasing high error probability.

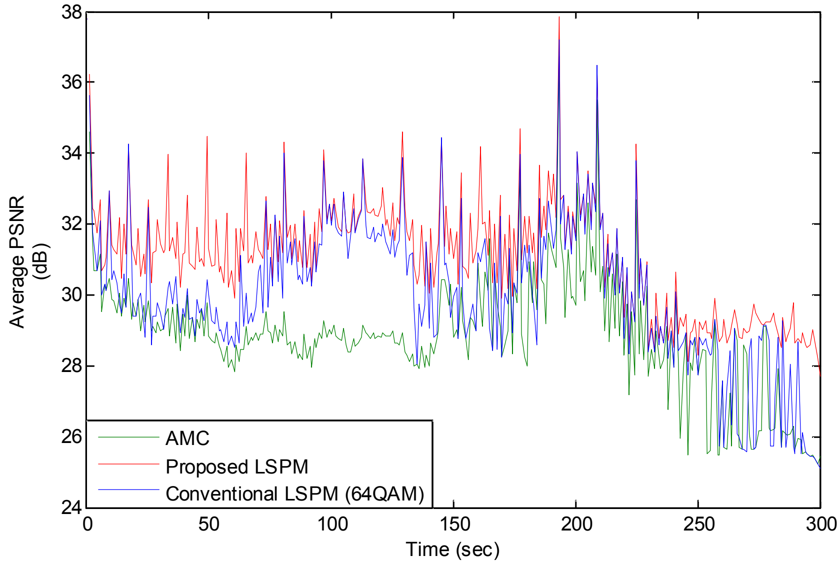


Figure 12. Average PSNR according to subscriber mobility.

Modulation Scheme	**Video average PSNR (dB)**		
	City	Soccer	Foreman
Proposed Adaptive LSPM	27.30	29.79	30.13
Conventional LSPM	25.97	28.46	28.90
AMC	24.21	26.92	27.49

Table 6. The average PSNR values of test video sequences.

(a)

(b)

(c)

Figure 13. Subjective video quality comparison of the 96th frame in CIF City video sequence : (a) Proposed adaptive LSPM, (b) Conventional LSPM, (c) AMC.

The average PSNR values of the proposed system and others by experiments of CIF sized test video sequence City is shown as Figure 12, and Figure 13 is shown subjective video quality comparison. The summary of average PSNR values about City , Foreman, and Soccer as shown Table 6. Based on improved network throughput and transmission of much more enhancement layer video data, the average PSNR value of proposed system is higher than other systems. In Figure 13, the proposed system is shown that provides enhanced quality of video service than other systems by red circles.

V. Conclusion

We propose adaptive LSPM and H.264 SVC based video streaming multicast system considering mobility and wireless channel condition of subscribers. The goal of proposed system improves network utilization by providing high quality of video service according to wireless channel condition of subscribers over guaranteeing minimum quality of video service for every subscriber. For this goal, we propose adaptive LSPM which considers estimation of each subscriber`s wireless channel condition and determination of modulation schemes for maximizing total network throughput. In experiments, the proposed system estimates accurately the wireless channel condition by using Kalman filter. Then, the proposed system determines sub-modulation scheme combination which increases average network throughput in comparison with the AMC system and the conventional LSPM system. Also in video experiments, the proposed system is shown more enhanced video quality than other systems by using improved network throughput.

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요 약 문

본 논문에서는 와이맥스 망에서 가입자들의 움직임과 채널 상태를 고려하여 영상 스트리밍 서비스를 제공하는 Adaptive LSPM과 H.264 SVC 기반의 영상 스트리밍 멀티캐스트 시스템을 제안한다. 기존의 LSPM 시스템은 채널 상태와 가입자의 움직임에 상관없이 초기 결정된 변조기법을 이용해서 OFDM 심볼을 가입자들에게 전송하였다. 이때 가입자들이 빠른 움직임을 보이거나 채널 상태가 급격히 변동하게 될 경우 AMC 시스템보다 낮은 네트워크 처리량을 나타내게 된다. 제안하는 adaptive LSPM은 가입자들의 채널 품질 정보와 칼만 필터를 이용해 전송 시 채널 상태를 정확히 예측한다. 예측된 채널 상태에서 가입자들의 전체 네트워크 처리량이 최대가 되는 변조 기법을 선택한다. 그리고 h.264 SVC 영상 데이터를 선택된 변조 기법에 할당하여 가입자들에게 전송해 스트리밍 영상의 품질을 향상 시킨다. 실험을 통해 adaptive LSPM은 AMC나 기존의 LSPM보다 높은 성능을 보임을 알 수 있다.

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그리고 개인적인 욕심으로 공부하기 위해 집에서 먼 포항으로 가는 것을 허락해 주신 가족들께 감사 드립니다. 항상 힘들지 않은지 걱정해주시고 몸 건강이 우선이라고 말씀하시는 아버지, 어머니, 그리고 자주 찾아 뵙지 못했지만 항상 반갑게 맞아 주시는 할머니, 같이 석사과정을 준비했던 동생... 모두 사랑하고 감사합니다.

또 연구실에 있는 동안 가족같이 대해 줬던 형래형, 현철이형, 완이형, 오찬이, 동주형, 희진이, 동혁이, 혜정이, 윤민이, 기석이형, 경빈이, 승재, 건우에게 감사합니다.

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