A Scheduling Algorithm for Interactive IPTV over WiMAX

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In this paper we study transmission and broadcast of interactive IPTV traffic wherein in addition to multimedia traffic, traffic of user's interactive requests are included. We have introduced a new service class for Interactive IPTV to the current service classes available in IEEE 802.16 standard. Afterwards, we propose a new scheduling algorithm for this class called I_IPTV. Proposed scheduling allocates the resources to all internal IPTV traffic including video, voice, interactive data and EPG. For transmission of its video part, we take advantage of H.264/SVC coding in which video stream is coded into a base layer and several extra ones. Then, a priority is assigned to each layer which transmission is carried out by this priority. This examination is pursued by a simulation in NS-3 simulator. Results of simulation shows that the proposed algorithm transmits the video with higher quality compared to other algorithms. Besides, interactive data is transmitted with lower delay. Finally, results reveal that video transmitted by SVC coding is performed much better compared to AVC coding.

Key words: IPTV, Interactive, SVC, Scheduler, WiMAX

1. Introduction

In recent years, transmission and broadcasting of TV channels over IP protocol has been one of the important applications called IPTV (Internet Protocol TV). This service is usually conveyed in a common packet with other services like Video on Demand, internet telephony, broadband internet, personal services such as video conference, e-shopping and so on. Interactive IPTV services use bidirectional transmission in order to satisfy users' requests. This is done in a way that service provider transmit its data according to users' requests. On the other hands, IPTV is capable to deliver more TV channels to a subscriber compared to traditional TV technology. Besides, because of data-centric nature of the packet and interactivity (bidirectional) of transmitting medium, a subscriber is able to decide in selecting "what" and "when" to see the TV [1]. Transmitter, Institute of Radio and Television, upon receiving user's request provides his/her requested choice [2].

In order to provide TV channels in remote locations where there is no way to cabling, WiMAX technology which is a wide broadband network is a promising and pioneer solution [3]. IPTV consists of several different traffics which require to be sent from transmitter toward receivers. Besides, important part of traffic is feedback received from each receiver to transmitter. In fact according to these feedbacks it adjusts amount and type of transmitting traffic. In order to be able to implement this kind of traffic, base station of WiMAX network needs to present a suitable scheduling. Although five service class including UGS, RTPS, nRTPS, ERTPS and BE have already been included, none of them cannot alone support IPTV traffic appropriately. As a result we need a multicast scheduling algorithm which can be able to manage different data traffic existing in IPTV services. More specifically, we mean it should handle video, voice, interactive, internet, VoD data, and at the same time should assign available resources to the services appropriately in a

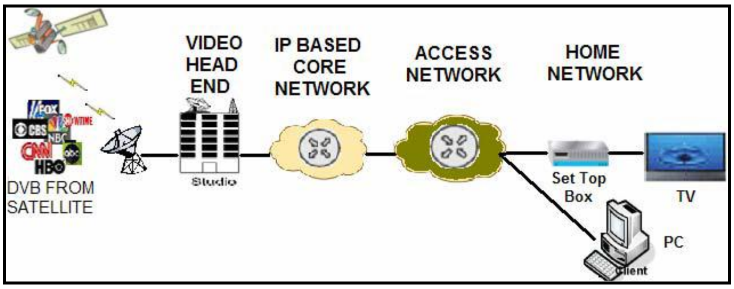

Fig. 1: Schematic of IPTV architecture[4]

a way that keeps overall quality of traffic in a acceptable level. . Fig. 1 shows the architecture of an IPTV system .The system consists of four elements which are depicted at Fig 1.

In this paper, we broadcast IPTV traffic over a WiMAX network. Considered traffic includes users' requests as well. A new scheduling algorithm is proposed which allocates resources to all IPTV traffic properly. One of the challenges of transmitting video is applying the coding consuming less bandwidth and present higher quality. Over the recent years, there have been plenty of works for investigating video transmission with scalable coding H.264/SVC. In this paper, we take advantage of layered coding H.264/SVC for video coding wherein video stream is divided into a base layer and some extra layers as well. A priority value is assigned to each layer too. This priority determines precedence of transmission.

Rest of this paper is as follows. In section 2 we survey related works. In section 3, we explain proposed algorithm. In section 4, we present simulation results plus evaluation of proposed algorithm. This paper concludes in section 5.

2. Related Works

There have been numerous public attentions for IPTV. Therefore, plenty of works have been done in wired or wireless networks aiming at transmitting high quality multimedia. In [4] a semi-optimal known as U-LEM has been proposed which adjusts number of layers received by each user dynamically according to channel conditions and available bandwidth. The authors of [5] have proposed a resource allocation approach which firstly serves base layers then next layers aiming at optimizing total performance. In [6] an error recovery method based on mutual collaboration has been presented which uses two-phase technique for improving reliability. First phase has been considered for base station and second phase belongs to communications of collaboration. During the second phase, the user who has receive the content from receiver successfully, disseminate them to other ones in order to increase reliability. In [7] an opportunistic scheduling algorithm has been proposed for IPTV. In [8] , by matching multicast communications with unicast method, a realistic simulation of IPTV over NGN networks has been presented. But, in there, no specific algorithm has been mentioned for scheduling. In [9] a new service class in WiMAX called artPS has been proposed to transmit multiple layer video. This class according to channel conditions sends whether high quality or low quality layer. Besides, it considers service priority for video layers. In [10] a real time schedule for downlink traffic in WiMAX known as DLRTS has been proposed. Results of simulation show that this algorithm obtains better performance compared to round-robin ones. However, in this algorithm there is no consideration for interactive IPTV as well. Generally, in aforementioned papers there is no room for interactive IPTV. If so, they have just sufficed to an overall framework without addressing any specific algorithm and mechanism. To best of our knowledge, all of the accomplished works and designed scheduling algorithms up to now have lent themselves to regular video transmission in WiMAX. Although, for interactive mode, there are some works in cable-TV, no specific algorithm has been emerged to interactive IPTV. Therefore, we motivated to design a scheduler capable of controlling and allocation resources to IPTV traffic.

3. Proposed scheduling algorithm

According to ITU definition, interactive services include services of multimedia broadcasting like electronic guide of EPG, commercial information of goods, transmitted requests from users and in general: existing a return path for network interactions. Fig. 2 shows all flows present in interactive IPTV.

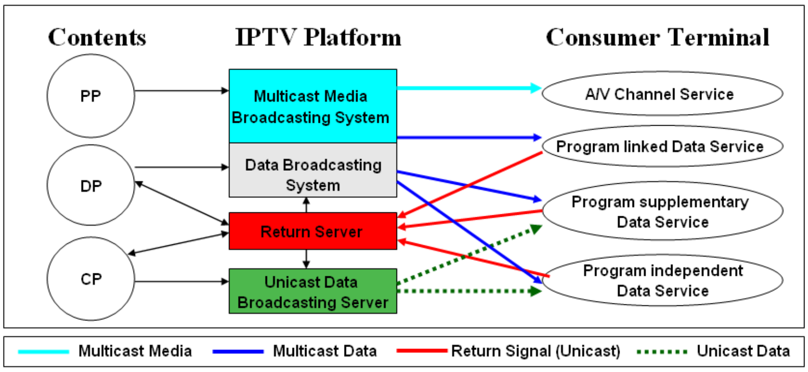

Fig. 2: stream of interactice services in IPTV [11]

None of existing class services in WiMAX can support this kind of traffic. As a result we propose a new class known as I_IPTV designed especially for IPTV transmission. This class itself consists of three subclass: class of video (I_IPTV_Video), voice class (I_IPTV_Voice), electronic program guide class (I_IPTV_EPG) and data class (I_IPTV_IData). The later is responsible for conveying subscribers' requests.
Motivation behind defining of new service class stems from the fact that using existing WiMAX class services lead to no discrimination over flows required in an interactive IPTV traffic. In order to distinguish between four traffic of IPTV (Video, Voice, EPG and IData) we take advantage of a enumerate DSA parameter known as QOS parameter. For determining type of layered video sixth parameter of DSA known as Traffic Priority is used. Table. 1 shows these parameters and their values for different flows.

Service-Flow Type=IIPTV		
QosParamSetType=0	TrafficPriority=0	Video BaseLayer
QosParamSetType=0	TrafficPriority=1	Video Enhancement Layer
QosParamSetType=1	Voice Flow	
QosParamSetType=2	EPG Flow	
QosParamSetType=3	IData Flow	

Table. 1: DSA Parameters for Define Iiptv Traffic

As a result, scheduler is fully aware of undergoing flows, and can distinguish among video file flows and other traffics which provide a capability to apply different scheduling mechanisms.

3.1 I_IPTV scheduler

Now, after defining new class service and distinguishing between types of I_IPTV flows, we can present I_IPTV scheduler. In fact this scheduler is in charge of resource (time slots) allocation to different flows. Having previous flows in WiMAX (RTPS, UGS and etc) we perform following precedence of resource allocation among them.
EPG is assigned 64 Kb/sec of bandwidth and priority of its service precedes any other flows. Meaning that, at each stage of scheduling, if it has data to transmit, scheduler sends its data first earlier than other flows. Then, data of voice flow of I_IPTV is served. After that UGS class gets service. Then, base layer of layered videos of I_IPTV is served. If there is no sufficient bandwidth for all of them, computed bandwidth is scaled down by Δ according to Equation (1).

$$\Delta = \frac{Available\ Bandwidth}{Number\ of\ \ BLayerFlows} \qquad (1)$$

$$BLayer\_BW = ReqBW \times \Delta$$

Layers of a video flow are assigned bandwidth according to their priority (parameters of Traffic Priority). More specifically, first of all layer 1, then layer 2 and so on. Afterwards, scheduler serves RTPS flows. Then, nRTPS flows get service. Finally flows of BE traffic are served. Base layer is sent to all subscribers because each of them should have a video with least quality. If extra resource is available, higher layers which are goaled to improve video quality can be sent. Traffic flow of I_IPTV_Data is an uplink flow which conveys users' requests to base station. Since this data plays an important role in interactive IPTV commucnication, we have assigned rate of 512 kb/s to its bandwidth. This rather high amount of bandwidth has been allocated for sake of ensurance for delivery of this kind of traffic. One should note that since in interactive IPTV, there is uplink traffic is rare, designing an uplink scheduler does not seem necessary.

4. Simulation

4.1 Simulation settings

We conducted extensive simulation to evaluate propose approach. We have taken advantage of NS-3 [12] network simulator for simulating the approach. One of challenges of NS-3 is lack of various applications like voice, FTP and so on. Indeed, NS-3 has left this matter to developers through presenting some tools need to generate traffic. Thus, we developed a program in charge of video transmission which takes Trace file and data file as input parameters and generates different traffics.
An application called SVC_Trace_Client has been developed in order to simulate video transmitter. This application takes Trace file, video file, destination IP address, destination port as input parameters, and generates packets and transmits them toward the destination. Indeed, for each line of Trace file, a header is generated by class of H.264/SVC-header. Then its data section is filled with corresponding data content from video file. A packet with header, data, destination IP, and destination port is sent down to IP layer. Correspondingly, a program known as H.264/SVC-header is responsible for receiving

packets at other receiver side. This program separates headers and data of received packets and records them respectively in a Trace file and video file.

Rest of traffics has been generated from NS-3 built-in traffic generators. EPG traffic is a stream of data which is always sent. We use ON-OFF traffic generator in a way that ON=1, OFF=0 and its rate is set to 32 Kb/sec. This traffic is broadcast to multicast groups. Voice traffic is generated by ON-OFF which ON=0.35, OFF=0.65 and rate of 64 Kb/sec. IData traffic is produced by Upd_Client application with packet size of 512 bytes and time interval of 0.2 sec. Simulation parameters have been summarized in Table 2.

Operating Frequency	5 GHZ
Channel Bandwidth	12 MHz
Duplexing	TDD
FFT Size	556
Symbol Duration	27.777 us
BS Tx Power	43 db
TDD Frame Duration	0.01 s
SS Noise Figure	7 db
Available Modulation	QPSK/QAM16/QAM64/BPSK

Table. 2: Simulation settings

4.2 Designed scenarios

We have designed four different scenarios. In all scenarios multicast groups are scattered randomly in 7 km distance far from BS. We repeat every experiment ten times and then compute its average. We have used three YUV Video Soccer ,City and Crew in 4CIF format with resolution of 704 × 576 pixel. We decode this Video file in two formats AVC and SVC with 30 frame per second. We use JSVM[13] Software for decoding raw file in SVC format and for decoding utilize JM 18.4 [14] software. Data rates of different streams have been shown in Table. 3.

Bit Stream Name	BitRate(bps) at
Crew _Svc_BaseLayer	1732.00
Crew _Svc_Layer1	1364.00
Crew _Svc_Layer2	1163.20
Soccer _Svc_BaseLayer	1117.80
Soccer _Svc_ Layer1	1344.80
Soccer _Svc_ Layer2	2060.00
City_Svc_BaseLayer	697.50
City_Svc_ Layer1	994.60
City_Svc_ Layer2	1504.60
Crew_Avc	2012.12
Soccer_Avc	1258.88
City_Avc	1817.71

4.2.1 AVC_RTPS scenario

In this scenario regular IPTV traffic is transmitted in RTPS service class. In this scenario single layer video is coded with AVC coding and is transmitted by RTPS service class. Voice and IData traffics are transmitted by UGS service class, and EPG flow is conveyed by BE. Received video traffic is evaluated by three multicast groups. Except the video traffic, rests of traffics are sent to all multicast groups. We increase multicast groups from 2 to 6.

4.2.2 AVC_IIPTV scenario

In this scenario interactive IPTV traffic is transmitted in RTPS service class. In this scenario we take advantage of proposed I_IPTV scheduling algorithm. Besides, single layer video is coded with AVC coding and is transmitted by I_IPTV_Video service class. Voice and IData traffics are generated by I_IPTV_Voice and I_IPTV_IData service classes respectively, and EPG flow by I_IPTV_EPG. Received video traffic is evaluated by three multicast groups. Except the video traffic, rests of traffics are sent to all multicast groups. We increase multicast groups from 2 to 6.

4.2.3 SVC_RTPS scenario

This scenario is like AVC_RTPS except that used coding is H.264/SVC. As was explained in section 2, this coding makes the video into several layers. However, since RTPS cannot discriminate between different layers, whole video file is generated by H.264/SVC-Trace-Client and is sent by RTPS service class. Other settings are the same as those of AVC_RTPS scenario.

4.2.4 SVC_IIPTV scenario

Table. 3 : bitrate of the SVC

In this scenario, interactive IPTV traffic is transmitted by H.264/SVC coding. Using this coding each layer is produced separately and is transmitted by SVC-Trace-Client in a multicast manner. I_IPTV scheduler can distinguish different layers and applies different scheduling mechanisms on them as was mentioned before. As it is shown later on, proposed scheduling algorithm lends itself for this case wherein in layered video is transmitted since the scheduling can detects these layers and take appropriates decision regarding to their required resources.

4.3 Results

Fig. 3 (a)-(c) show number of received frames in aforementioned scenarios for three different video files. As these charts demonstrates, I_IPTV with layered H.264/SVC coding scheduler lead to high percent of frame reception. Indeed, this coding along with proposed scheduling algorithm is a very promising pair for transmitting video files in IPTV. As the charts in Fig. 3 (a)-(c) by increasing number of multicast groups, other scenario except scenario SVC_IIPTV go through tremendous reduction.

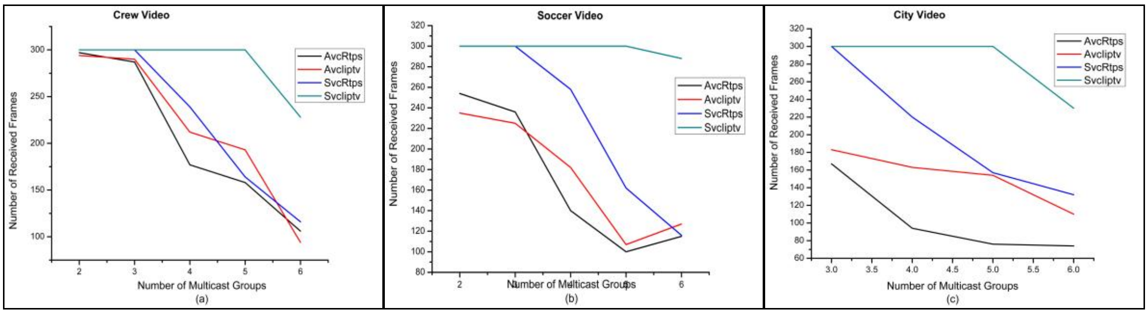

Fig. 3: Comparison in number of received frames for 4 Scenarios (a) Crew video for MG1 (b) Soccer video for MG2 (c) City video for MG3.

For calculating PSNR and Mean opinion scores we use EvalVid [15] toolset. Fig. 4 (a) -(c) show PSNR for three considered videos. As these figures exhibit, when number of multicast groups increase, PSNR decreases. However, first of all this reduction for I_IPTV with H.264/SVC coding is trivial. Second of all, I_IPTV scheduler with H.264/SVC coding obtains better PSNR compared to other scenarios.

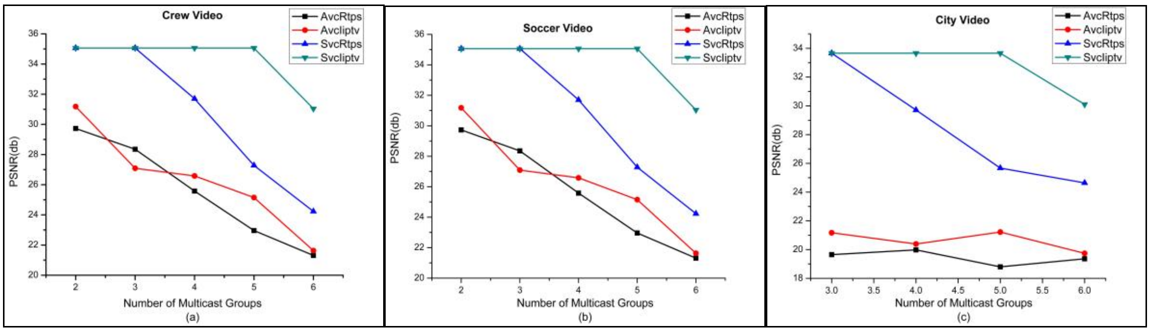

Fig. 4: Comparison the Y-PSNR of frames in 4 scenarios (a) Crew video for MG1 (b) Soccer video for MG2 (c) City video for MG3

Fig. 5 (a)-(c) show MOS for four described scenarios. As it is evident from these charts, transmitted traffic using I_IPTV scheduling algorithm achieves better performance. Besides, H.264/SVC coding leads to delivering more frames and higher quality video.

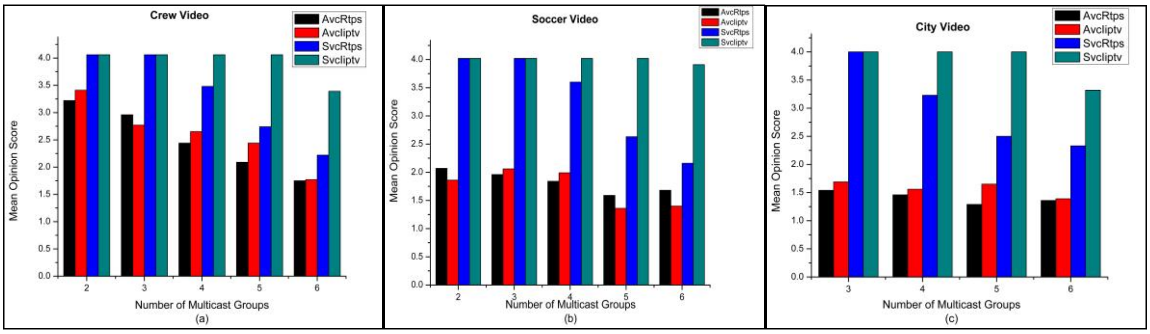

Fig. 5: MOS of (a) Crew video for MG1 (b) Soccer video for MG2 (c) City video for MG3

Fig. 6(a)-(b) show lost packets for different traffics. Indeed, we have computed how many packets have been lost during transmission. Note that, since no lost was observed for voice traffic, we have not depicted its chart. Bellow figures reveal that number of lost packets completely depends on utilized scheduler. As it is clear, I_IPTV scheduler brings about better performance regarding to number of lost packets compared to other scheduling policies. This is more conspicuous when H.264/SVC coding is used.

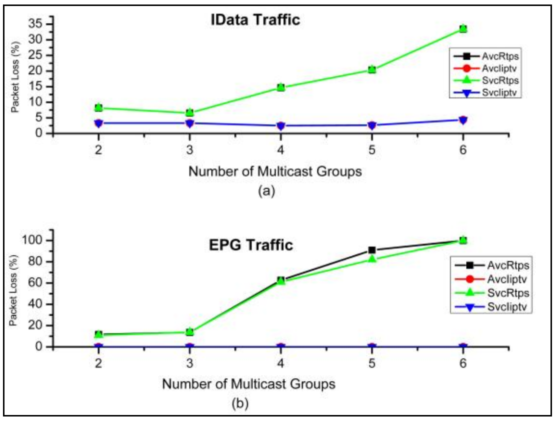

Fig .6: Comparison of packet lost percent for (a) IData Traffic (b) EPG Traffic

AVC_RTPS scenario (a)	AVC_IIPTV scenario(b)	SVC_RTPS scenario(c)	SVC_IIPTV Scenario (d)

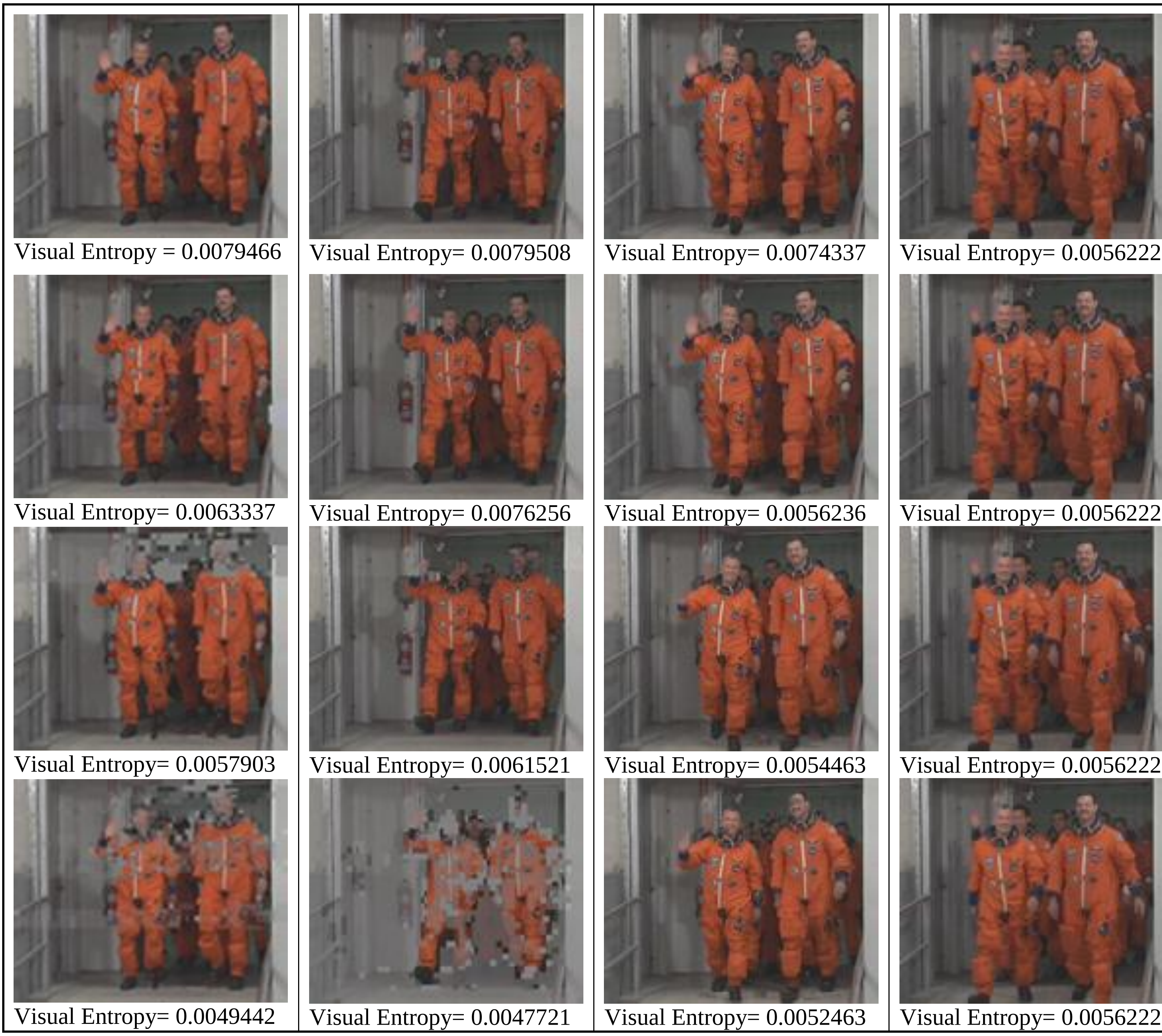

Fig. 7: Comparison of reconstructed video quality between designed scenarios (a) AVC_RTPS scenario (b) AVC_IIPTV scenario (c) SVC_RTPS scenario (d) SVC_IIPTV Scenario (d)

Finally, visual entropy [16] of received videos for four different scenarios and different number of multicast groups (from 3 to 6 groups) has been computed at Fig. 7. First row has 3 multicast groups, second row has 4 multicast groups, third row has 5 multicast groups and finally fourth row has 6 multicast groups. In each row visual entropy has been computed for each designed scenario. As Fig. 7 shows, at each row visual entropy of SVC_IIPTV is less than other scenarios. Besides, when number of multicast groups increase, quality of video decreases drastically, however, using proposed scheduling while taking advantage of layered video (SCV coding) quality of received video in regardless of number of multicast groups.

5. Conclusion

Including users' requests in IPTV is one of the requirements in order to this technology being realized as a leading one. This state of the art technology is called interactive IPTV or briefly IIPTV. In this paper we investigated transmission of IPTV traffic transmission over IEEE 802.11 standard which plays an important role in future of multimedia transmission. Although there is several service class already included in this standard, we introduced a new class for interactive IPTV named I_IPTV. Having this class plus other previous services in WiMAX, we proposed a scheduling in charge of resource allocation between various traffics including voice, video, interactive data and EPG. For video part we took advantage of AVC and H.264/SVC encodings. In H.264/SVC video stream is coded into a base layer and several extra ones. This coding is at perfect conform to considered multicast groups which are receiving groups classified according to their distance from video transmitter (base station). Then, proposed scheduling algorithm could be able to distinguish between these layers and assign priority to them appropriately. We run extensive simulation to investigate the performance of proposed scheduling algorithm in IIPTV traffic. Aiming at this goal we defined four comprehensive scenarios. Results of simulation revealed that SVC_IIPTV (scv coding plus I_IPTV scheduling) dramatically achieves high performance regarding to the following factors: a) number of received frames b) PSNR c) MOS and d) visual entropy.

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