Big Data Video through Efficient Dynamic Frame Aggregation over WLAN

Ujjwal Bishnoi, Gajendra Kumar Vishwakarma

Abstract— There is rapid development in IoT based analytics applications such as hotel, hospital and traffic control. The Big Data collection has started using Wireless Local Area Networks (WLANs) for visualizing and analyzing real time video through Wi-Fi network, which reduces the network deployment cost. There are several challenges for collecting and analyzing real-time generated video, which include fast and good quality transmission, storage and analysis. In such multimedia applications the IEEE 802.11n standard's Quality of Service (QoS) has important role in designing and implementation real-time video by using Big Data application. In this study, the simulation results verify the proposed Efficient Dynamic Frame Aggregation (EDFA) mechanism for improving big data video transmission over WLAN. This EDFA mechanism changes the frame aggregation size according to video Access Category (AC) queue filled size at runtime. As the number of elements in AC queue increases then aggregation size decreases. It reduces the packet waiting queue delay compared to default fixed aggregation mechanism. From the results of EDFA mechanism the video quality parameters like Peak Signal-to-Noise Ratio (PSNR), Mean-Squared Error (MSE), Video Quality Metric (VQM), Structural Similarity Index (SSIM) are calculated and compared with IEEE 802.11n draft's default frame aggregation results. The results show that Big Data real time video quality is better in the proposed EDFA mechanism.

Index Terms— QoS, Video over WLAN, Big Data, 802.11n, aggregation

1 Introduction

The WLAN standard IEEE 802.11 [1] was developed by IEEE in 1997. It operated at a frequency of 2.4 GHz and data rate of 2Mbps. Then in 1999 after modification of 802.11 standards, two new standards IEEE 802.11a and IEEE 802.11b were developed. The 802.11a operated at frequency of 5GHZ and 54 Mbps data rate while 802.11b operated at frequency of 2.4 GHz and 11 Mbps data rate. Due to its unique advantages, IEEE 802.11 became popular as WLAN for offices, public places and homes. It was easy to deploy, cost effective, simple, flexible, highly mobile and offered fast data transmission rates. A user could connect to WLAN anywhere and have guaranteed internet access. As the IEEE 802.11 provided only Best-Effort service, it was better only for data transmission or net surfing and not for multimedia services. There was a need to enhance IEEE 802.11 WLAN to suit multimedia traffic.

Later in 2005, the 802.11 standard was enhanced for multimedia traffic and new version IEEE 802.11e came up with Quality of Service (QoS). By using traffic differentiation, the MAC layer was updated to achieve QoS. This new standard was then used in audio, video and real time voice over IP applications. Then in 2009, it was updated to IEEE 802.11n [2] after enhancing the MAC and physical layers. This new version operated on 20 and 40 MHz radio frequency band. It could transfer data at speed of 300 Mbps using the MIMO (multiple input and multiple output) techniques. Also, it was backward compatible with 802.11e and also supported QoS. Today Big Data handling very lard live video data. So, this also require an efficient mechanism for processing live video. In hotel, traffic control, and university are using Big data surveillance applications. In shopping mall centralized monitoring system use Big Data video techniques.

This paper emphasizes on the study of H.264/SVC video traffic performance in IEEE 802.11n for dynamic aggregation conditions. The authors have proposed a dynamic frame aggregation approach which improves the quality of all categories of H.264/SVC video delivery over IEEE 802.11n wireless networks.

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2 Aggregation Mechanism

In 802.11 b and 802.11n data frame transmission, an overhead is added per frame. This means for each frame there is an overhead. On the other side, in case of 802.11n with aggregation, frames are aggregated and transmitted and there is just one overhead for an aggregation. As overhead is less so transmission is more efficient and throughput is more.

2.1 A-MSDU Scheme

In this mode of aggregation, multiple MSDUs are aggregated into a single MPDU and are sent to the same receiver. A subframe header (18 byte) has a destination address, source address and length. MSDU payload and padding of 0-3 byte is added to this subframe header to form MSDU sub frame. Multiple MSDU subframes are aggregated to from A-MSDU frame. A MAC header, A-MSDU frame and FCS together make the MPDU frame. The maximum receiving size of single A-MSDU by station is either 3839 bytes or 7935 bytes. The frame check sequence (FCS) and MAC header attached with all subframes for generating PSDU (Physical Service Data Unit) [2]. A-MSDU aggregation shown in Fig. 1.

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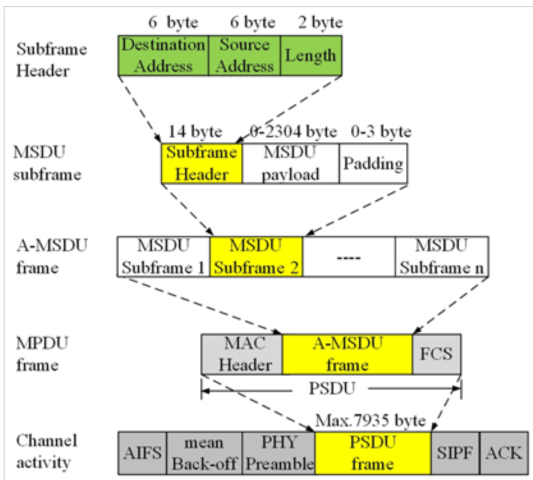

Fig. 1. A-MSDU Aggregation

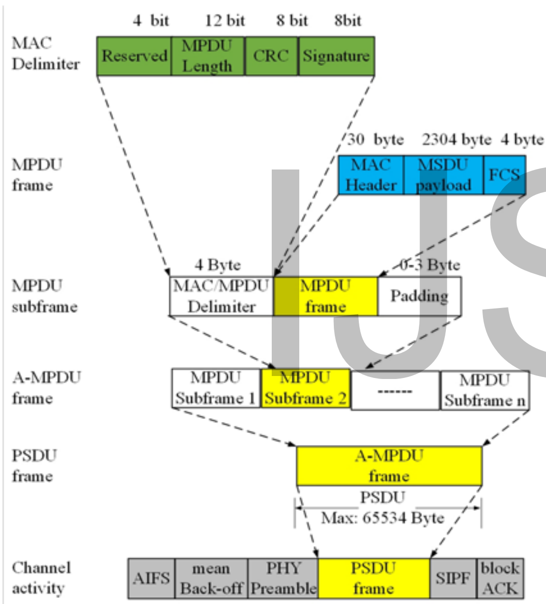

Fig. 2. A-MPDU Aggregation

2.2 A-MPDU Scheme

MAC header is encapsulated within each MPDU frame. Multiple MPDU subframes are aggregated to form the A-MPDU frame. The maximum length of A-MPDU is 65535 bytes [2]. A-MPDU aggregation shown in Fig. 2.

2.3 Two Level Aggregation Scheme

This involves blending these 2 aggregations together. The first level involves constructing an A-MSDU frame using multiple MSDU subframes. Then, a MAC header and A-MSDU frame are encapsulated to form a MPDU frame. The second level uses the MPDU sub frame formed at the first level. The MPDU subframes are combined to form the aggregated A-MPDU frame. Finally, the channel activity has the PSDU frame, AIFS, backoff, PHY preamble, SIPF and block ACK [3, 4]. This is best aggregation techniques for video transmission. Two level aggregation shown in Fig. 3.

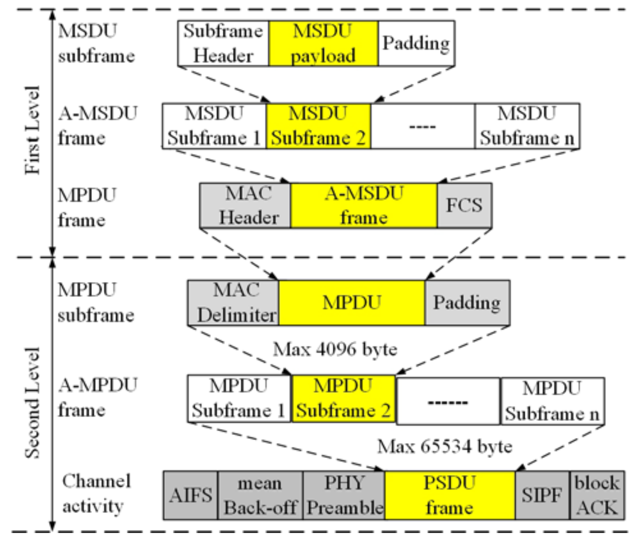

Fig. 3. Two Level Aggregation

3 Proposed Efficient Dynamic Frame Aggregation (EDFA)

In this proposed efficient dynamic frame aggregation (EDFA) mechanism is applied at MAC layer and video queue (AC2) filled size is examined at runtime. Accordingly, decision is taken for modifying the frame aggregation size with the help of probability value (prob), $Threshold_{low}$, $Threshold_{high}$) and half value of maximum packet fragment size. The proposed mechanism reduces the aggregation size if queue is near to full ($Threshold_{high}$). Similarly, it increases the aggregation size if queue filled level is near to empty ($Threshold_{low}$). All these decisions are taken at runtime. The detail proposed Efficient Dynamic Frame Aggregation (EDFA) mechanism is as follows:

BEGIN
  // setting Threshold values
  set $Threshold_{low} \leftarrow$ 20% of video AC queue size
  set $Threshold_{high} \leftarrow$ 80% of video AC queue size

  // Setting Aggregation parameters
  RN←uniform(0.0, 1.0) function for random number generation

$$prob \leftarrow RN^* \left| \frac{qlen[AC_2] - Threshold_{low}}{Threshold_{high} - Threshold_{low}} \right|$$

$$Aggr_{new} \leftarrow (16 - prob * 10) * \left(\frac{PacketFragmentSize_{Max}}{2} \right)$$

  set $AggrSize_{max} \leftarrow Aggr_{new}$
END;

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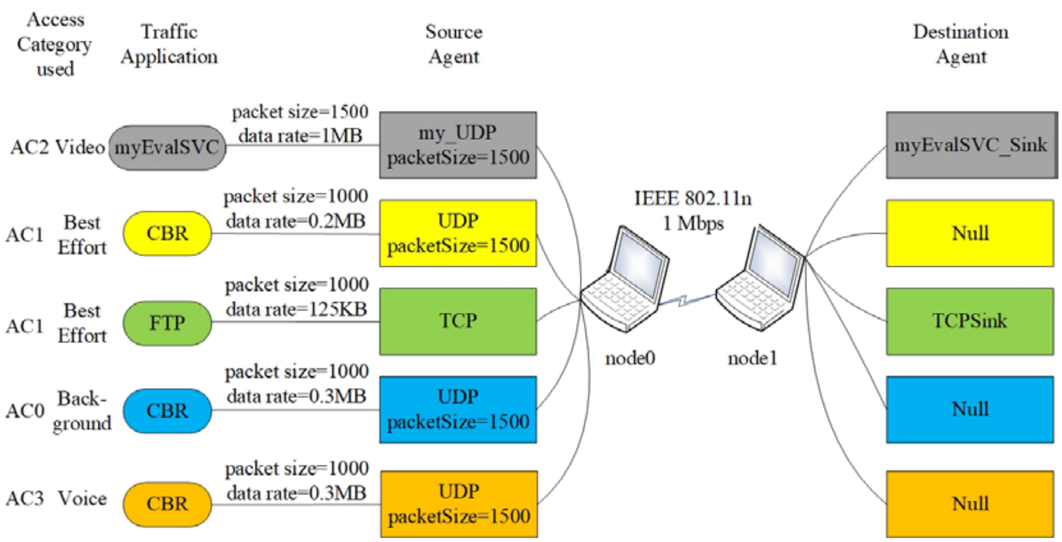

Fig. 4. Simulation Topology

4 Simulation Scenarios

In this study, researcher has developed a framework for H.264/SVC video transmission for IEEE802.11n WLAN. Simulation is done using NS2.29 under Fedora 16 (32 bit) operating system. Two IEEE802.11n wireless nodes were connected with 1Mbps data rate in this simulation study. Other simulation parameters such as simulation time is 50 sec, routing protocol as DSDV, number of antennas as 4, MIMO system as SM-STBC are used. Nine different types of video traffic of YUV CIF (352x288 pixels) type selected for this simulation. The jsvm 9.19.14 [5] and svef 1.5 software are used for coding and decoding SVC video. The simulation topology is shown in Fig. 4.

The video transmission is tested with other parallel traffic load of best effort, background, FTP and voice data. The video transmission packet size is 1500 and data rate is 1 mbps. A myEvalSVC [6] traffic application is used for video transmission and queued in AC2. A my_UDP with packet fragment size 1500 used as source agent and myEvalSVC_Sink used as destination agent for this video traffic [6].

The AC1 queue is used for Best Effort data and uses CBR and FTP traffic application. The 1000 packet size used during best effort transmission. The best effort CBR data rate set as 1MB and FTP data rate set as 0.2MB. The UDP source agent used with packet fragment size set as 1500. The TCP source agent used for CBR and FPT application. The destination agent used as Null and TCPSink for UDP and TCP respectively in best effort traffic.

The background data transmitted through AC0 queue by using CBR traffic application with packet size 1000 and data rate 0.3Mb and UDP protocol used as source agent with packet fragment size 1500. The destination agent Null used for this UDP in background traffic.

The voice data transmitted through AC3 queue by using CBR traffic application with packet size 1000 and data rate 0.3Mb and UDP protocol used as source agent with packet fragment size 1500. The destination agent Null used for this UDP in voice traffic.

5 Result and Discussion

To validate the proposed mechanism, various video quality parameters were calculated and examined using the MSU Video quality measurement tool version 10.1 [7]. For simulation, H.264/SVC common intermediate format (CIF) video with resolution 352x288 pixels and 9 different type of YUV videos were used [8]. For decoding a video from YUV to SVC format, Group of Picture (GOP) of 16 and frame rate of 30 frames per second was used. In this study, 3-Component SSIM (3SSIM), Delta, End-to-End Delay, Mean Absolute Difference (MSAD), Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Structural Similarity (SSIM), Throughput, and Video Quality Metric (VQM) video quality parameters were examined. The comparison is done between IEEE802.11n default aggregation and the proposed Efficient Dynamic Frame Aggregation (EDFA) mechanism.

5.1 Delta

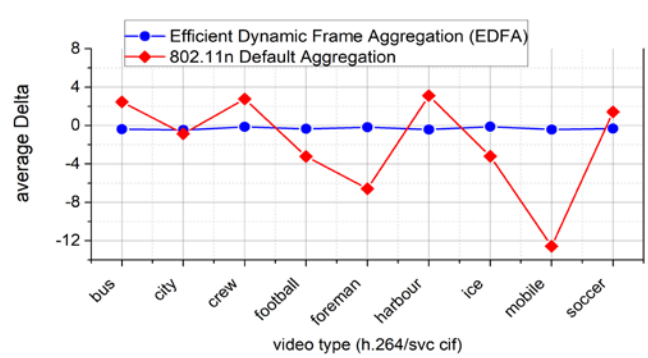

Fig. 5. Delta

This metric is calculated by taking the mean difference of color

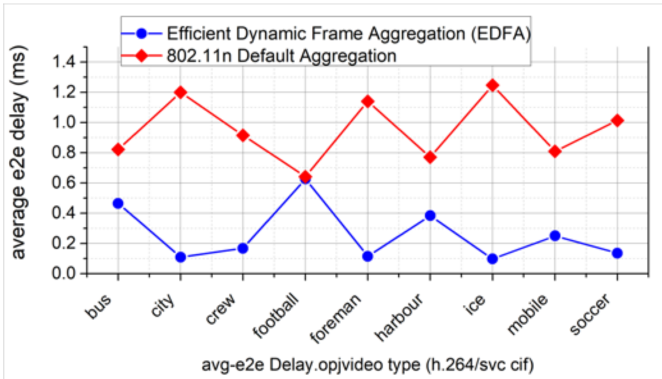

Fig. 6. End-to-End Delay

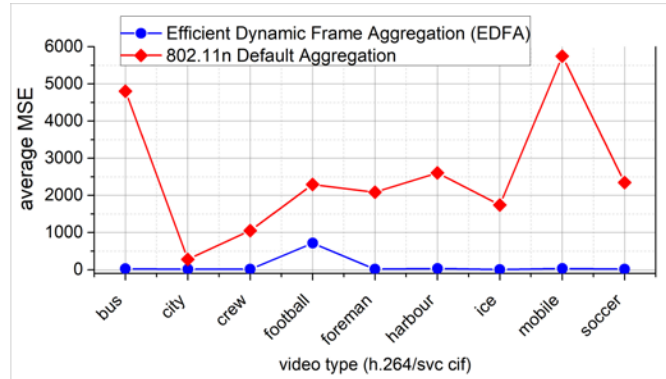

Fig. 8. MSE

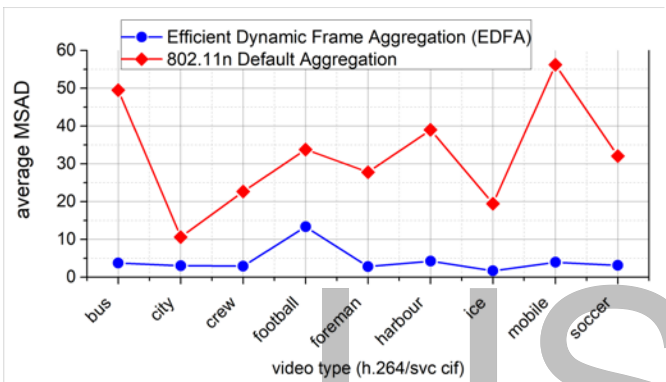

Fig. 7. MSAD

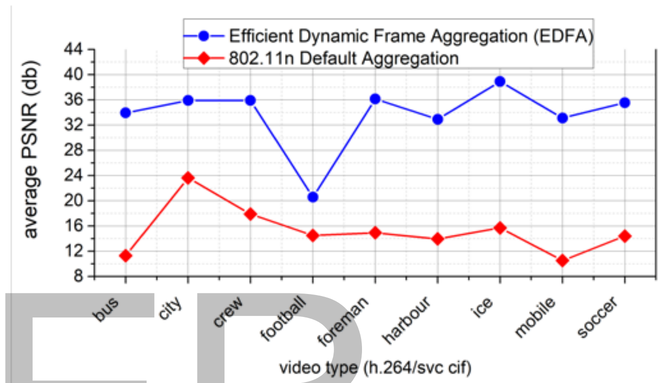

Fig. 9. PSNR

components using correspondent points of image. The Delta of 802.11n default aggregation varies from -12.6 to 3.1 while in the proposed EDFA mechanism it varies from -0.4 to -0.1. Hence, the proposed EDFA mechanism gives better Delta results as shown in Fig. 5.

5.2 End-to-End Delay

It is the time delay between receiver and transmitter. The End-to-End delay of 802.11n default aggregation varies from 0.6 ms to 1.2 ms while in proposed EDFA mechanism it varies from 0.1 ms to 0.6 ms. Hence, the proposed EDFA mechanism gives better End-to-End delay results as shown in Fig. 6.

5.3 Mean Absolute Difference (MSAD)

This metric is calculated by taking the mean absolute difference of color components using correspondent points of image. The MSAD of 802.11n default aggregation varies from 19.5 to 56.2 while in the proposed EDFA mechanism MSAD varies from 1.7 to 13.4. Hence, the proposed EDFA mechanism gives better MSAD results as shown in Fig. 7.

5.4 Mean Square Error (MSE)

A small MSE results in a high signal to noise ratio. If MSE tends to zero, then PSNR tends to infinity. The MSE of 802.11n default aggregation varies from 280.3 to 5748.2 while in proposed EDFA mechanism MSE varies from 8.3 to 715.4. Hence, the proposed EDFA mechanism gives better MSE results as shown in Fig. 8.

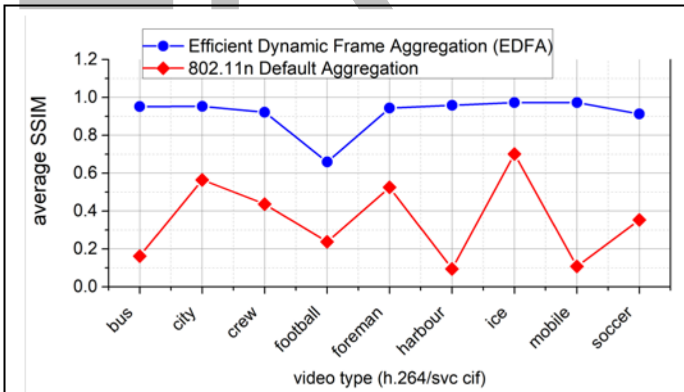

Fig. 10. SSIM

5.5 Peak Signal to Noise Ratio (PSNR)

The PSNR values from 30 to 50 dB are considered to be quite excellent, while 20dB is the normal acceptable range in wireless transmission. The PSNR of 802.11n default aggregation varies from 10.5dB to 23.7dB while in the proposed EDFA mechanism PSNR varies from 20.6dB to 38.9dB. So, our proposed EDFA mechanism gives better PSNR results as show in Fig. 9.

5.6 Structural Similarity (SSIM)

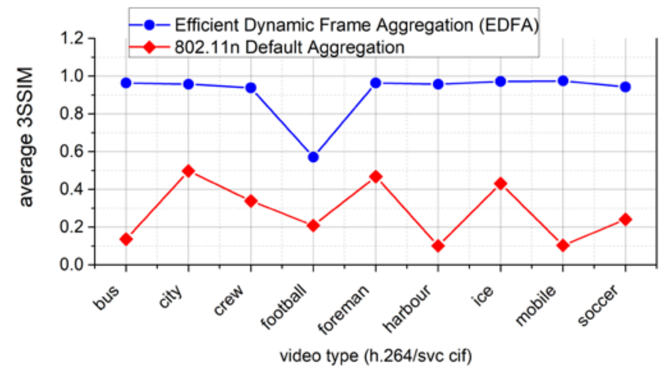

Fig. 11. 3SSIM

The SSIM index value can vary from 0 to 1 whereas value of 1 represents maximum quality. The SSIM of 802.11n default aggregation varies from 0.1 to 0.7 while in the proposed EDFA mechanism SSIM varies from 0.7 to 1.0. Hence, the proposed EDFA mechanism gives better SSIM results as shown in Fig. 10.

5.7 3-Component SSIM (3SSIM)

It is similar to SSIM. It uses three components viz. edges, texture and smooth regions for measuring video quality. For better quality video its value should be 1.0. The 3SSIM of 802.11n default aggregation varies from 0.1 to 0.5 while in the proposed EDFA mechanism 3SSIM varies from 0.6 to 0.9. Hence, the proposed EDFA mechanism gives better 3SSIM results as shown in Fig. 11.

5.8 Throughput

Throughput is used for examining the data transmission rate in WLAN for successfully moving data from other place to other in given slot of time period. For best system, throughput should be almost equal to data transmission rate. We used 1Mbps data rate in our simulation topology. The throughput of 802.11n default aggregation varies from 865.8 Kbps to 871.1Kbps while in the proposed EDFA mechanism throughput varies from 866.6 Kbps to 874.1 Kbps. Hence, the proposed EDFA mechanism gives better throughput results as shown in Fig. 12.

5.8 Video Quality Metric (VQM)

In real situation values of VQM start from 0 and it can reach up to 12. VQM value of 0 represents minimum distortion and maximum quality. The VQM of 802.11n default aggregation varies from 4.5 to 21.8 while in the proposed EDFA mechanism VQM varies from 0.8 to 7.3. Hence, the proposed EDFA mechanism gives better VQM results as shown in Fig. 13.

6 CONCLUSIONS

In this study, experimental results of proposed Efficient Dynamic Frame Aggregation (EDFA) mechanism for H.264/SVC CIF video over IEEE802.11n WLAN were examined. The results of IEEE 802.11n default aggregation and proposed EDFA mechanism were compared. The nine different types of H.264/SVC video's YUV (i.e. bus, city, crew, football, foreman, harbour, ice, mobile, and soccer) samples were taken. In this study proposed mechanism gives better video quality in all aspects of video quality parameters.

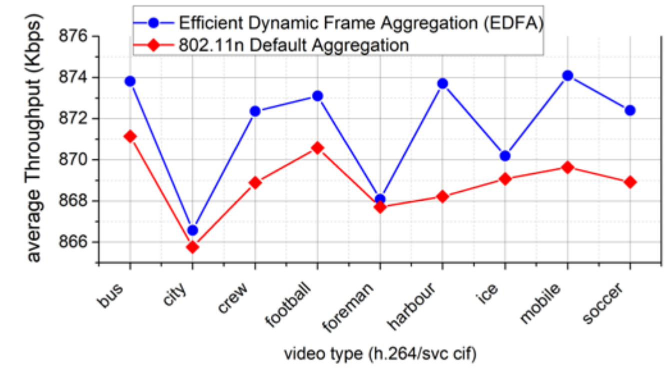

Fig. 12. Throughput

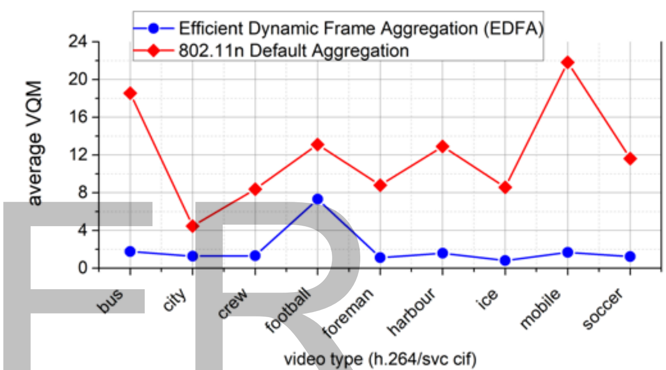

Fig. 13. VQM

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