Evaluate the Performance of Video Transmission Using H.264 (SVC) Over Long Term Evolution (LTE)

Mr. Jaimin Surati
PIT, Vadodara
Email id: jaiminsurati192@gmail.com

Mr. Ketan Goswami
Assistant Professor
PIT, Vadodara
Email id: ketanec11@gmail.com

Abstract- In recent years, the mobile Internet has increased dramatically with the development of 3G and 4G technologies. Especially the usage of mobile broadband internet on the devices like cellular mobiles, Tablets and Laptops has skyrocketed. Among the multimedia applications video streaming is the most popular mobile application. But, making these services available to users in a cost effective way without compromising quality is a big challenge. The development of Long Term Evolution (LTE) technology in the mobile world made this task achievable. The features of LTE technology provide effective services in multimedia applications with high data rates and low latency. The aim of this paper is to evaluate the quality of service (QoS) performance over LTE.

Key Terms* – *LTE, Video, QoS, H.264/SVC.

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1. INTRODUCTION

Mobile broadband has changed the way we live and work. LTE is future of mobile broadband. The recent increase of mobile data usage and emergence of new applications such as MMOG (Multimedia Online Gaming), mobile TV, Web 2.0, streaming contents have motivated the 3rd Generation Partnership Project (3GPP) to work on the Long-Term Evolution (LTE). LTE is the latest standard in the mobile network technology tree that previously realized the GSM/EDGE network technologies that now account for over 85% of all mobile subscribers.

LTE is long-term evolution, marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements. The standard is developed by the 3GPP (3rd Generation Partnership Project) and is specified in its Release 8 document series, with minor enhancements described in Release 9.

LTE system architecture

LTE system architecture is shown in figure. UE supports uplink downlink air interface. UE sends information to ENB. ENB is LTE base station. It is different from other base station that it can manage radio resource, while other base stations requires nodes like RNC (Radio Network Controller) for radio resource management. ENB sends mobility information to MME (Mobility Management Entity) and forwards uplink data to S-GW (Service Gate Way) [1].

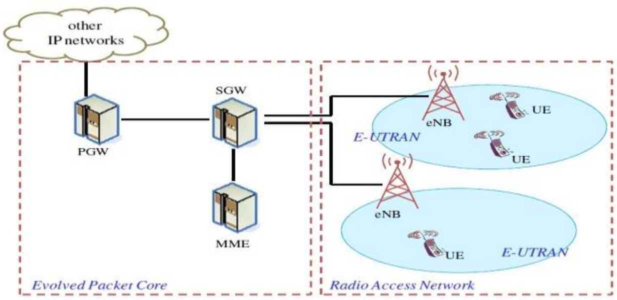

Fig-1 LTE system architecture

A. User Equipment (UE)

UE is the device that the end user applies for communication. UE contains the Universal Subscriber Identity Module (USIM) that is a separate module from the rest of the UE, which is often called the Terminal Equipment (TE). USIM is used to identify and authenticate the user and to derive security keys for protecting the radio interface transmission. Functionally the UE is a platform for communication applications, which signal the network to set up, maintain and remove the communication links the end user needs.

B. E-UTRAN Node B (eNodeB)

The only node in the Evolved Universal Terrestrial Radio Access (eUTRAN) is the eUTRAN Node-B (eNodeB). It is a radio base station that is in control of all radio related functions in the fixed part of the system. Typically, the eNodeBs are distributed throughout the networks coverage area, each residing near the actual radio antennas. A noteworthy fact is that most of the typical protocols implemented in today's Radio Network Controller (RNC) are moved to the eNodeB. The eNodeB is also responsible for header compression, ciphering and reliable delivery of packets.

C. Mobility Management Entity (MME)

The Mobility Management Entity (MME) is a signalling only entity, thus user's IP packets do not go through the MME. Its main function is to manage the users mobility. In addition, the MME also performs authentication and authorization; idle mode user tracking and reaching abilities; security negotiations; and Network-Architecture Specific (NAS) signalling. An advantage of a separate network element for signalling is that operators can grow signalling and traffic capacity independently.

D. Serving Gateway (S-GW)

S-GW does functions of packet routing/forwarding, and inter ENB handover.

E. P-GW (PDN Gate Way)

P-GW allocates ip address to UE and also does functions like packet filtering. PCRF (Policy and Charging Rules Function) interfaces with P-GW to convey policy decisions to it. PCRF also decides how users should be provided services and what charges to apply.

2. VIDEO COMPRESSION TECHNIQUES

Video can be described as any sequence of digitized or rendered moving images. It is combination of rendered moving images which required a lot of the number of images which make a large size for a video File. For example, a single second of uncompressed video running at 10 frames per second may require more than 10 MB of storage space. By considering storage, bandwidth, and amount of data that communication channel can carry it can be a major problem for the transmission of raw video. Good compression technique or algorithm may help to solve the problems.

Table 1. Comparison between Various Standards [2, 3, 4]

Feature	MPEG 2	MPEG-4 part 10 (H.264)
Macroblock Size	16x16	4x4 to 16x16
Transform	8x8 DCT	Approximation of 4x4/ 8x8 Integer DCT
Quantization	Scalar Quantization with Constant Increment	Scalar Quantization with Adaptive Increment
Reference Picture	One	Multiple
Prediction mode	Forward/ Backward	Forward/ Forward Forward/ Backward Backward/ Backward
Error Robustness	Data Partitioning, Forward Error Correction	Data Partitioning, Parameter Setting, Redundant Slice, Flexible Macroblock Ordering, Switched Slice
Transmission Rate	2-15 Mbps	64 kbps – 240 Mbps
Backward Compatibility	Yes	No
Picture (Slice) Types	I, P, B	I, P, B, SP, SI

B. H.264

H.264 is the latest generation standard for video encoding. This initiative has many goals. It should provide good video quality at substantially lower bit rates than previous standards and with better error robustness – or better video quality at an unchanged but rate. The standard is further designed to give lower latency as well as better quality for higher latency [5]. In addition, all these improvements compared to previous standards were to come without increasing the complexity of design so much that it would be impractical or expensive to build applications and systems.

An additional goal was to provide enough flexibility to allow the standard to be applied to a wide variety of applications: for both low and high bit rates, for low and high resolution video, and with high and low demands on latency. Indeed, a number of applications with different requirements have been identified for H.264:

Entertainment video including broadcast, satellite, cable, DVD, etc. (1-10 Mbps, high latency)

Telecom services (<1Mbps, low latency)

Streaming services (low bit-rate, high latency)

And others.

As a note, DVD players for high-definition DVD formats such as HD-DVD and Blu-ray support movies encoded with H.264.

3. BACKGROUND AND RELATED WORK

A. H.264 - Scalable Video Coding

In order to support scalability, H.264 SVC allows for the creation of "layers" within a single video file allowing for the transmission of different layers of a video sequence from the same file. The most basic representation of the video sequence is contained within the "base layer" which consists of the lowest quality representation in each of the temporal, spatial and quality dimensions. A series of "enhancement" layers are then encoded, each of these layers represent a point in the 3-dimensional (temporal, spatial and quality) space. Each enhancement layer is seen as an improvement in terms of one or more of the 3 dimensions and requires that all of the lower layers have been received and decoded successfully in order for itself to be decoded successfully. Using this approach the visual quality of a particular sequence can be tailored to suit the devices decoding complexity, as well as to satisfy bandwidth restrictions during periods of congestion.

There are three orthogonal dimensions along which scalability can be achieved. Spatial scalability refers to scalability with respect to resolution of decoded video. Quality scalability refers to scaling in terms of the level of compression applied to the source video during encoding. This is primarily controlled using the quantization parameter (QP). Temporal scalability refers to scaling a video in terms of frames displayed per second. To generate a H.264 SVC stream, we can use one of these scalable dimensions independently or scale along multiple dimensions. The selection of the layer parameters to scale up/ down is decided prior to the encoding phase and consequently during playback we need to scale up/ down along same path chosen before encoding. For example - if we encode using temporal and then spatial scalability (two layers), we have to upscale the video first along temporal and then over spatial dimension, we must follow the reverse path for the case where we wish to change to a lower layer during playback.

B. System Design Issues

Wireless is a challenging medium for delay sensitive applications. Transporting video over multiple wireless links poses additional challenges that must be addressed to ensure error resilience and to guarantee acceptable levels of performance and user experience under different conditions. The following are some of these considerations:

End to End Delay. The system needs bounded end to end delay for appropriate functioning. Several steps must be taken to achieve this. For example, wireless link errors or network congestion can lead to significant packet loss and retransmissions at Layer 2. If packets/frames are delayed on the send side beyond a certain limit they are discarded.

Buffer Queue Length. The buffer queue length should be adjusted based on link throughput and quality of content. For high quality/resolution content with high throughput links the queue size must be larger while for lower quality content or with lower throughput links the queues could be shorter.

Out of Order Packets and Reliability. Given that packets corresponding to different layers and links may arrive out of order at the receiver, there can be excessive delay in detecting missing packets. Intelligent decisions based on packet arrival sequences for different frames can be made and fed back to the Sender, so that the frame may be discarded if there are errors at the Receiver. Fine tuning the speed and reliability of feedback link for overall content delivery is quite important for efficient operation of the system.

Overhead and Tradeoffs between Parameters. Changes in content coding, adjustments in quality etc. need to be communicated between the Sender and the Receiver with appropriate synchronization to ensure smooth system operation. The system must also make appropriate tradeoffs between number of enhancement layers, quality of content on each layer, number of links to use, etc. Using more links and greater number of enhancement layers gives more flexibility on overall content quality delivered, but increases system overhead in terms of additional transport channels, greater synchronization and sensitivity to system and network errors.

C. Quality Assessment for Video Services

When it comes to the point of video quality assessment, there are mainly two types of methods. They are as follows.

I. Objective Assessment.

II. Subjective Assessment.

The Objective video quality assessment method is based on Mathematical models and fast algorithm that produces the results approximately equals to the subjective video quality assessment and it does not involve any human grading. It is a software program designed to deliver results based on error signal ratio of the original and processed video. The most popular Objective methods are Mean Squared Error (MSE), Perceptual Evaluation of Video Quality (PEVQ) and the Peak Signal -to- Noise Ratio (PSNR) [6][7]. This method has few categories referred as Full-Reference (FR) and Reduced - Reference (RR) video quality metrics [8].

The other video assessment includes Subjective analysis, which is based on human perception. The subjective video quality assessment is considered as accurate way of measuring quality of video compared to objective assessment. For subjective video quality assessment, a set of videos are given to the subjects for rating the videos on a scale of five (5) and the grades for quality is given in Table 2. The rating given by the subjects are known as Mean opinion Score (MOS). The subjects include experts and non-expert observers.

Table 2: Five-level scale for rating overall quality of video

Scale	Quality	Impartment
1	Excellent	Imperceptible
2	Good	Perceptible, but not annoying
3	Fair	Slightly annoying
4	Poor	Annoying
5	Bad	Very annoying

Previous work [9] has shown that the scalability offered by the SVC can provide a graceful degradation of service in an MBMS scenario to increase the number of customers served in areas where the radio signal quality is variable. Our work extends some of these concepts to a multidimensional adaptation regime which can yield greater flexibility in the bit rate to give improved control of the user perceived quality.

4. Performance algorithm

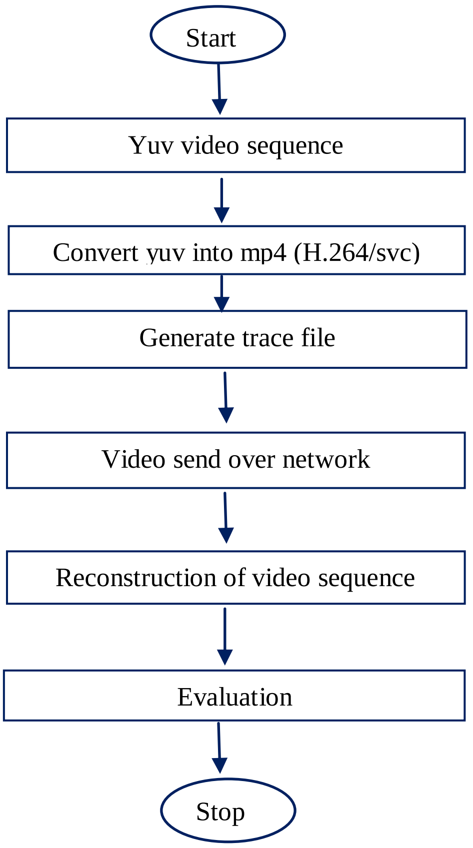

Fig 2 performance algorithm

5. SIMULATION FRAMEWORK

A reference H.264 SVC encoder [10] was used to encode the videos. Due to the relatively recent emergence of H.264 SVC, the transmission of videos of this type has not fully been implemented in the majority of network simulators. In order to overcome this fact, JSVM allows for the generation of a "packet trace" for a video sequence. This contains information about the output video file such as, length of each Network Abstraction Layer (NAL) unit, a pointer to the location of a slice in the H.264 bitstream, as well as other data regarding to which level in each of the 3-dimensions this slice belongs.

To simulate the transmission of the video sequence over an LTE network the NS3 network simulator will used. The properties of the physical channel were configured in order to provide a highly dynamic transmission rate along with bursts of packet loss occurring throughout the simulation. In order to obtain a realistic simulation of the streaming of an H.264 SVC video we enable the generation of network packets at the eNB according to the trace of encoded video (Venc) obtained from JSVM. The video receiver at UE is modified as well in order to save the trace of the received packets along with the delay values to simulate a playout buffer. Figure 3 gives

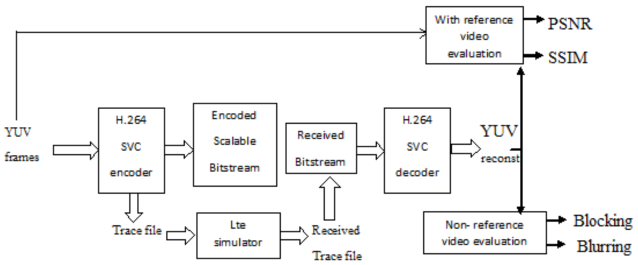

Fig. 3. Experimental setup to evaluate SVC video performance

A block diagram of the simulation process. In the case of a total loss of an I-Frame, we replace the lost I frame with the last correctly decoded frame. The decoded video at UE (Vdec) is used to assess the level of distortion in terms of full-reference (PSNR, SSIM), and no-reference (blurring and blocking) metrics.

6. Result & Discussion

Simulation is done in NS-3. Program file is in .cc format

Fig 4 show that two UE is connected with one eNB.video data packet is transferred from one UE to other interconnecting with eNB.

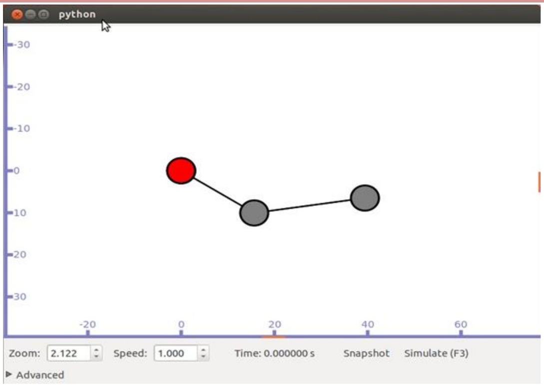

Fig 4- Communication between two UE using LTE

7. Conclusion

Studied about the LTE Technology and referred the various papers consisting of video transmission over LTE Network. Thus created an LTE network with 2 UE and shown eNodeB and UE interconnected with X2 interface also transmitted video data from one user to another user using NS3.

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