Cairo University

AVIS: ADAPTIVE VIDEO STREAMING SIMULATION TOOL

By

Ghada Gamal Abd El-ghany Rizk

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electronics and Communications Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2016

AVIS: ADAPTIVE VIDEO STREAMING SIMULATION TOOL

By

Ghada Gamal Abd El-ghany Rizk

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE in
Electronics and Communications Engineering

Under the Supervision of

Prof. Neamat S. Abd El-kader

Professor
Electronics and Communications Engineering
Faculty of Engineering, Cairo University

Assoc. Prof. Mahmoud H. Ismail

Associate Professor
Electronics and Communications Engineering
Faculty of Engineering, Some University

Dr. Ahmed H. Zahran

Assistant Professor
Electronics and Communications Engineering
Faculty of Engineering, Other University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2016

AVIS: ADAPTIVE VIDEO STREAMING SIMULATION TOOL

By

Ghada Gamal Abd El-ghany Rizk

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electronics and Communications Engineering

Approved by the Examining Committee:

____

Prof. Neamat Sayed Abd El-kader , Thesis Main Advisor

Professor, Faculty of Engineering, Cairo University

____

Assoc. Prof. Dr. Omar A. Nasr, Internal Examiner

Associate Professor, Faculty of Engineering, Cairo University

____

Prof. Elsaied Moustafa Saad, External Examiner

- Professor, Faculty of Engineering, Helwan University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2016

Engineer's Name: Ghada Gamal Abd El-ghany Rizk
Date of Birth: 01/09/1990.
Nationality: Egyptian
E-mail: ghada_gamal_rizk@yahoo.com
Phone: +201144117554
Address: 23 Sherbiny street, Dokki square, Giza
Registration Date: 1/10/2012
Awarding Date: 14 /2/2016
Degree: Master of Science
Department: Electronics and Communications Engineering
Supervisors:

Prof. Neamat Sayed Abd El-kader
Assoc. Prof. Mahmoud Hamed Ismail
DR. Ahmed Hamdy Zahran

Examiners:

Prof. Elsaied M. saad	(External examiner-Helwan university)
Prof. Dr. Omar A. Nasr	(Internal examiner)
Prof. Neamat S. Abd El-kader	(Thesis main advisor)

Title of Thesis:

AVIS: Adaptive VIdeo Streaming Simulation Tool

Key Words:

Scalable Video Coding (SVC); Simulation; Adaptive Streaming; myEvalSVC; NS2

Summary:
In this thesis; we aim to develop a simulation tool to evaluate H.264/SVC-based video streaming. Scalable video coding (SVC), e.g. H.264/SVC, features a flexible media representation that enables adaptive streaming as network conditions change. However, existing SVC simulation tools do not support adaptive video transmission. So, we present an Adaptive VIdeo Simulation (AVIS) framework for scalable video in network simulator 2 (NS2). The adaptation is enabled by introducing two new objects including AVIS transmitter and receiver. Additionally, this framework includes preprocessing and postprocessing tools that enable the simulation for different encoding configurations. AVIS design provides a flexible and configurable means for supporting a wide range of time-based and traffic-based input parameters for adaptive algorithms. Hence, AVIS represents a unique framework that would speed the performance evaluation of newly developed adaptive streaming algorithms for scalable video. Using AVIS, people who work on video coding can simulate the effects of a more realistic network on video sequences resulting from their coding schemes, while people who work on network technology can evaluate the impact of real video streams on the proposed network architecture or protocols. To demonstrate the usefulness of AVIS, we introduce two different examples for adaptive video streaming algorithms according to available bandwidth variation in first one and according to the service cost in heterogeneous network in second. The results of both examples, show that controlled video streaming maximizes the utility of the final video representation while satisfying various constraints.

Acknowledgments

First and foremost, I am thankful to Almighty God for His uncountable grants upon all of us.

I owe sincere gratitude to **Dr. Ahmed H. Zahran**, **Associate Prof. Mahmoud H. Ismail** and **Prof. Neamat S. Abd El-kader** for their valuable guidance and support. It is my pleasure to have this distinguished group of professors as thesis advisors, and I hope I managed to be as trustworthy as they expected. They gave me so much of their precious time and helped me out of many problems with their knowledge and experience.

I am deeply indebted to **Dr. Ahmed H. Zahran** for his keenness on keeping my morale high. He has played a major role in the development of this work. He has always encouraged me to explore new areas of science whenever I come across them. He provided me with invaluable guidance in my early experiences in international publication. He answered my questions patiently and paid attention to every fine detail. All words of gratitude fail to express how much I owe him for he always guides, helps, and encourages me to acquire more skills and experiences.

Moreover, I would like to thank **Prof. Neamat S. Abd El-kader** for being confident in my capabilities, answering all my inquiries on the spot in spite of her busy schedule.

My deepest gratitude to my father who always supports me. I could not have accomplished any success without his continual efforts to let me focus on my studying. Not to mention my mother who is a source of inspiration and a motivation for success. Also, my husband who believes in me. He endured me patiently and always inspires and motivates me to exert relentless efforts in my work.

Finally, I would like to thank my dear friends and colleagues; specifically those who are patiently always a source of support and kindness. May Allah bless and reward all those who have supported me. Without their encouragement, I would not have gone this far.

Ghada Gamal.

Table of Contents

List of Tables

List of Figures

Nomenclature

ρ_b	The targeted proactively buffered media in seconds .
ρ_q	The initial playout latency in seconds.
τ_c	Average residence time in the cheap network in seconds .
τ_e	Average residence time in the expensive network in seconds .
D	The simulated video duration.
FLR	Frame Loss Rate.
HBRP	Higher bit-rate policy.
HFRP	Higher frame-rate policy.
NADP	Non-adaptive.
q_b	Base layer quality.
q_{max}	Maximum video quality.
PLR	Packet Loss Rate.
ν_q	Selected Quality.
q	Selected Quality.
ρ	The ratio between the selected download rate and the encoding rate of the selected quality **q**.
τ_b	The buffered media duration.

Abbreviations

3G	Third Generation.
ATM	asynchronous transfer mode network.
AVIS	Adaptive VIdeo Simulation framework.
CGS	Coarse Grain Scalability.
CIF	Common Intermediate Format.

E-UTRAN Evolved Universal Terrestrial Radio Access.

EvalSVC An evaluation platform for Scalable Video Coding transmission.

EvalVid A Framework for Video Transmission and Quality Evaluation.

GoP Group of Picture.

HDTV High-Definition TV.

HetNets Heterogeneous Networks.

IDR Instantaneous Decoding Refresh.

ILP Inter-Layer Prediction.

ISO/IEO an information security standard published by the International Organization for Standardization (ISO) and by the International Electro technical Commission (IEC).

ITU-T Telecommunication Standardization Sector of the International Telecommunication Union (ITU).

JSVM Joint Scalable Video Model.

JVT Joint Video Team.

LTE Long Term Evolution.

LTE-A Long Term Evolution - Advanced.

MGS Medium Grain Scalability.

MPEG Moving Picture Experts Group.

NAL Network Abstraction Layer.

NALU Network Application Layer Unit.

NS-2 Network Simulator version 2.

PSNR peak signal to noise ratio.

QCIF Quarter Common Intermediate Format.

QoS Quality of service.

RAN Radio Access Network.

RTSP real-time streaming protocol.

SEI Supplemental Enhancement Information.

SNR signal to noise ratio.

SVC Scalable Video Coding.

UMTS Universal Mobile Telecommunications System.

VCEG ITU-T Video Coding Experts Group.

VCL Video Coding Layer.

WiFi Wireless Fidelity.

WiMax Worldwide Interoperability for Microwave Access..

WLANs Wireless Local Area Networks

Abstract

Scalable video coding (SVC) features a flexible media representation that enables adaptive streaming as network conditions change. However, existing SVC-based simulation tools do not support adaptive video transmission.

In this thesis, an Adaptive VIdeo Streaming Simulation tool (AVIS) for scalable video in network simulator 2 (NS-2) is introduced. Video adaptation is en- abled by introducing two new objects including AVIS transmitter and receiver. Additionally, this framework includes preprocessing and postprocessing tools that enable the simulation for different encoding configurations. AVIS design provides a flexible and configurable means for supporting a wide range of time-based and traffic-based input parameters for adaptive algorithms. Hence, AVIS represents a unique framework that would evaluate the performance of newly developed adaptive streaming algorithms for SVC-based video streaming.

Then, two different examples for adaptive video streaming algorithms are introduced to show the strongest of AVIS. In the first example, video streaming is adapted according to the variation in the available bandwidth. While in the second example, streaming parameters are adapted according to the service cost in heterogeneous network.

The results of both examples, show that controlled video streaming maximizes the utility of the final video representation while satisfying various constraints. These results propel the development of smarter adaptive strategies to achieve the best performance.

Chapter 1 : Introduction

Transmission of multimedia content (e.g. video streaming) is extremely exploding and composing a large portion of the overall data traffic. While on-demand video streaming is delay-sensitive, also to meet different end-user de- vices with different capabilities and bandwidth fluctuations of access networks; controlled video streaming is needed. So that streaming parameters should be adjusted to satisfy various constrains.

1.1. Motivation

SVC is developed as an extension to the H.264/MPEG-4 Part 10 compression standard [8]. Any SVC-based video is encoded hierarchically into a base layer and one or more enhancement layers. In order to successfully decode a specific quality, one should receive the base layer and all enhancement layers required for decoding such quality. Hence, an SVC video can be streamed at different rates based on the number of included substreams. So, the layered structure of SVC made it the pillar of many adaptive streaming algorithms that change their streaming parameters according to the network conditions. On the other hand, SVC suffers from resiliency issues, the loss of a base layer packet completely prevents the decoding of all the dependent video frames. So that, adaptive techniques needed to reduce probability of losing base layer by adjusting streaming quality and/or transmission rate.

Consequently, developing new tools for evaluating video streaming performance evolves as a key requirement for enabling thorough testing of video compression and streaming techniques before their real deployment. The performance evaluation of newly developed schemes may be conducted using analytic techniques, simulations and/or experimentation. Generally, simulations and experimentation capture the complete protocol stack operations while in analytic techniques several details are usually abstracted in one way or another. Experimentation usually takes time for both setup and testing. On the contrary, simulations enable fast testing over a variety of networks. However, a few tools exist to evaluate the developed solutions for SVC streaming but none of them enables adaptive streaming operation at the server that continuously pumps the video packets of the highest video quality into the network.

1.2. Thesis Contribution

In this thesis, an Adaptive VIdeo Streaming Simulation tool (AVIS) is presented. AVIS enables adaptive streaming by changing the streamed video quality and/or its transmission rate. AVIS implementation includes a transmitter and a receiver. AVIS transmitter filters the packets according to the selected quality and encoding type while AVIS receiver monitors the streaming process and provide information that can be used as input for adaptive streaming algorithms. Additionally, we developed generic pre- and post processing tools to accommodate generic en- coding configurations that cannot be handled by existing tools.

To the best of our knowledge, AVIS represents the first simulation framework for adaptive SVC- based streaming performance evaluation.

Also, different adaptive algorithms are introduced to maximize the utility of final video representation within various constrains. The performance of the developed adaptation strategies is evaluated using AVIS showing noticeable gains in the video quality compared to non-adaptive streaming. we developed these strategies to show the strongest of AVIS, while their results propel the development of smarter adaptive strategies to achieve the best performance.

1.3. Thesis Outline

This thesis is organized as follow, background and related works are presented in Chapter 2.

In Chapter 3, our developed simulation tool “AVIS” is introduced. The architecture of AVIS is illustrated. Also, how it to use AVIS in adaptive transmission is presented.

In chapter 4, two examples for adaptive streaming algorithms and their performance compared to non-adaptive streaming are developed. It is shown through simulations that the adaptive streaming algorithms, realize better video representation, compared to typical non-adaptive streaming.

Finally, the conclusions that have been drawn from all the results obtained in this thesis work are presented in Chapter 5. Our recent research and recommendations for further future research are also presented in this chapter.