A Study of Adaptive Video Streaming Over MANETS Using AQA-AODV

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Abstract

The unipath routing protocols have typically been used in MANETs to construct a route between a sender and a receiver. Streaming video necessitates a high level of customer support. If a single channel is used between the sender and receiver, there may be a delay in repairing or identifying an alternate video transmission line. As a result, customers are left with a subpar experience and a lot of time spent. For smoother on-demand video streaming, MANET multipath routing solutions may be used. On-demand video streaming over MANETs will be made possible with the development of new multipath routing protocols in this thesis. The thesis proposes an efficient multipath routing protocol with replication (EMRP R). Maintaining two independent and non-overlapping routes between the source and destination is the basic objective of EMRP R. Based on an estimate of their energy, stability, and traffic load; the routes are selected from a pool of available choices. The current ii video streaming backup has been selected to be stored on a single-hop node of the destination on the backup path. It is maintained by a source node, which connects to its destination, and a replica of the source node. Even if the primary route fails to deliver the video stream, on-demand video streaming may continue since all of the video frames sent to the destination are also sent to the replica node.

Keywords: *Adaptive Video Streaming, Manets, Aqa-Aodv, sender, receiver, smoother.*

1. INTRODUCTION

A network allows several computers to share files and information. There are two ways to connect computer networks: Ethernet cables or wireless cards that broadcast and receive data via a wireless medium such as air. An ad hoc network connects a large number of nodes without the need for a central station. It is becoming more common to employ Mobile Ad Hoc Networks (MANETs) as a means of communication due to its ease of deployment and quick setup. Military and emergency situations such as earthquakes, flooding and storm are examples of when they are used. Changing the topology, maintaining the network, and sending out alerts all require the use of broadcasting in these networks. There is no need for any specific infrastructure to link the nodes, which are connected to each other through a wireless medium like as air. Every node is a source, a router, or a destination in this scenario. The network's topology may change over time due to the movement of the nodes, which either leave or join the network. The loss of energy, increased latency, and connection instability caused by such a change makes it difficult to maintain the routing process.

This paper analyses the combined use of the cross-layer mechanisms included in AQA-AODV and the Scalable Video Coding (H.264/SVC). The main aim is to build a solution for supporting adaptive video streaming that can significantly contribute to increasing the quality of video streaming services while the bandwidth efficiency is achieved. In addition, an evaluation framework for adaptive scalable video streaming is also presented and evaluated. This framework has been developed in order to solve the lack of video evaluation tool-sets that support simulation tests that involve rate-adaptive video transmission using the H.264/SVC standard.

2. ADAPTIVE SCALABLE VIDEO STREAMING

As described in previous chapter, AQA-AODV provides mechanisms not only for route discovery and route maintenance but also for estimating the available bandwidth. Moreover, it also provides a cross-layer feedback for sending information about the network state to application layer. Nevertheless, in a realistic scenario are necessary additional techniques to carry out the content adaptation taking into account the network conditions? Some possibilities were analysed in the revision presented in Chapter. In summary, among the adaptive streaming techniques are: i) semantic techniques, ii) having multiple versions for the same content and iii) scalable coding. Either option can be used to adapt the encoding rate by modifying characteristics of multimedia content, such as the resolution (dimensions of the video), the number of frames per second or the quality of the frames. Whereas the first option involves complex analysis of semantic information, the techniques of multiple versions require extra storage capacity since it will be necessary to store different copies of each video, with different quality levels, which is a non-scalable option. The third option allows us to have different levels of scalability in a single video stream. Therefore, it is not necessary to have multiple versions of the same content with different levels of quality, saving storage space. Thereby a wide range of terminals over heterogeneous networks can be served with a single version of the video. This is possible because the video stream will consist of several layers, each with different characteristics of quality. The number of layers that are sent to the client will depend on the state of network. This technique is called SVC (Scalable Video Coding). SVC has the advantage of scalability with a low computational cost, which is a very desirable feature especially when the service is accessed by a large number of users.

This paper presents an adaptive solution based on the combination of SVC with the available bandwidth estimation algorithms of AQA-AODV. This solution is able to adjust of the content quality to the transmission condition in order to avoid network congestion as well as further degradation of the quality of experience (QoE). This idea is illustrated in Figure 1. The scalable video coding (H.264/SVC) provides features to generate different representations of the same video integrated within a same bit stream. A video encoded using the SVC standard has a layered structure where the layers correspond to different quality, spatial or temporal representations. A SVC video is composed of a base layer, which corresponds to the lowest representation, and one or more enhancement layers that increase the video quality when these are added to the base layer. The layered scheme of SVC can provide higher robustness during video streaming over networks with continuous fluctuations of the bandwidth. SVC allows the sender to adapt the bit rate of the video traffic adding or removing SVC layers from the video stream based on the estimation of the available bandwidth (as described the bottom part of Figure 1). Therefore, in order to adaptively control the bit rate of the video source, the adoption of cross-layer mechanisms in video streaming is required. To build a realistic solution, the cross-layer mechanism of AQA-AODV is applied. This mechanism involves information exchange and the generation of an adaptive video stream with adjusted bit rate as well as the establishment of optimal routing policies.

Before making the description of the integration of AQA-AODV and the SVC coding, it is important to review some concepts related to the SVC coding. Therefore, a brief introduction about SVC is presented in next section.

3. SCALABLE VIDEO CODING

This section briefly describes the main technical features of SVC, the scalable extension of the H.264/AVC standard. A more detailed explanation of the fundamentals of SVC can be found in the study of Schwarz et al..

With H.264/SVC, the encoder produces a scalable bit-stream, which consists of a multiple layers. A base layer provides a basic video quality (e.g. low spatial or temporal resolution) and adding enhancement layers improves the quality (e.g. increases spatial resolution or frame rate). There are three modes of video scalability supported by SVC: temporal scalability, spatial scalability and quality scalability. When using temporal scalability, layers improve the frame rate. With spatial scalability, the base layer is coded at a low spatial resolution and enhancement layers give progressively higher spatial resolution. Finally, quality scalability refers to scaling in terms of the level of compression applied to the source video. This is primarily controlled using the quantization parameter (QP). With quality scalability the base layer contains a strongly compressed version of each picture, and enhancement layers incorporate more information to increase the SNR (Signal-Noise-Ratio) value.

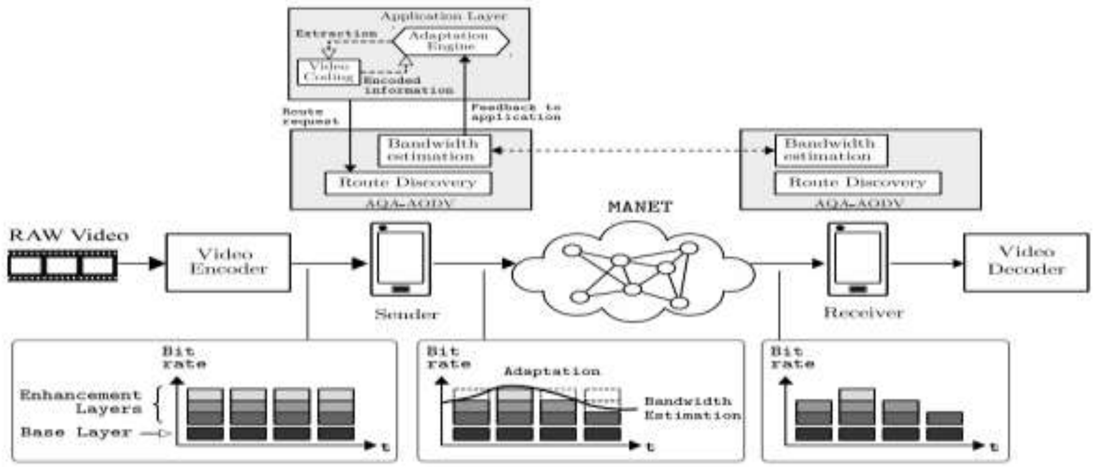

Figure 1: Adaptive scalable video streaming using AQA-AODV.

The H.264/SVC standard supports combined scalability, i.e. a scalable video can use any combination of the three types of scalabilities. For instance, Figure 2 shows a SVC stream encoded with four temporal levels {T0, T1, T2 and T3} and two quality levels {Q0 and Q1}. Thus, eight scalable layers are generated by combining these levels as is listed in the Figure 1.2. The base layer consists of the lowest temporal resolution (T0) and the lowest quality level Q0 (i.e. frames 1 and 8). In addition, an example of enhancement layer can be the layer consisting of the temporal layer T2 and the quality level Q1. This encoded video stream exploits the hierarchical prediction structure using B-pictures for enabling temporal scalability.

In H.264/SVC, the codec is divided in two subsystems: the Video Coding Layer (VCL) and the Network Abstraction Layer (NAL). Basically, the VCL is in charge of the source video coding and the NAL is the interface between the encoder and the actual network protocol, which will be used to transmit the encoded bit-stream. This thesis focuses on the NAL subsystem, since it provides the required information to identify the data relating to each layer.

In the VCL subsystem, each picture of the video is partitioned into macro blocks that each covers a rectangular area of 16 x 16 luminance samples. The macro blocks of a picture are organized in slices each of which can be parsed independently of other slices in a picture. Each slice encoded in VCL is encapsulated into Network Abstraction Layer Units (NALU), which are suitable for transmission over networks.

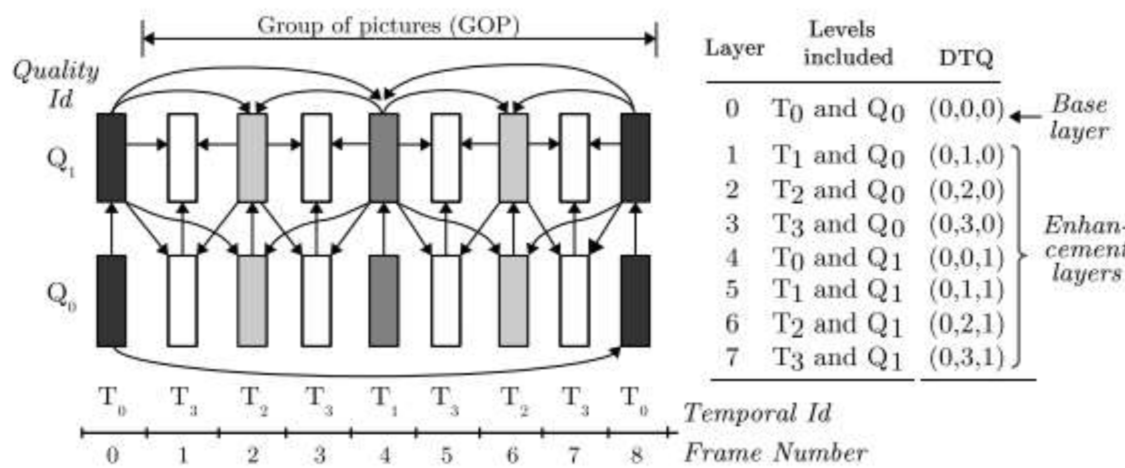

Figure 2: Example of coding structure of a SVC stream with temporal and quality scalability

The main characteristic of the NALUs used in SVC is a sequence of 3 bytes that contain three identifiers: dependency identifier (DID) temporal identifier (TID) and quality identifier (QID). These identifiers represent a point in the spatial, temporal and quality scalable dimensions, respectively. The values of DID, TID and QID are also known as DTQ parameters. For instance, a NALU of the base layer should be identified as (0,0,0) and for instance the enhancement layer consisting of the T2 and Q1 levels should be identified as (0,2,1). The inspection of the DTQ values permits to identify the NALUs belonging to a specific enhancement layer. This fact is particularly important since the NALUs may be identified and removed from the SVC encoded video, in order to reduce the bit rate. The remaining NALUs may integrate a valid video bit-stream with a lower visual quality. Nevertheless, the dependencies of the layers would be taken into account. Layers in SVC can be decoded independently but there is a logical dependency between them. This interdependency must be considered in order to obtain a correct decoding of the video. In the example shown in Figure 2, the arrow lines represent dependencies between frames in a combined scalable stream. For instance, the frame 2 of the layer T2Q1 depends on the layer T0Q1 and the layer T1Q1 (which also depends on base layer). Because of these dependencies, discarding a quality layer from a reference frame (e.g. frame 2) affects the quality of dependent frames (e.g. frames 1 and 3).

4. VIDEO TRANSMISSION EVALUATION

Video transmission evaluation requires some characterization of the video. Basically, three methods can be used to characterize encoded video in networking research: i) video bit stream, ii) video traffic model, and iii) video traffic trace. The first option involves the generation of a video bit stream using the output of a video encoder, so that it contains the complete video information. This method is focused mainly on real networks. Therefore, expertise and equipment are necessary for both video coding and networking in order to perform research studies on video transmission evaluation with actual bit streams. In addition, the difficulty to carry out a reliable assessment of new protocols is another limitation. Some examples of video bit stream include REALTRACER and ORB. The second method is based on using video traffic models, which are mathematical models that describe the essential properties of the real video streams. These models are generally developed based on the statistical analysis of video trace samples of real video traffic. Several models for video traffic have been proposed in the literature. Although using mathematical modelling has advantages such as the rapid generation of the results for video traffic and queue statistics analysis, the complexity of the actual heterogeneous networks makes realistic simulation a better tool, especially when an evaluation of the perceived visual quality of the video is required. Finally, the third method is the generation of video traffic traces, which are an abstraction of real video stream. A video trace is a text file where the characteristics of real video traffic, such as the frame number, frame type and frame size, are described. These video traces can be employed to simulate video traffic in a wide range of network simulation tool, which has been considered a viable approach for evaluation of various video delivery systems. Several simulation tools of video traffic based on trace files have been developed, for example the EvalVid tools-set and its extended versions for NS-2. These platforms support trace-driven simulations of H.263 and H.264/AVC video transmission. One possibility for support simulation with rate-adaptive video transmissions is to use the Evalvid-RA (Evalvid Rate Adaptive) framework. Evalvid-RA is a simulation tool that supports adaptive video transmission using MPEG-4 VBR (Variable Bit Rate) videos. The adaptive mechanism of this platform involves switching between different pre-encoded versions of the video (each with different levels of quality). However, a more efficient solution is provided by the H.264/SVC standard, which supports encoding of a video in different qualities within the same bit-stream. This includes different resolutions, different frame rates (fps) and different quality levels, avoiding the compression of a video into multiple representations at different bitrates.

Concerning simulation platforms for scalable video, in recent years, have been implemented few solutions, such as SVEF (Scalable Video-streaming Evaluation Framework). SVEF is a tools-set for empirical evaluation of real- time SVC streaming. However, its practical application is limited because SVEF tool-set cannot support experiments that involve new technologies or network protocols. Moreover, it does not take the spatial scalability into consideration and only supports SVC videos with a single dependency layer. Other evaluation platforms for scalable video streaming are EvalSVC (Evaluation of SVC) and myEvalSVC simulation framework, which were developed respectively. These simulations platforms extend the EvalVid framework in order to provide a simulation framework where SVC video transmissions can be evaluated over a general network simulator as NS-2. Nevertheless, these frameworks were not designed to allow source traffic to adapt its bit rate adding or removing layers from the video stream. Therefore, they do not provide a suitable solution for rate-adaptive video investigation. Consequently, an open issue in the development of adaptive video delivery systems is the lack of freely available video evaluation tool-set where researchers and network developers can test the performance of their network-adaptive techniques. In order to solve the above-mentioned problem, it is proposed the SVCEval-RA evaluation framework for more realistic simulations of adaptive scalable video transmission.

5. PROPOSED EVALUATION FRAMEWORK FOR SCALABLE VIDEO STREAMING

This section describes a novel simulation framework called SVCEval-RA (SVC Evaluation Platform for Rate-Adaptive Video), which can be used in the assessment of rate-adaptive video streaming using Scalable Video Coding. This approach is a modified and enhanced version of the myEvalSVC tool-set. More precisely, a new procedure have been implemented in SVCEVal-RA in order to adapt the bit rate of the traffic source adding or removing SVC layers from the video stream based on the estimation of the available bandwidth. This procedure (referred to hereafter as the Adaptive SVC scheme of SVCEval-RA) provides better conditions to carry out performance evaluations of network protocols for adaptive video transmission, compared with the other evaluation platforms. For providing a more realistic simulation environment, the developed algorithms have been integrated in the simulation tool NS-2. Nevertheless, as discussed later, the proposed architecture can be integrated within any network simulator.

The main contributions of SVCEval-RA compared to referenced works are:

The SVCEval-RA framework is enhanced to support rate adaptive scalable video.

The modular structure of SVCEval-RA makes possible that third party modules can be easily integrated in order to extend its capabilities. For instance, transport protocols for video streaming with their own algorithms for network resource estimation, such as TFRC (TCP Friendly Rate Control) and RTMP (Real Time Messaging Protocol).

Simulation studies using adaptive SVC techniques can be performed using SVCEval in different network scenarios (e.g. Internet, WLANs and MANETs) where video streaming services require adaptation to the network conditions, such as DASH.

In contrast to the other simulation platforms, SVCEval-RA supports SVC- encoded video flows with both quality and temporal scalability.

A simulator-independent tool, written in C++, is also provided. This software integrates, in only one application, the tasks that must be executed for the interfacing between the encoder and the simulator.

The SVCEval-RA framework performs video transmissions over a packet network using a general network simulator. Thus, any specific trace format defined by the integrated simulator can be easily adapted in the proposed evaluation platform. However, SVCEval-RA has been integrated to the NS-2 simulator.

Figure 3 illustrates the workflow of the SVCEval-RA evaluation framework. The software modules inherited from the JSVM (Joint Scalable Video Model) package and SVEF (Scalable Video coding Streaming Evaluation Framework) scripts are represented in grey. The whole process, from the encoding of the original video source to the evaluation after the streaming over a simulated network can be summarized in four phases, better detailed in the following sub-sections: encoding, pre-processing, simulation and post-processing. In the encoding phase, the original uncompressed video is encoded in H.264/SVC format through the JSVM Encoder and a corresponding trace file (NALU trace) is produced. Pre-process consists of the generation of the Bit Rate Trace and the NS-2 Traffic Trace file. During simulation, the NALUs are forwarded to the receiver through a simulated network.

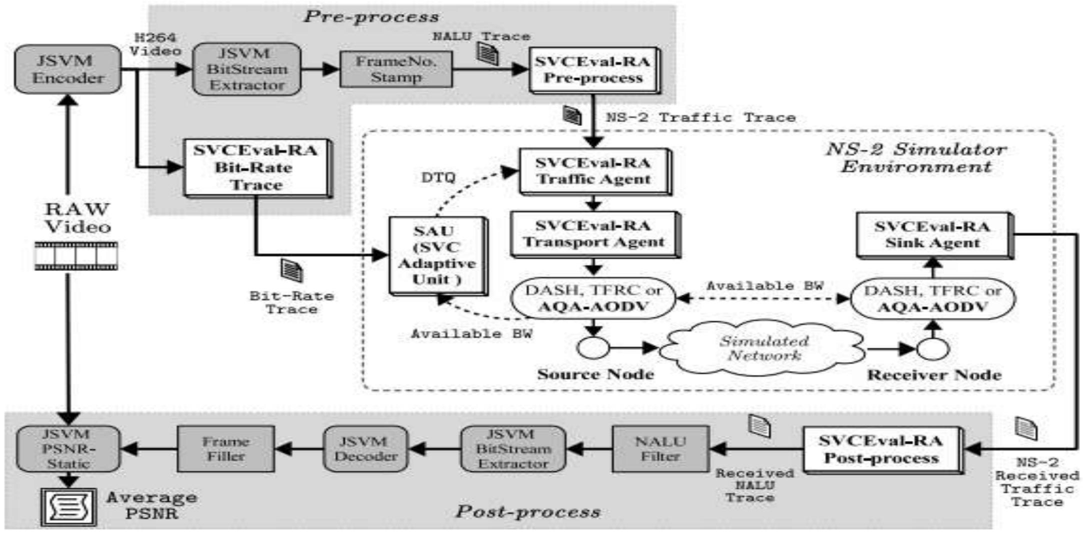

Figure 3: Workflow of the SVCEval-RA framework

Moreover, the source can adjust its data rate by selecting a set of SVC layers to be transmitted based on the estimation of the available bandwidth. After simulation, the received NALU trace is processed in order to produce a YUV file, which may be affected by missing frames due to transmission losses, unsatisfied decoding dependencies or excessive delay. Finally, the PSNR (Peak Signal- to-Noise Ratio) is evaluated by comparing the original uncompressed video with the distorted one. In Figure 3, the different phases are further detailed.

6. CONCLUSION

In this research work, energy aware and link stability techniques have been considered in multipath routing. The proposed energy aware schemes increase the overall efficiency of the network by making use of a few nodes and, at the same time, increasing the overall lifetime of the network. The aforementioned approaches are simulated in a diverse network scenario, and analyzed for measuring their ability and performance. REEDRP and ERFSR schemes are found to give the minimum end to end delay. The REEDRP has a lower packet drop count, and the REEDRP and ER-FSR Schemes show higher packet delivery ratio and lower overhead. The proposed approaches can achieve better performance by providing proper energy aware and link stability schemes efficiently. When comparing the results of all the energy awareness routing schemes proposed in this dissertation, energy realization fish eye based schemes are applied in places where the applications wherein the energy imbalance is the major constraint. LSEAMR schemes are more useful when a large number of nodes regarding the network traffic and accuracy are required. The adaptive reliable energy aware routing scheme performs better in terms of packet delivery ratio and reduces the routing end to end delay. This scheme is applicable to any real time MANET even larger number of nodes in the network. In general terms, the results of the simulation study demonstrate that the combination of the layered scheme of SVC and the QoS mechanisms of AQA-AODV provides an efficient system for network-adaptive video streaming. The bandwidth estimation algorithms of AQA-AODV gather accurate information about the network resources. This information is then sent to the application layer of the source node in order to transmit only the SVC layers that could be efficiently supported by network. This fact helped or avoided the network congestion providing better conditions to video streaming. For example, in all simulated scenarios, the rate-adaptive strategy implemented using SVC and AQA-AODV shows better performance in terms of packet loss, end-to-end delay and video quality. It is important to note that, even though with AQA-AODV video source sends only some video layers, the decoded frame rate is higher than using AODV, with which the entire video flow is transmitted. Consequently, the quality of the received video (in terms of PSNR) obtained with AQA-AODV also is better than the quality obtained when AODV is used. The adaptive mechanisms of AQA-AODV provided a rapid response to the abrupt decrease of the available bandwidth; especially in the first scenario, when the route went from having two to four hops. Similarly, even though the mobility conditions in the second scenario affected the performance of the three evaluated protocols, the combination of the adaptive feedback scheme and the fast re-routing algorithm, allow AQA-AODV to minimize the impact of the mobility over the pauses or video gaps.

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