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PSNR Analysis of video transmission in VANETS, using NS2 and Evalvid Framework

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RESUME: Recent developments in wireless technologies and the Internet of Things have led to the design of new communication systems, such as ad-hoc vehicle networks (VANETs) [1]. These networks are expected to offer new entertainment applications and traffic security services with intelligent equipment in a smart environment. A smart city is designed as a controlled and monitored environment using advanced technologies and new types of communication to improve the quality of life through innovative services. One of the key challenges of smart city communication is ensuring effective service delivery in economic, social and environmental conditions. As a result, multimedia communications, including streaming video, should be very beneficial for traffic management as well as for the provision of entertainment and advertising services. With video streaming services, real-time information will be used and provided by vehicle networks for safety and efficiency purposes. In this article, we focus on studying the effect of streaming low brightness video feeds on PSNR.

Mots clés : VANET, video transmission, road traffic, EvalVid, framwork, tool-set, NS-2, SUMO, YUV video, PSNR.

INTRODUCTION

Video transmission and communication in VANETs represents a major challenge because the video streaming [2] in real time will considerably enrich the quality of experience perceived by the user as there will be more visibility on its environment, the conditions of the road traffic, the possibility of using applications such as emergency video calls, etc. However, the transmission of video data in the VANETs is a difficult task since the vehicular networks are a hostile environment for any kind of data especially video transmission (numerous packet losses, mobility of the nodes, etc.), as a result, researchers have focused on improving and optimizing video communication. Unfortunately, evaluating video transmission performance has not been an easy task. Therefore, finding a powerful and an easy tool is fundamental to advancing researches.

In this presentation, we propose an advanced simulation tool-set which integrates EvalVid framework [3] [4] into NS-2[5], plus the addition of a mobility file generated from a real life map using SUMO[6] which will make this tool-set credible while measuring delivered videos quality. With the enhancements, the tool-set allows network-related researchers to evaluate real video streams using their proposed network designs or protocols as well as evaluate video quality of their designed video coding mechanisms using a more realistic network.

The tool can adopt both raw YUV video files and downloadable video trace files as a video stream source, hence, researchers get to focus more on their area of research without worrying about having an available video source for the simulation. To evaluate the performance, the toolset uses PSNR which compares each pixel between the original and delivered video trace file. Furthermore, the tool-set combines the received video frames into real video that we can play before our eyes.

SYSTEM MODEL

Figure 1 shows the overall system model: Initially, a raw YUV video file is converted to an MPEG4 file. The latter is introduced in Evalvid to generate a video trace file which is the actual video object sent via a simulated transmission in NS2. The received video file, received at the receiving node in the simulation environment, is returned to Evalvid, which generates the PSNR quality model from among various other measures of quality of service.

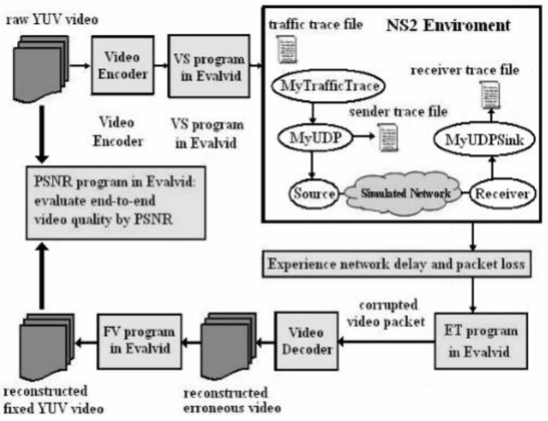

Fig. 1: System Model: Evalvid Framework integration with NS2 [7]

The structure and main components of the Evalvid Evaluation Framework are described as follows:

Source: There are two video source formats, YUV QCIF (176x144) and YUV CIF (352x288).

Video Encoder and Video Decoder: EvalVid currently supports two MPEG4 codecs, the NCTU codec [8] and ffmpeg [9].

VS (Video Sender): This component plays the compressed video file produced by the video encoder, fragments the largest video image into smaller segments, and then transmits these segments over a real or simulated network. For each packet transmitted, the timestamp, packet ID, and payload size of the packet are stored in the sender's trace file. After that, this component also generates a video trace file containing information about each image in a real video file. The video trace file and the sender trace file can be used to evaluate the video quality.

ET (evaluation of the trace): the evaluation is carried out on the side of the sender once the video transmission is finished. That is, the timestamp, packet ID, and packet payload information available to the recipient must be returned to the sender. Based on the encoded video file, the video trace file, the sender trace file, and the original receiver trace file, this AND component can report frame / packet loss and frame / packet jitter. and generate a reconstructed video file corresponding to the eventual reproduced video found to the end user. In addition, this component considers a lost frame if it arrives later than its predefined reading time.

FV (Fix Video): The measurement of the video quality is done frame by frame. Therefore, the total number of receiver-side video frames and the lost frames must be the same as the original transmitter-side video. If the codec cannot handle missing images, the FV component is an error concealment technique used to deal with this problem by inserting the last correctly decoded image in place of each lost image [10].

PSNR (Peak Signal Noise Report): The PSNR is one of the most widely used objective metrics for evaluating the quality of service of video transmissions at the application level. The following equation shows the PSNR definition between the luminance component Y of the source image S and the destination image D:
where Vpeak = 2k-1 and k = number of bits per pixel (luminance component). The PSNR measures the error between a reconstructed image and the original.

$$PSNR(n)_{dB} = 20\log_{10}\left(\frac{V_{peak}}{\sqrt{\frac{1}{N_{col}N_{row}}\sum_{i=0}^{N_{col}}\sum_{j=0}^{N_{row}}[Y_S(n,i,j)-Y_D(n,i,j)]^2}}\right)$$

$$V_{peak} = 2^k - 1$$

k = number of bits per pixel (luminance component)

WORK APPROACH

Our working approach is summarized in four main steps, illustrated in Figure 2. Each step is explained separately in the following subsections.

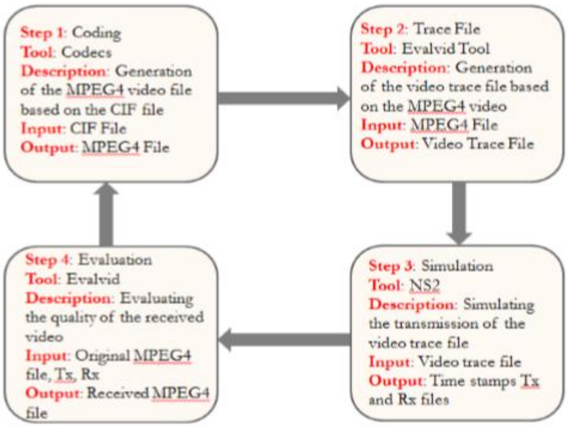

Fig. 2 : Work steps

The Coding Process

The video file types used in our simulations are the standard H.261 Standard Interface Format (CIF) with a resolution of 352 × 288 because this format is commonly used in video conferencing, one of VANET's important applications. Before a CIF file can be used for simulation purposes, it is first encoded in MPEG, one of the widely used industrial standards for streaming video over the Internet.

Video Trace File Generation

The second step is to generate a video trace file from the original MPEG4 video file using the mp4trace tool. The video trace file contains the number, type and size of the image, as well as the number of segments in case of image segmentation. The Evalvid tool was originally designed to evaluate actual video transmissions, which is why the mp4trace tool specifies the destination URL and the port number.

Simulation in NS2

In our simulation, we chose to use AODV protocol which has been determined to be the best in terms of packet delivery, jitter and throughput.

The other parameters are mentioned below:

Simulation parameter	Configuration
MAC	802.11
Routing protocol	AODV
Number of vehicles	4, 9, 25, 64
Image resolution	352*288
Video file frame Size	30fps

RESULTS AND ANALYSIS

The video we used our simulation is based on "Highway CIF". Figure 3 shows the PSNR performance of the AODV protocol when the network sparsity is set at D = 100 m and its density is increasing. We used 100 frames to smooth the results to obtain a clearer analysis.

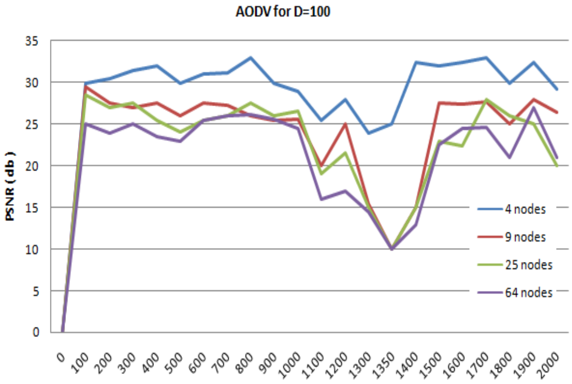

Fig. 3: PSNR Performance of AODV for various network densities (4, 9, 25, 64)

The PSNR variation model is maintained at different network densities and it's affected by the brightness content of the images constituting the transmitted video. Since we are transmitting the same video file across different topologies, the brightness content of each frame in this video remains the same. We verified this by examining the two major drops in PSNR performance in Figure 5. The first occurred at approximately F = 500, corresponding to the approximate video playback time of T = 19s. We observed that during this period, the brightness decreased due to the appearance of a black car in excess, as can be seen in FIG. 4. The second major drop in PSNR occurred between F = 1300 and F = 1400, video playback time of T = 43 and T = 46. During this period, a black bridge appears first in the video, and then the car passes under its shadow, as shown in Figure 5. Therefore, the fall of the PSNR in both cases can be justified by the fact that when the brightness content of a frame decreases, the noise energy dominates the maximum signal energy and therefore degrades the PSNR

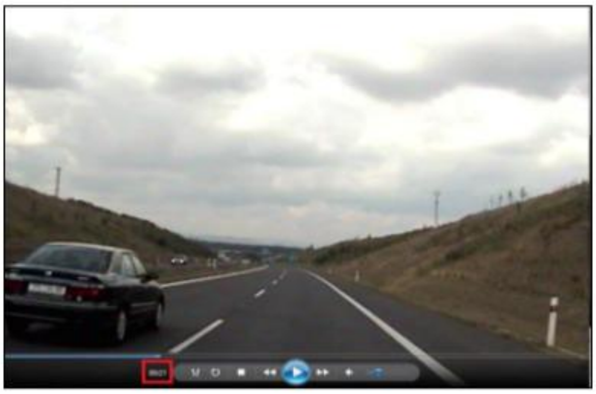

Fig. 4: screenshot of the video at T=21s

Fig. 5: screenshot of the video at T=41s

It can also be noted in Figure 5 that the performance of the AODV on the PSNR degrades as the density of the network increases. The PSNR decreases by approximately 5 dB between Frame = 500 and Frame = 650 frames when the network goes from N = 4 nodes to N = 9 nodes. However, this attenuation is less important when the network is changing to N = 25 nodes and N = 64 nodes. This is because the 4-node topology allows direct communication between the sending and receiving nodes; but, when the network density increases to N = 9, 25 or 64 nodes, data is routed through intermediate nodes. In this case, the multiple jumps considerably reduce the performance of the PSNR.

CONCLUSION

In this paper, we have investigated the combined effect of the network density and the image britheness on the PSNR performance. Various network sparsity models were designed with varying network densities. Simulation and evaluation results presented interesting findings. PSNR performance worsens as the density of the network increases. We have also determined that PSNR is heavily affected when the network density increases because of packet loss.

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