A DISTORTION RESISTANT ROUTING FRAMEWORK FOR VIDEO TRAFFIC IN WIRELESS MULTI HOP NETWORKS

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Abstract
Traditional routing metrics designed for wireless networks are application-agnostic. In this paper, we consider a wireless network where the application flows consist of video traffic. From a user perspective, reducing the level of video distortion is critical. We ask the question “Should the routing policies change if the end-to-end video distortion is to be minimized?” Popular link-quality-based routing metrics (such as ETX) do not account for dependence (in terms of congestion) across the links of a path; as a result, they can cause video flows to converge onto a few paths and, thus, cause high video distortion. To account for the evolution of the video frame loss process, we construct an analytical framework to, first, understand and, second, assess the impact of the wireless network on video distortion. The framework allows us to formulate a routing policy for minimizing distortion, based on which we design a protocol for routing video traffic. We find via simulations and test bed experiments that our protocol is efficient in reducing video distortion and minimizing the user experience degradation.

Keywords

1. Introduction
With the advent of smart phones video traffic has become very popular in wireless networks. In tactical networks or disaster recovery, one can envision the transfer of video clips to facilitate mission management. From a user perspective, maintaining a good quality of the transferred video is critical. The video quality is affected by (i) the distortion due to compression at the source and (ii) the distortion due to both wireless channel induced errors and interference. Video encoding standards, like MPEG-4 [1] or H.264/AVC [2] define groups of I, P and B type frames that provide different levels of encoding and thus, protection against transmission losses. This Group of Pictures (GOP) allows for the mapping of frame losses into a distortion metric which can be use to assess the application level performance of video transmissions. One of the critical functionalities which is often neglected, but affects the end-to-end quality of a video flow is routing. Typical routing protocols, designed for wireless multi hop settings are application agnostic and do not account for correlation of losses on the links that compose a route from a source to a destination node. A frame loss will result in some amount of distortion. The value of distortion at a hop along the path from the source to the destination depends on the positions of the unrecoverable video frames (simply referred to as frames) in the GOP, at that hop. As one of our main contributions, we construct an analytical model to characterize the dynamic behavior of the process that describes the evolution of frame losses in the...
GOP (instead of just focusing on a network quality metric such as the packet loss probability) as video is delivered on an end-to-end path. Specifically, with our model we capture how the choice of path for an end-to-end flow affects the performance of a flow in terms of video distortion. This is in stark contrast with traditional routing metrics (such as the total Expected Transmission Count (ETX) [3]) wherein, the links are treated independently. Our solution to the problem is based on a dynamic programming approach which effectively captures the evolution of the frame loss process. We then design a practical routing protocol, based on the above solution, to minimize routing distortion. In a nutshell, since the loss of the longer I frames that carry fine-grained information affect the distortion metric more, our approach ensures that these frames are carried on the paths that experience the least congestion; the latter frames in a GOP are sent out on relatively more congested paths. Specifically, our contributions in this paper are as follows:

Developing an analytical framework to capture the impact of routing on video distortion:
As our primary contribution, we develop an analytical framework that captures the impact of routing on the end-to-end video quality in terms of distortion. Specifically, the framework facilitates the computation of routes that are optimal in terms of achieving the minimum distortion. The model takes into account the joint impact of the PHY and MAC layers and the application semantics on the video quality. Design of a practical routing protocol for distortion resilient video delivery: Based on our analysis, we design a practical routing protocol for a network that primarily carries wireless video. The practical protocol allows a source to collect distortion information on the links in the network, and distributing traffic across the different paths in accordance to (a) the distortion and (b) the position of a frame in the GOP.

Evaluations via extensive experiments: We demonstrate via extensive simulations and real test bed experiments on a multi-hop 802.11a test bed that our protocol is extremely effective in reducing the end-to-end video distortion and keeping the user experience degradation to a minimum. In particular, the use of the protocol increases the PSNR of video flows by as much as 20MOS that is on the average 2-3 times higher compared to the case when traditional routing schemes are used. These PSNR and MOS gains project significant improvements in the perceived video quality at the destination of a flow [4]. We also evaluate our protocol with respect to various system parameters.

2. RELATED WORK
The plethora of recommendations from the standardization bodies regarding the encoding and transmission of video indicates the significance of video communications. Standards like the MPEG-4 [1] and the H.264/AVC [2] provide guidelines on how a video clip should be encoded for a transmission over a communication system. Typically, the initial video clip is separated into a sequence of frames of different importance with respect to quality and hence, different levels of encoding. The frames are called I, P and B frames and groups of such frames constitute a structure named the Group of Picture (GOP). In each such GOP, the first frame is an I-frame which can be decoded independently of any other information carried within the same GOP. After the I-frame a sequence of P and possibly B-frames follows. The P and B-frames use the I-frame as a reference to encode information. There has been a body of work on packet loss resilient video coding in the signal processing research community [5]. In [4], the video stream is split into high and low priority partitions and FEC is used to protect the high priority data. To account for temporal and spatial error propagation due to quantization and packet losses, an algorithm is proposed in [6] to produce estimates of the overall video distortion that can be used for switching between inter and intra coding modes per macro block, achieving higher PSNR. In [7], an enhancement to the transmission robustness of the coded bit stream is achieved through the introduction of inter/intra coding with redundant macro blocks. The coding parameters are determined by a rate-distortion optimization scheme. These schemes are evaluated using simulation where the effect of the network transmission is represented by a constant packet loss rate, and therefore fails to capture the idiosyncrasies of real world systems. In [8], an analytical framework is developed to model the effects of wireless channel fading on video distortion. The model is however, only valid for single hop communication. In [9], the authors examine the effects of packet loss patterns and specifically the length of error bursts, on the distortion of compressed video. The work, although on a single link, showcases the importance of accounting for the correlation of errors across frames. The performance of video streaming over a multi-hop IEEE 802.11 wireless network is studied in [10], and a two-dimensional Markov chain model is proposed. The model is used not only for performance evaluation but also as a guide for deploying video streaming services with end-to-end QoS provisioning. Finally, a recursion model is derived in [11] to relate the average transmission distortion across successive P-frames. None of these efforts consider the impact of routing on video distortion. There have also been studies on the performance of video transmissions over 4G wireless networks that have been designed to support high Quality of Service (QoS) for multimedia applications. In [12] an assessment of the recently defined video coding scheme (H.264/SVC) is performed over mobile WiMAX. Metrics such as the Peak Signal to Noise Ratio (PSNR) and the Mean Opinion Score (MOS)
are used to represent the quality of experience perceived by the end user. The results show that the performance is sensitive to the different encoding options in the protocols and respond differently to the loss of data in the network. Again, these are single link wireless networks and routing is not a factor. In [13], a multi-path routing scheme for video delivery over IEEE 802.11 based wireless mesh networks is proposed. To achieve good traffic engineering the scheme relies on maximally disjoint paths. However, this work does not consider distortion as a user-perceived metric. It simply aims to reduce the latency of video transmissions, and thus, its objective is different from what we consider here.

3. SYSTEM ANALYSIS

3.1 Existing System
Different approaches exist in handling such an encoding and transmission. The Multiple Description Coding (MDC) technique fragments the initial video clip into a number of sub-streams called descriptions. Standards like the MPEG-4 and the H.264/AVC provide guidelines on how a video clip should be encoded for a transmission over a communication system based on layered coding. Typically, the initial video clip is separated into a sequence of frames of different importance with respect to quality and, hence, different levels of encoding. In another existing model, an analytical framework is developed to model the effects of wireless channel fading on video distortion. In other existing models, the authors examine the effects of packet-loss patterns and specifically the length of error bursts on the distortion of compressed video.

3.2 Disadvantages of Existing System
From a user perspective, maintaining a good quality of the transferred video is critical. The video quality is affected by:

- The distortion due to compression at the source, and
- The distortion due to both wireless channel induced errors and interference. The model is, however, only valid for single-hop communication. The existing model is used not only for performance evaluation, but also as a guide for deploying video streaming services with end-to-end quality-of-service (QoS) provisioning.

4. PROPOSED SYSTEM
In this paper, our thesis is that the user-perceived video quality can be significantly improved by accounting for application requirements, and specifically the video distortion experienced by a flow, end-to-end. Typically, the schemes used to encode a video clip can accommodate a certain number of packet losses per frame. However, if the number of lost packets in a frame exceeds a certain threshold, the frame cannot be decoded correctly. A frame loss will result in some amount of distortion. The value of distortion at a hop along the path from the source to the destination depends on the positions of the unrecoverable video frames (simply referred to as frames) in the GOP, at that hop. As one of our main contributions, we construct an analytical model to characterize the dynamic behavior of the process that describes the evolution of frame losses in the GOP (instead of just focusing on a network quality metric such as the packet-loss probability) as video is delivered on an end-to-end path. Specifically, with our model, we capture how the choice of path for an end-to-end flow affects the performance of a flow in terms of video distortion. Our model is built based on a multilayer approach.

5. Advantages of Proposed System
Our solution to the problem is based on a dynamic programming approach that effectively captures the evolution of the frame-loss process. Minimize routing distortion. Since the loss of the longer I-frames that carry fine-grained information affects the distortion metric more, our approach ensures that these frames are carried on the paths that experience the least congestion; the latter frames in a GOP are sent out on relatively more congested paths. Our routing scheme is optimized for transferring video clips on wireless networks with minimum video distortion.

6. SYSTEM DESIGN
The data outline is the connection between the data framework and the client. It involves the creating determination and methods for information arrangement and those strides are important to put exchange information into a usable structure for handling can be accomplished by examining the PC to peruse information from a composed or printed archive or it can happen by having individuals entering the information straightforwardly into the framework. The outline of information spotlights on controlling the measure of data required, controlling the mistakes, maintaining a strategic distance from deferral, staying away from additional steps and keeping the procedure straightforward. The information is composed in such a path along these lines, to the point that it gives security and convenience with holding the protection. Input Design considered the following things: How the data should be arranged or coded?

- The dialog to guide the operating personnel in providing input.
• Methods for preparing input validations and steps to follow when error occur.

UML is a technique for portraying the framework engineering in point of interest utilizing the plan. UML speaks to a gathering of best building rehearses that have demonstrated fruitful in the displaying of extensive and complex frameworks. The UML is a vital piece of creating articles arranged programming and the product improvement process. The UML utilizes for the most part graphical documentations to express the configuration of programming tasks. Utilizing the UML ventures groups impart, investigate potential plans, and accept the compositional outline of the product. Definition: UML is a broadly useful visual demonstrating dialect that is utilized to determine, picture, build, and archive the ancient rarities of the product framework. UML is a dialect: It will give vocabulary and guidelines to correspondences and capacity on applied and physical representation. So it is demonstrating dialect. UML Specifying: Specifying implies building models that are exact, unambiguous and complete. Specifically, the UML address the determination of all the critical examination, configuration and usage choices that must be made in creating and showing a product escalated framework. UML Visualization: The UML incorporates both graphical and printed representation. It makes simple to envision the framework and for better understanding. UML Constructing: UML models can be specifically associated with an assortment of programming dialects and it is adequately expressive and free from any vagueness to allow the immediate execution of models. UML Documenting: UML gives assortment of archives furthermore crude executable codes. The objective is for UML to wind up a typical dialect for making models of article situated PC programming. In its present structure UML is contained two noteworthy segments: a Meta-model and documentation. Later on, some type of technique or procedure may likewise be added to; or connected with UML. The UML speaks to a gathering of best designing practices that have demonstrated effective in the displaying of vast and complex frameworks. The UML is a critical piece of creating items situated programming and the product advancement process. The UML utilizes for the most part graphical documentations to express the configuration of programming ventures.

7. SYSTEM IMPLEMENTATION

With most programming dialects, you either incorporate or decipher a system so you can run it on your PC. The Java programming dialect is unordinary in that a project is both incorporated and deciphered. With the compiler, first you make an interpretation of a project into a moderate dialect called Java byte codes the stage autonomous codes deciphered by the translator on the Java stage. The mediator parses and runs every Java byte code direction on the PC. Arrangement happens just once; understanding happens every time the project is executed. The accompanying figure represents how this functions.

8. Results

We show the performance gains of the proposed routing scheme via extensive simulations and test bed experiments. For the simulation experiments we use the network simulator ns-2 [1]. The simulator provides a full protocol stack for a wireless multi-hop network based on IEEE 802.11. We extend the functionality of ns-2 by implementing our proposed routing scheme on top of the current protocol stack. For the testbed experiments we implement our scheme using the Click modular router [2], [3] Further, we use EvalVid [4], which consists of a set of tools for the evaluation of the quality of video which is transmitted over a real or simulated network. The toolset supports different performance metrics such as the Peak Signal to Noise Ratio (PSNR) and the Mean Opinion Score (MOS). To adapt the EvalVid to the ns-2 simulator we follow the procedure described in [6]. Specifically, for each simulated video flow between two nodes in the network we need to produce a sequence of files. We start with the initial uncompressed video file which consists of a sequence of YUV frames. Using the EvalVid tool-set we transform the YUV format first to the MP4 and then to the MPEG4 format which contains hints of how the video file should be transmitted over a network. We then need to capture a log from an attempted transmission over a real network. This log is fed as an input to the ns-2 simulation which plays back the video transmission producing at the end, two sets of statistics regarding the transmission, one for the sender
and one for the receiver. By applying the EvalVid toolset on this sequence of files we can reconstruct the video file as it is received by the destination and compare it to the initial video file. The comparison provides a measure of the video quality degradation due to the transmissions over the network.

9. CONCLUSION

In this paper, we argue that a routing policy that is application-aware is likely to provide benefits in terms of user-perceived performance. Specifically, we consider a network that primarily carries video flows. We seek to understand the impact of routing on the end-to-end distortion of video flows. Toward this, we construct an analytical model that ties video distortion to the underlying packet-loss probabilities. Using this model, we find the optimal route (in terms of distortion) between a source and a destination node using a dynamic programming approach. Unlike traditional metrics such as ETX, our approach takes into account correlation across packet losses that influence video distortion. Based on our approach, we design a practical routing scheme that we then evaluate via extensive simulations and test bed experiments. Our simulation study shows that the distortion (in terms of PSNR) is decreased by 20

References

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