A Distortion-Resistant Routing Framework for Video Traffic in Wireless Multihop Networks

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Abstract
In general, traditional routing paths which are designed for wireless sensor networks are application-agnostic. We are considering an application flow in a wireless sensor networks consists of video traffic. To overcome the problem of video distortion there are many routing metric mechanisms. Popular link-quality-based routing metrics (ETX) do not account for the dependence of video across the links of a path which can cause a video to flow through few paths, thus causing high video distortion. In this paper, we construct an analytical framework model to evaluate the video frame loss process to understand the impact of wireless network not account for the dependence of video across the links of a path, thus causing high on video distortion. This framework allows to minimize the video distortion by formulating a routing policy by accounting the distortions caused by a flow, end-to-end by distributing the frames across the paths through priority based. We evaluate via testbed experiments that our protocol is efficient in reducing the video distortion and minimizing the user experience degradation.

Keywords
Routing, Protocol Design, Video Distortion Minimization, Wireless Networks, Video Communication

I. Introduction

Video traffic became very popular in wireless networks because of the invent of smartphones. But maintaining the good quality of the video has become critical because of the distortion occurred due to the compression at the source and wireless channel induced errors and interference.

Usually MPEG-4 [1] or H.264/AVC [2] video encoding standards define groups of I- , P- , and B-type frames which provides the different levels of encoding for protecting the video from transmission losses. By this different levels of frames either i) the information encoded independently in case of I- frames , or ii) encoding information is related to already encoded information in other frames, as in case of P- and B- frames.

The main critical functionality which is often neglected over here is routing which effects the end-to-end quality of a video flow. In typical routing protocols, the flows are considered independently, they can converge onto certain links that then become heavily loaded while others are underutilized. The decision of the flow made by such typical routing protocol depends upon the network parameters.

Here we are mainly considered with the improvement of the user-perceived video quality by accounting the application requirements. Here the schemes which are used to encode the video clips can accommodate a certain number of packet losses per frame by considering some threshold for packet loss per frame in the Group of Pictures(GOP). The losses in the GOP are in stark contrast with the traditional routing metric like expected transmission count (ETX) [3] where the links are treated independently.

In this project we are considering an analytical model [6] to characterize the dynamic behavior of the process which describes the frame losses in the GOP as the video is delivered on an end-to-end path. Here we also capture how the choice of path for an end-to-end flow effects the performance of the flow in terms of video distortion by using this model as it is built based on a multilayer approach.

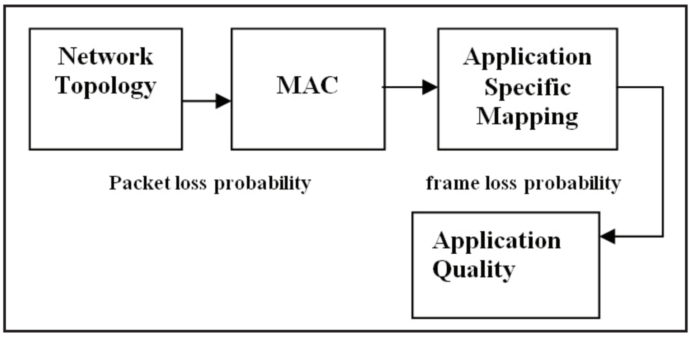

Fig. 1: System Architecture of an Analytical Model with Multilayer Approach

Here the packet loss probability on a link is mapped to the probability of a frame loss in the GOP which directly associated with the video distortion metric. As mentioned above main problem in the wireless sensor networks is routing, to resolve this problem we are following a dynamic programming approach which effectively captures the evolution of the frame-loss process by using which we are generating a practical routing protocol to minimize routing distortion.

II. Contribution of Paper

In this approach we are developing an analytical framework which captures the impact of video distortion and facilitates the computation of routes that are optimal in terms of achieving the minimum distortion when video is transmitted end-to-end flow.

We develop a practical routing protocol for a network which primarily carries the wireless video by allowing the source to collect the distortion information on the links and distributing the traffic across the different paths in accordance to (i) the distortion, (ii) the frame position in the GOP.

By demonstrating the practical routing protocol via various extensive simulations and testbed experiments we prove that it is extremely effective in reducing the end-to-end video distortion and keeping the user experience degradation to a minimum. As we are using a protocol it will increase the peak signal-to- noise ratio(PSNR) of video flows by 20% with a mean opinion score (MOS) that is on the average of 2-3 higher than the traditional routing schemes.

III. Related Work

According to the standardized bodies video communication is done through encoding and transmission techniques. Various approaches exist in handling such an encoding and transmission techniques. The Multiple Description Coding (MDC) technique fragments the video clip into number of substreams called descriptions which are transmitted on network over the disjoint paths. Here all the descriptions are equivalent. Layered Coding(LC) produces a base layer and multiple enhancement layers. The enhancement layers

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are not so useful on their own because they serve to refine the base layer. Therefore, base layer represents the most critical part of the encoding signal [4-5]. In our project we are approaching through the layered coding due to its popularity in application and adoption standards.
The video clip is separated into different frames depending upon the importance with respect to quality, hence different levels of encoding through I- , P- , B- frames. Group of Such frames structured together to form GOP.
The Analytical framework[6] is developed to model the effects of wireless channel fading on video distortion , were the model, only valid for single-hop communication. Due to the complexity and optimization problem genetic-algorithm-based heuristic approach is used to compute which in turns use MDC. Our approach not only differs in model for video distortion, but also on the fact that we use LC, which is more popular in applications today. The model assumed over here is a flat model so all the nodes in the model are given the equal importance and perform the same set of tasks.

IV. Implementation

The Analytical model for video distortion resistant framework is implemented through various modules like

A. Model Formulation

Here the analytical model couples the physical and MAC layers of the network with the application layer for a video clip that is sent from a source to a destination node. The model for the lower layers computes the packet-loss probability through a set of equations that characterize the multiuser interference, physical path conditions, and traffic rates between source-destination pairs in the network. This packet-loss probability is input to the second model to compute the frame-loss probability, and from that, the corresponding distortion. The value of the distortion depends upon the first unrecoverable frame in the GOP along the path from source to destination at a particular hop.

B. Video Distortion Model

According to our analysis the Video transmission distortion in a model is breakdown into source distortion and wireless transmission distortion over a single hop. Here we develop a model to captures the evaluation of the transmission distortion along the links of a route from source node to destination node. If we consider a GOP structure which consists of I- frames followed by P- frames then we corresponds the I- frame index with 0 , and the P- frames corresponds to index to 1 up to (F-1).Assuming that the packet-losses in different frames in the GOP are independent events, the transition probabilities for the process, can be computed.

C. Video Distortion Dynamics

The value of the distortion at hop along the from source to the destination node depends on the position of the first unrecoverable frame in the GOP.
The value 0 indicates that the first I- frame is lost, and therefore the whole GOP is unrecoverable. A value between 1 and (F-1) denotes that the corresponding P- frame is the first frame in the GOP that cannot be decoded correctly, and the values indicate that no frame has been lost thus far, yielding a distortion.

D. Optimal Routing Policy

In this module, our objective is to find the path that yields the minimum transmission distortion between any source and destination. The control to the optima control problem is the selection of the next node to be visited at each intermediate node from the source to the destination. In essence, the MDR routing policy distributes the video frames and the packets along the multiple paths by minimizing the interference experienced by the frames that are the beginning of the GOP. I-frames are the longer frames than other frames so the loss of those frames results in heavy distortion, and thus these are transmitted on relatively interference-free paths. The higher protection given to I- frames is the key contributing factor in decreasing the distortion with MDR(Minimum Distortion Routing).

V. Protocol Design

To compute the solution to the MDR problem complete knowledge of the network is necessary. Here because of the dynamic nature and distributed operations of a network , such complete knowledge of the global state is not always available to the node. So the solution to the MDR problem can be computed through the source node by gathering the information partially about the global state. In order to collect the information regarding the particular state the source node has to sample the network during the path discovery process.
Here the sampling process includes the estimation of the ETX metric [3] for each wireless link in the network which provide a measure of quality of the links.
Here from the source node we have send a Route Request Message to the server regarding the video file. After sending the request we will get a pop up message showing that request has sent to server. In the near the particular video file is divided into number of chunks showing a pop up message that video file has been chunked successfully. Now the Route Reply Message has been to the particular destination from the source node. After that he video file has been played.
Here we can see two cases: i) While requesting for a video file we can select distortion resistant routing which leads to the normal node, ii) While requesting for a video file we can distortion routing which leads to attacker node.

VI. Execution Results

Click Modular Routing mechanism [10-11] is used to implements the dynamic protocol in order to compute the routes on the wireless network that achieve minimum video distortion.
Here we are having three forms:
1. Server form
2. Node form
3. Router form

Case 1: When the request for the video file has been sent from the Source node(Normal node) to the server.

Fig. 2: The Video File Playing at the Destination Node

Case 2: When the request for the video file has been sent from the Source node (Attacker node) to the server.

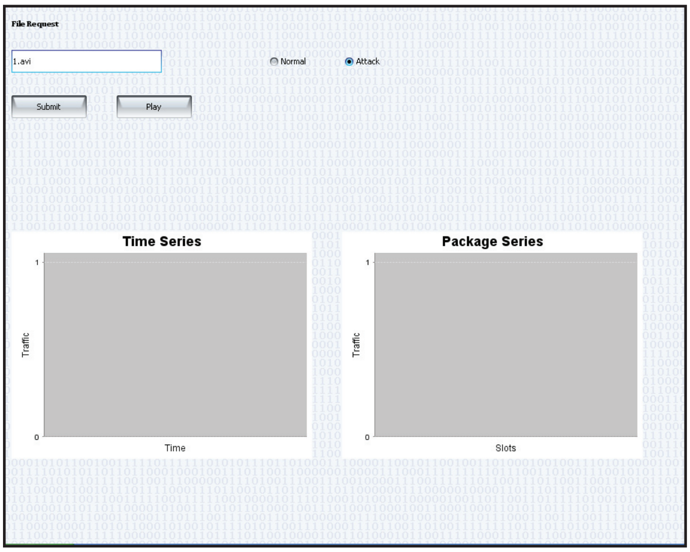

Fig. 3: Selection of Attacker Node and the Video File in the File Request Form

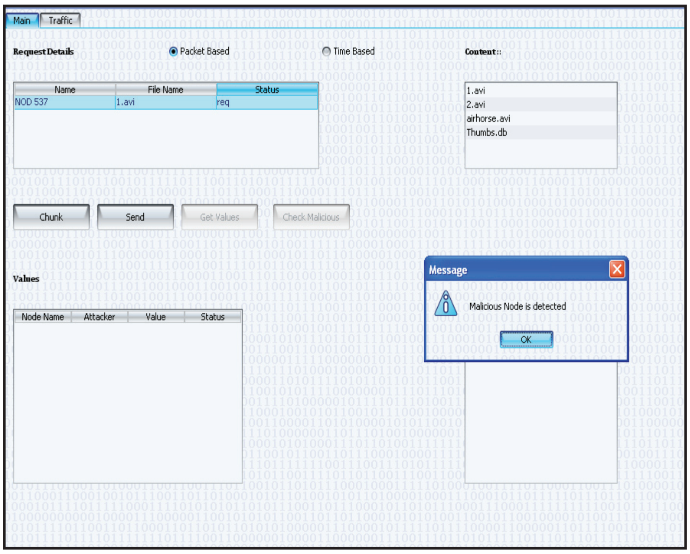

Fig. 4: Video File has Been Chunked Successfully

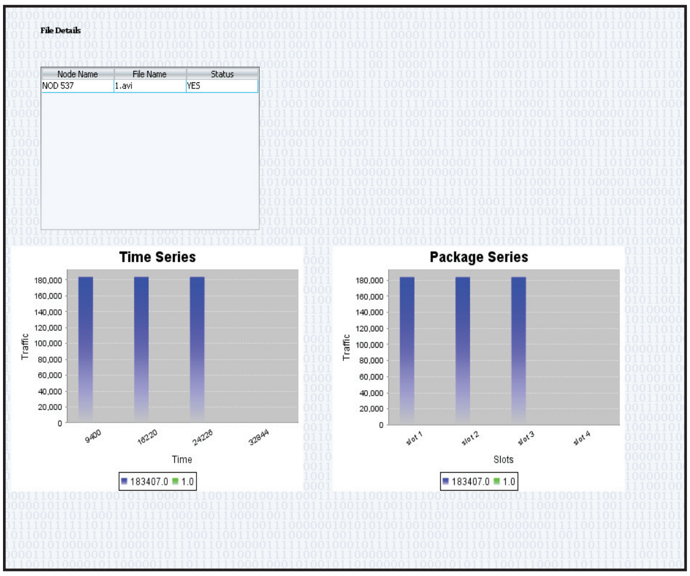

Fig. 5: Time Series and Package Series in the Router Form

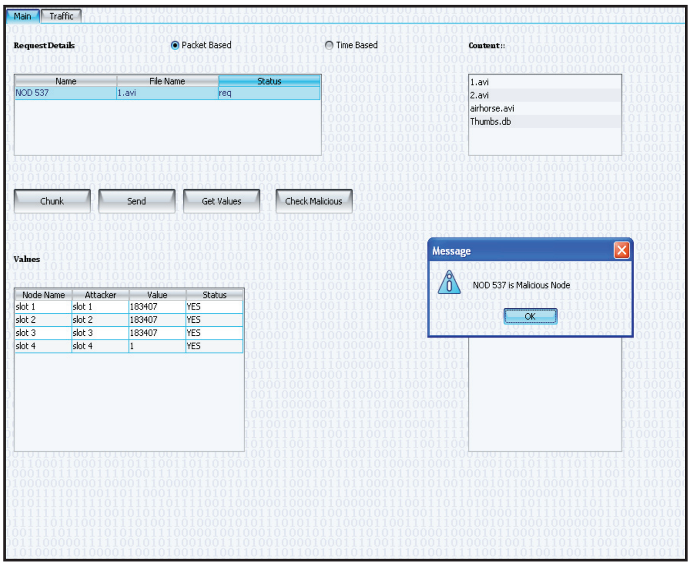

Fig. 6: NOD 535 has been detected has Malicious node

Table 1: Test Cases

Video File	Normal/ Attacker node	Node	Status	Traffic Detected
1.avi	Normal	NOD704	Video Played	No
airhorse. avi	Normal	NOD345	Video Played	No
2.avi	Attacker	NOD177	Malici-ous node detected	Yes
Thumbs. db	Normal	NOD545	Video Played	No
1.avi	Attacker	NOD283	Malici-ous node detected	Yes

VII. Conclusion

In this paper, we contented that 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. The impact of routing is clearly understandable on the end-to-end distortion when a video flows from sender to destination node. By the analytical model which we have constructed we are tying up the video distortion to the underlying packet-loss probabilities in the multilayer approach by finding an optimal route between source and destination node using dynamic programming approach. A practical routing scheme has been designed for which we evaluate via extensive simulations and testbed experiments. By the which we have used it is shown that distortion is decreased by 20% compare to traditional (such as ETX-based routing). The user experience regarding the degradation is kept to minimum by using this analytical framework.

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