Survey on Enhancement of Performance of Video Streaming over Ad Hoc Wireless Network

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ABSTRACT

With the development of communication technology and the extensive use of mobile devices, streaming video content through wireless network is becoming popular application. Several works have been conducted to address its challenges as well as improve its performance. This paper will re-observe the problem of video streaming over ad hoc wireless network. It explains the background concept of ad hoc network as well. Subsequently, various proposed improvement methods are discussed. It finally summarizes how these methods answer the challenges and improve the performance of video stream on ad hoc wireless network.

KEYWORDS - video stream, ad hoc wireless network, performance

1 Introduction

Various types of mobile devices equipped with wireless connectivity are now widely used. While these devices can be utilized for various purposes, such as e-learning [1], e-comic [2] and storing multimedia contents, it is preferred that these devices are able to exchange their contents. For this reason, multimedia streaming between mobile clients is becoming a widespread-used application these days. In order to be able to share their contents, mobile devices should communicate between each other by using existing infrastructure or deploying their own connectivity tools. They are also capable of forming a self-regulating ad hoc network among themselves without necessarily utilize a pre-established communication infrastructure.

Ad Hoc Wireless Network (AWN) can be seen as a collection of wireless devices which dynamically form a network without using the existing fixed infrastructure [3]. Having the ability to self-configure and self-administer makes it possible to be created in any situation. It is very useful in an environment where temporary connection is needed and there is no available network infrastructure, such as in a battlefield, deep-jungle exploration, disaster recovery, small conference and so on [4, 5]. During these operations, a cheap and easy to set up network is urgently required for performing coordination between team members. One of the most common applications that typically needed and should be accommodated in this kind of situation is video conference, which involves multimedia streaming over ad hoc wireless network.

Video streaming over AWN is a complex and challenging issue. One reason is because transmitting video data, generally, requires high bandwidth and minimum delay. Moreover, an AWN is usually susceptible to failure due to the limited power and broken links because of the increasing distance between mobile devices. A reliable streaming mechanism, therefore, is essential to guarantee that the video data is completely received by recipient devices without a significant amount of delay. In order to realize this purpose, two major elements of the mechanism should be considered, they are video coding and routing protocol.

This paper will discuss several methods which have been proposed to improve AWN's video streaming performance. The rest of the paper provides a review about the challenges of video streaming over AWN and the efforts have been done to tackle them.

2 Problem Definition

Video streaming over AWN poses two major problems due to the specific characteristics of both video stream and AWN. Firstly, in regard to the large size and smooth flow requirement of video data, there is a challenge to ensure that all large video packets are completely delivered to the recipient devices within boundary time. The video data is required to be encoded and decoded appropriately so that they can be transmitted efficiently through the wireless medium. Packets delay should be minimized to maintain the smoothness of the video sequence without leaving the quality of the video itself.

Moreover, in regard to the mobility, power limited and the absence of fixed infrastructure on an AWN, a problem arises in preserving the communication links between devices. The route to the destination devices should be kept available even there are changes in the topology which may caused by broken link or dropped wireless bandwidth. A broken link is likely to happen in an AWN due to devices' power limitation and their mobility which may leads them to be unreachable by other devices in the network.

The paper categorizes the efforts to improve the performance of video streaming over AWN into five different methods. It, subsequently, explains their mechanisms in addressing the problem as well as their advantages and disadvantages.

3 Solution Approach

Five methods discussed in this paper are considered as the most recent techniques in mobile ad hoc streaming. They are the latest development of all methods which have been proposed to enhance the performance of video streaming over AWN, so that they represent their previous proposed methods.

3.1 Adaptive Layer Selection

Qin et.al [6] have proposed an improvement method which works based on the probability of a video data to be successfully streamed between mobile ad hoc clients. The main focus is to deliver the whole video data to the receiver while its quality is maintained as good as possible according to the probability value of the streaming. Scalable Video Coding (SVC) is utilized to allow the video data to be multi-layerly encoded. The sender device is capable of autonomously selecting streamed enhancement layers to upgrade the quality of the video received by other devices in AWN.

A model of streaming probability is built as the function of receiver's buffer size, duration of the sender to operate in the delivery zone and the size of the streamed multimedia object. This model is applied to estimate the available buffer size of the receiver which will then used to optimize the video transmission by selecting the total enhancement layers that should be streamed to guarantee that the entire video data is delivered to the receiver.

In this method, each video data to be streamed is divided into one base layer and several enhancement layers. The lower bit rate base layer ensures that the whole part of the video will be streamed, while the enhancement layers may be added to the base layer when adequate buffer size of the receiver is available to enhance the video quality. The base layer will be always prioritized to be delivered successfully to the receiver.

The implementation of this method increases the streaming probability up to 60%, while the quality of the streamed video can be maintained to be relatively good. It guarantees that the entire video data is streamed so that users will have a picture about the general content of the video. However, there is no certain standard on what level the quality of a streamed video is considered as relatively good and can be tolerated by the users. Moreover, this method is not appropriate to be implemented in an environment where users more interested in the quality of the video and not in the general content of the video itself.

3.2 Multi-source Video Transmission with Optimum Perceptual Quality

In [7], the authors have proposed an optimization of ad hoc video streaming by introducing rate allocation to competing sources in order to minimize the total distortion of streamed video. This method is a further development of Multipath Routing Scheme [8, 9], congestion-aware [10] and congestion-minimized stream routing approach [9]. The main idea behind this method is allocating video traffic to multi routes in such way so that each video data transmitted by different sources can be received with minimum distortion.

This method is brought up to address the problem of limited bandwidth which may produce video packets delay while there are many sources competing for available links to stream the video data. Each video source is capable of using multiple routes to split and transmit the entire video traffic. The distortion level, which is used as the measurement units of the effectiveness of the packets routing, is expressed as the function of packet error rate correlated with each video source. An optimization algorithm is deployed to help the sources to allocate streamed video data to available links so that the probability of packet error of the whole traffic is minimum.

By implementing the resulted optimization algorithm, total distortion of the whole streamed video can be reduced to 70% compared to non-optimal equal share links. However, this method can be effectively applied for a particular strict AWN scenario where there are several sources competing for multiple route and at least one shared link is available. Moreover, it does not consider the effect of the devices' mobility.

3.3 Hierarchical Routing Protocol

Arce, et.al [11], have proposed a special hierarchical optimized link state routing protocol (HOLSR) to improve the performance of video streaming over AWN. The objectives of this method are to reduce routing computational cost and to optimize the use of high capacity devices so that the number of lost packets can be minimized. To realize these purposes, a new metric called interruption is introduced to evaluate the performance of the streaming. This metric is measured as how long an interruption occurs in a video stream. An interruption is mostly caused by packets lost during the video transmission, which then makes a sequence of streamed frames can not be decoded properly in the receiver.

In this protocol, there are two levels of the routing hierarchy, they are level 1 which is responsible for connecting type 1 devices as a core network and level 2 which connecting type 2 devices. All devices in the AWN are grouped into clusters, each of which has type 1 device as the cluster head. The cluster head is responsible for informing its availability to devices inside its cluster as well as to other clusters. Each device within an AWN should maintain its updated information and send it to its cluster head. The illustration of clustered hierarchy AWN is depicted in Figure 1.

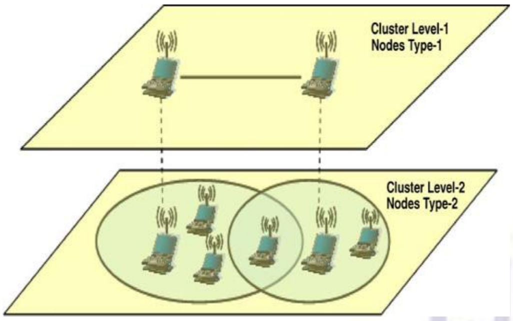

Figure 1. Hierarchical Ad Hoc Network [11]

Through a comprehensive comparison with typical flat routing protocol, it has been verified that this routing protocol increases the packet delivery ratio up to 50%. It reduces the routing overhead and enhances the video quality from 1 to 6 dB. On the other hand, this method gives disadvantages on the need of higher capacity cluster head devices and the higher possibility of traffic overload to occur in the link between cluster head devices. Therefore it is important to initiate an effort on implementing traffic load balancing between multiple routes in this method.

3.4 Route Stability

Calafate et.al [12] have proposed a method to improve the performance of video streaming over AWN by increasing route stability. In an AWN, it is important to maintain the route information to be continuously available even there are many devices with high level of mobility within the network. For this reason, route stability is essential to prevent the devices within an AWN lose their route information which then makes them perform route discovery mechanism. The more frequent the devices carry out route discovery mechanism, the higher amount of the packets gaps and the lower quality of the streamed video data.

This method increases the route stability by implementing extended Dynamic Source Routing (DSR) protocol called Super Restrictive (SR) mode, splitting algorithms and preventive route discovery mechanism. While SR improves route discovery by utilizing a low memory cost list to store route information, the other two mechanisms ensure that the effect of video gaps caused by the lost of certain route is minimized to the quality of the streamed video. To evaluate the effectiveness of this method, a metric called Video Annoyance (VA) is introduced to measure the video gaps which represent the number of lost frames in a video sequence.

The implementation of this method in an AWN scenario reduces the size of the video gaps to be not more than 20 frames, while the conventional DSR can result as much as 217 consecutive frames. It reduces the VA level up to 60% as well. However, this method suffers from higher routing overhead compared to its traditional DSR counterpart.

3.5 Multiple Description Video Multicast

In [13], Mao et.al have extended the work of [14] by developing multicast of multiple description (MD) video in AWN. The method proposed in their work introduces the use of the combination of several metrics to optimize the video quality. It also utilizes the multicast trees to support each video description. It still maintains the advantages of MD coding which is able to encode a video into multiple streams and decode them independently according to the available link capacity.

In this method, each receiver is connected through multi routes to the sender, so that the streaming still can be continued when there is a broken link. The video description is encoded into different layers to cope the problem of the heterogeneity of the wireless links, especially in the diverse of the bandwidth. While there is streaming scheme consists of multiple layers and multiple routes, the optimization of the multiple trees is achieved by deploying Genetic Algorithm (GA) to get the overall best video quality. A model which describes the relationship between the bit rate and the distortion level is built to measure the effectiveness of the scheme. The illustration of the scheme of this method is depicted in Figure 2.

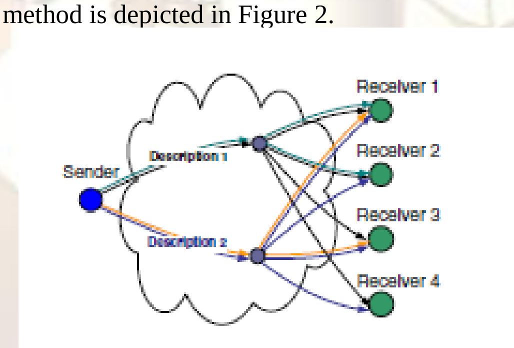

Figure 2. MD video multicast with two trees [13]

Implementing this GA based multicast scheme reduces the distortion level of the streamed video data up to 30% compared to the typical scheme which utilizes Dijkstra's algorithm. A comparison with another multicast scheme called Independent-Tree Ad Hoc Multicast Routing (ITAMAR) shows that this GA based method enhance the Peak Signal to Noise Ratio (PSNR) up to 3,72 dB over ITAMAR algorithm. However, this method spends higher computational cost for the deployment of Genetic Algorithm to find the optimum multiple trees.

4 Conclusions and Future Development

Multimedia sharing between mobile devices has been extensively used, while one of the most significant applications is video streaming. This paper reviews the challenges of video streaming over ad hoc wireless network and discusses several approaches to enhance its performance. While there are number of methods have been proposed, five representatives of the most updated methods are discussed in previous chapter.

These methods utilize different approaches for improving the performance of mobile ad hoc streaming. Each of them works appropriately in particular different scenarios. They use different metrics to measure the effectiveness of the method as well. Therefore, it is required to introduce a flexible method that is able to accommodate different AWN scenarios and use the combination of all metrics to optimize the streamed video quality. One reason is because the best performance of ad hoc video streaming can be achieved by utilizing all possible metrics simultaneously. Optimizing one metric can lead to the degradation of other metrics.

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