Transmission of Video Streaming Over Ad Hoc Networks

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Abstract

Ad hoc networks pose a great challenge to video communication with the advances in low bit-rate video coding technology and the increase both in the bandwidth of wireless channels and in the computing power of mobile nodes. In this scenario, this paper gives a video transporting architecture in mobile ad hoc networks. We also propose a multipath routing layer which sets up multimedia transmission paths between source and destination. Transmission of video streaming with a set of quality-of-service (QoS) parameters in terms of bandwidth, delay, and expiration time is applied with on-demand multicast routing protocol and weight-based solution. To further validate the viability and performance advantages of our scheme, simulation result was provided.

Keywords: QoS, Multicast, Video streaming, Ad Hoc.

1. Introduction

A Mobile Ad Hoc Network (MANET) is a collection of mobile devices that wish to communication, and each device is required to act as a router to relay packets on behalf of others nodes in order to deliver data across the wireless network without a pre-installed infrastructure. A significant feature of ad hoc networks is that rapid changes in network topology and link characteristics are introduced due to node mobility, bandwidth and power control constrains. This kind of networks can be deployed freely and instantly in an environment where infrastructure is either not available or not trusted [1,2]. Ad hoc networks pose a great challenge to video communication with the advances in low bit-rate video coding technology and the increase both in the bandwidth of wireless channels and in the computing power of mobile nodes. [4,5].

The goal for developing multicast is that there are applications that need to send a packet from a multicast source to a group of nodes (multicast receivers). There are two types of configurations for an ad hoc wireless multicast [8]. One is tree-based protocol and another is mesh-based protocol. The On-Demand Multicast Routing Protocol (ODMRP) [6] as a kind of mesh-based protocol implies multiple routing paths between two communication nodes. With multiple routing paths, a complex video stream can be divided into multiple sub-streams and each sub-stream is sent on one of the routing paths. In this paper, a novel multicast protocol for adapted multi-stream video coding is proposed due to the error-prone nature of wireless networks and the susceptibility of compressed video stream to transmission errors. And a multistream-based video transport scheme with weight criteria is provided for multimedia OoS transmission.

The remainder of the paper is organized as follows. In Section 2, we present the system architecture for video transporting. Next, a multistream-based video transport scheme with weight values as path quality information is discussed in Section 3. Section 4 presents the performance study and our experimental results with NS2 simulation. In Section 5 we conclude our paper.

2. Video communication and system architecture

The video communication system is shown in Figure 1. The camera of a mobile device continuously captures a scene. The digitized video is passed to a multi-stream video encoder. Based on path quality information, the multi-stream video encoder generates N sub-streams. A function is often part of the encoder is the bit-rate control, which is used to regulate compression to adapt the bandwidth constrain to the channel in the ad hoc network. Typically, a common reconstruction and re-sequence is that of the access capacity to the wireless network. A multipath routing layer sets up *P* paths between the source and destination, each with a set of quality-of-service parameters which give the information for routing protocol in ad hoc networks. Segments that are formed at the application level of video streaming typically constitute the loss unit. Further segmentation occurs at the network level, where the video data is segmented into IP packets, which is the loss unit for the network. The receiver side performs functions that are reciprocal to the sending functions and may compensate for errors during the communication. Packets arriving from all the paths are put into a re-sequencing module where they are reassembled into N sub-streams for the multi-stream video decoder.

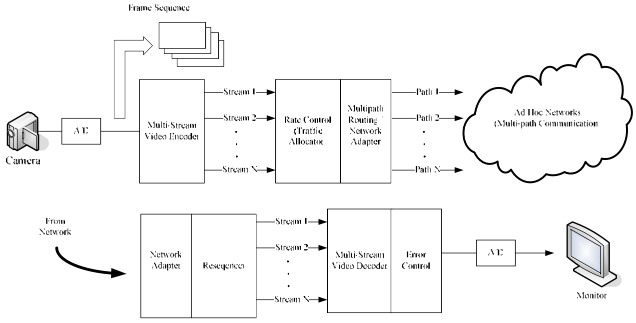

Figure 1: A system architecture of the required techniques using multi-stream video coding and multi-path transport.

3. Video Transport of Multiple Multimedia Servers

The essence of ad hoc networks is node mobility, bandwidth and power control constraints, limiting multimedia streams to difficult transmission. In this paper, we propose multimedia servers adopting layered coding technique and ODMRP scheme make multicast services for clients in instable ad hoc networks. The establishment of multiple paths in ad hoc networks supplies multimedia transport on redundant ways to solve a sudden break of wireless links. We also consider few multimedia servers could service at the same time for clients, which reduces resource consumption of multimedia servers.

3.1. Routing Protocol with Mobility Prediction

The ODMPR protocol with mobility prediction proposed by [3] provides multiple routing paths with forwarding group nodes and forecasts the reconstruction of multi-paths at a suitable time. The time of route disconnection between two nodes is computed loosely with their GPRS location, distances, and mobility information. Based on the predictable expiration time, a source node floods a JOINREQUEST packet only when needed instead of the periodic flooding. The expiration time of a routing path stands on the minimal time of staying connection between any two nodes on the path, calculated with the mathematical equation. Therefore, JOINREQUEST and JOINTABLE packets on ODMRP append extra fields, the so-called Minimum Link Expiration time (MIN_LET) and Route Expiration Time (RET), to record the expiration information of routing paths.

We claim the transmission of high priority data is necessary on high stable and low delay routing path, and the low priority data is transmitted on a second path to clients, which utilizes efficient yet efficient bandwidth of multiple paths. Few multimedia servers provided with same video context service simultaneously clients with the cooperation of forwarding group nodes.

3.2. Multi-Servers transport with Layered Coding

A query phase and a reply phase comprise our routing paths to construct multi-paths with mobility prediction and forwarding groups. Figure 2 illustrates how multimedia sources (S1, S2) establish multicasts routes and provide multimedia streams to receivers (R1, R2, R3). Other nodes (A, B, C) are forwarding group members relaying multimedia streams. First, we describe the establishment of multicast routs with mobility prediction. Second, multimedia service provided from multi-servers to clients is introduced, cooperating with particular forwarding group members, so-called connector and coordinator.

By ODMRP, S1 sends a JOINREQUEST to its neighbors, appending its location, speed, direction, and max LET information. A next-hop node receiving a non-duplicates JOINREQUEST records the upstream node address, predicts the expiration time of the link between itself and the previous node, compares with the value of MIN_LET field, and flood its' JOINREQUEST after inserting the minimal LET value and overwriting the location, speed, and direction information. Finally, a client accepts the JOINREQUEST and evaluates the min LET value on the path from S1 to itself – R1 for example. R1 inserts or updates a multimedia server entry in its member table, then broadcasts a JOINTABLE involving a RET value. The RET is equal to the minimum among MIN_LET values on a routing path. During a client reply, when a node accepts a JOINTABLE, it inspects if the next node address of one of entries fits its own address. If matches, the node is to be a member of forwarding group with a FG_FLAG setting.

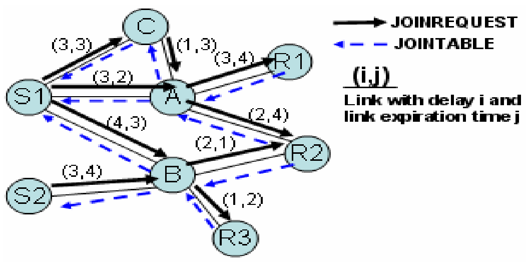

Figure 2: The routing path construction with mobility prediction

S1 node has two available routes to R1, a path of (S1-A-R1) and another path of (S1-C-A-R1). The Route1 and Route2 got the delay time of six (3+3=6) and seven (3+1+3=7). The expiration time of Route1 is min (2, 4) and another is min(3,3,4). Upon comparing two routes, the Route2 is more stable and delay than Route1. After generating multiple streams by layered video coding, S1 chooses the best path to transmit BASIC layered streams and the second path to transmit ENHANCEMENT layered streams.

We propose a weight criterion for video transporting to choose the path with the maximal weight for transmitting high priority streams. Severs must give a pair threshold values (max_DELAY, min_RET) consisting of maximal delay and minimal expiration time for its essential transmission quality. A routing path between server and client should be ignored, if exceeding the max_DELAY or lowering the min_RET values. The formula calculating the combined weight W_{path} for each passed path is equal to W_{path} = w1*(RET-min_RET)+w2*(DELAY-max_DELAY). Weighing factors, w1 and w2, are positive numbers and changed flexibly to help a multimedia server apply its transmission on heterogeneous ad hoc network.

Table 1: Route Selection Example

S1 -> R1	Route1	Route2
PATH	S1-A-R1	S1-C-A-R1
DELAY	6	7
RET	2	3

S1 -> connector	Route1	Route2
PATH	S1-A	S1-C-A
DELAY	3	4
RET	2	3

The transmission paths with different priority steams are reelected since the existence of connectors between servers and clients. We define a connector is to connect two or more clients. The weight of paths is re-calculated from the server to the connector. In Figure 2, A is a connector from S1 to R1 and R2. By weight computing, the S1 chooses the best path of S1→A for BASIC streaming and the second path for ENHANCEMENT streaming.

Servers with same context enable to service synchronously clients through coordinators. A coordinator connects two or more multimedia servers and allots transmission of layered streams to multiple servers. It adjudges that one of multimedia servers owning the most suitable path transmits high priority streams and another server transmits low priority streams. In Figure 2, B is the coordinator to choose S2 to transmit BASIC streams. S1 is assigned to transmit ENHANCEMENT streams. By the way, it is also a connector for R1 and R2.

4. Performance study and simulation results

Our simulation modeled a network of 60 mobile nodes in a 1200mx1200m area. Each node has a speed of 10m/s, radio propagation range is 250m, and bandwidth is 2 Mbps. We used NS2 to simulate VBR sources and the network topology. Figure 3 shows the traces of routes maintained by video source during a simulation. The number of forward group nodes is denoted by the total number of nodes the route traverses, including the source and destination. For most of the simulation period, the number of forward group nodes is 4 or 5.

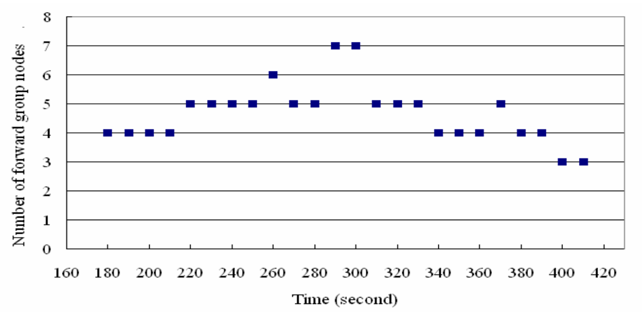

Figure 3: the traces of number of forward group nodes

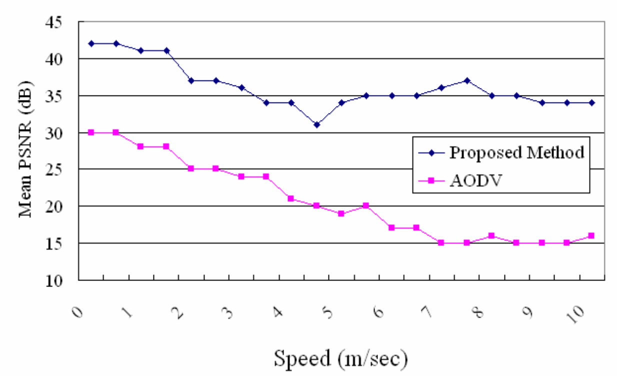

Figure 4 : the average peak signal-to-noise ratio (PSNR)

For each simulation run in Figure 4, we recorded the average peak signal-to-noise ratio (PSNR) in dB of the component of decoded video and the average aggregate transmission rate (Kbps) that is available on the forward group channels of the routing paths for our method and AODV protocol. During the initial increase in mobility, routes break down more easily, which leads to an increase in the mean packet loss rate and a drop in the PSNR. The turning point is at 4.5m/s, and is determined by the node density in the region and the transmission range.

5. Conclusions

In this paper, we propose the specific implementation, layered coding with multi-path routing, for streaming packetized video content over the ad hoc networks. Our multipath routing layer sets up paths between the source and destination, each with weight criteria to judging the QoS transmission in terms of routing path bandwidth, delay, and expiration time to perform an efficient multimedia communication in ad hoc networks.

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