Multi - point Cooperative Multicast Video Design and Research

Wang Tao
Wuxi Environmental Science and Engineering Research Center,
School of Internet of Things Engineering,
Wuxi City College Of Vocational Technology,
Wuxi, Jiangsu
Wang_830@163.com

Abstract—Internet era in the context of increasing popularity of mobile terminals, network video browsing has become an indispensable feature of wireless terminals. However, in order to improve the reliability of video multicast, this paper increases the gain system from the overlapping access points in the coverage area, because of the low reliability of the inter-link interference between the wireless networks. Improve the fairness of the system, and propose and design a multi-point broadcast scheme based on network coding and multi-access point collaboration. The program will first divide each video segment into the same segment and divide the access point completely and not completely interfere with the two models. The video multicast problem when the transmission range between the access points is overlapped is modeled as Linear programming optimization problem, a two-stage heuristic algorithm is designed to solve the problem. By using multiple access points to get the gain of space and time diversity, the reliability of data transmission is improved, and data is transmitted in parallel by allowing access points that interfere with , To improve the system utility. Finally, the simulation experiment is used to verify the validity of the number of packets to be decoded, the total amount of packets received and the fairness.

Keywords-Video multicast; network coding; multi-point access collaboration; Linear programming optimization, heuristic algorithm; fairness

I. INTRODUCTION

With the rapid development of mobile devices such as tablets and smart phones, the popularity of mobile devices continues to increase. Watching video via the Internet is becoming an important feature of these devices. Recent studies have shown that [1], the main data flow on the Internet is the multimedia data stream. For example, YouTube and Netflix traffic in the overall share of the Internet traffic reached 20-30%. Because of the low link reliability of wireless network, it will have a great impact on the video quality received by the user, so it is significant to study the reliability of video data stream transmission [2].

At present, the most common method of video data transmission reliability is the message feedback mechanism, the automatic repeat request (Automatic Repeat reQuest, ARQ) is the most commonly used [3]. In order to reduce the overhead of ARQ message, the [4-6] method is proposed by combining Hybrid-ARQ with erasure code and ARQ. But in general, all of the methods using feedback packets can lead to additional costs and increase the energy consumption of nodes. In addition, the feedback mechanism is not feasible for some applications. For example, in multicast applications, the cost of deploying a feedback mechanism is high, because it is a waste of time to transmit a feedback message to each receiver. The use of random linear network coding [7] (Random Linear Network Coding, RLNC) and fountain code [8], such as network coding without feedback packets which can improve the reliability of data transmission. For example, the RLNC method uses the random coefficient to fuse the original message, the destination node receives a sufficient number of encoded messages and decodes the encoded messages. Thus, the source node does not need to know what the destination node is missing.

II. SYSTEM MODEL

A. Setting and objectives

It is assumed that the video server in the research environment sends the video stream to an m adjacent WiFi access point, and then transmits to the wireless users such as smart phone, tablet and desktop. Suppose the access point is connected to the video server via a wired link. The reliability of these wired links is high, so it will not become the bottleneck of data transmission. Thus, we can further assume that the video message at the access point can be transmitted to the user at any time. In this paper, the system model and the labeling method are shown in Figure 1, respectively.

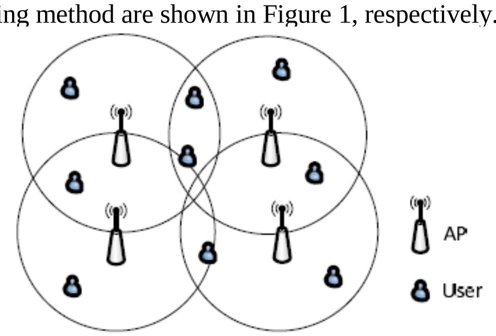

Figure 1. System model

When the data is transmitted by wireless link, some of the destination node may lose the transmitted video message. We show $\grave{o}_{ij}$ the probability of deletion of the link between the access points i to j and the access points to J. Each access point has a circular coverage area. In addition, the overlap region of WiFi access points may overlap with each other. As a result, these WiFi devices will interfere with each other, and if the access point transmits the message at the same time, then the user node located in the overlap region will not be able to receive the message correctly. The purpose of this paper is to improve the fairness of the video multicast to the user by properly scheduling access points. Specifically, we want to maximize the expected value of the number of messages received by the user.

B. *Interference model [5] [6]*

In this paper, we consider two kinds of interference models: complete interference and incomplete interference between access po(1) complete interference graph: in this model, each access point interferes with all other access points. In other words, the interference graph is a complete graph. In order to avoid interference between the access points when the interference graph is complete, the access point can not be scheduled at the same time.

III. SCHEME

A. *Video coding*

improve the reliability of data transmission in the absence of feedback packets, the RLNC mechanism is adopted in this paper. First, each video is divided into the same size packets. Then, we use RLNC to encode the packets of each segment. Figure 2 (a) in the video is divided into multiple message segments, figure 2 (b) gives the original video encoding message. For simplicity, we do not show a factor in the graph. For example, the graphic $p_1+p_2+p_3+p_4$ is expressed $\alpha_1 p_1+\alpha_2 p_2+\alpha_3 p_3+\alpha_4 p_4$ as α_1 to α_4 a random coefficient. Therefore, the encoded messages of each segment in Figure 2 are not the same. The coding process is carried out on the video server, and the coded message is transmitted to the access point through a high reliability wired link.

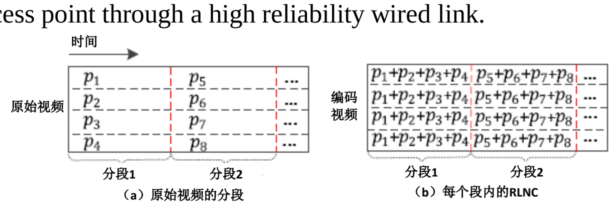

Figure 2. Network coding mechanism

B. *Access point scheduling algorithm under complete interference graph [7] [8] [9]*

The goal of this paper is to achieve fair scheduling by maximizing the expected value of the number of messages received by the user. In other words, we want to maximize the number of messages received at each access point. As shown in the following section, the problem of solving the above problem can be solved in polynomial time when the data transmission range of the access point is not overlapped. Conversely, if the scheduling of a WiFi access point overlaps, I It may exist the number of parallel transmissions. Therefore, the time complexity of this scheduling is very large. To this point, we propose a two-phase scheduling algorithm for access points. In the first stage, we use linear programming optimization theory to determine the optimal scheduling scheme when the access point does not overlap. Then in the second stage, we use the results of the first phase as the initial solution, and then allow the interference of the access points to a certain degree of parallel transmission, which aims at improving the overall utility. In the second stage, we use linear programming theory to determine the parallel transmission scheme which can improve the overall utility.

1) phase 1 (no overlapping scheduling scheme): we obtain the basic solution of the problem at this stage, and does not allow access to parallel transmission. The optimal scheduling scheme is obtained by solving the following linear programming problem without transmission overlapping:

$$\max \quad y \tag{1}$$

$$s.t \quad \sum_{j \in B} x_j \le 1 \tag{2}$$

$$r_i = \sum_{j \in C(i)} b \cdot x_j \left(1-\varepsilon_{ji}\right), \forall i \in U \tag{3}$$

$$y \le r_i, \forall i \in U \tag{4}$$

We show that the access point can be represented as a time proportional to the data transmission. The main constraint of this scheduling is that the access point can not transmit data at the same time. Thus, the sum of the time allocated to the access point shall not exceed 1, as shown in the constraint (2). We represents the transmission bandwidth of the access point as B. Therefore, if the user is located within the transmission range of the access point, the number of messages received by the user from the access point is $b \cdot x_j\left(1-ò_{ji}\right)$. . Since we do not allow parallel transmission, the total expected value of a message received by a user is equal to the sum of the expected value of the number of messages received by the user from the point of access to the user. The constraint (3) calculates the total expected value of the message received by each user. Constraint (4) is fairness constraint which represents the total expected value of the message received by the user. In order to achieve fair scheduling, the number of messages received by the user should be close to the expected value. Therefore, we do not maximize the expected value of the total amount received by users , but maximize the minimum expected value. To this point

C. *Access point scheduling algorithm under the condition of incomplete interference graph [9]*

There is no interference between nodes in the interference graph. According to graph theory, we need to find the maximum independent set at the same time. However, the determination of the maximum independent set is a NP problem [11]. So we will search for maximal independent sets instead of maximal independent sets. A maximal independent set is an independent set that is no longer an independent set when the other nodes are added to the collection. For an $|S|$ independent set of overlapping scheduling, there may be a $2^{|S|}-1$ parallel transmission. Thus, the time complexity of the scheduling problem is very similar to that of the complete interference graph. In this paper, a 3 stage algorithm is used to schedule the access points under the condition of incomplete interference graph, and the time complexity is low.

1) phase 1 (finding the maximal independent set): we first construct the interference graph of the access point. We use the nodes in the interference graph to represent each access point. If the node of a two node is isturbed, the two nodes are connected. In order to avoid interference between access points, we can only allow some nodes that do not interfere with the simultaneous transmission of data. A common scheduling method is to use large independent sets that can be determined in polynomial time, rather than the largest independent set.

Detection algorithm of Maximum independent Set is shown in algorithm 2. In this algorithm, the B UN marked access points are put into the set A. In order to determine the independent set, the algorithm searches for the smallest node in each iteration, and puts it into an independent set. Then, the algorithm removes the adjacent nodes j from the set and marks the nodes. Repeat the process until the collection is empty. After an independent set is determined, all the nodes in the independent set are marked in the collection. Then, the non tagged nodes are added to the collection, and then run the set of nodes that have never been marked by the algorithm to look for other independent sets. Repeat this process until al.

Algorithm 2: maximum independent set detection
1：input：B , $N(j)\forall j \in B$;
2：$S=\{\ \}$，$A=B$;
3：Remove the label of the node
4：while B （There are not marked nodes in） do
5： while A Not empty do
6： $I=\{\ \}$
7： j Finding the lowest node ;
8：   Mark the right node;
9： $I=I\cap j; A=A/N(j)$;
10： $S=S\cup I$;
11： Put the UN marked nodes in the

IV. EXPERIMENTAL EVALUATION[10]

In this section, through the performance proposed by a comprehensive simulation, it can evaluate the performance of the scheme when receiving messages, the number of decoding messages and the fairness.

A. *Simulation settings*

We deploy the simulator in the MATLAB environment and evaluate the performance of the various algorithms under 1000 network topologies with random link delivery rates. The simulation results presented in this paper are the average of the 50 simulation results. We assume that the wireless link delivery rate is independent of each other. The nodes are randomly deployed on a square area of 20 x 20 meters, and the rate of the link between them is calculated according to the Euclidean distance between the access point and the user. For the two nodes with interval distance, the Rayleigh fading model [12] is used to calculate the probability of successful delivery:

$$P=\int_{T^*}^{\infty}\frac{2x}{\sigma^2}e^{-\frac{x^2}{\sigma^2}}dx \tag{5}$$

$$\sigma^2 @ \frac{1}{(4\pi)^2 L^{\alpha}} \tag{6}$$

Among them, the link loss index, the decoding SNR threshold.

B. *Simulation results [4]*

We first evaluate the performance of the method of complete interference graph and then demonstrate the evaluating results under the condition of incomplete interference graph. Finally We compare the scheme with the present more typical video multicast scheme.

(1) Completely interference graph: we will set the number of nodes as 10, and the number of access points will change from 3 to 7, which evaluate the impact of access point of the user node. The results is shown in Figure 3 (a). When we increase the number of access points, the total amount of received messages has increased. This is because when we increase the number of access points, each user will be covered by more access points. Thus, each user has at least one high quality wireless channel with a probability of rise. As a result, the number of messages delivered to the user increases successfully.

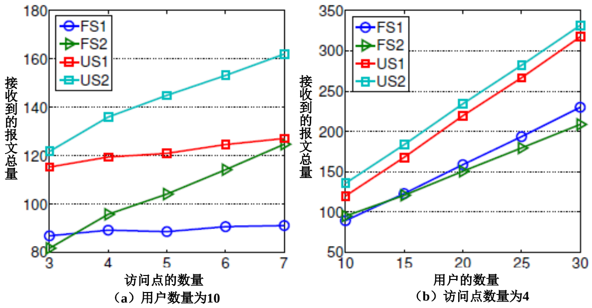

Figure 3. The total amount of messages received by the user in the complete interference graph

From Fig. 1 (a), the total amount of received messages in the unfair method is the largest. This is because we set the objective function to maximize the amount of messages received at the time of optimization. In the second phase of the fair scheduling method, we allow some nodes to transmit data in parallel, thus increasing the number of messages received by users. Fig. 1 (a) proves the validity of the parallel access point. When there are 3 access points, the number of received messages of FS2 is less than FS1. This is because many users are more likely to be covered by a single access point. Thus, phase 2 cannot increase the number of messages received. On the other hand, FS2 aims to increase fairness.

We set the number of access points as 4, and the number of users ranges from 10 to 30, which evaluate whether the number of users have impact on the total amount of received messages, and the results are shown in Figure 3 (b). As we expect, the total amount of the received message increases with the increasing of the number of users.

V. Concluding Remarks

The main application of wireless devices such as smart phones and tablet is to watch video through the Internet. In this paper, we use multiple access point cooperation and network coding mechanism to transmit the video data stream to the client node. After a plurality of access points, the client node can obtain spatial and temporal diversity, and then receive more messages. In addition, after using the network coding mechanism, all transmission messages are of equal importance. As a result, reliable transmission of data can be achieved even without feedback mechanism. Compared with previous video multicast schemes that do not allow access point to be transmitted in parallel, this method supports the parallel transmission of data with interference access points, which effectively improves the performance of the system. In the next step, we will consider the impact of video encoding hierarchical structure on the performance of the system, through searching matched available resources to video encoding hierarchical structure of available used in user channel conditions, modulation encoding and system to optimize the performance of the system, which proposed for wide band wireless network layered video multicast transmission mechanism.

Acknowledgment

The author are grateful for financial support from the funding project :

(1) outstanding young teachers and principals outside the training project Department of Education , Jiangsu Province

(2) Education Science Planning Leading Group Office ,Jiangsu Province (grant no.D/2016/03/62)

References

[1] Han, Z. Guo, and D. Zhang. Multispectral palmprint recognition using wavelet-based image fusion[C]. In ICSP, 2010:2074–2077.

[2] Y. Hao, Z. Sun, T. Tan, and C. Ren. Multispectral palm image fusion for accurate contact-free palmprint recognition[C]. In Proc. ICIP, 2008: 281–284.

[3] Kisku, P. Gupta, J. Sing, and C. Hwang. Multispectral palm image fusion for person authentication using ant colony optimization[C]. In IEEE Workshop on Emerging Techniques and Challenges for Hand-Based Biometrics, 2010:1–7.

[4] Lin P, Bi J, Wolff S, et al. A west-east bridge based SDN inter-domain testbed[J]. IEEE Communications Magazine, 2015, 53(2): 190-197.

[5] Yu K, Li F Y, Wu X, et al. The heterogeneity of inter - domain Internet application flows: entropic analysis and flow graph modelling[J]. IEEE Transactions on Emerging Telecommunications Technologies, 2015, 26(5): 760-771.

[6] Dong M, Ota K, Liu A, et al. Joint optimization of lifetime and transport delay under reliability constraint wireless sensor networks[J]. IEEE Transactions on Parallel and Distributed Systems, 2016, 27(1): 225-236.

[7] Larsson P, Rasmussen L K, Skoglund M. Throughput Analysis of Hybrid-ARQ—A Matrix Exponential Distribution Approach[J]. IEEE Transactions on Communications, 2016, 64(1): 416-428

[8] Wang Q, Jing Y. Closed-Form Average SNR and Ergodic Capacity Approximations for Best Relay Selection[J]. IEEE Transactions on Vehicular Technology, 2016, 65(4): 2827-2833.

[9] Bai C, Leeson M, Higgins M D, et al. Throughput and energy efficiency - based packet size optimisation of ARQ protocols in bacterial quorum communications[J]. IEEE Transactions on Emerging Telecommunications Technologies, 2016, 27(8): 1128-1143.

[10] Li Jiao, Shang Tao, and. Secure quantum repeater network coding scheme based on identity authentication [J]. Journal of electronics, 2016, 44(3): 560-564.

[11] Niu Fanglin, Li Baoming, Chen Fuliang, et al. An improved design of fountain codes based on partial information [J]. 2016, 44(2): 295-300.

[12] Choi M, Sun W, Koo J, et al. Reliable video multicast over Wi-Fi networks with coordinated multiple APs[C]//IEEE INFOCOM 2014-IEEE Conference on Computer Communications. IEEE, 2014: 424-432.

[13] Tassi A, Chatzigeorgiou I, Lucani D E. Analysis and optimization of sparse random linear network coding for reliable multicast services[J]. IEEE Transactions on Communications, 2016, 64(1): 285-299.

[14] Tang Qiang, Xie Mingzhong, Luo Yuansheng, et al. An algorithm for constructing minimal connected dominating set based on two hop independent neighbor covering [J]. mini computer system 2016, 37(6): 1245-1249.

[15] Khreishah A, Khalil I, Wu J. Universal Network Coding-based Opportunistic Routing for Unicast[J]. IEEE Transactions on Parallel and Distributed Systems,2015,26(6):1765-1774.