

# A NEW RELIABLE MULTICAST SCHEME FOR MULTIMEDIA APPLICATIONS IN WIRELESS ENVIRONMENT

Wang Chaohui<sup>1</sup>, Li Yuhong<sup>1</sup>, Han Li<sup>2</sup>, Ma Jian<sup>2</sup>

<sup>1</sup>State Key Laboratory of Networking and Switching Technology,

<sup>1</sup>Beijing University of Posts and Telecommunications, Beijing

<sup>2</sup>Nokia Research Center, Beijing

wchaohui@gmail.com, hoyli@bupt.edu.cn, jian.j.ma@nokia.com

## Abstract

With the constant development of multimedia technologies and mobile devices, the demand of transmitting multimedia streams to mobile devices will be one of the major applications in wireless networks. However, IEEE 802.11 does not support reliable multicast due to its inability to exchange ACKs with multiple recipients and the influence of signal interference, congestion and hidden terminal problems. It is not suitable for the real-time multimedia transmission in this environment. In this paper, we propose a new reliable multicast scheme to solve the above problems by using a three-layer scheme. Our simulation results show that the performance of the wireless network with this proposed reliable scheme is much better than the original 802.11 protocol. The loss rate of the packets transmitted in this reliable 802.11 environment decreased a lot and the throughput of this reliable wireless environment performed constantly well compared with the original 802.11 protocol for mobile nodes.

**Keywords:** multimedia; multicast; reliable; wlan

## 1 Introduction

With the constant development of multimedia technologies and mobile devices, the demand of transmitting multimedia streams to mobile devices will be one of the major applications in wireless networks. With such a trend, IEEE 802.11 has been widely used as a wireless transmission medium between the media source senders and receivers. The popular IEEE 802.11 wireless LAN standard [1] deals with collisions in its Distributed Coordination Function (DCF) and it uses collision avoidance along with RTS/CTS/ACK control frames to transmit unicast packets in order to combat hidden and exposed terminals and high bit error rates.

For multicast packets, no RTS/CTS/ACK control frames are used. Therefore, multicast packets are

sent blindly without consideration of hidden and exposed terminals and wireless channel noise. This leads a high packets loss rate and damage rate especially in the real-time multimedia services.

In this paper, we propose a new reliable multicast scheme to solve the above problems by using a three-layer scheme which is consisted of the detection layer, the feedback layer and the decision layer. The detection layer is used to detect the channel condition of the transmission medium in the multicast wireless environment by sending a RTS frame in the sender side. The feedback layer which depends on a control frame is used to feedback the channel condition captured by the detection layer to the sender side by returning a modified CTS frame in the receiver side. And in the decision layer three methods are defined to increase the reliability of the wireless environment by decreasing the loss rate in the multicast transmission. The sender side decides which method should be used by comparing the feedback information and the predefined thresholds. With this three-layer scheme the loss rate in the multicast wireless multimedia transmission decreases very much.

The rest of this paper is organized as follows. Section 2 provides a review of the related work. In section 3 we introduce our three-layer scheme to reduce the loss rate in the wireless transmission. Section 4 describes the simulation results by using our three-layer scheme. And finally we summarize the conclusions of this paper.

## 2 Related Work

Available approaches to handle reliable multicast transmission in wireless environments have been a research topic for many years. Adaptive FEC Reliable Multicast MAC Protocol for WLAN [2] propose an adaptive H-ARQ MAC layer protocol where different levels of FEC encodings are used depending on the channel conditions which are notified in the receiver side by using a modified

RTS/CTS exchange protocol. In [3] it proposes a scheme by using a virtual ACK bitmaps which constructed in the sender side and filled in the receiver side, the sender checks the filled-in bitmap to determine if transmission is needed for the packet. A TWO-STAGE FEC SCHEME in [4] proposed an enhanced MAC Node Cooperation to support multimedia data transmission over wireless LANs by using both header CRC and FEC to enhance the MAC/PHY layers. And in [5][6][7] three methods are proposed to improve the reliability of the wireless transmission by modifying the RTS/CTS protocol and using the Fountain codes.

These approaches are all proposed to recovery packets in particular and limited scenarios, these scenarios are little bad and are not very terrible. Thus if the channel condition of the wireless environment is terrible bad these methods could not make sense. Our new reliable multicast scheme is aimed to provide reliable multimedia services in almost any channel conditions whether it is terrible bad or not.

### **3 The three-layer scheme for the reliable multicast transmission**

As described above, for multicast packets, there are no RTS/CTS/ACK control frames which lead blindly transmission and high packets loss rates in the wireless environment.

If the sender side could know the current channel condition of the transmission medium, then transmit the multicast packets rely on this medium performance, the reliability of the multicast could be highly improved. Based on the above concept we propose this new three-layer scheme which is consisted of the detection layer, the feedback layer and the decision layer to provide reliable multicast multimedia services in wireless environment.

In the original IEEE 802.11 wireless LAN RTS/CTS exchange is proposed to solve the hidden terminal problem and as a result the collision and damage rates are highly decreased with the unicast transmission method. However, due to the feedback collision problem described earlier, this exchange sequence is not used in the IEEE802.11 multicast mode. As described in [7] and [8] the authors add RTS/CTS exchanges in the multicast transmission which can significantly improve the multicasting efficiency in wireless LANs. So in this paper, we also use RTS/CTS control frames to extend the DCF mode from the unicast case to the multicast case. By using the RTS/CTS frames transplanted from unicast to multicast, we propose a three-layer scheme to improve the multicast reliability in the wireless environment which is the core concept in

this paper and the description of this concept will be given below.

#### **3.1 The detection layer**

The main function of this layer is to detect the channel condition of the transmission medium in the wireless network. There are several methods can be used to detect the channel condition of wireless transmission medium which are described in [2][3]. In this paper, we propose a modified RTS control frame as a detector to detect the channel condition by measuring the signal strengths of the received RTS frame in the receiver sides and comparing these signal strengths with predefined thresholds.

In the original IEEE 802.11 wireless LAN if a node receives a RTS frame, it immediately sends a CTS frame as a response to the sender node. And in the multicast multimedia applications the sender multicasts the RTS frame to variable nodes which are expected to receive the multimedia packets. In this situation, the traditional CTS control frames which are used to response the RTS frame will be immediately transmitted to the sender side and this will cause highly collisions.

To solve this terrible problem we will define and modify the traditional RTS/CTS control frames to provide a security feedback between the sender node and the receiver nodes.

By using the modified RTS/CTS control frames. The channel condition of the transmission medium will be detected by measuring and comparing the signal strengths of the received RTS frame with predefined thresholds.

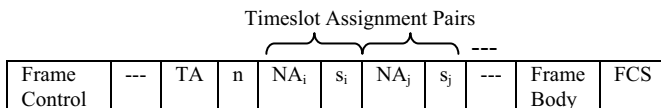
#### **3.2 The feedback layer**

The channel condition of the transmission medium has been detected by the detection layer in section 3.1, but this detected channel condition is captured in the receiver nodes. To provide a reliable service we must feedback the channel condition to the sender side. How to feedback this condition is the mainly work of the feedback layer.

This will be done by defining a new control frame which will be sent after the modified RTS control frame. The main function of this control frame is used to determine at which time slot one predefined receive node should response a modified CTS frame to the sender side. And the control frame is defined in picture 1 as follow.

In this feedback layer we define a modified CTS frame by dividing the traditional CTS time slot into  $n$  mini-slots each reflecting a unique channel condition. Then this modified CTS frame will be

multicast to the receive nodes. The receiver nodes are up to select a mini-slot according to the received control frame and send the modified CTS frame to the sender to reflect the channel condition of the receiver independently. This is done by measuring the signal strength of the received RTS frame and comparing it with some predefined thresholds. The feedback information will be transmitted to the decision layer in the sender side to determine which method should be used to provide a reliable service. receive node knows which timeslot should it uses by determining whether it comes to its timeslot to send back a modified CTS frame. The field n in the control frame is to indicate the number of timeslot assignment pairs and each pair of the timeslot is assigned to one only receiver. This efficient mechanism of disseminating timeslot is feasible because when a receiver needs to send back a modified CTS frame, it has correctly received the multicast packet including the timeslot assignment information.



TA: Transmission Address    n: number of NA/s pairs  
 NA: neighbor address        FCS: Frame Check Sequence  
 s: the s<sup>th</sup> timeslot is assigned to the NA address

Figure 1. Timeslot assignment fields in a data frame

### 3.3 The decision layer

By receiving the modified CTS frame which contains the channel condition of the wireless transmission medium, the sender node would decide to choose an available method which can provide reliable multicast multimedia services to the receiver nodes.

In this paper we propose three methods and each of them deals with different situations depending on the feedback information which is captured in the feedback layer. The structure of this decision layer is shown in figure 2 as follow.

We provide three dependently methods which depends on the channel condition of the wireless transmission medium to deal with the reliable multicast services. These three methods (multicast to unicast, single multicast and adding FEC Algorithm) are all provided in the IEEE 802.11 MAC layer. the detail description of these three methods are given below.

M2U (Multicast to Unicast): This method will be chosen if the terrible bad channel condition is detected by comparing the feedback information of

the channel condition and the predefined thresholds. The principle of this method is to maintain the application layer and the IP layer, but in the MAC layer the packets are transmitted in the form of unicast to the members of the terrible channel condition. This method could provide favorable multicast multimedia services but it occupied lots of wireless resources.

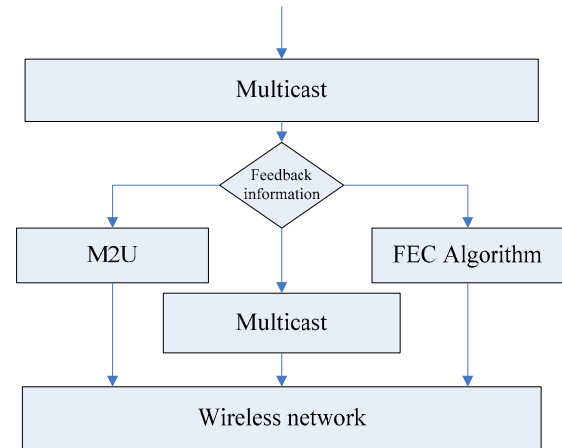


Figure 2. Approaches for reliable multicast transmission in decision layer

Multicast: this method will be chosen if good channel condition is detected by comparing the feedback information of the channel condition and the predefined thresholds. The wireless resources are enough so that the sender node does not need to worry about the packets loss in this scenario.

FEC Algorithm: after comparing the feedback information and the predefined thresholds if the channel condition is between the terrible predefinition and good predefinition we will use the RS (Reed-Solomon) codes for packet protection in the MAC layer. The RS codes are determined by the feedback information in the modified CTS frames. Due to the variations of channel conditions, the RS codes rates are different from each other. To make sure that all the packets in this scenario can be received in the receiver side we will encode the data frames with the strongest RS code rate selected from the feedback CTS frames. But a data frame might not be successfully received even after FEC encoding. Therefore, we choose the M2U method. The principal of FEC Algorithm [2] is shown in figure 3 as below.

Figure 3 gives an example where receivers are under different channel conditions. A,B and D fall under low channel conditions and require FEC to correctly receive the expected frame. But the required RS code rates are different, the sender will encode the frame based on D's request (having highest rate). Thus all receivers can successfully receive the data frame.

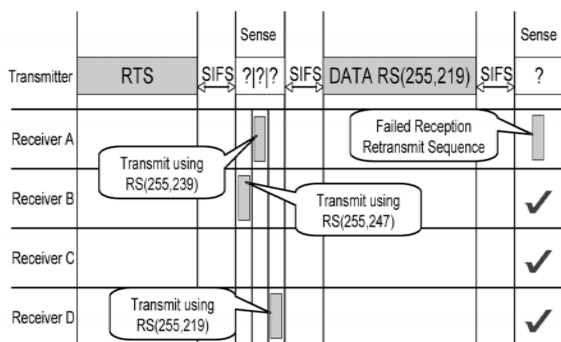


Figure 3. The principal of FEC Algorithm for reliable Multicast transmission

## 4. Simulation

The objectives of our simulations are to study the performance of the new multicast scheme under different channel conditions. We will mainly focus on measuring the loss rate of packets as well as reliable throughput. The results in this paper were generated using the NS2 network simulation from LBNL [9].

### 4.1 Simulation Scenarios

In our approach, we mainly use the following bit rates of the multimedia streams 256kbps and 512kbps to verify the performance of our new reliable multicast scheme compared with the traditional IEEE 802.11 multicast scheme. In each bit rate scenario we use are 20 nodes in the receiver side.

When the channel condition reaches a level where the error correction is between the good scenario and the terrible bad scenario we will start encoding the data by using the simplest RS coding, i.e. RS(255,247). A more powerful RS coding rate will be used when the error rate of bits further increases to make sure that the packets in the receiver side could be correct. And in the terrible bad scenario the M2U method will be choose if the errors become impossible to correct by the FEC encoding by the error bit rates further increases to ensure the performance of the multimedia in the mobile terminals.

### 4.2 Simulation results

Based on the above simulation scenarios we mainly detected the packets loss rates and the throughputs in the wireless environment.

Scenario 1: in this scenario the bit rate of the multimedia stream we choose is 256kbps, and there are 20 nodes in the receiver side. The simulation time is 20s, the length of the packets is 1000 bytes and the broadcast circle is 0.2s. The simulation

result of this scenario is as figure 4 and figure 5 shown as following.

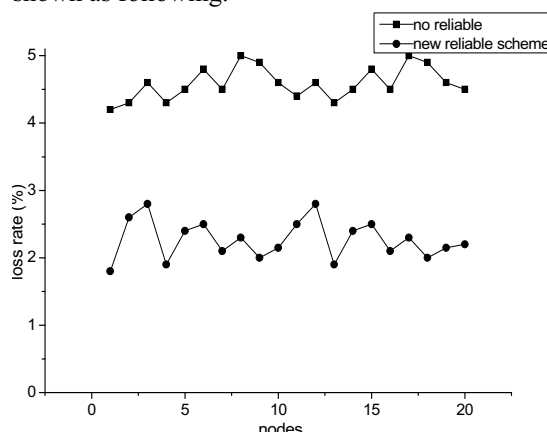


Figure 4. Loss rate in the reliable scheme and no reliable scheme (256kbps)

Scenario 2: the basic principle of this scenario is the same as scenario 1 except the bit rate of the multimedia stream which is 512kbps in this scenario. The simulation result of this scenario is as figure 6 and figure 7 shown as following.

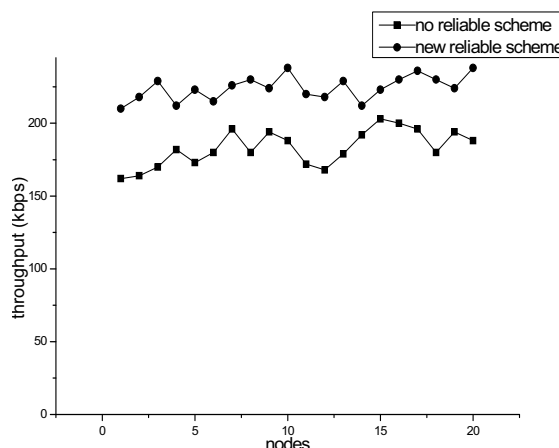


Figure 5. Throughput in the reliable scheme and no reliable scheme (256kbps)

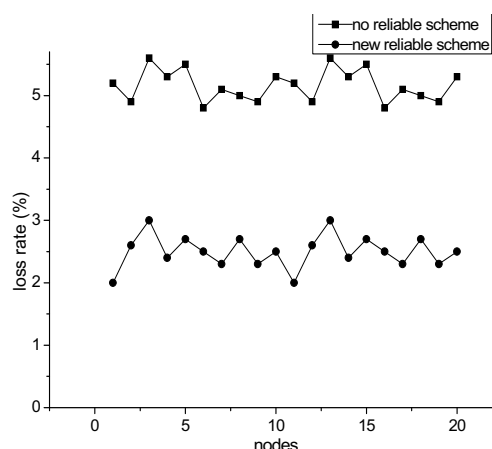


Figure 6. loss rate in the reliable scheme and no reliable scheme (512kbps)

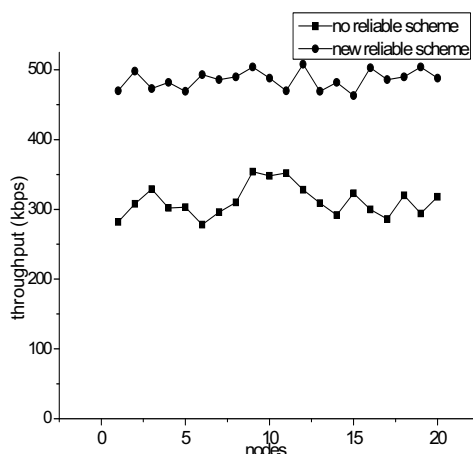


Figure 7. Throughput in the reliable scheme and no reliable scheme (512kbps)

The M2U method has highly improved the reliable multicast multimedia services in the terrible bad wireless channel conditions. But because the unicast occupied lots of limited wireless resources the performance of the wireless services decreases much more by the number of unicast nodes increasing. Although the M2U method occupies the wireless resources it is remain a very useful method to deal with terrible bad wireless channel conditions. And in the next study we will try to overcome this problem.

## 5 Conclusions

In this paper, we proposed a new reliable multicast scheme for real-time multimedia applications in wireless local area networks by using our three-layer scheme which can work fine in different wireless channel conditions.

Our simulation results show that the performance of the wireless network with this proposed reliable scheme is much better than the original 802.11 protocol. The loss rate of the packets transmitted in this reliable 802.11 environment decreased a lot and the throughput of this reliable wireless environment performed constantly well compared with the original 802.11 protocol for mobile nodes.

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