Improving the Performance of IEEE 802.11e using A Dynamic Adaptation Approach

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Abstract--- Providing Quality of Service (QoS) for real time applications in mobile Ad hoc networks is a challenging task, due to the characteristics of the wireless links and networks. These characteristics include: dynamic nature, infrastructure less architecture, and time varying unstable links and topology.

Features as: low cost, ease of deployment, increased coverage, and enhanced capacity make IEEE 802.11 distributed coordination function (DCF) more popular in wireless applications. However, DCF is unsuitable for real time applications which have strict demands on QoS. IEEE 802.11e Medium Access Control (MAC) was introduced to support QoS in Wireless Local Area Networks (WLANs).

Many researches have been proposed to enhance IEEE 802.11e such as Gentle Decrease, and SCW.

In this paper, we propose a new approach called “Dynamic Adaptive Approach for enhancement of EDCA” (DAA_EDCA). The proposed approach was inspired from the Gentle Decrease Scheme.

Keywords—Ad hoc Networks, MANET, QoS, DCF, EDCA, Gentle Decrease, SCW, DAA-EDCA.

I. INTRODUCTION

A mobile Ad hoc network consists of a collection of mobile nodes forming a dynamic autonomous network. Nodes communicate with each other over the wireless medium without the intervention of centralized access points or base stations. Due to limited transmission range of wireless network interfaces, multiple hops may be needed to exchange data. When using of a wired or an infra structured wireless network is either impractical or expensive we need to use Mobile Ad hoc networks.

Conferencing, Home Networking, Emergency Services, Sensor Fields, Military Battle Site Networks are examples of Applications, where mobile Ad hoc networks can be deployed.

Nowadays, real time applications using wireless links is getting more attention. Such kind of applications demands specific characteristics on QoS, such as throughput, delay, jitter, and error rate. [1]

IEEE 802.11 is the most deployed wireless MAC protocol, but it gives only best effort support for the applications. This means that IEEE 802.11 deals equally with all applications.

IEEE 802.11e was introduced as an extension of IEEE 802.11 to give support to applications, which have demands on QoS.

A. IEEE 802.11

IEEE 802.11 standard defines two medium access mechanisms: the Distributed Coordination Function (DCF), and the Point Coordination Function (PCF).

DCF is based on the Carrier Sense Multiple Access with Collision Avoidance (CSMA-CA) mechanism, to transmit data. The access mechanism of the PCF is contention free central polling, where the Access Point (AP) controls all transmissions.

According to DCF, a station senses the medium before a transmission of a packet. The station starts sending the packet, after sensing the medium Idle for the duration of DIFS (Distributed Interframe Space).

Otherwise, the transmission is deferred and a backoff process starts. Each station stores a variable called CW (Contention Window). A backoff timer is set to the value of the CW, initially the timer is initialized with the value of CWmin. During the backoff period, the backoff timer is decremented by one for each time slot of the idle medium. When the backoff timer reaches zero, the packet is sent out. A collision occurs when two or more stations begin to transmit at the same time.

Once an error occurs, the packet has to be retransmitted. The CW is incremented exponentially with each attempt to retransmit the packet. CW is reset to CWmin after the successful transmission of the packet. [3]

DCF has not any mechanism to differentiate different flow types.

B. IEEE 802.11e

IEEE 802.11e introduces a new coordination function called Hybrid Coordination Function (HCF). HCF combines the aspects of DCF and PCF with enhanced QoS mechanisms. The Enhanced Distributed Channel Access (EDCA) is the contention based channel access mechanism of HCF. The contention free channel access mechanism of HCF is called Haf Controlled Channel Access (HCCA).

The transmission opportunity (TXOP) was introduced by IEEE 802.11e. It is defined as the time period during which a station has the right to transmit.

EDCA introduces four Access Categories (ACs) for different types of data traffic. Service differentiation is achieved through assigning different parameters to each AC. The parameters are AIFS, maximum/minimum contention window, and TXOP.

These parameters are referred as EDCA parameters. Frames from different types are mapped into different ACs according to the QoS of their applications.
Each station has four transmission queues, one for each AC, and four Enhanced Distributed Channel Access Functions (EDCAFs). Each AC contends for the channel as the standard DCF. Each access category has its own backoff, and accordingly a different channel access probability.

EDCA parameters are not adapted according to the network conditions.

Detailed description of IEEE 802.11e can be found in [4], and [5].

Approaches as Sliding Contention Window (SCW) and Gentle Decrease are proposed to enhance the performance of 802.11e. In this paper we propose a new approach called DAA-EDCA.

The rest of the paper is organized as follows: Some approaches to enhance the performance of IEEE 802.11e are covered in Section II. Section III describes our proposed approach DAA-EDCA, followed by a performance evaluation.

The experimental results are discussed in Section IV. Finally, conclusions would be discussed in Section V.

II. RELATED WORKS

A lot of works has been done to make a better service differentiation than EDCA. Several methods make use of changing the value of the contention window, to achieve this goal.

The Adaptive EDCF (AEDCF) resets the contention window after the successful transmission of the packet based on the collision probability. The collision probability is defined as the ratio of the number of collisions experienced by the transmitted packets to the number of the sent packets during a defined interval. The approach resets the contention window to a value related to the network load. [9]

Gentle Decrease is a mechanism, which operates as EDCA, when the contention window is increased, but it reduces the contention window size to CW / 2 after c consecutive successful transmissions.

It uses a Multiplicative Increase Multiplicative Decrease (MIMD) method. [10]

Sliding contention Window (SCW) associates each AC with a Sliding Contention Window SCW[AC] defined by a lower bound and an upper bound. These bounds delimit the interval, from which the backoff value is chosen.

The CW size is adjusted dynamically, according to a parameter called the loss rate. If the loss rate of an AC is less than the half of its tolerated loss rate, then SCW increases the CW size.

The CW size is decreased for the loss rate more than the tolerated loss rate of the AC.

SCW has a different strategy to deal with best effort access category. It makes use of the instantaneous medium occupancy rate B(T) to adjust the CW of this access category.

SCW uses a Linear Increase Linear Decrease (LILD) strategy to adjust the SCW ranges. [11]

III. METHODOLOGY

EDCA uses static values for the minimum/maximum contention window for each access category. The probability of collisions increasing, due to the increasing of the network load, thus enlarging the contention window could be helpful to reduce collisions.

EDCA has not any mechanism to deal dynamically with the changing of the network load to change the contention window size of the access categories.

A. The Dynamic Adaptation Approach (DAA-EDCA)

DAA-EDCA adapts the contention window size dynamically according to the network load. It uses frames loss rate as a parameter, to change the contention window size.

The frames loss rate of an access category is defined as the ratio between the lost frames of an access category to the number of the total sent frames of this access category, during a given observation interval.

DAA-EDCA compares the frames loss rate of each access category with a corresponding threshold α(AC), which is the maximum tolerated loss rate of this access category.

If the frames loss rate of an access category is below the half value of α(AC), which means that the network is under loaded., then reduces DAA-EDCA the contention window size from CW to CW / 4.

DAA-EDCA reduces the contention window size from CW to CW / 2, when the loss rate access category is in between α(ac) / 2 and 3 * α(ac) / 4.

The contention window size is increased when α(ac) is greater than 3 * α(ac) / 4.

The contention window size is limited by the minimum and the maximum contention windows. Increasing the contention window means doubling its value.

DAA-EDCA deals differently with best effort access category. The contention window size is reduced to CW / 2 when the instantaneous network load is less than 0.75, otherwise is increased to 2 * CW.

DAA-EDCA Pseudo-code

If (AC != “Best Effort”)
{
  if ( loss rate[AC] < α[AC] / 2 )
    then
      CW = CW / 4
  else
    if ( α[AC] / 2 < loss rate[AC] < 3 * α[AC] / 4 )
      then
        CW = CW / 2
    else
      if ( loss rate[AC] > 3 * α[AC] / 4 )
        then
          CW = 2 * CW
    else
      
}
if (network load > 0.75)
then
CW = 2 * CW
else
CW = CW / 2
/

B. Simulation Setup and parameters

The approaches described above and DAA-EDCA were simulated using the Network Simulator (NS) version 2.28 [14], with the patch [13] for EDCA.

The simulation setup involves six stations randomly placed in a grid. All stations are placed in the range of each other, to alleviate the effect of routing layer.

All traffics are periodic of CBR type, with a constant packet size of 512 Bytes.

Average throughput and average delay are used as simulation metrics.

The physical and MAC layer parameters were set as in table 1.

The simulations were conducted in two scenarios, to compare the performance of DAA-EDCA with EDCA, Gentle Decrease, and SCW.

All simulations have the duration of 40 seconds with changing network load.

Each scenario was deployed three times, with three different data rates of each source, to change the network load. The data rates were of 16.38 Mbps, 32.76 Mbps, and 40.96 Mbps.

In this paper, these rates are indexed in all figures as a, b, c respectively.

In scenario I, generates each station two flows of two different access categories, one of them is a High Priority flow (HP), while the other one is of a Medium Priority flow (MP).

Each station in scenario II generates three flows of three access categories. Two of them are as in scenario I, while the third one is of best effort type (BE).

From seconds “0” to “3” the channel is empty in both scenarios.

Six HP and six MP flows are generated in scenario I from second “3” to second “18”. The channel is shared by the 12 flows from second “18” to second “25".

Network load is decreased by stopping one HP flow and one MP flow each 3 seconds after the second “25".

We investigate the presence impact of the BE flows in scenario II.

The behavior of scenario II is the same as in scenario I with the inclusion of new 6 BE flows. Each station generates three flows of different access categories. The starting and ending timing of the HP, and MP is as in scenario I. Each station generates one BE flow type from second “3” to second “18”. The channel remains loaded by the 18 flows from second “18” to second “25".

The network load is decreased by stopping one HP flow, one MP flow, and one BE flow each 3 seconds.

IV. EXPERIMENTAL RESULTS

Figures 1, 2, 3, and 4 depict the simulation results as in scenario I.

Figure 1 shows the average throughput of each access category achieved by the different approaches as in scenario I. It is to see, that both Gentle Decrease and DAA-EDCA show the best performance for HP flows. The performance of DAA-EDCA is the best for MP flows.

Figure 2 compares the overall aggregate throughput achieved by the different approaches as in scenario I. We can see that DAA-EDCA performs as the best approach in Figure 2.

From figure 3 we can see, that the average delay of the four approaches for HP flows is closed to each other. SCW shows a better average delay in the very high loaded case for HP flows.

SCW and DAA-EDCA show a better average delay than EDCA and Gentle Decrease for MP flows as in figure 4.
Figures 5, 6, 7, and 8 show scenario II simulation results. Figure 5 shows that Gentle Decrease has a better average throughput than the other approaches for HP flows. DAA-EDCA performs better than the other approaches for MP flows.

Figure 6 compares the overall aggregate throughput by the four approaches. It is clear to see that, DAA-EDCA shows the best performance.

The four approaches have nearly the similar average delay for HP flows as in figure 7.

DAA-EDCA shows the best average delay comparing with the other approaches for MP flows as in figure 8.

DAA-EDCA shows in both scenarios the best aggregate throughput, which means that it utilizes the channel better than the other approaches. The best performance of DAA-EDCA for MP flows is not affected by the network high load conditions.

V. CONCLUSIONS

In this paper, we proposed the new channel access mechanism DAA-EDCA.

DAA-EDCA can be seen as an EDCA extension for highly loaded networks. From simulation results, we concluded that DAA-EDCA best results for the channel overall achieved throughput. It is evident to see, that DAA-EDCA gives best results for MP flows.

Using of different access categories does not degrade the performance of DAA-EDCA.

The newly proposed mechanism is suited for applications, where the network is heavily loaded with different access categories.

Applications for MP flows, which need QoS support is best served by DAA-EDCA.

Further work will deal with the effect of DAA-EDCA in the routing layer.

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REFERENCES


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