Protection and Guarantee for Voice and Video Traffic in IEEE 802.11e Wireless LANs

INFOCOM 2004

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Outline

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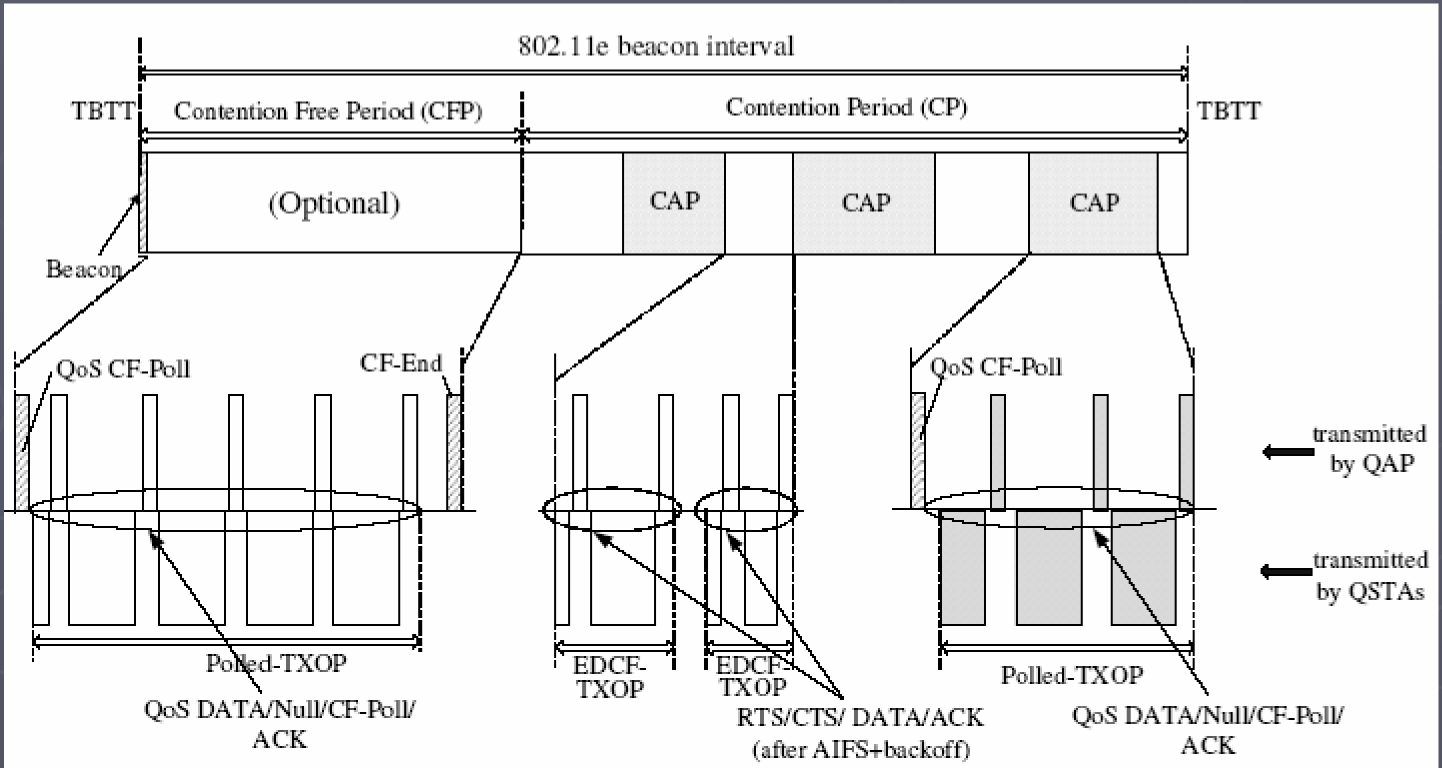
Introduction

- The IEEE 802.11e MAC employs a channel access function, called Hybrid Coordination Function (HCF) . It includes
  - contention-based channel access mechanism (EDCF)
  - centrally-controlled channel access mechanism
- The EDCF provides a priority scheme by differentiating the inter-frame space, the initial and the maximum contention window sizes.
- Without a good admission control mechanism and a good protection mechanism, the existing multimedia traffic cannot be protected and QoS requirements cannot be met.

802.11e HCF beacon interval

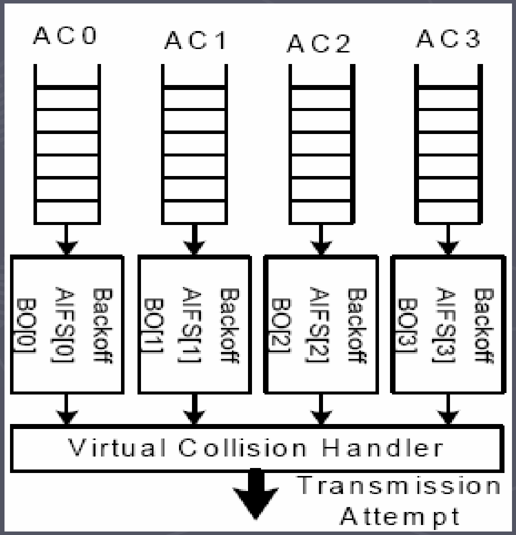


Introduction

- In this paper, we propose a *two-level* protection and guarantee mechanism for voice and video traffic.
- First level
  - Distributed admission control
  - Tried and known
  - Early protection
- Second level
  - Dynamically control EDCF channel access parameters

Related work

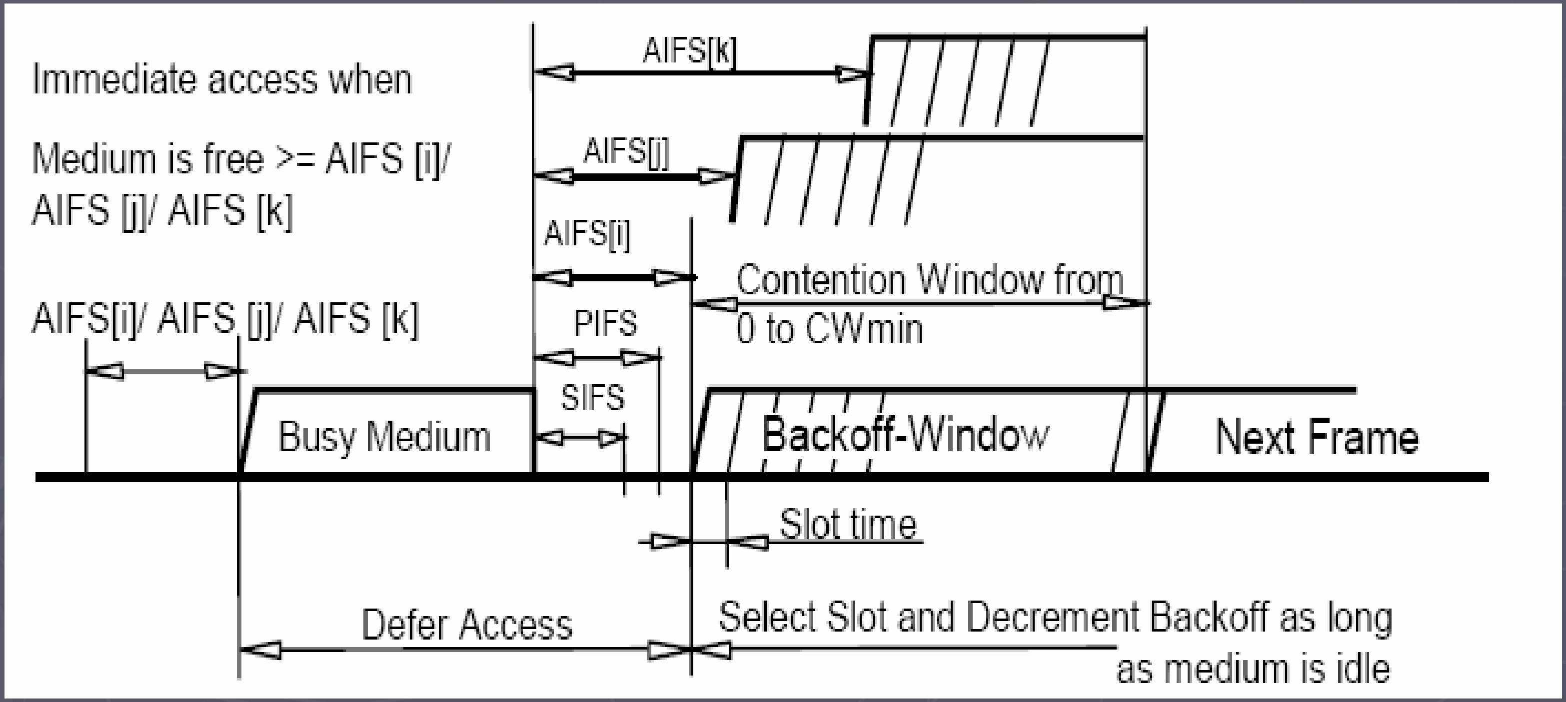
- Enhanced Distributed Coordination Function (EDCF)
  - Transmission opportunity (TXOP) is a time period that a station can transmit frames.
  - Four Access Categories (ACs) are virtual DCFs.
  - The EDCF supports eight different priorities, which are mapped into four ACs



PRIORITY TO ACCESS CATEGORY MAPPING

PRIORITY	AC	DESIGNATION
1	0	BEST EFFORT
2	0	BEST EFFORT
0	0	BEST EFFORT
3	1	VIDEO PROBE
4	2	VIDEO
5	2	VIDEO
6	3	VOICE
7	3	VOICE

EDCF timing diagram

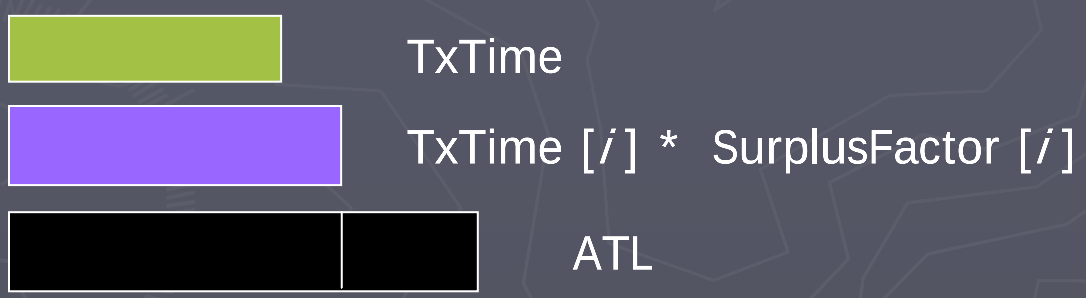


The first-level protection and guarantee

- To protect and guarantee the existing voice and video flows from the new and other existing voice and video flows.
- Distributed Admission Control for EDCF (DAC)
- Two additional enhancements for the admission control algorithm：
  - Enhancement with Required Throughputs and/or Delays (ETD)
  - Enhancement with a Non-Zero Budget Value (ENB)

Distributed Admission Control for EDCF

- DAC is developed to protect voice and video.
- *Procedure at QAP*
  - The QoS Parameter Set Element (QPSE) provides global variables needed by QSTAs :
    - *CW* [*i*], *AIFS* [*i*], for *i*=0,…,3
    - *TXOPBudget* [*i*], *SurplusFactor* [*i*], *TxTime* [*i*], for *i*=1,2,3
  - TXOPBudget [*i*] = Max(ATL [*i*] -TxTime [*i*] * SurplusFactor [*i*], 0)



  - The QPSE is calculated by the QAP for each beacon interval and embedded into the next beacon frame.

Distributed Admission Control for EDCF

► *Procedure at Each QSTA*

- Each QSTA has to maintain the following local variables for each AC: *TxUsed* [*i*], *TxSuccess* [*i*], *TxLimit* [*i*], *TxRemainder* [*i*], and *TxMemory* [*i*].
- *TxUsed* [*i*] ：counts the amount of time occupied by transmissions, irrespective of success or not, from AC *i* of this station
- *TxSuccess* [*i*] ：counts for the transmission time for successful transmissions
- *TxRemainder* [*i*] = *TxLimit* [*i*] - *TxUsed* [*i*] or 0
- *TxMemory* [*i*] ： memorizes the amount of time that AC *i* of this station has been able to utilize per beacon interval

Distributed Admission Control for EDCF

- At each TBTT, the *TxMemory*, *TxLimit* and *TxSuccess* variables are updated according to the following procedure:

TXOPBudget[i] = 0

No:

1. For new QSTAs, *TxMemory*[*i*] =[0, *TXOPBudget*[*i*] / *SurplusFactor*[*i*]]
2. All other QSTAs' *TxMemory*[*i*] :

   TxMemory[*i*] = *f* * *TxMemory*[*i*] +
   (*1-f*) * (*TxSuccess*[*i*] x *SurplusFactor*[*i*] + *TXOPBudget*[*i*])

   f : the damping factor

Yes:

1. TxMemory[i] & TxRemainder[i] = 0 for new QSTAs
2. All other QSTAs' TxMemory[i] remains unchanged

As long as the transmission budget is larger than zero, both *TxMemory* [*i*] and *TxLimit* [*i*] need be adjusted periodically.

TxSuccess[*i*] = 0

TxLimit[*i*] = *TxMemory*[*i*] + *TxRemainder*[*i*]

Tried-and-Known

- To enhance the above distributed admission control considering the required throughput and/or delay performance.
- By observing several beacon intervals, the information whether the currently-available capacity can accept a new flow can be determined.
- At each of the very first *k* beacon intervals for a newly-started flow, if

$$\frac{\sum_{j=1}^{k} Throughout[j]}{k} \le \alpha T_{\min} \quad \text{and/or} \quad \frac{\sum_{j=1}^{k} Delay[j]}{k} \ge \beta D_{\max}$$

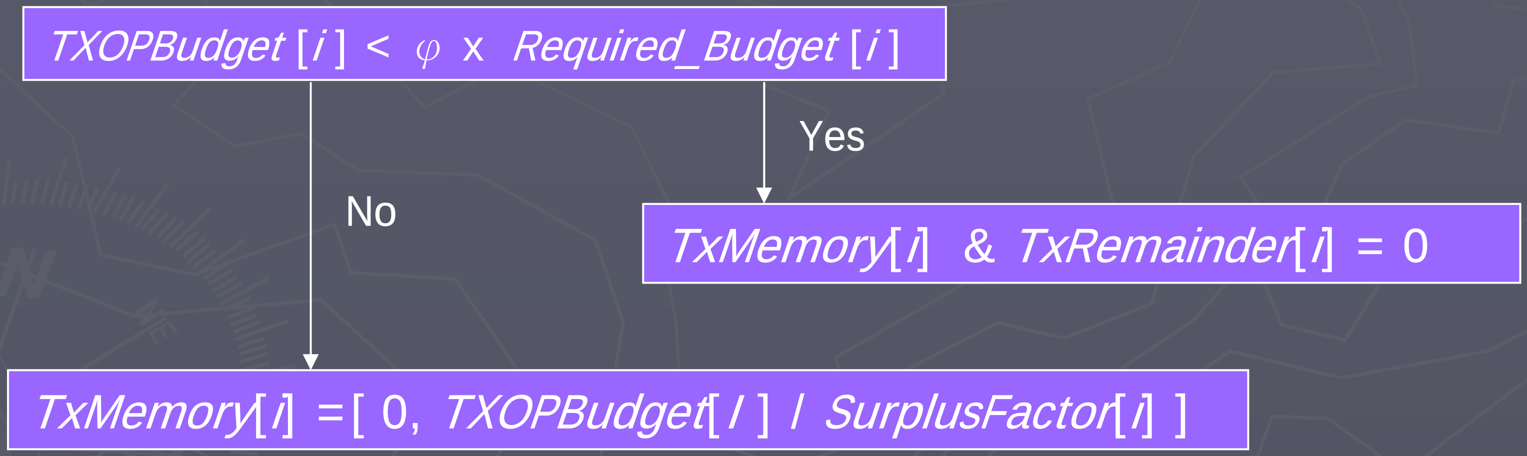
Tmin ：the required minimum throughput
Dmax：the maximum tolerable delay

$0 < \alpha < 1$ and $\beta \ge 1$

then this flow rejects itself.

Early-Protection

- When the budget is below some threshold, new flows are not allowed to enter.
- For a new flow,



Required_Budget[*i*] ：the required budget for a new flow

φ (< 1) ： a fraction

The second–level protection and guarantee

- To protection and guarantee of the existing voice and video flows from data traffic.
- Why not use the admission control with *TxLimit*[0] for data traffic ?
  - Data traffic does not typically involve flows with stationary traffic amount.
  - It will cause unfairness among stations.
- Our approach is to dynamically control data traffic's parameters (i.e., *AIFS*[0], *CWmin*[0], and *CWmax*[0]) based on data traffic load.

The second–level protection and guarantee

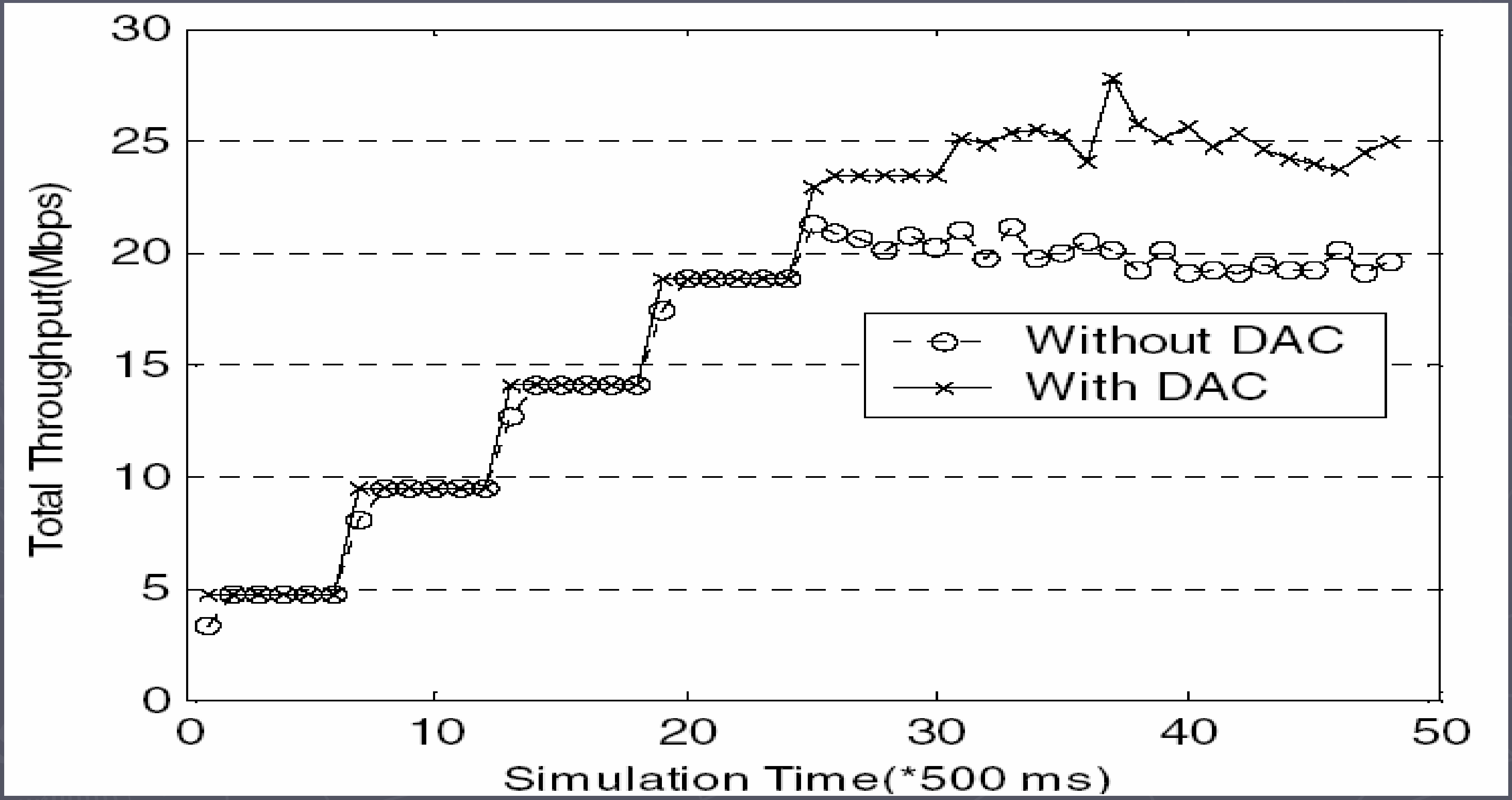
- *Fast-backoff :*
  - Define the window-increasing factor σ which changes with the backoff stage.
- *Dynamically adjusting parameters when fail:*

$$CW_{\min}[0] = \theta \times CW_{\min}[0] \ (\theta > 1)$$
$$AIFS[0] = \psi \times AIFS[0] \ (\psi > 1)$$

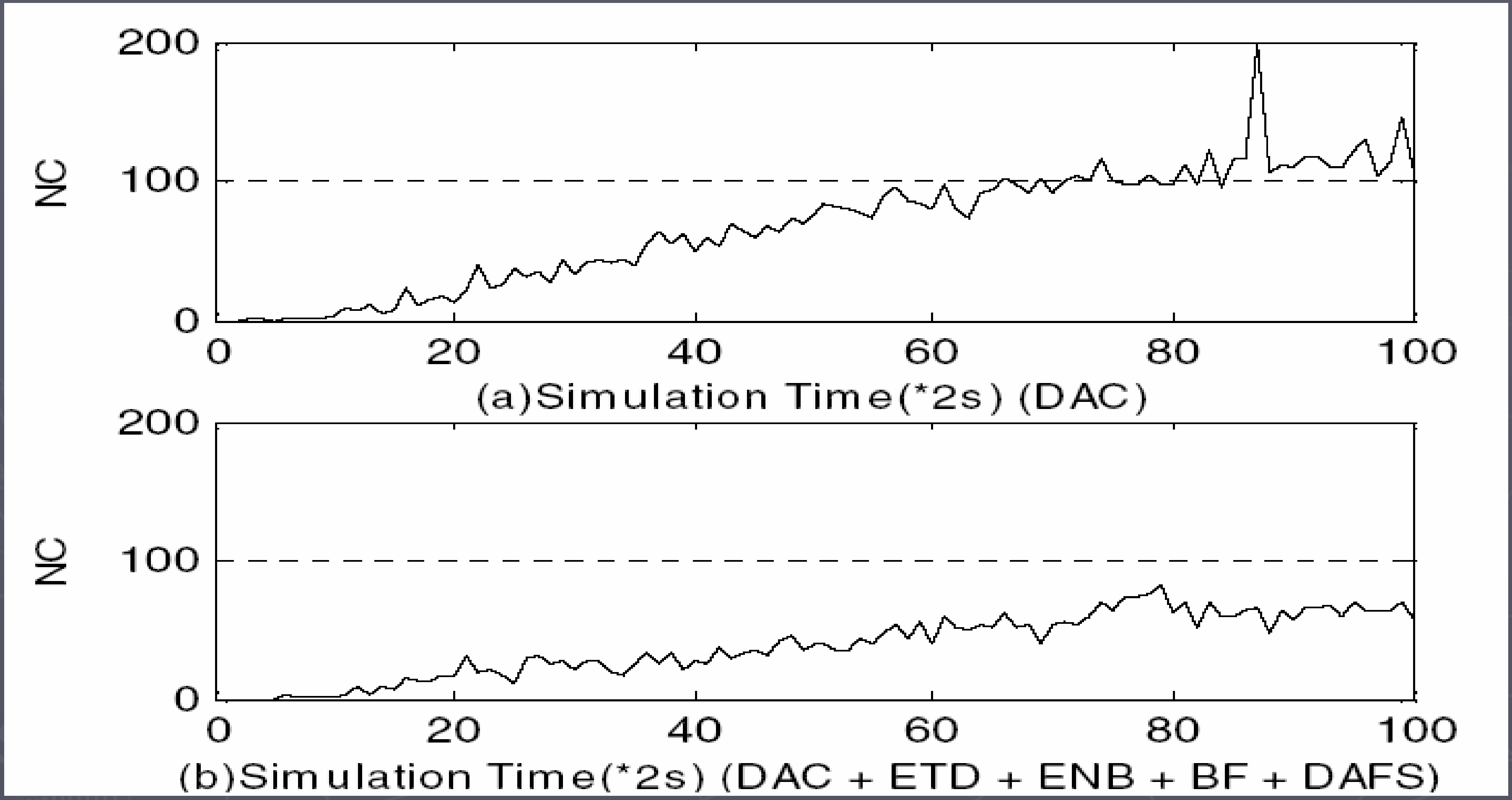
- *Dynamically adjusting parameter when consecutive successful:*

$$CW_{\min}[0] = CW_{\min}[0] / \theta \ (\theta > 1)$$
$$AIFS[0] = AIFS[0] / \psi \ (\psi > 1)$$

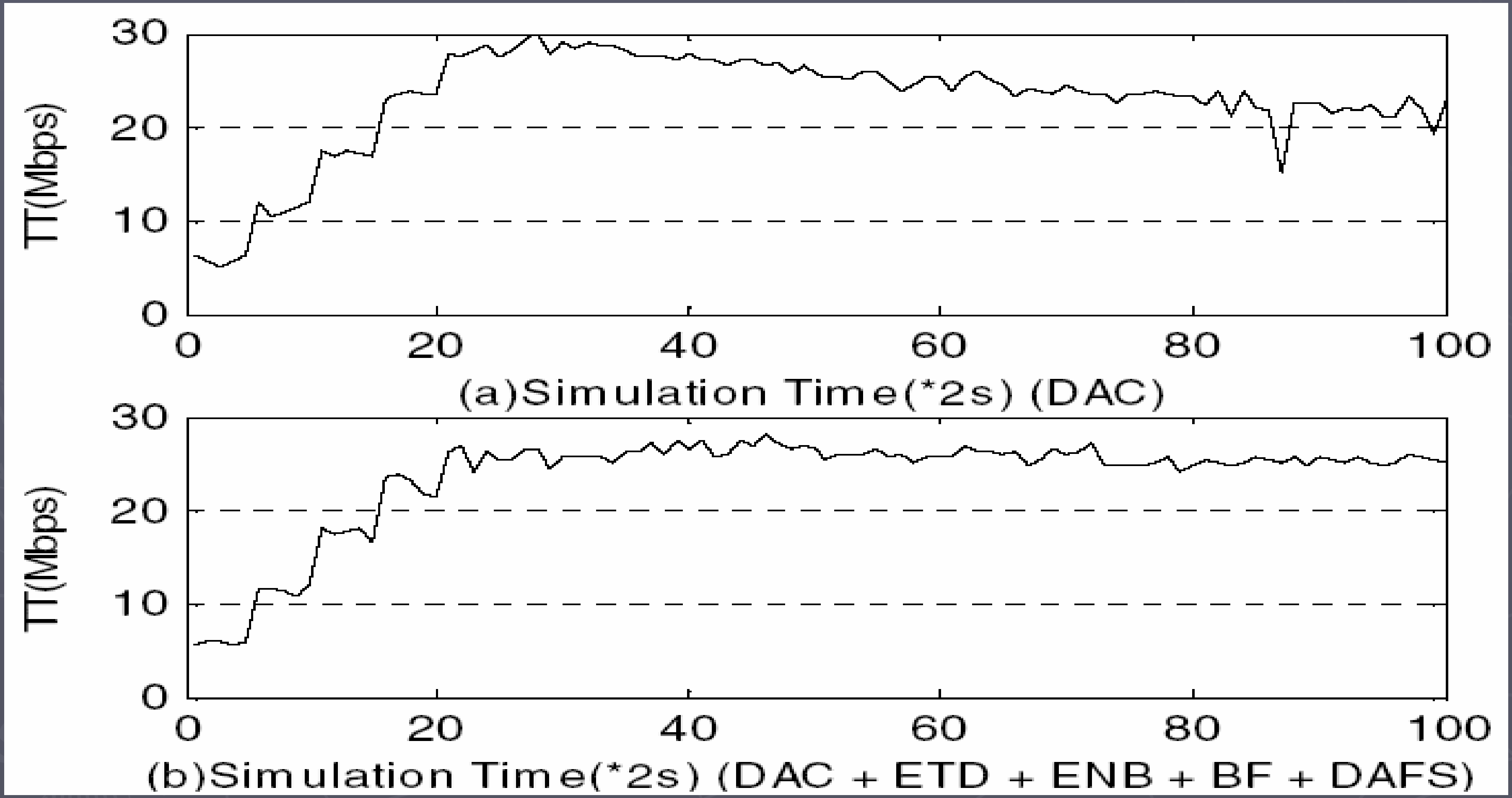
Performance evaluation



Performance evaluation



Performance evaluation



Conclusion

- In this paper, we propose a two-level protection and guarantee mechanism for voice and video for EDCF of the IEEE 802.11e WLANs.
- DAC+ETD+ENB+BF+DAFS is found to be the best approach.