PLUS-DAC: An Admission Control Scheme for IEEE 802.11e Wireless LANs

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M Tech. Project Presentation

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Introduction

According to Infonetics Research

“Spending on VoIP, or next-generation networking equipment, will jump from $1.71 billion in 2004 to nearly $6 billion by 2008."

According to In-Stat/MDR.

“voice over 802.11 handsets will reach 500,000 units by 2006."

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- measure of over all experience of an application
- achieved by giving importance through “Controlled Unfairness"

Requirements

- For a good quality VoIP
  - uni-directional end to end latency < 150ms
  - Packet loss <10%
- Bandwidth Requirements
  - VoIP (e.g. G.711, G.723 Codec) < 100 Kbps
  - Video conferencing (e.g. H.261 and h.263) < 400 Kbps
  - MPEG Video 1-4 Mbps

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QoS in IEEE 802.11 WLANs

- IEEE 802.11 designed for Best Effort Data Traffic. Doesn't provide QoS.
- Task Group E is going to finalize a QoS extension to the base standard called IEEE 802.11e
- service differentiation based on priorities.
- Transmission Opportunity (TxOP)
- Hybrid Coordination Function.
  - Contention Based Channel Access (EDCA)
  - Controlled Channel Access (HCCA)

EDCA

- Multiple Access Categories (AC) with in each Station
- Different EDCA Parameters specific to access category

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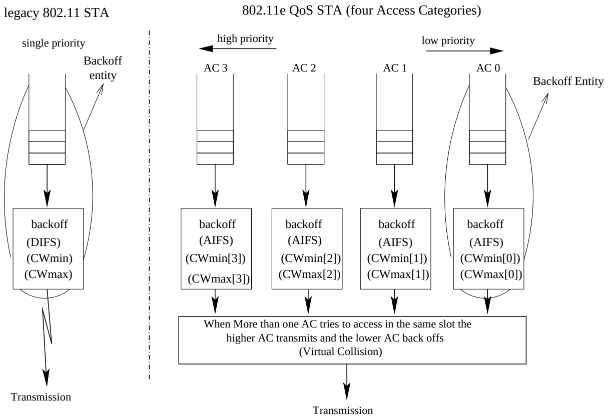
EDCA Station Model



QoS Control and TSPEC

QoS Control

- Additional two byte field added to MAC header for QoS related information.
- Identifies the Traffic category (TC)
- A frame sent by non-AP station contains *queuesize*

TSPEC

- Ported from RSVP.
- Typical Parameters
  - Mean Data rate
  - Nominal MSDU Size
  - Min. PHY rate

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Problem Statement

EDCA suffers at high load due to increased collisions.

Admission Control

- Given that there are N[TC] flows of each traffic category existing in Basic Service Set (BSS), whether the new flow of a particular TC should be admitted or not?
(With out effecting the guarantees given to the existing flows).
- Load measure
- State Information and its Distribution.

Bandwidth Reservation

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Partioning based Distributed Admission Control (Xiao)

Procedure at Access Point (AP)

- Available Time limit for each AC is calculated by BW Partitioning.
- TxTime is calculated by looking into the header of the frames being transmitted.
- Calculate the TxOPBudget of each AC as follows

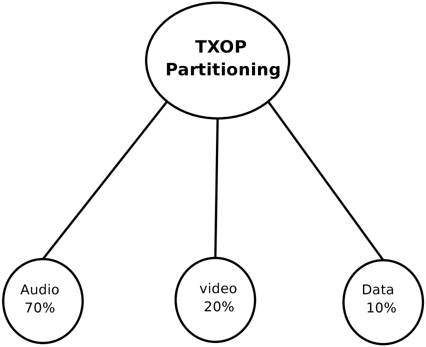
$$TXOPBudget[AC] = \max(ATL[AC] - TxTime[AC] \times SurplusFactor[AC], 0)$$

- Transmit the TxOPBudget[AC] through Beacon.

Admission Control at the Station

Reject new flows when TxOPBudget[AC] is zero.

Example Scenario



Consider Beacon Interval is 100 ms.
ATL[3] = 70ms, ATL[2] = 20ms, ATL[0] = 10ms

Note

- If average occupation of audio traffic is 30ms. Hence 40ms in every beacon interval is unused.
- We can reduce this effect by partitioning the unused TXOP.
- Further, we can adapt the partitioning ratios dynamically.

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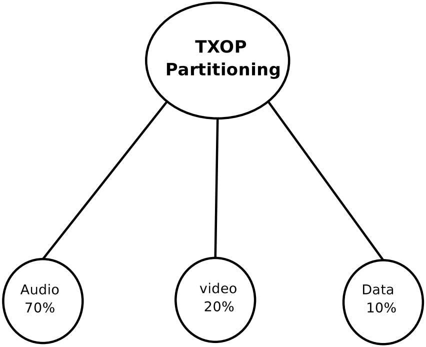

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PLUS-DAC: Proposed Scheme

Goal

To achieve better channel utilization while still satisfying the QoS requirements.

Key Idea

Give importance to traffic categories having sufficient load and priority and have not utilized the channel to the required extent.

- Consider Queue Size at each of the Station as a measure of load and estimate TXOP required to service the load.
- Partition the cumulative unused TXOP based on priority, load and utilization measures.

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Mechanism

- An AP assisted scheme.
- The AP records the amount TXOP used by that traffic category in the previous beacon interval by looking at duration-id in MAC header.
- AP records the buffered queue length for each access category by looking at the QoS Control field of frame sent by non-AP stations and estimates the load.
- The priority for TXOP partitioning will be decided by AP, may be based on policy.
- The unused time will be partitioned based on different normalized weights calculated from the above values.
- The the available TXOP partitioning forms the TXOP_Grant for each traffic category.

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Fraction of TXOP assigned by the Administrator at the QAP. Forms the Default partitioning of the available TXOP.

utilization weight (uw[i])

$$uw[i] = \frac{TXOP\ used\ by\ traffic\ category, i}{Total\ TXOP\ used}$$

load weight (lw[i])

$$lw[i] = \frac{TXOP\ required\ to\ service\ the\ queues\ of\ traffic\ category, i}{Total\ TXOP\ required\ to\ service\ all\ the\ queues}$$

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TXOP_ Grant Calculation

effective weight, $ew[i]$ of each traffic category, i, is calculated as,

$$ew[i] = pw[i] \cdot \left(\frac{0.5 + \alpha \cdot lw[i]}{1 + \alpha \cdot uw[i]} \right)$$

α : balance factor
$pw[i]$: priority weight
$lw[i]$: load weight
$uw[i]$: utilization weight

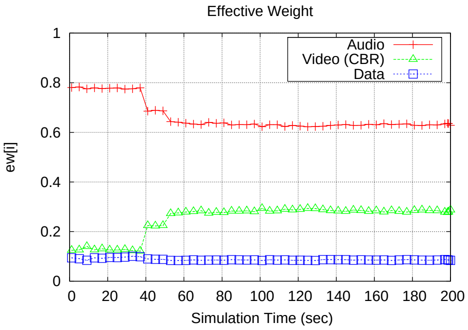
TXOP_Grant

We estimate the TXOP_Grant[i] for each traffic category, i, as,

$$TXOP\_Grant[i] = Total\_TXOP\_Available * ew'[i]$$

- $ew'[i]$ is the normalized effective weight.
- $TXOP\_Grant[i]$ is sent to all the stations as a part of the beacon frame.

ew[i] Variation



NOTE: The ew[i] is used to partition only the unused time. Hence the admitted flows are protected.

Note

- ew[i] for voice decreased and gradually became constant priority is still respected.
- For CBR traffic, ew[i] increased (0.3) and became constant once it accepted enough flows.
- For Data traffic ew[i] value is constant. Though it has load requirement, priority is less.

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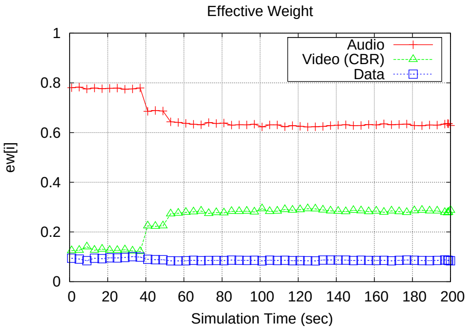

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Distributed Admission Control

The nominal TXOP $\Delta[i]$ required for an incoming traffic stream can simply be calculated as,

$$\Delta[i] = \frac{\lambda[i] \times T_{Beacon}}{R}$$

$\lambda[i]$: arrival rate
R : PHY transmission rate
T_{Beacon} : length of beacon interval

Admissibility Condition

A request for a new flow belonging to traffic category, *i*, can be admitted if the following inequality is satisfied.

$$TXOP\_Grant[i] \geq \Delta[i]$$

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Simulation I

Simulation Setup

- Extended the FHCF ns2-patch to support Admission Control
- Single BSS and AP is the sole Receiver
- Exponential On/Off audio traffic (high priority)
- VBR and CBR Video traffic (medium priority)
- Poisson Data traffic (low priority)
- Traffic stream per station is assumed to be flow.
- Simulation Duration is 200ms.
- starts with low load and gradually increases the load in the BSS.

Simulation II

Simulation Scenarios

- High priority scenario: Audio, VBR and CBR video traffic.
- Low priority scenario: Audio, CBR video and data traffic.

Observed Parameters

- Mean Latency
- Mean Jitter
- Mean Bandwidth per stream
- Total Bandwidth
- Packet loss ratio
- Latency Distribution

Simulation Parameters

Description of Traffic Stream

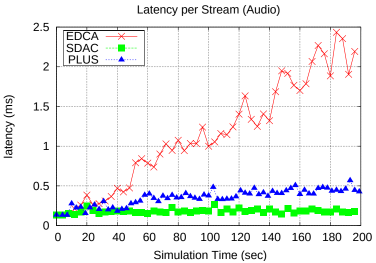
Parameters	Audio	H.261 video	MPEG4 video	Data
Packet Size (bytes)	160	660	1000	1500
Arrival Period (ms)	4.7	26	2.5	12
Sending rate (Kbps)	64	200	3200	1000
AIFS (μs)	25	25	25	34
CW_{min}	7	31	31	127
CW_{max}	15	63	63	1023

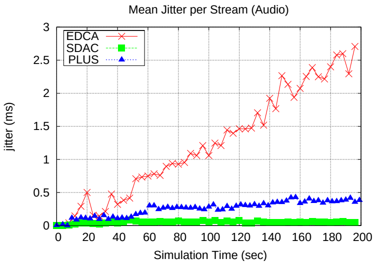
PHY and MAC Parameters

Parameters	Value
SIFS	16 μs
DIFS	34 μs
Slot Time	9μs
CCA Time	3μs
Beacon Interval	500ms
PHY Rate	54 Mb/s
Min. bandwidth	24 Mb/s
MAC header	38 bytes
PLCP header	4 bits
Preamble Length	20 bits

Mean Latency and Mean Jitter (Audio)

High Priority Scenario



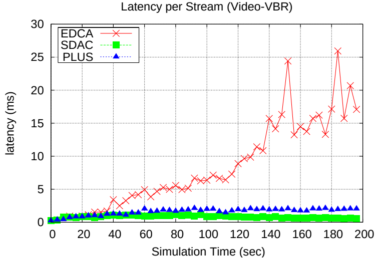


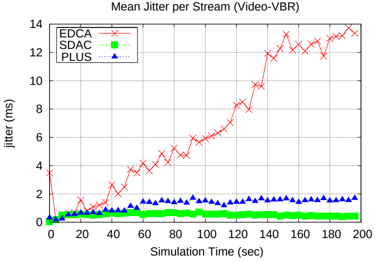
Observations

- EDCA performed slightly worse than the admission control schemes. But experienced latency and jitter are well below the QoS limits.
- This is because we are using Strict EDCA.
- The bandwidth requirements of Audio traffic are very minimal.

Mean Latency and Mean Jitter (H.261 VBR Video)

High Priority Scenario



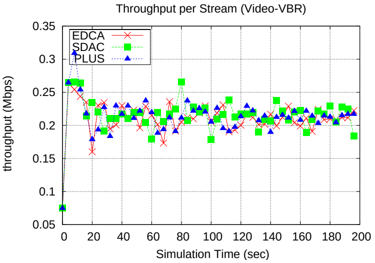


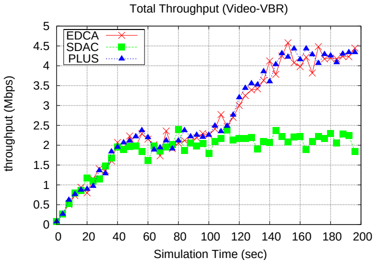
Observations

- Latency and Jitter of the VBR traffic are worse when compared to audio
- This is a result of increase in bandwidth requirements.
- The values are still well inside the QoS limits. (strict EDCA!)

Throughput Characteristics (H.261 VBR Video)

High Priority Scenario



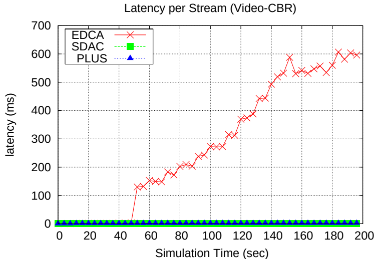


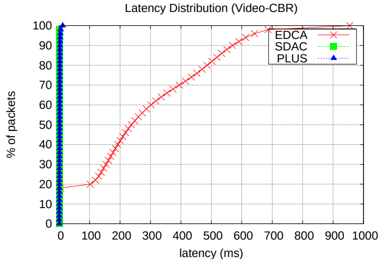
Observations

- per stream bandwidth is almost same for all the scemes: requirements of accepted flows are satisfied.
- SDAC has accepted only Half as many flows as that of PLUS-DAC.
- EDCA achieved better VBR throughput than SDAC, as no calls are blocked (strict EDCA!!).

Mean Latency and Latency distribution (MPEG Video)

High Priority Scenario



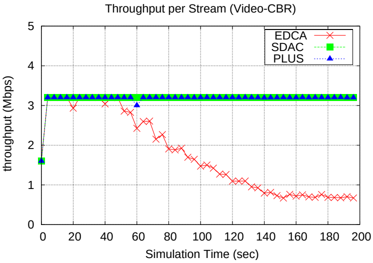


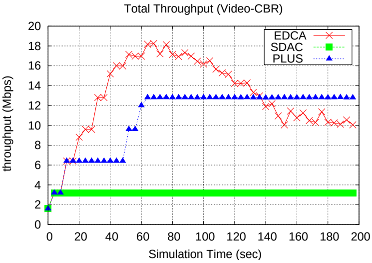
Observations

- Bandwidth requirements of MPEG are significant.
- Admission control schemes admitted only few flows, and performed better.
- With out admission control only 20% of the packets experienced a delay of less than 100ms.

Throughput Characteristics (MPEG CBR Video)

High Priority Scenario



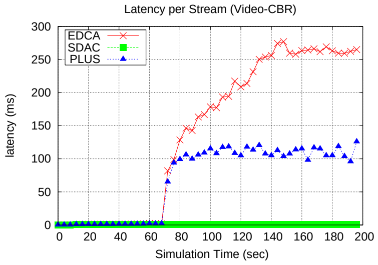


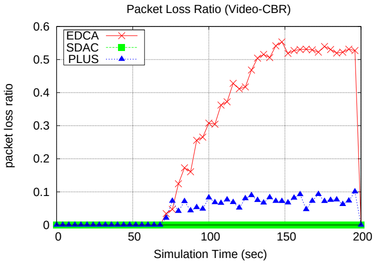
Observations

- per stream throughput of both the admission control schemes is same and constant : Admitted flows are protected.
- SDAC admitted only one flow to PLUS-DAC’s four.
- High total throughput of EDCA is not useful, as loss and delay requirements can not be satisfied.

Mean Latency and Packet loss (MPEG CBR Video)

Low Priority Scenario



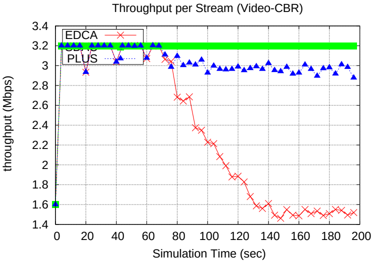


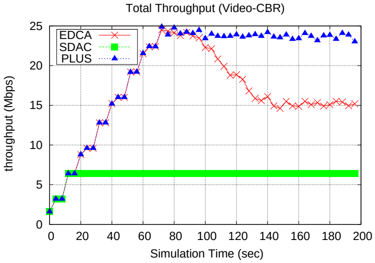
Observations

- PLUS-DAC experienced delay and packet loss at high load.
- But the values are still with in the limits.
- This is because the low priority flows will disturb the traffic at high load.

Throughput Characteristics (MPEG CBR Video)

Low Priority Scenario



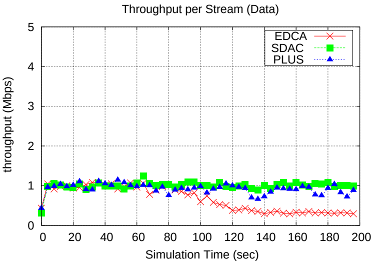


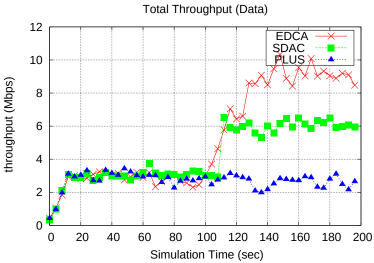
Observations

- per stream throughput of PLUS-DAC is slightly worse than SDAC -result of packet loss.
- Total throughput of PLUS-DAC is high. Accepted Eight flows opposed to SDAC's two.
- PLUS-DAC achieves better utilization while protecting the flows satisfactorily.

Throughput Characteristics (Data)

Low Priority Scenario



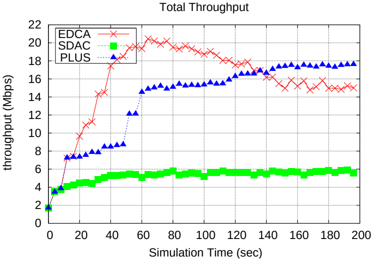


Observations

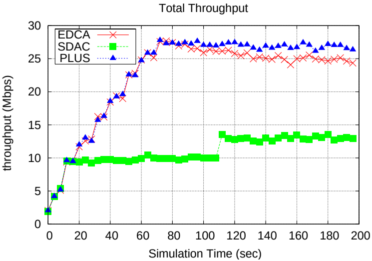
- The per stream throughput of the admission control schemes is similar.
- Total throughput of PLUS-DAC is low. Accepted only three flows opposed to SDAC's six.
- The Bandwidth is used up by high priority flows by the time data flows arrive.

Total Throughput (Both scenarios)

High



Low



Observations

- EDCA achieves throughput but could not satisfy the latency and loss requirements.
- PLUS-DAC admits more flows than SDAC by reallocating the unused bandwidth.
- PLUS-DAC achieves better channel utilization, while satisfying the QoS requirements.

Summary of Work done

- Extensive study of QoS provisioning in IEEE 802.11e standard.
- Studied the admission control problem for QoS in 802.11e LANs.
- Implemented the partitioning based admision control by Xiao in ns2 and analyzed it.
- proposed a new scheme, PLUS-DAC for intelligent admission control, which strictly adheres to the standard with minimal over heads.
- implemented PLUS-DAC in ns2 by extending FHCF ns2 patch.
- Evaluated PLUS-DAC with various metrics and compared it with the previous scheme, and with pure EDCA, within many scenarios.

submitted paper to MICC-ICON 2005

Conclusion

- EDCA suffer at high load due to increase in collisions.
- Admission control and bandwidth reservation improve the QoS guarantees.
- bandwidth partitioning should not be static and purely based on priority.
- Atention to the current load and utilization in the network is necessary for better channel utilization.

- PLUS-DAC achieves significant improvement in the channel utilization, while satisfying the QoS guarantees simultaneously.

Future work

Future Work

- Policing and scheduling of packets at each of the stations can be done by deferring the channel access to misbehaving QSTAs in a manner similar to that of virtual collision.
- PLUS-DAC could be extended to HCCA.
- policy controller can be enhanced to support various admission control policies.

For Further Reading I

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For Further Reading III

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THANK YOU

QoS in IEEE 802.11 WLANs

problems with 802.11

- IEEE 802.11 designed for Best Effort Data Traffic. Doesn't provide QoS
- doesn't differentiate between traffic streams.
- transmission time is not in control of AP

802.11e

- IEEE 802.11 Task Group E is going to finalize a QoS extension to the base standard called IEEE 802.11e
- service differentiation based on a queue model.
- provisions for traffic negotiation are available.
- suffers at high load.

Summary

- Details about IEEE 802.11e are presented.
- The details about the algorithms implemented and proposed scheme are explained.
- The complete details about the Simulation, along with the observations are presented.

- PLUS-DAC achieves significant improvement in the channel utilization, while satisfying the QoS guarantees simultaneously.