# Dynamic Adaptation Policies to Improve Quality of Service of Multimedia Applications in WLAN Networks

**Broadband Networks, 2004**

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10/20/2006

# Outline

- Introduction
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- Adaptation Policy
- Adaptation Algorithm
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- Conclusion
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# Introduction

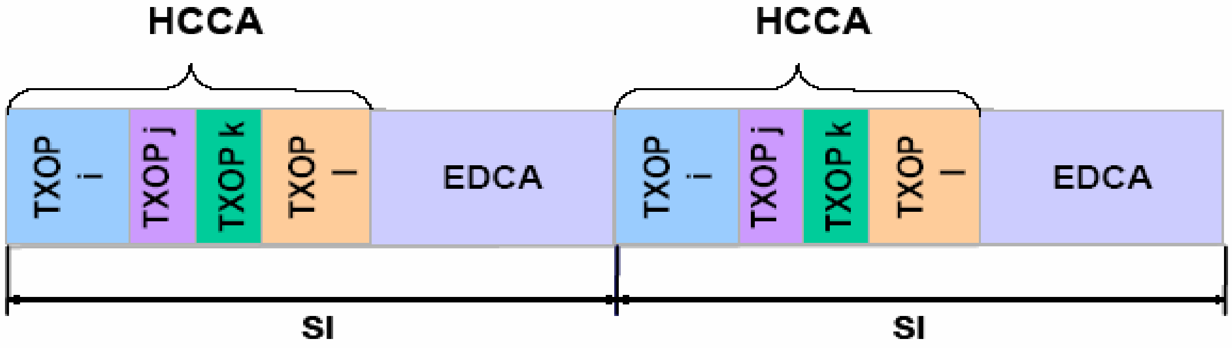
- The 802.11e standard provides
  - Hybrid Coordination Function (HCF)
    - EDCA (contention based) and HCCA (polling based)
  - A reference design of a scheduler
- Although 802.11e has provisions for supporting service differentiation, the reference scheduler does have a few limitations
  - Depending on the application, real-time flows may send reservation requests that are inaccurate and/or incomplete
  - The reservation request only includes averaged values, such as mean packet size and mean data rate
  - HCF can only allocate a fixed polling schedule suitable for constant bit rate (CBR) traffic

# Introduction

- With possible inaccuracies in received reservations and traffic variations, HCF scheduling during the polling based period can be inefficient and unsuitable, and can lead to unacceptable delays
- In this paper, to improve the support of QoS for multimedia applications by addressing the limitations, the author present an adaptation policy to dynamically associate traffic flows to the appropriate medium access mode

# IEEE 802.11e Background

- HCF multiplexes between two modes of medium access: EDCA, and HCCA




- TXOP is computed based on reservation information sent to the AP by each of the flows
- The AP determines the minimum service interval (SI) to be used for all of the nodes, where the SI is the time duration between successive polls for the node

# Motivation

- For real-time flows, the reference scheduler is not suited for Variable Bit Rate (VBR) traffic, such as MPEG4 video coding, high-motion real time video
- The static HCCA scheduling is inability to handle incorrect flow reservations
- By using the time allocated in HCCA efficiently, we can improve the experienced delay and throughput of nodes in EDCA

# Adaptation Policy

- How do we recognize which flows need to be adapted and select between flows in a fair manner?
  - By comparing the queue length information with an appropriate threshold to decide which flows need to be adapted
  - We sort the flows based on weights determined using timestamps of the last adaptation and current queue length information, and perform a priority-based selection

# Adaptation Policy

- What are the acceptable conditions to run the adaptation and when should it be run?
  - For the HCCA flow allocation, there are two possibilities, additional allocation in HCCA or encouraged access in EDCA
  - The network load must be estimated by the AP
    - Utilization ratio
    - Collision count

# Adaptation Policy

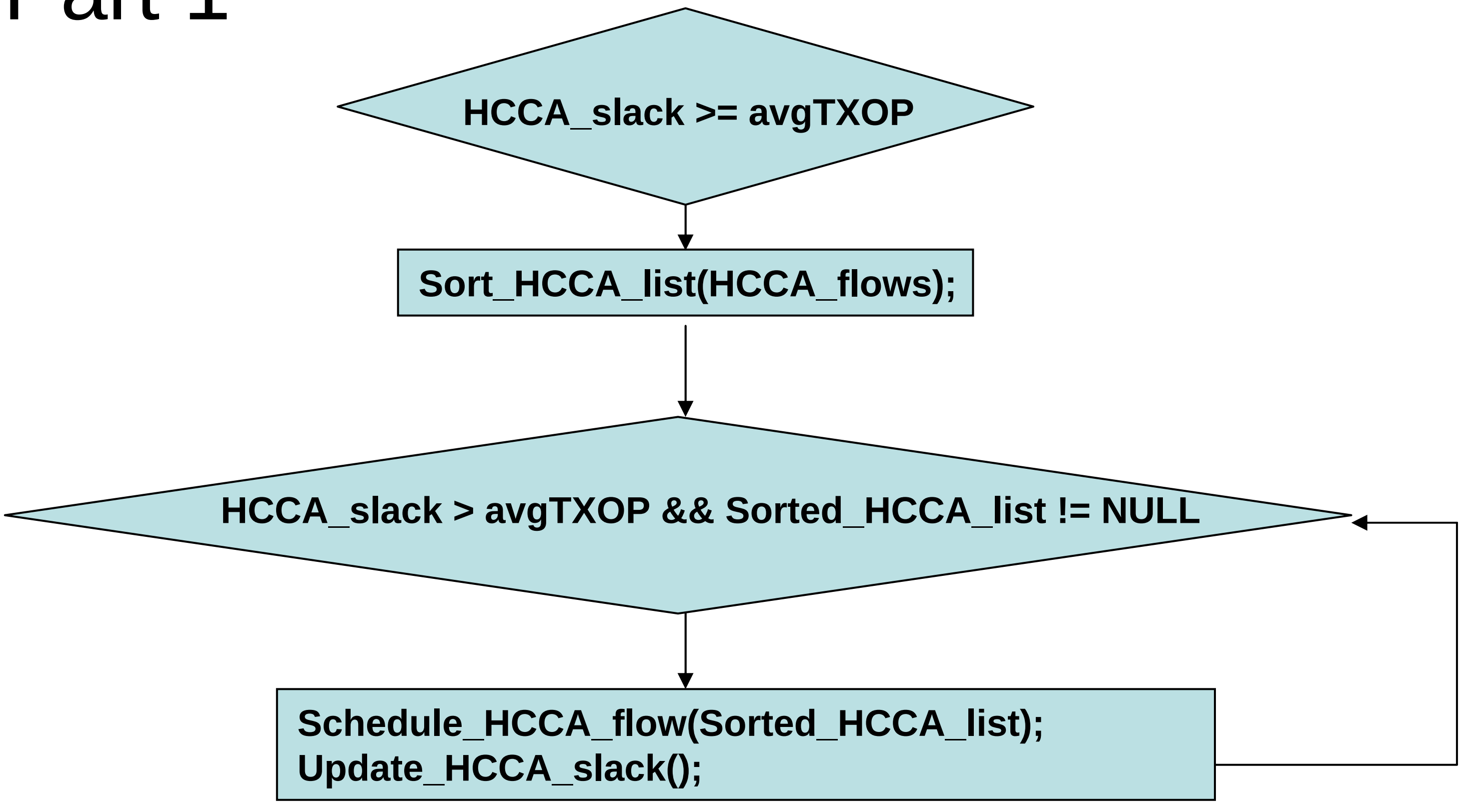
- How should we reallocate the time so as to minimize the effects on other flows in the network?
  - For real-time flows in the HCCA period, we allocate additional time by re-polling a flow after all previously scheduled flows have been polled
  - In the case where HCCA allocation is not possible, it encourages flows to send during the EDCA period only if the network load is low

# Assumptions

- The AP receives reservation requests, schedules the appropriate TXOPs to each node, and polls all nodes using a fixed SI
- The ideal queue length for flows scheduled in HCCA after each SI is zero
- Flows that have been scheduled in HCCA only send packets in the polling-based period and that the remaining flows without reservations are restricted to sending in the EDCA period
- All flows provide queue length information to the AP using the control field of the 802.11e packet header

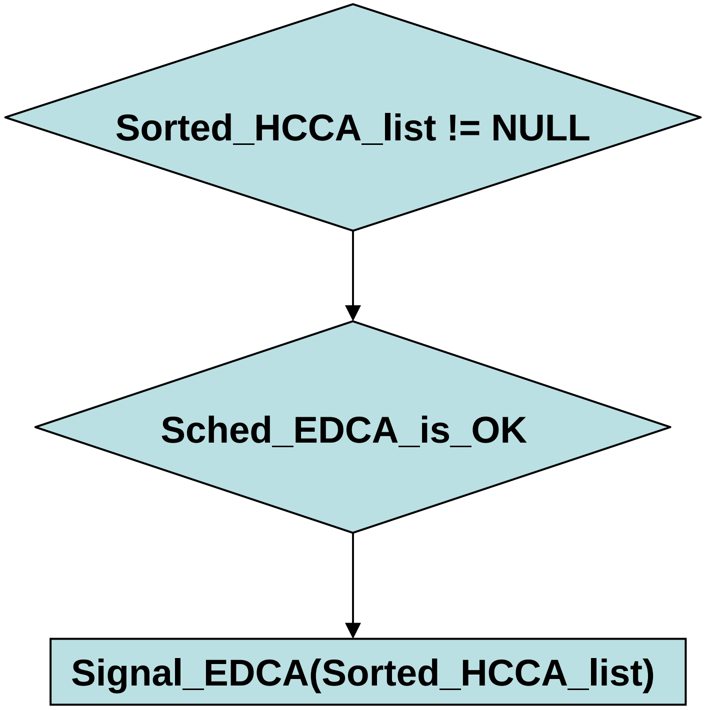
# Adaptation Algorithm

- Part 1



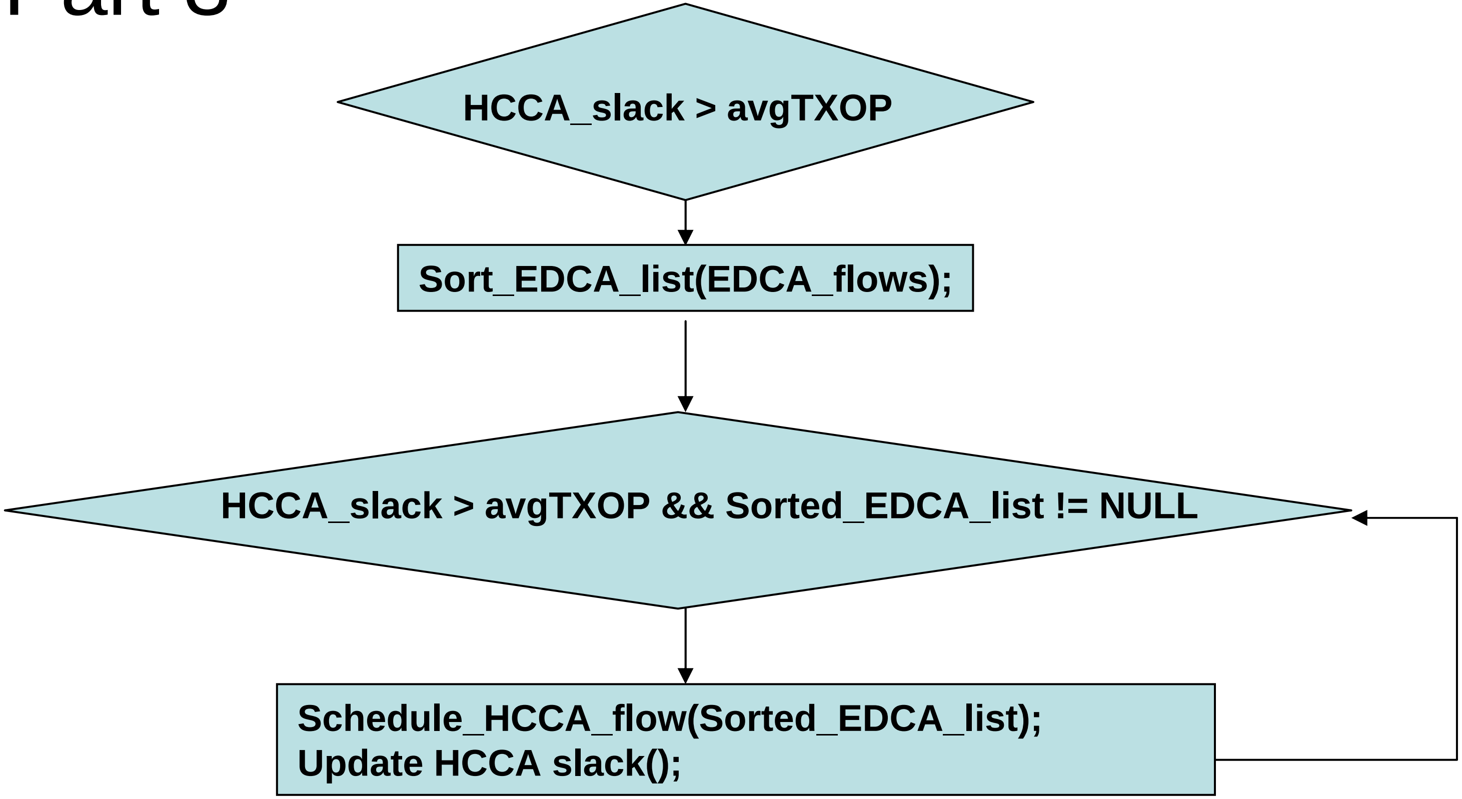
# Adaptation Algorithm

- Part 2

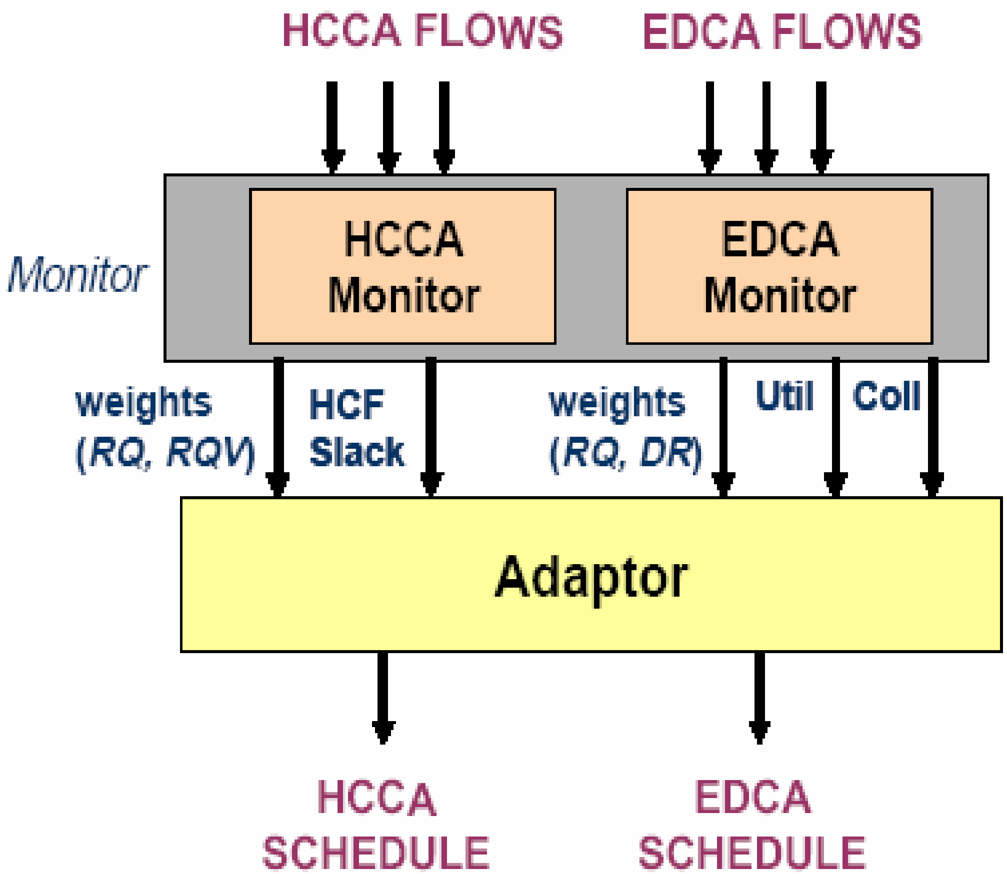


# Adaptation Algorithm

- Part 3



# Adaptation Framework




**Node Selection**

- Variability for HCCA Nodes
- Queue buildup for EDCA Nodes

***RQ:*** Mean Residual Queue Size
***RQV:*** Residual Queue Variance
***DR:*** Physical Data Rate

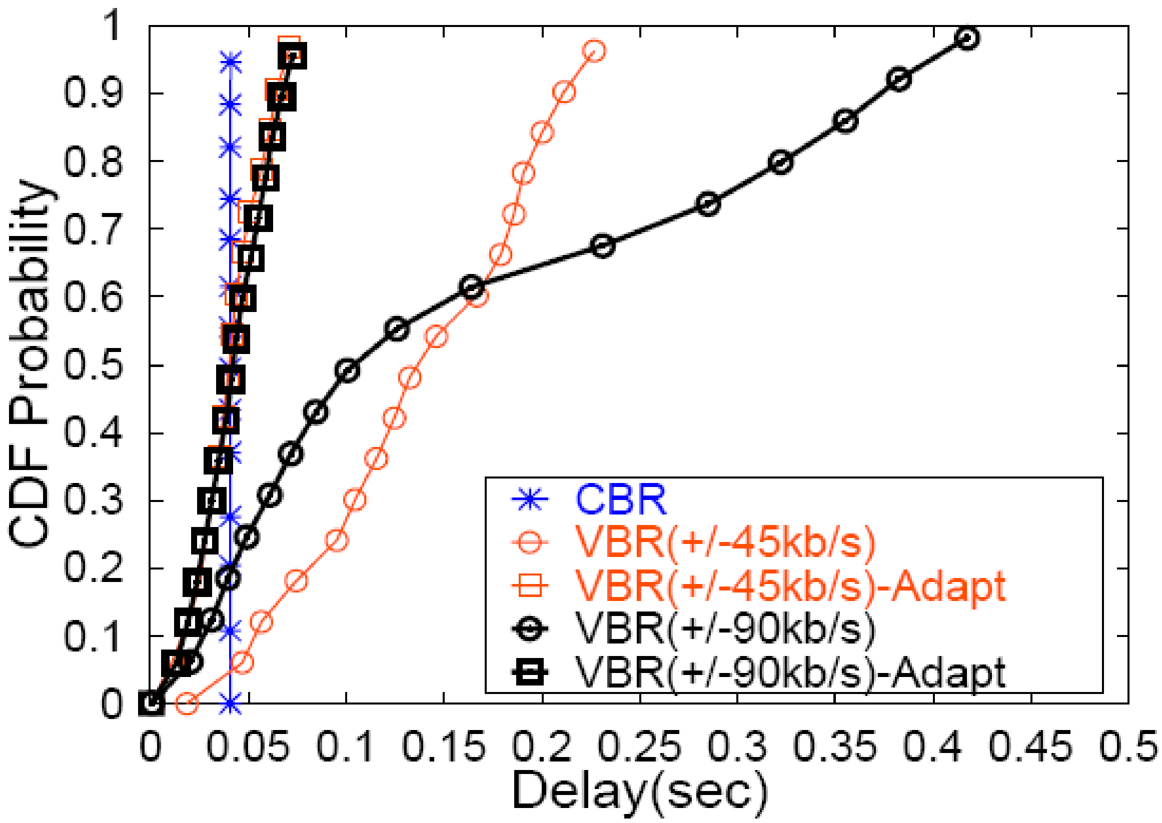
**Load Estimation**

- Time remaining in HCCA
- Utilization and collision factor in EDCA

$$Util = \frac{TotalTimeUsed}{TotalTimeEDCA}$$

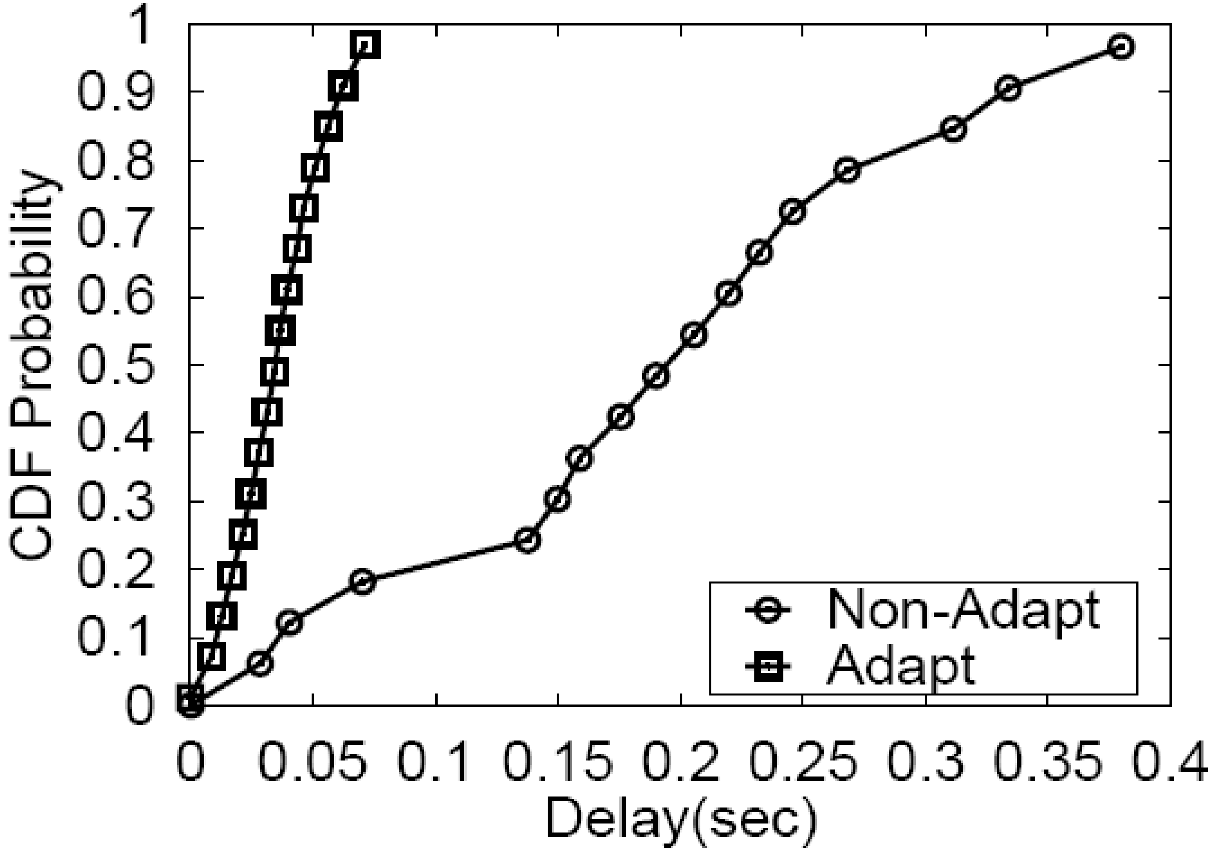
$$Coll = \frac{\#PktsColl}{Total\#Pkts}$$

# Simulation Results



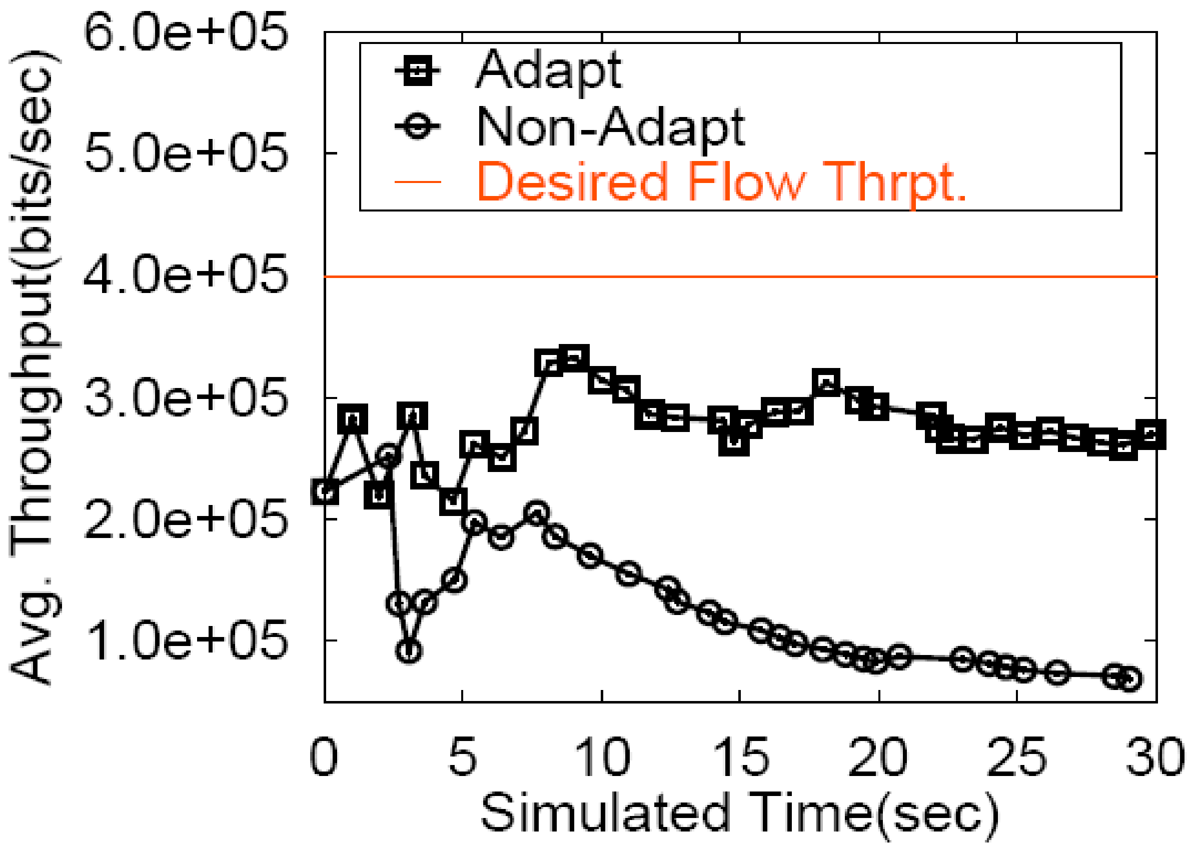

**Adaptation in HCCA**

# Simulation Results




**Adaptation in EDCA**

# Simulation Results




**Average Throughput of EDCA Flow w//o Adaptation**

# Overall Evaluation

| No. of VBR Flows | Thrpt (Kb/s) | | Factor of Improv. | Delay (ms) | | Factor of Improv. |
|---|---|---|---|---|---|---|
| | w/o | w/ | | w/o | w/ | |
| 1 | 119 | 536 | 4.5 | 173 | 39 | 4.4 |
| 2 | 159 | 502 | 3.2 | 145 | 40 | 3.6 |
| 3 | 164 | 500 | 3.0 | 240 | 40 | 6.0 |
| 4 | 230 | 465 | 2.0 | 171 | 49 | 3.5 |

**Effect of Adaptation Mean Throughput and Delay of HCCA VBR Flows**

# Conclusion

- In this paper, it addresses the mentioned limitations by dynamically associating traffic flows appropriately to the two medium access modes and adjusting the duration of access in each mode
- The proposed policy significantly improves the performance of multimedia applications in IEEE 802.11e, in terms of delay and throughput metrics, (3.5-6x) and (2-4.5x) respectively

# Conclusion

- Comparison

| | Proposed adaptations | | |
|---|---|---|---|
| | **TXOP** | **SI** | **Other** |
| **[1]** | Maintain average TXOP value but allow flexibility | Allow each flow to have varying SI values | Ordering of the flows is by earliest deadline first (EDF) |
| **[2]** | Determine based on queue length | Keep SI fixed | When no time left in HCCA, proportionally decrease or increase TXOP |
| **Proposed algorithm** | Keep TXOP value fixed but poll needing flows again after original polling schedule | Keep SI fixed | When no time left in HCCA, allow EDCA access if EDCA load is low |

# Conclusion

| | **Analysis** |
|---|---|
| **[1]** | It is most effective but has the overhead of supporting variable SI |
| **[2]** | It provides better QoS when there are a number of VBR flows present |
| **Proposed algorithm** | It works better in a mixed traffic scenario |

# References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