IEEE 802.11e
QoS for Wireless LAN:
A Research Direction

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IEEE 802.11 MAC Layer

- Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA)
  - Different from CAMA/CD (802.3)
  - STA cannot hear the **collision** signal as in the wired world.
- Two access methods:
  - Distributed Coordination Function (DCF)
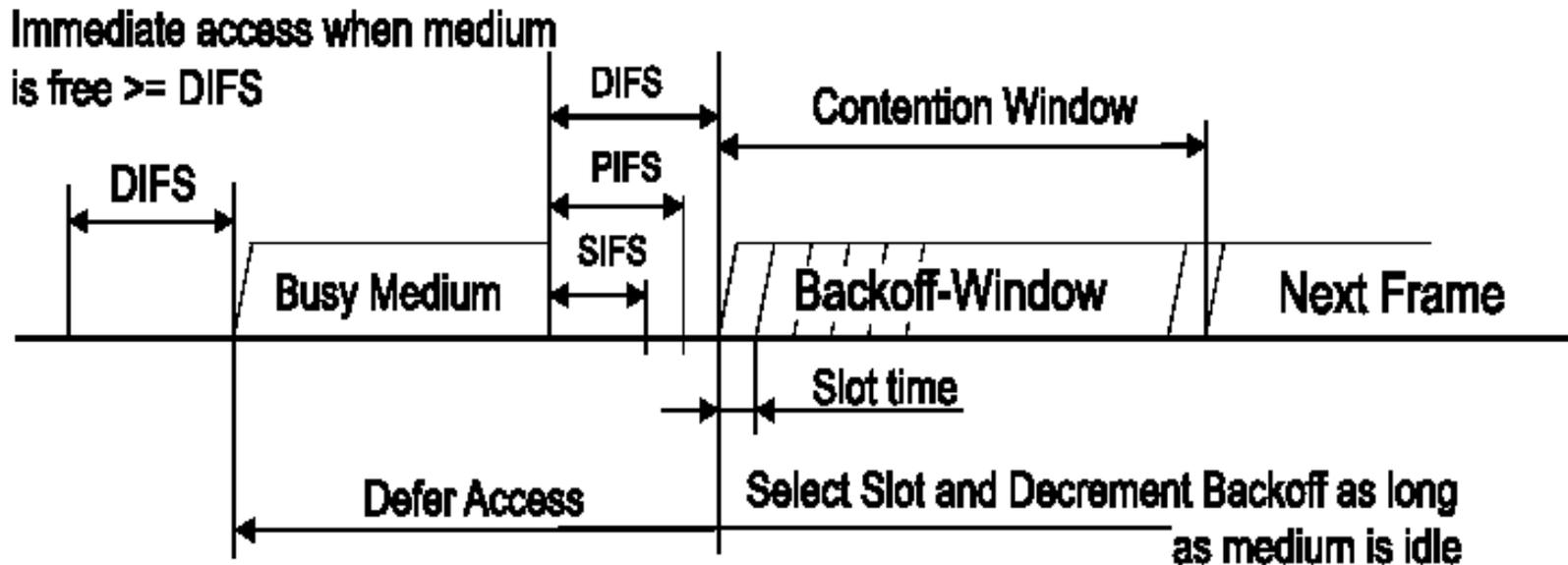 - Point Coordination Function (PCF) - optional

CSMA/CA

Figure 51—Basic access method

Backoff Time

- Backoff Time = Random() × SlotTime

where

- Random( ) = [0, CW]

$$CWmin \leq CW \leq CWmax.$$

- SlotTime = The value of the corresponding PHY characteristic.

- $CW_{new} = (CW_{old} + 1) \times PF - 1$ (where PF=2)
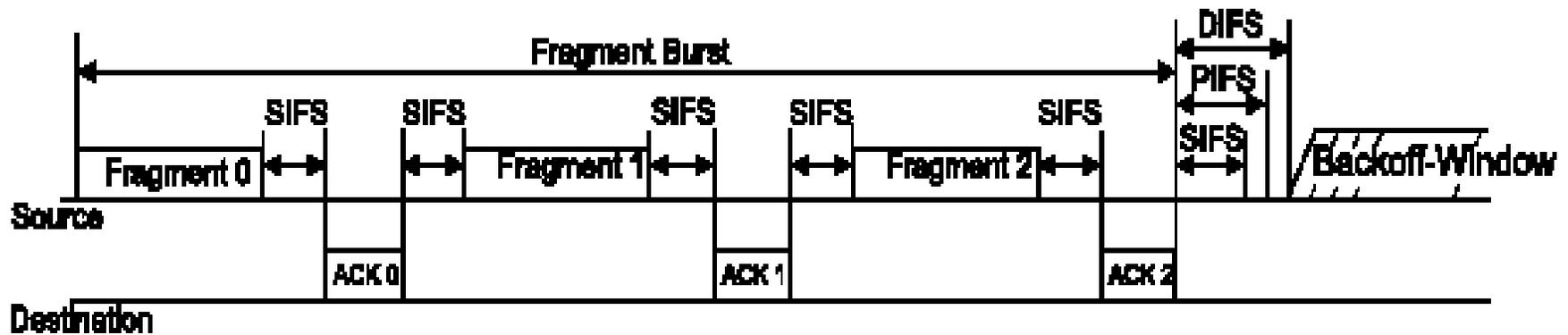
Frame Bursting

Figure 54—Transmission of a multiple-fragment MSDU using SIFS

Point Coordination Function (PCF)

- Optional and implemented on top of DCF
- A single AP controls access to the media, and a Point Coordinator (PC) Agent resides in the AP.
- AP polls each station for data, and after a given time interval moves to the next station.
  - Guaranteed maximum latency
- No stations are allowed to transmit unless it is pooled.
- AP could have a priority scheme for stations.
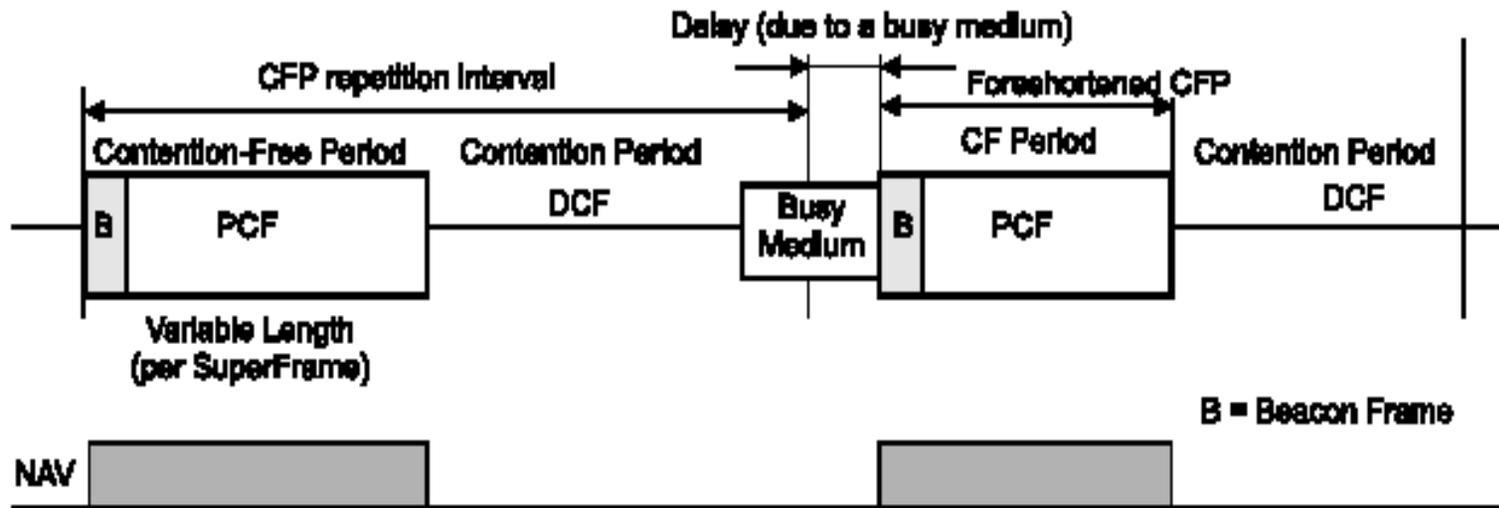- PCF is useful for *time-sensitive* applications.

PCF

Figure 59—CFP/CP alternation

NAV: network allocation vector

QoS Limitations of 802.11

- DCF (Distributed Coordination Function)
  - Only support best-effort services
  - No guarantee in bandwidth, packet delay and jitter
  - Throughput degradation in the heavy load
- PCF (Point Coordination Function)
  - Inefficient central polling scheme
  - Unpredictable beacon frame delay due to incompatible cooperation between CP and CFP modes
  - Transmission time of the polled stations is unknown

Overview of 802.11e

- Formed in Sep. 1999. The QoS baseline document was approved in November 2000. The first draft was available in late 2001.
- Aim to support both IntServ and DiffServ
- The new standard is still in debate and unstable
- Wireless Multimedia Enhancement (WME)
  - Subset of 802.11e to be implemented by the industry
- New QoS mechanisms
  - EDCF (Enhanced DCF)
  - HCF (Hybrid Coordination Function)
- Backwardly compatible with the DCF and PCF

QoS level in 802.11e

Priority	Access Category	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

QoS classes in 802.11e

- Implement 8 different traffic classes
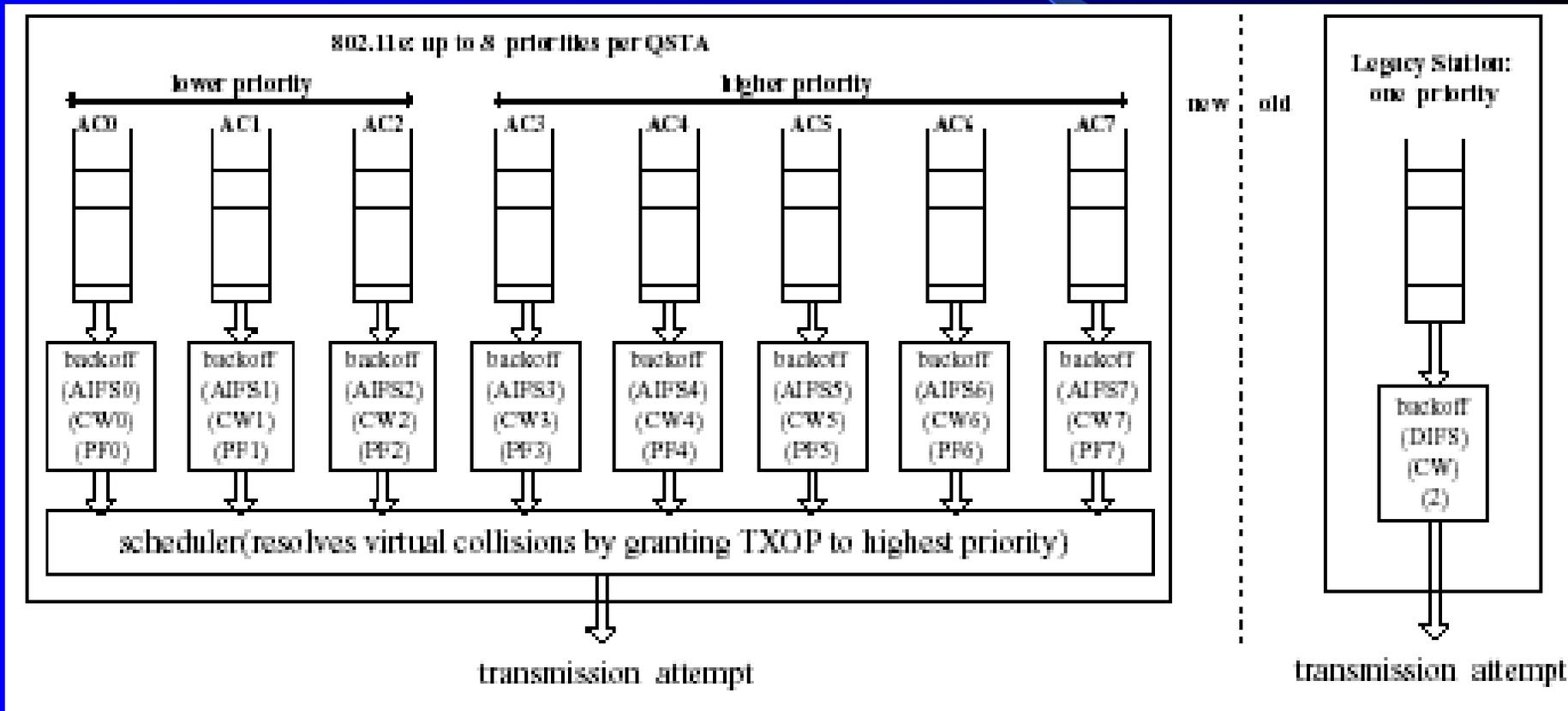
EDCF (Enhanced DCF)

- Enhanced DCF

- Also support bursting

- Different parameters for different TC/AC

- Replace DIFS with AIFS (AIFS>DIFS) which is shorter for audio and video traffic.
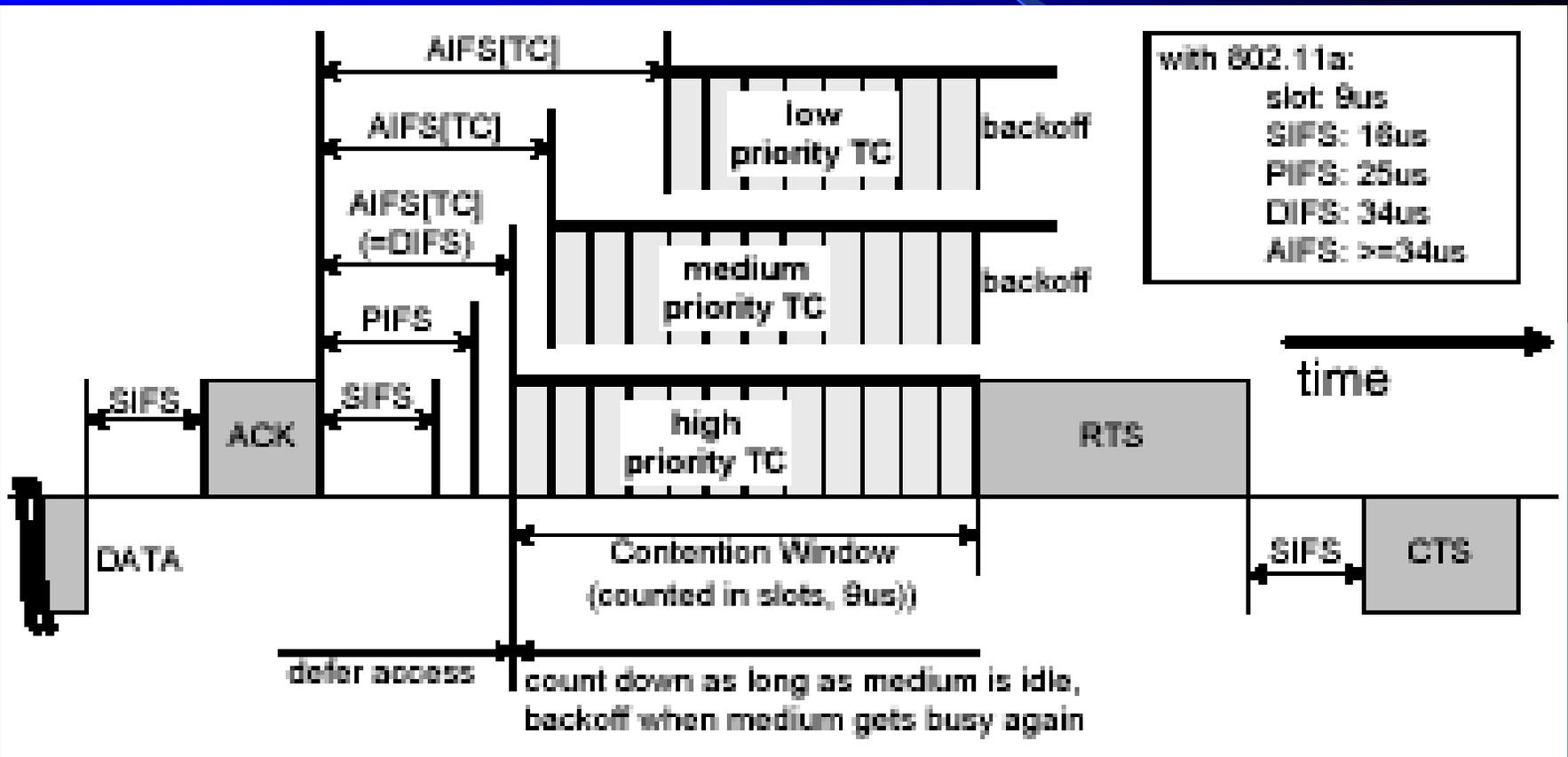
  Audio = Video < Data

- CW_{min} and CW_{max}

  Audio < Video < Data

- Different Persistence Factor (PF)

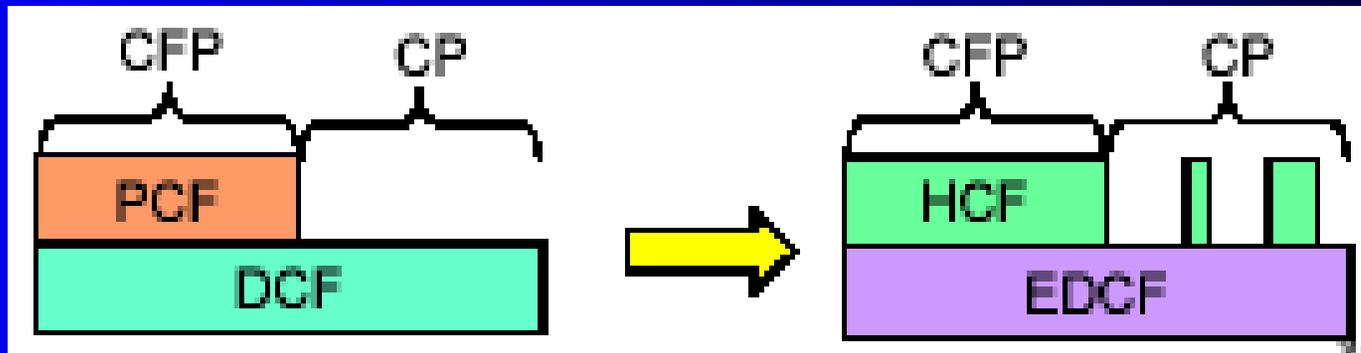AIFS: Arbitration Inter Frame Space

EDCF (Cont.)

Typical QoS Parameters

AC	CWmin	CWmax	AIFS
0	CWmin	CWmax	2
1	CWmin	CWmax	1
2	$(CWmin+1)/2 - 1$	CWmin	1
3	$(CWmin+1)/4 - 1$	$(CWmin+1)/2 - 1$	1

HCF (Hybrid CF)

- Provides policing and deterministic channel access by controlling the channel through the HC (Hybrid Coordinator)

- Operate in CFP and CP

HCF (Cont.)

- Detecting the channel as being idle for PIFS, shorter than DIFS, gives the HC high priority over EDCF

- HCF model can provide Guaranteed Services with a much higher probability than pure EDCF

- A signaling protocol can be used to facilitate admission control and specify service rate requirement

Research Topics

- Does 802.11e really work?
  - How do you validate the protocol?
  - measurements: throughput, delay, jitter
  - Is EDCF really better than DCF?
  - Is HCF better than EDCF?
- Support and interoperability with upper layer
- Relationship between traffic parameters and performance
- Does incoming traffic pattern makes any difference?   uniform, Poisson, bursting, etc.
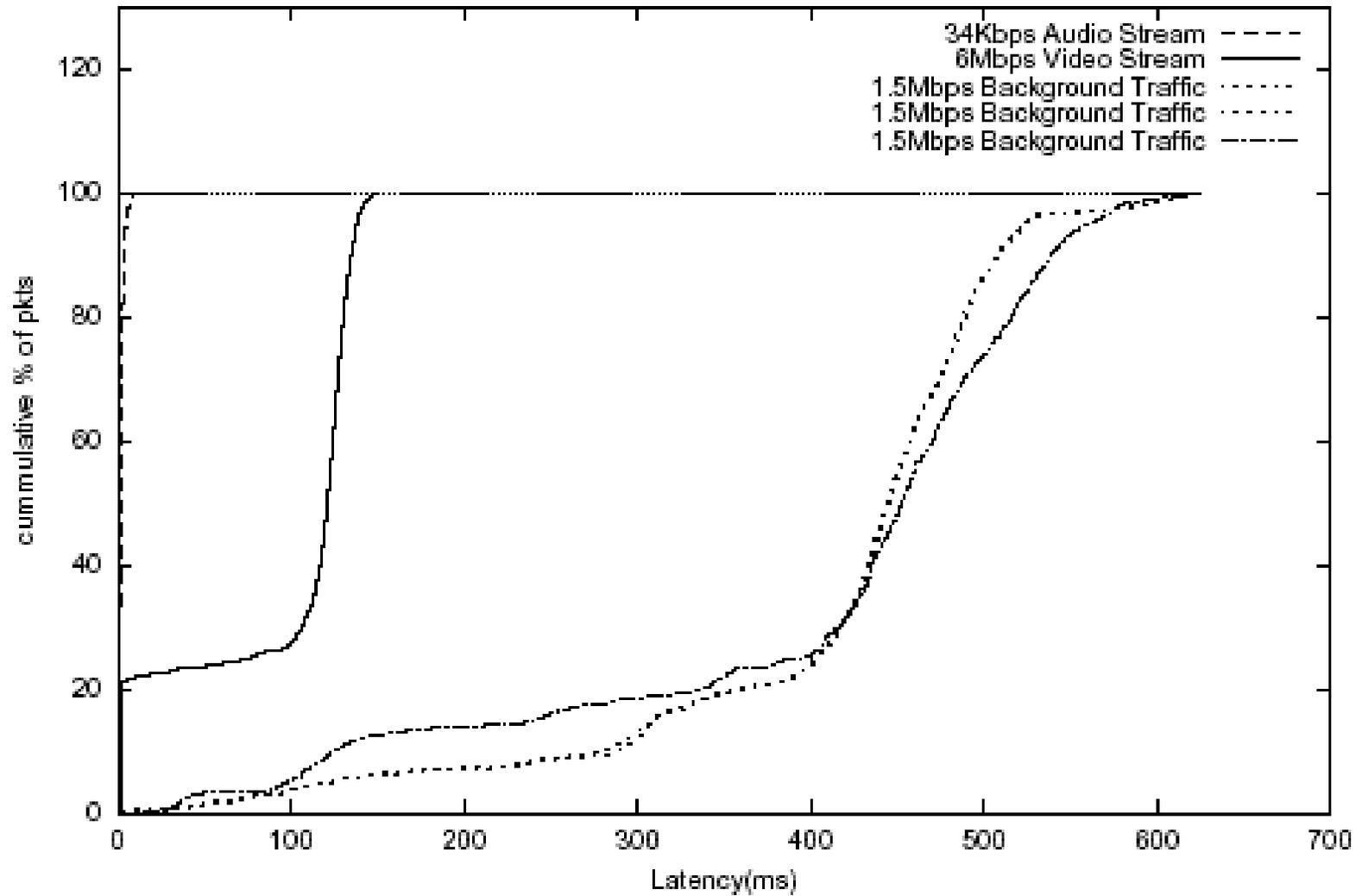- Scheduling policy

Simulation Tools
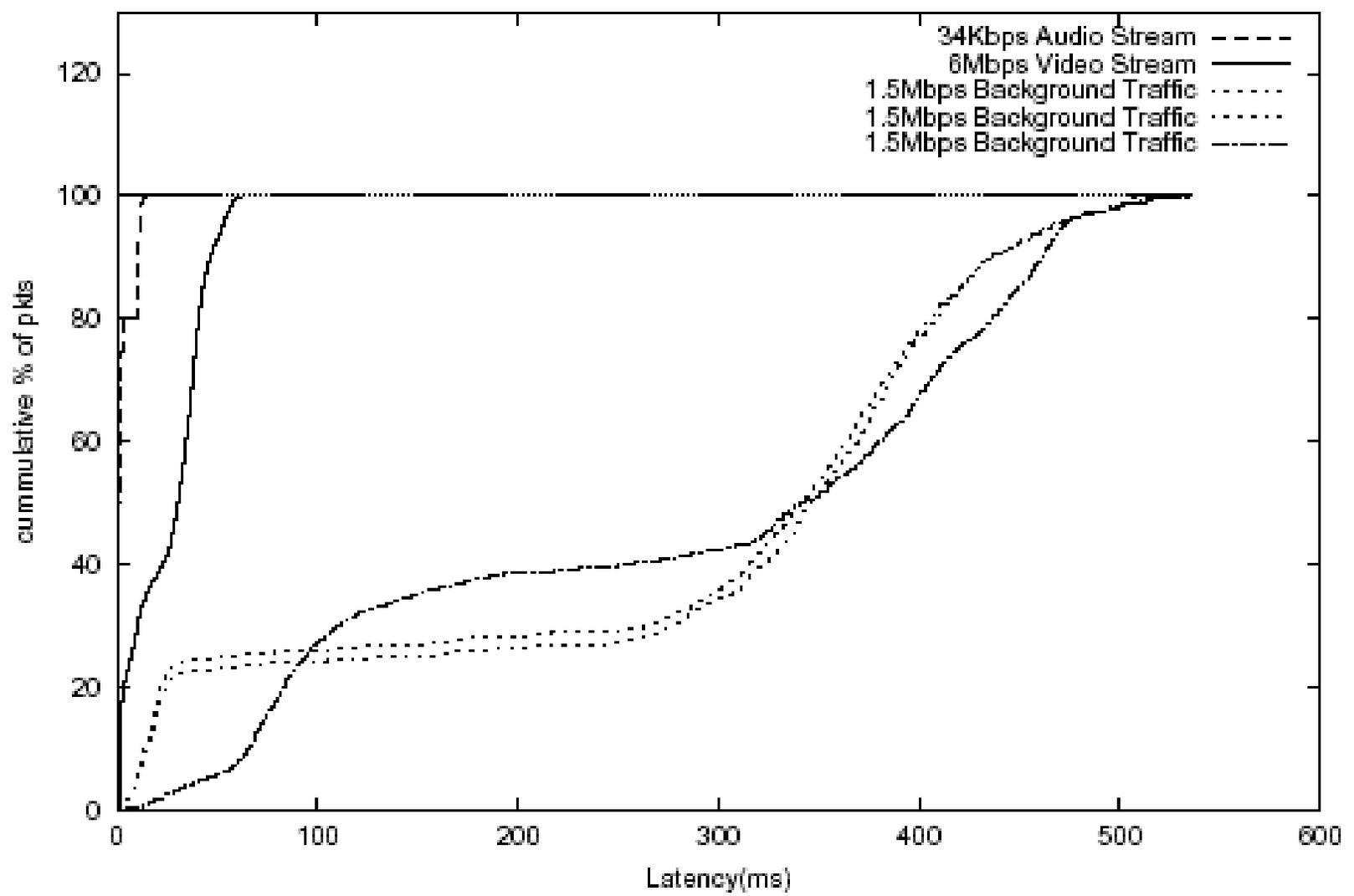
- ns2 – [2], [3], [4], [5]
- OPNET – [1]

Scenario 2: Running DCF -- Latency Distribution Plot
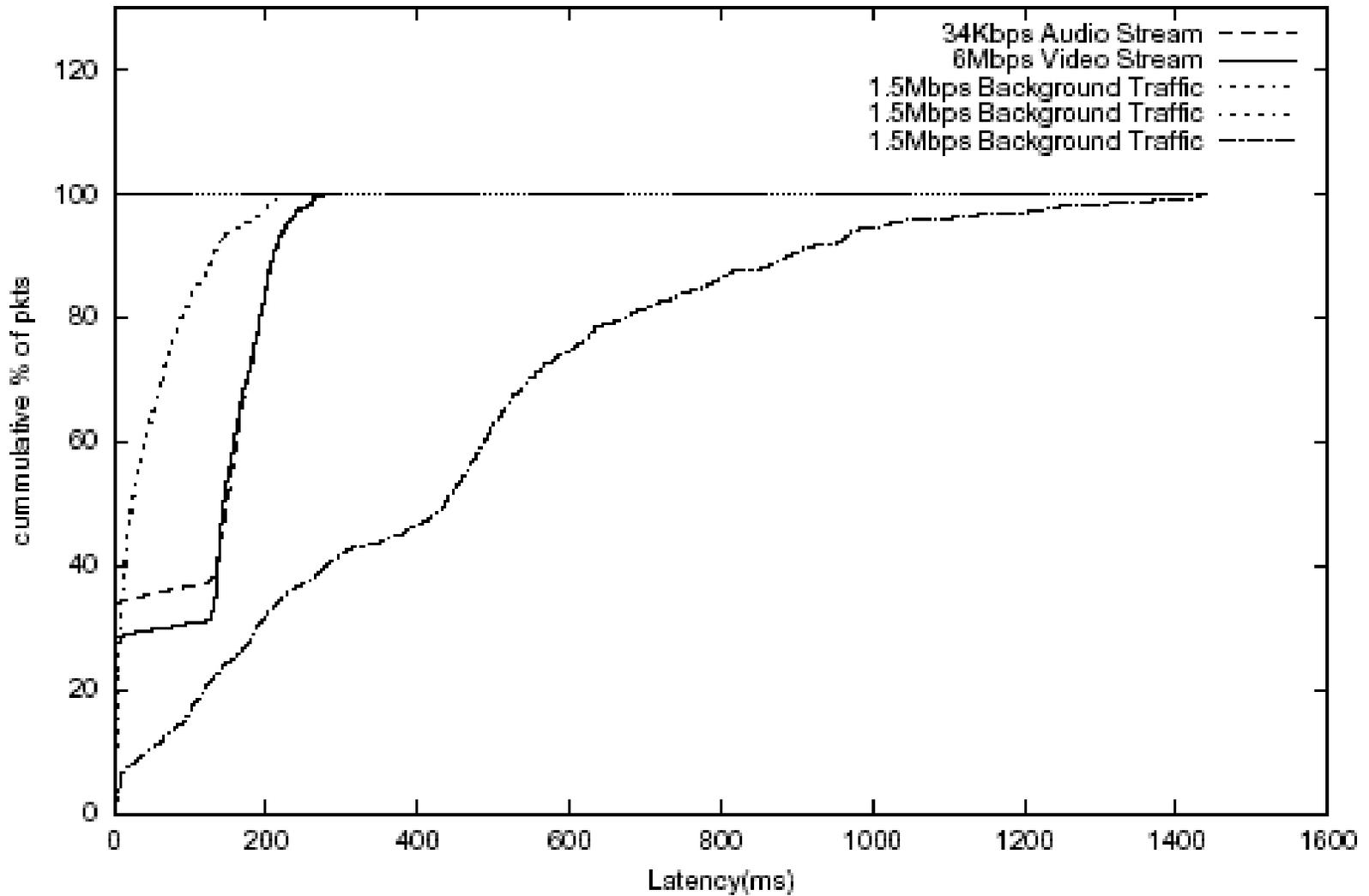
Scenario 2: Running EDCF -- Latency Distribution Plot

Scenario 2: Running HCF -- Latency Distribution Plot

Selfish Wireless Station [6]

- A wireless station can take advantage of the 802.11e scheme and arbitrarily set its traffic parameters to the *highest* priority (small AIFS, small backoff contention window, etc.)

- Not addressed in the standard

- possible solution: traffic parameters are set by the HC, instead of by individual stations.

Enhancement to 802.11e [4]

- WSTA piggybacks control information (More Data) to HC to indicate whether it needs to be pooled.

- The WSTA is pooled in CFP.

- No need for a QoS scheme in CP.

Wireless Redundancy Scheme [7]

- The QoS Scheme could be extended to support Redundant APs
- The primary AP functions in the contention period (CP) using DCF.
- The secondary AP functions in the contention free period (CFP) using PCF.
- Primary AP and Secondary AP coordinate with each other via wired link.

References

1. D. Gu and J. Zhang. "QoS enhancement in IEEE 802.11 wireless local area networks," IEEE *Communications Magazine,* June 2003, pp. 120-124.

2. Priyank Garg, et. al. Achieving Higher Throughput and QoS in 802.11 Wireless LANs, *IPCCC'03*, http://mosquitonet.stanford.edu/software/802.11e/

3. S. Mangold, et. al. *IEEE 802.11e Wireless LAN for Quality of Service , http://www.comnets.rwth-aachen.de/publications/Abstracts/MangoldChoi_EW02.html*

4. A. Velayutham and J. M. Chang, "An Enhanced Alternative to the IEEE 802.11e MAC Scheme", http://www.cs.iastate.edu/~vel/research/E-802.11.pdf

5. S. Choi, et. al. IEEE 802.11e Contention-Based Channel Access (EDCF) Performance Evaluation, ICC'03 http://path.berkeley.edu/dsrc/reading/03-ICC-EDCF.pdf

6. P. Kyasanur and N. Vaidya, "Detection and Handling of MAC Layer Misbehavior in Wireless Networks," Proceedings of the 2003 International Conference on Dependable Systems and Networks, June 2003, pp. 173-182.

7. D. Chen, et. al. "Dependability Enhancement for IEEE 802.11 Wireless LAN with Redundancy Techniques," Proceedings of the 2003 International Conference on Dependable Systems and Networks, June 2003, pp. 521-528.
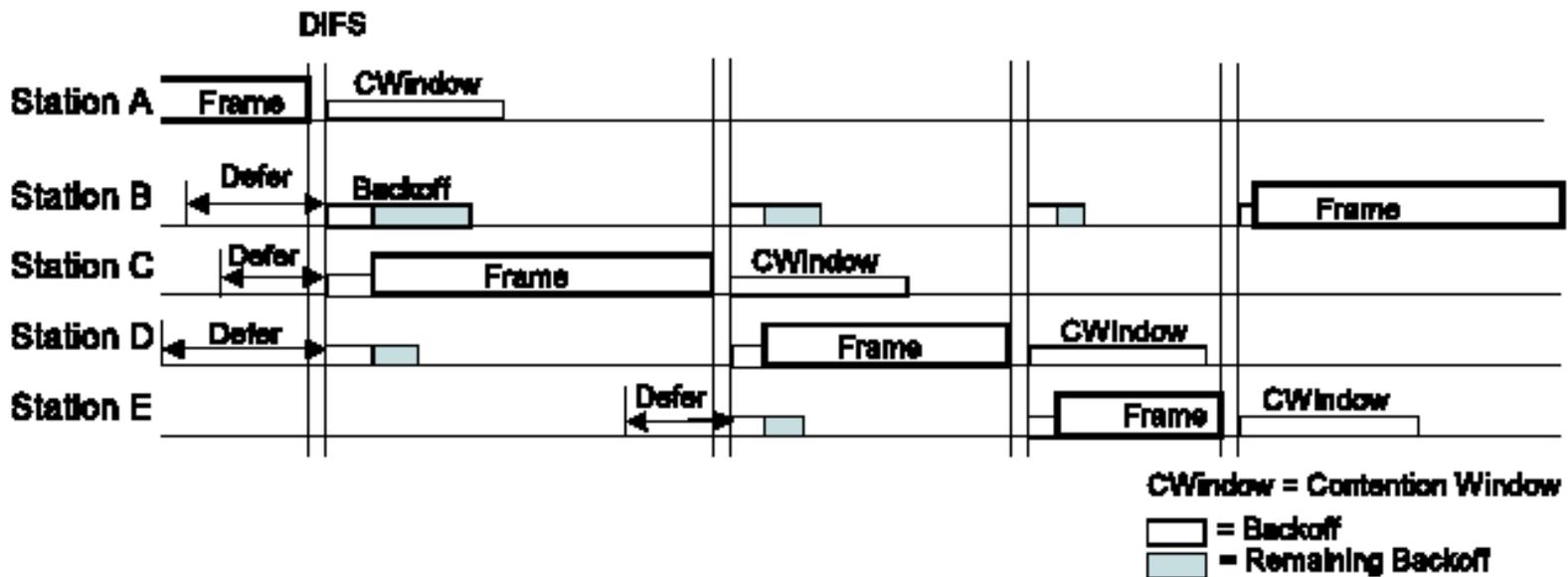
DCF Backoff Procedure

Figure 52—Backoff procedure