A Fair Scheduling Scheme for HCF

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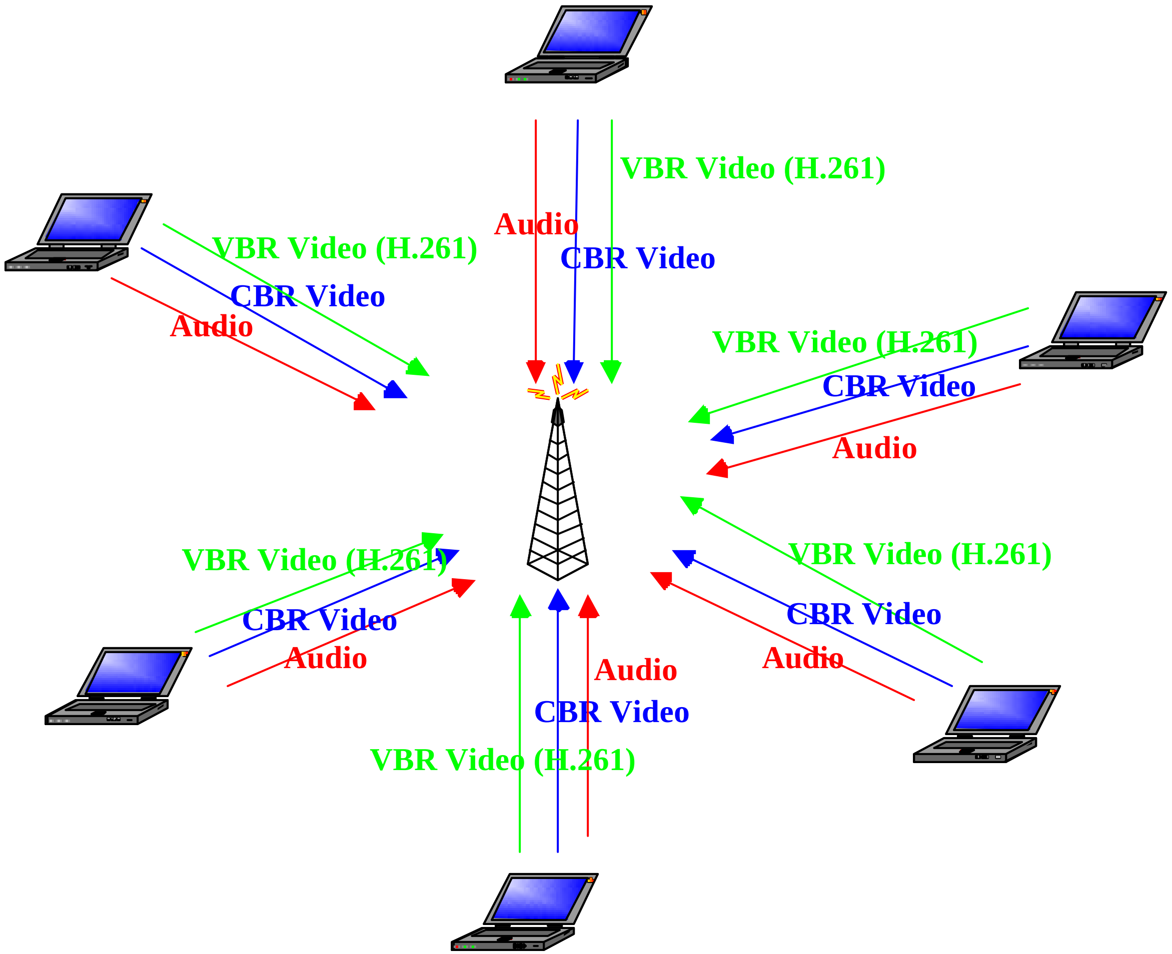
INTRODUCTION

- There is a simple round-robin scheduler in 802.11e D4.2 for HCF controlled channel access mechanism
- We have implemented 802.11e D4.2 HCF (HCCA and EDCF) in *ns* (network simulator)
- From simulation we found such a HCF scheduler is good for periodic CBR (Constant Bit Rate) traffic, but not good for VBR (Variable Bit Rate) traffic (such as Poisson, bursty traffic)

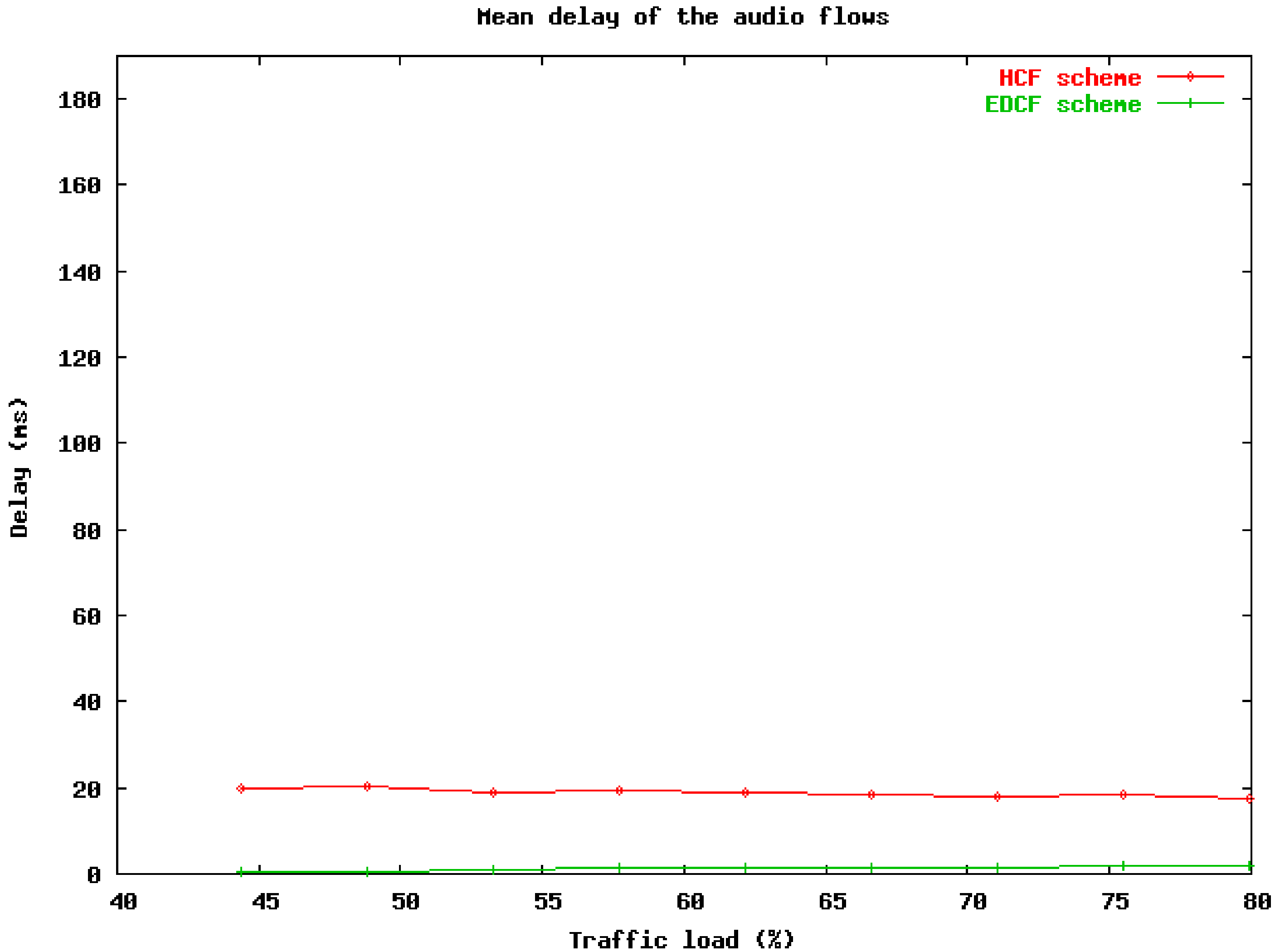


Simulation Topology 1: 6 QSTAs send three kinds of flow to QAP

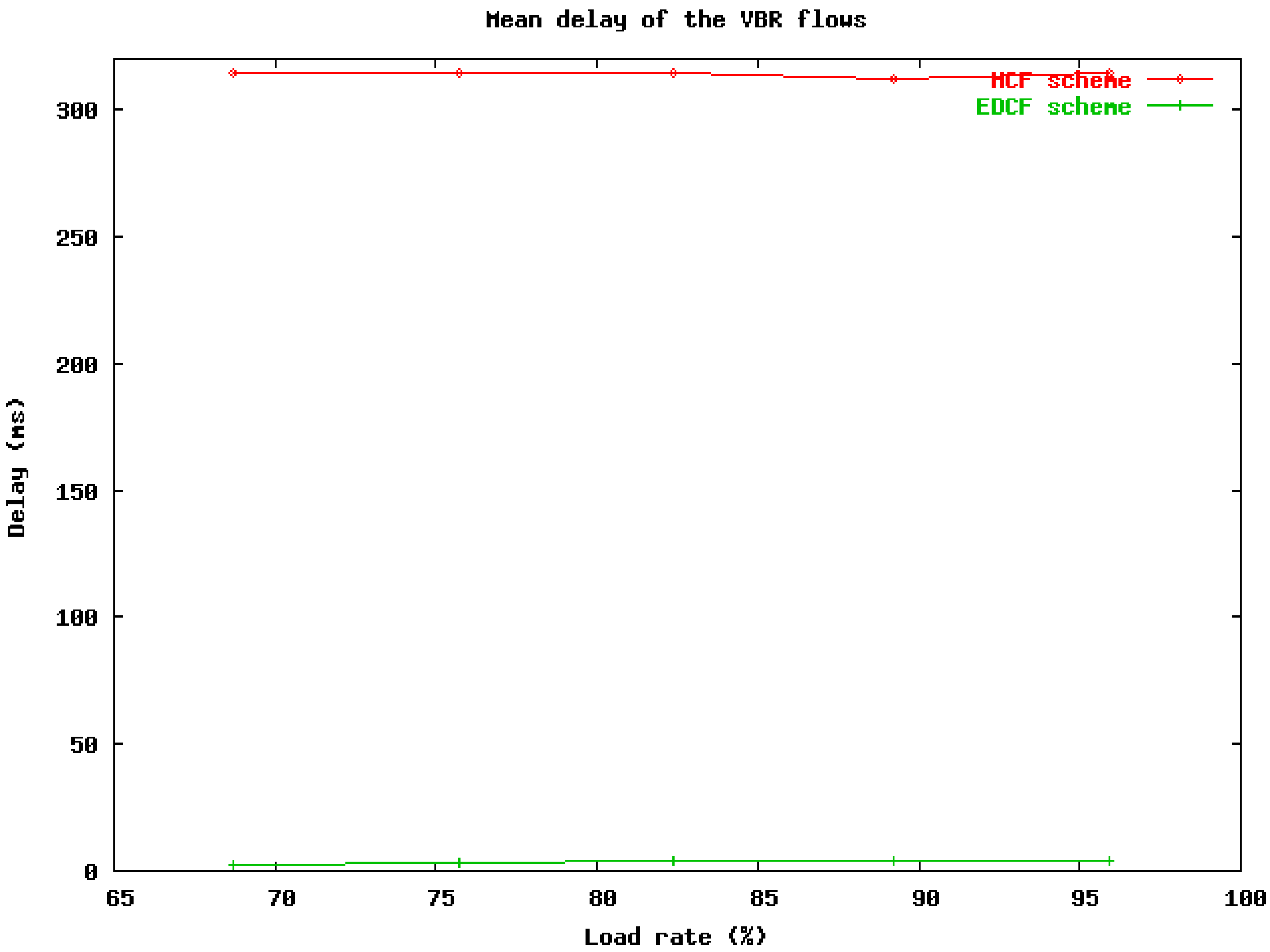
Simulation Parameters

- PHY layer: 802.11a rate 36Mbps
- Beacon interval: 500ms
- Audio: On-Off traffic, mean burst time: 400ms, mean idle time: 600ms
- VBR video: The VBR flows have been traced from the VIC video conferencing tool using H.261coding and QCIF format for typical “header and shoulder” video sequences (mean sending rate belongs to a window of 80Kb/s around the mean value of 200Kb/s, packet sizes of these flows belong to a large range of values between 20 and 1024bytes, and mean packet size is between 600bytes and 700bytes)
- CBR video: We increase the HCF load by increasing the packet size of CBR MPEG4 traffic from 600bytes (2.4Mb/s) to 1000bytes (4Mb/s)

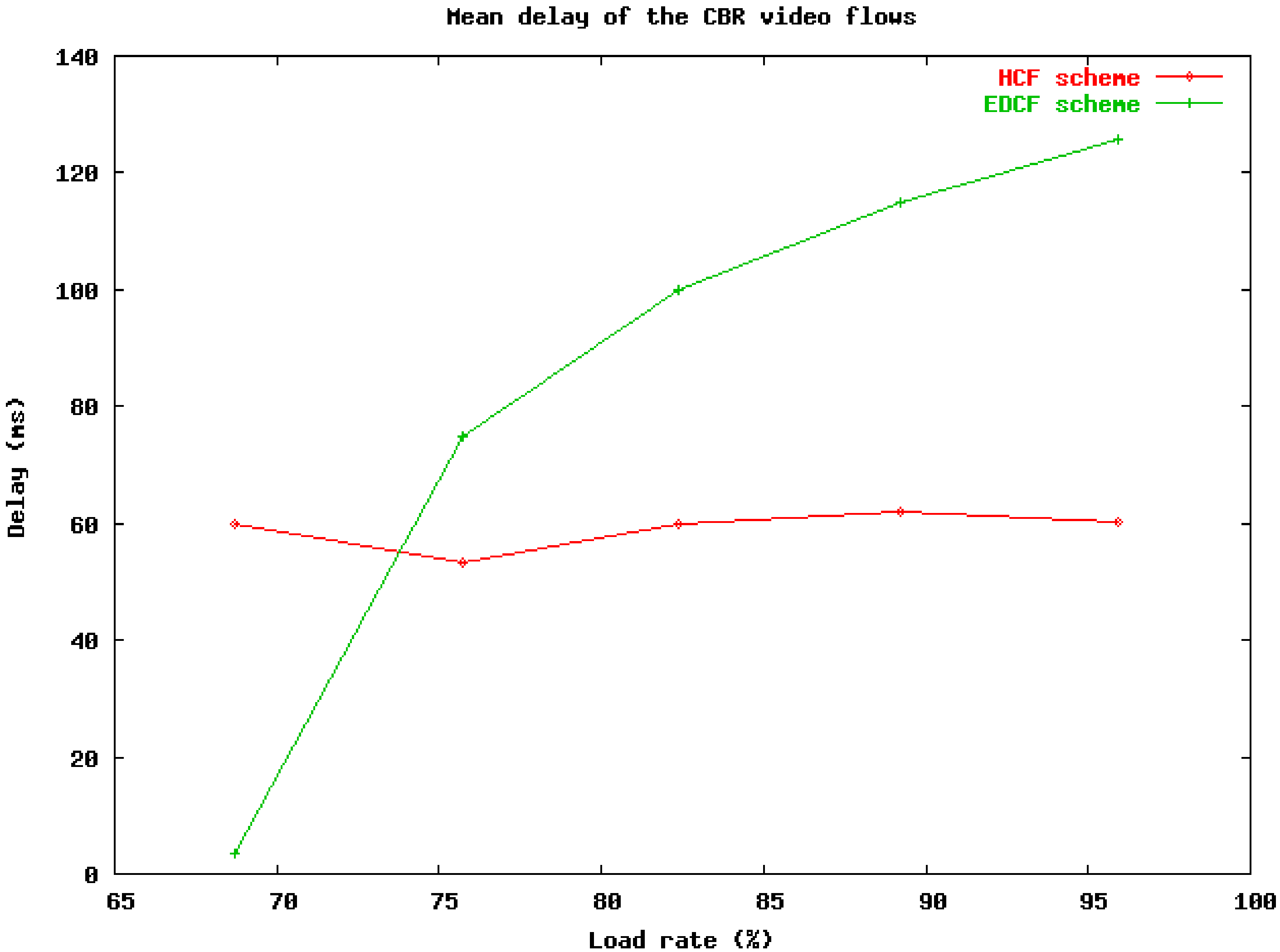
Application	Inter-arrival period (ms)	Packet size (bytes)	Sending rate (Kb/s)	Traffic Stream/User Priority	Maximal SI (ms)
Audio	4.7	160	64	TS6/UP6	50
VBR video	≈26	≈ 660	≈ 200	TS5/UP5	100
CBR video	2	600-> 1000	2400->4000	TS4/UP4	100



The mean delay of HCF audio is almost 20ms, and that of EDCF is much smaller



The mean delay of HCF VBR traffic is very high (about 300ms), and that EDCF remains smaller



The mean delay of HCF CBR traffic is almost 60ms, and that of EDCF increase according to the rate

Why HCF scheduler is good for periodic CBR (Variable Bit Rate) traffic, but not good for VBR (Variable Bit Rate)?

- Current scheduler computes the number of packets arriving in the TS queue *j* of QSTA *i* during a SI:

$$N_i^j = \left\lceil \frac{r_i^j \times SI}{M_i^j} \right\rceil$$,where r_i^j is the mean data sending rate

- However, for VBR traffic, the sending rate and packet size are varying, some packets may not be transmitted during the TXOP due to a higher sending rate than that specified in the TSPEC, in this case, latency of these packets can not be controlled by the QAP and some packets maybe dropped

Our solution

- First we derived a mathematic relationship between maximum delay, SI and queue length:

  $D_i = SI - T_i + \frac{q_i^e M_i}{r_i}$,where q_i^e is the queue length at the end

  of TXOP T_i, if $q_i^e = 0$, D_i can be almost equal to SI since $T_i << SI$
- The QAP computes the estimated queue length at the beginning of the next SI and the ideal queue length which provides $q_i^e = 0$

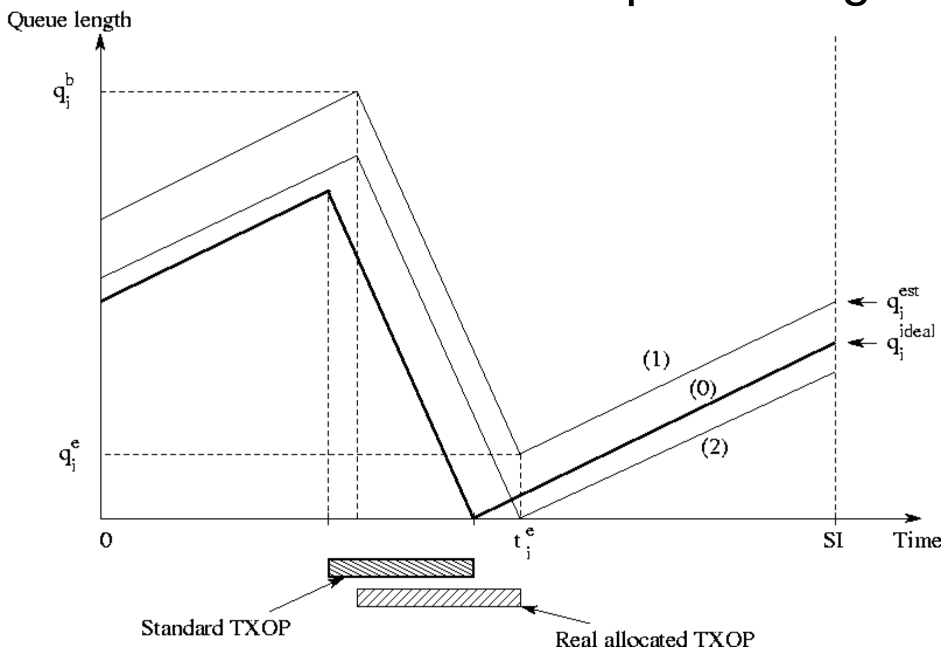
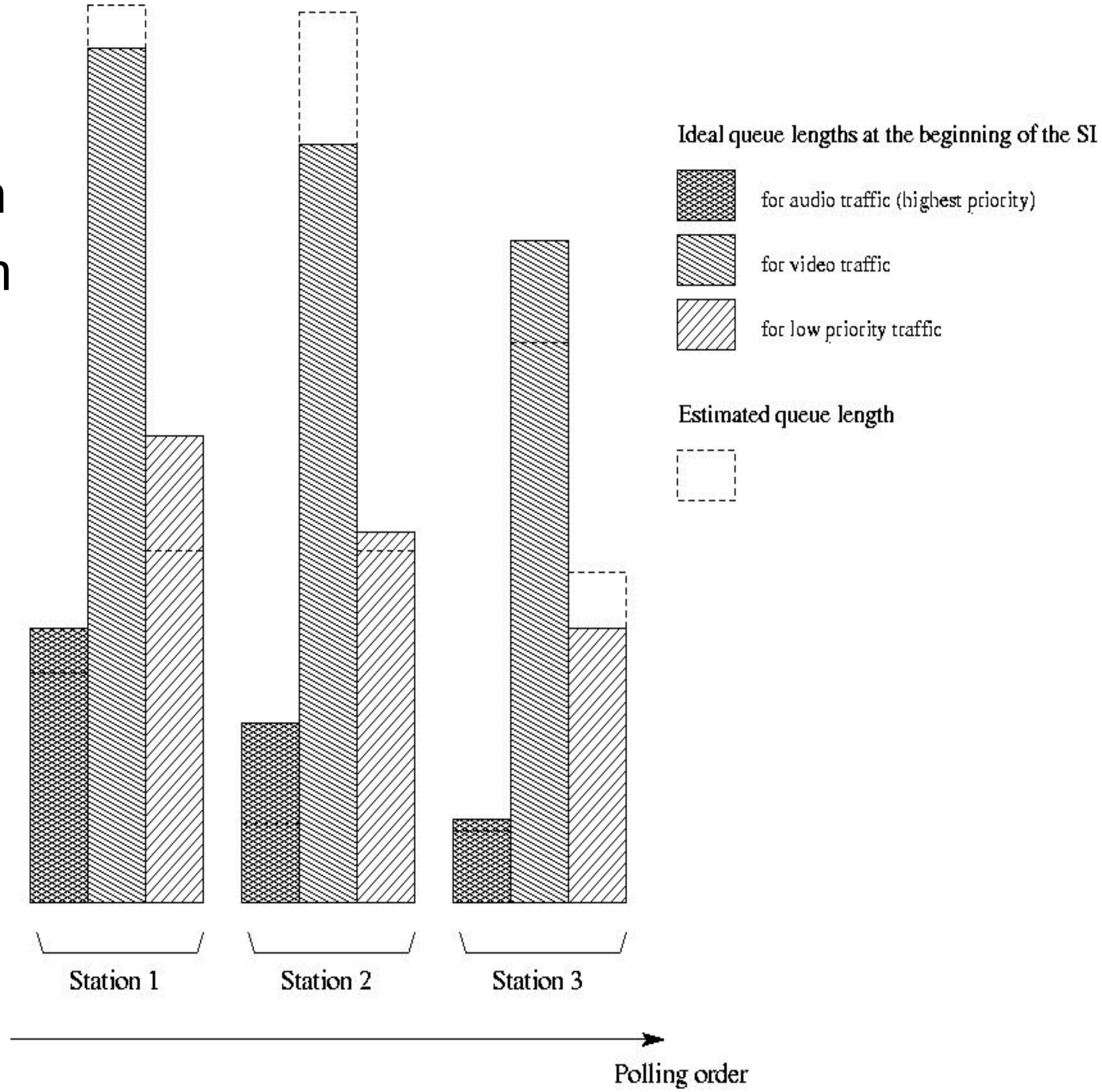


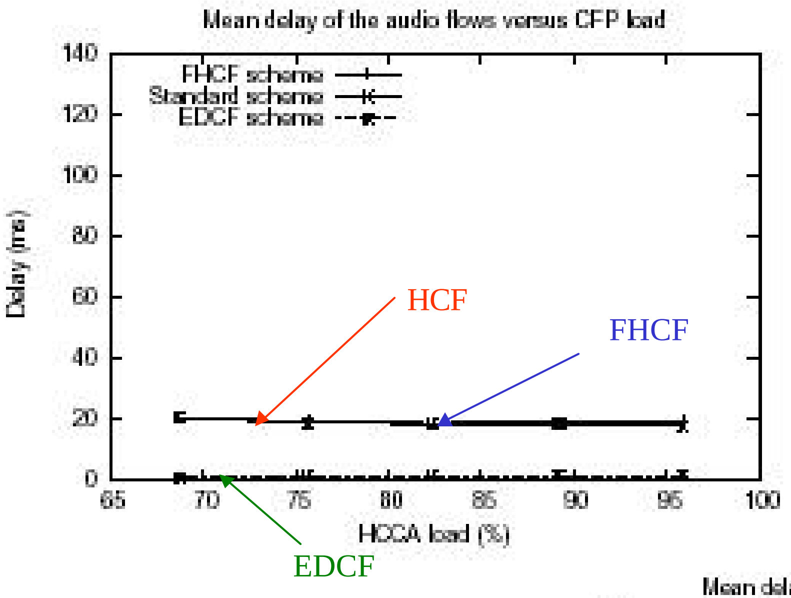
Fig. Queue length evolution for A TS: (0) ideal queue length; (1) $q_i^{est} > q_i^{ideal}$; (2) $q_i^{est} < q_i^{ideal}$

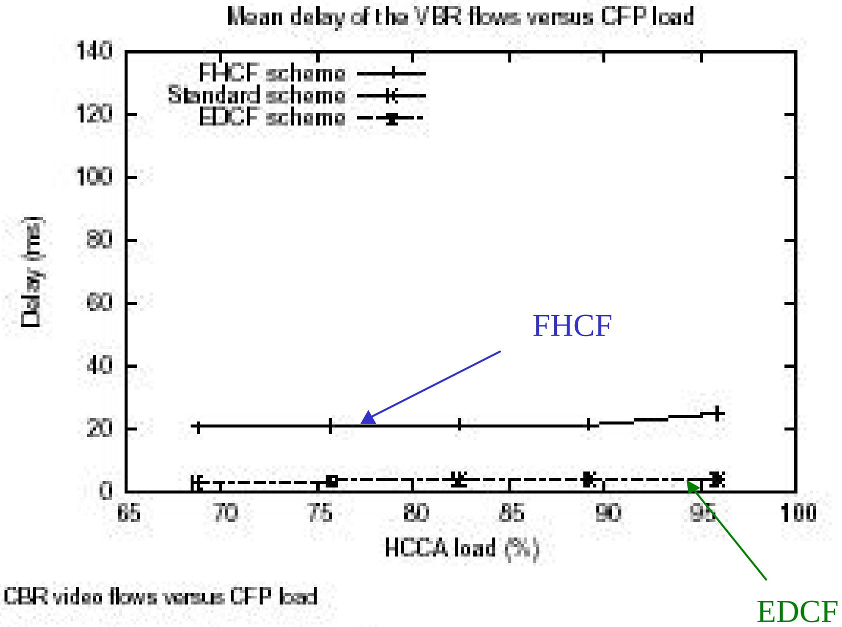
Our solution

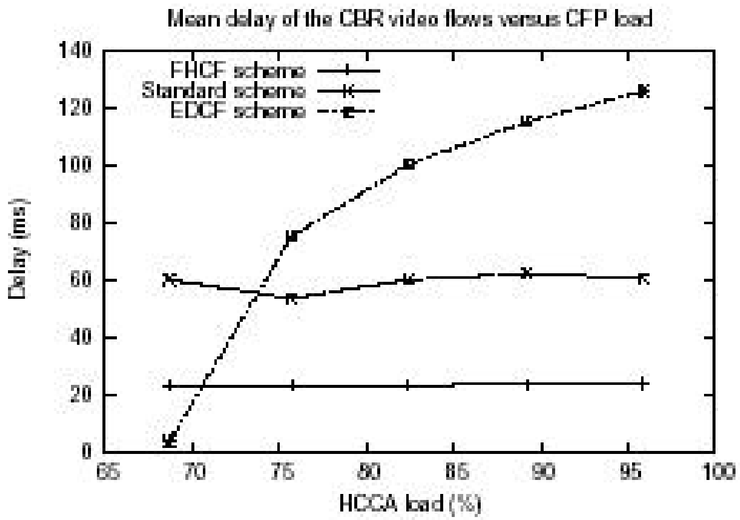
- Based on the difference between ideal queue length and estimated queue length the QAP calculates the additional time (positive or negative) to add to the TXOP
- The node scheduler recalculates the TXOP for each TS

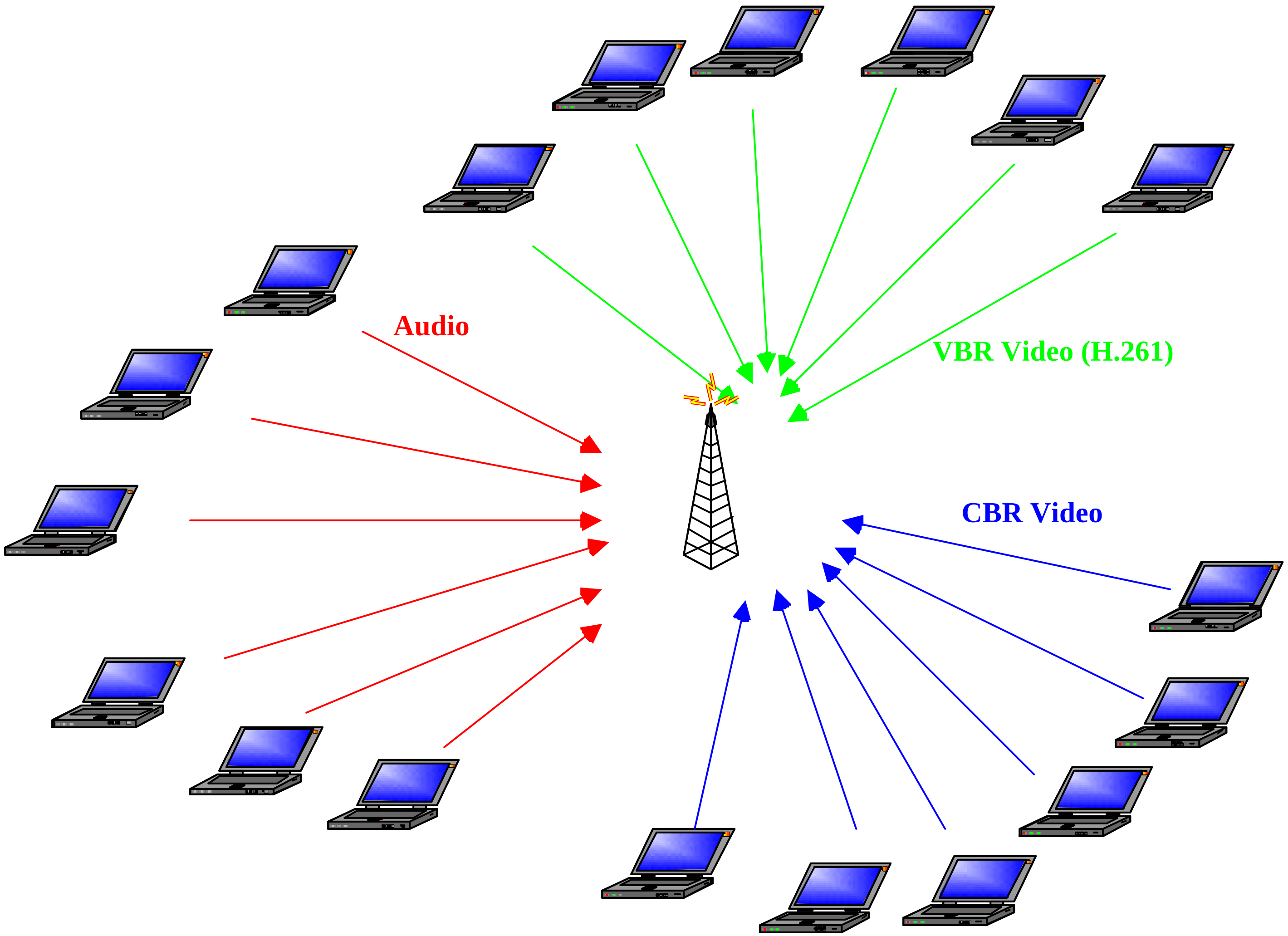


Simulation results







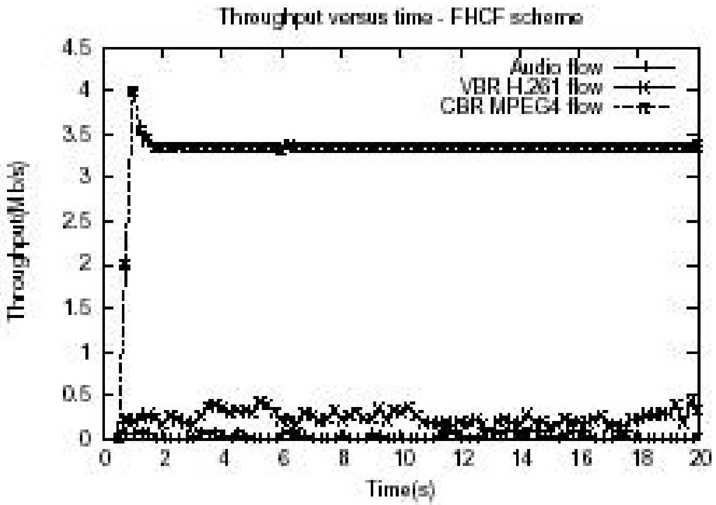


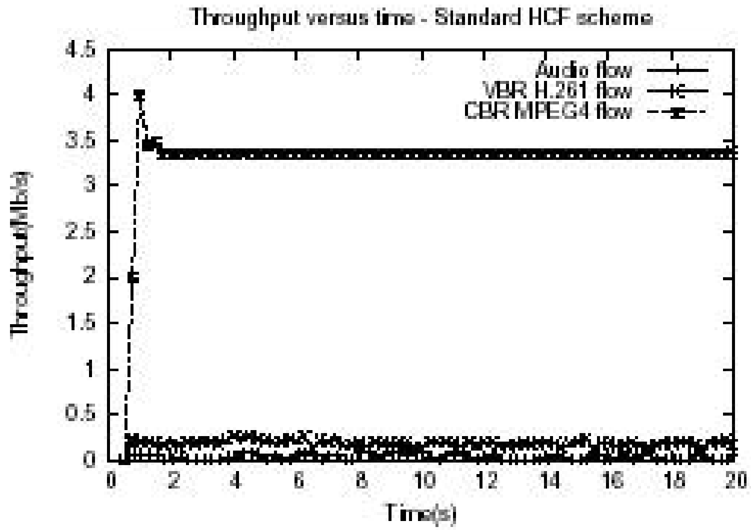
Simulation Topology 2

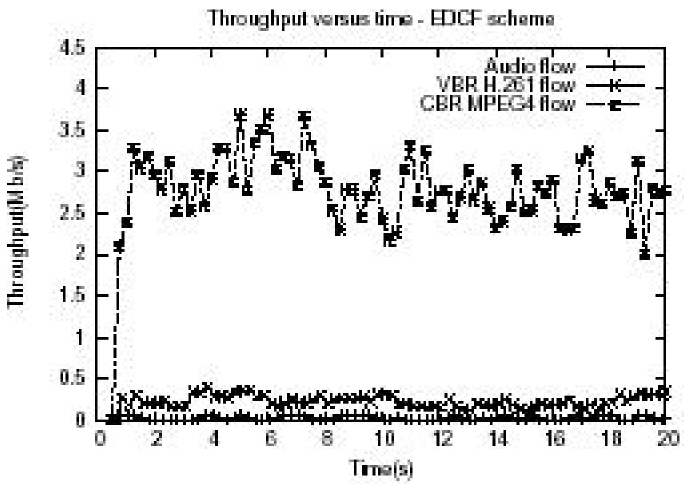
Simulation Parameters

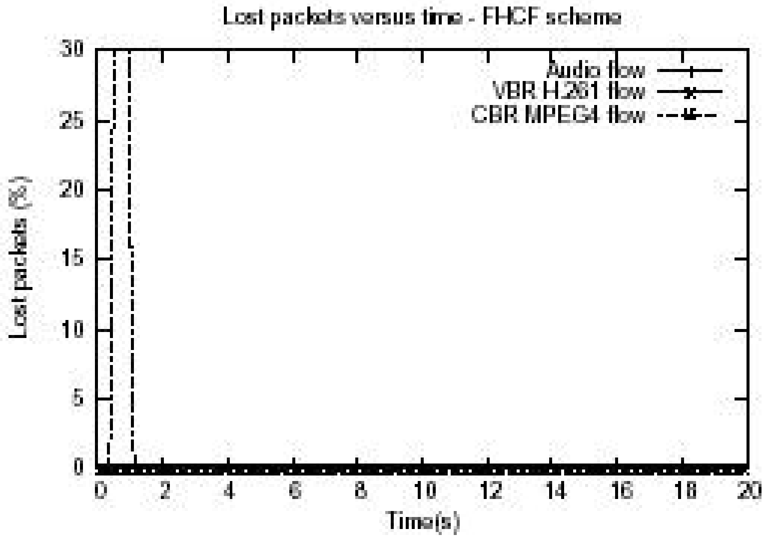
Application	Inter-arrival period (ms)	Packet size (bytes)	Sending rate (Kb/s)	Maximal SI (ms)
Audio	4.7	160	64	50
VBR video	≈26	≈ 660	≈ 200	100
CBR video	2	800	3200	100

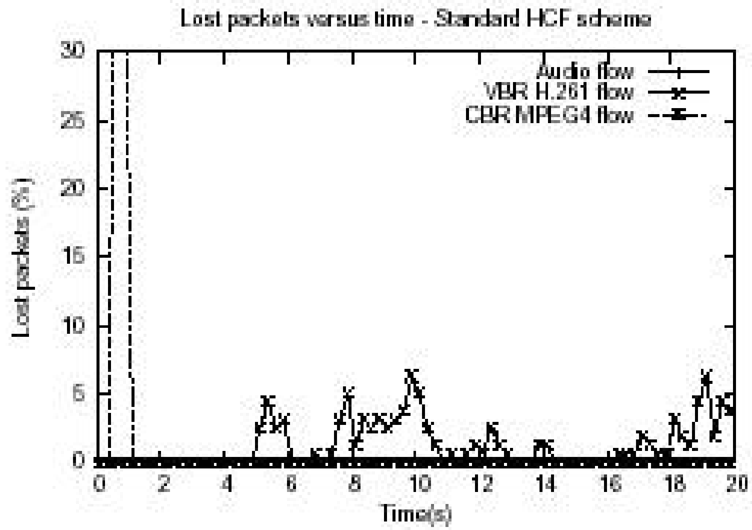
Simulation results





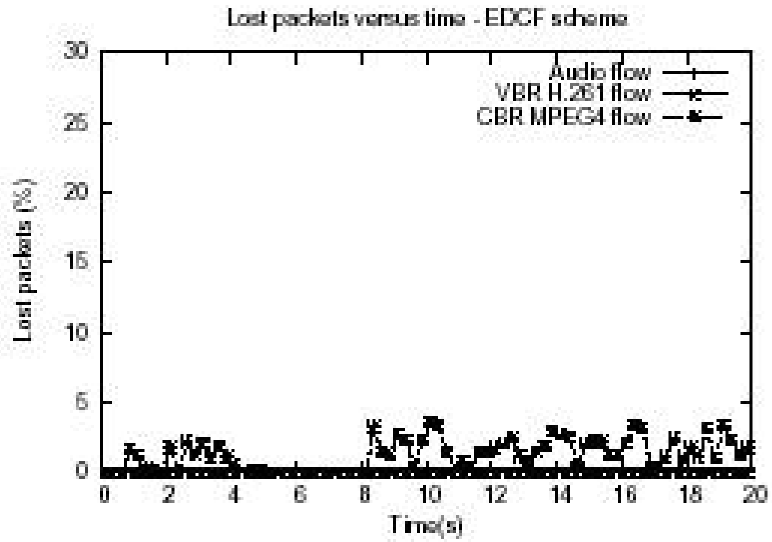


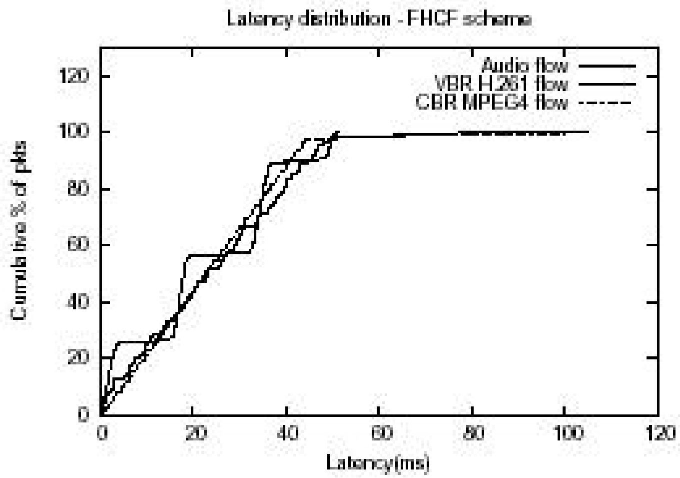


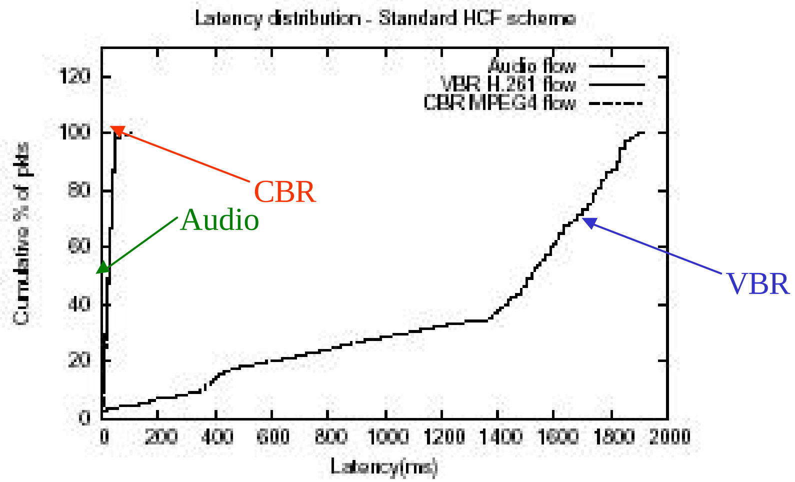


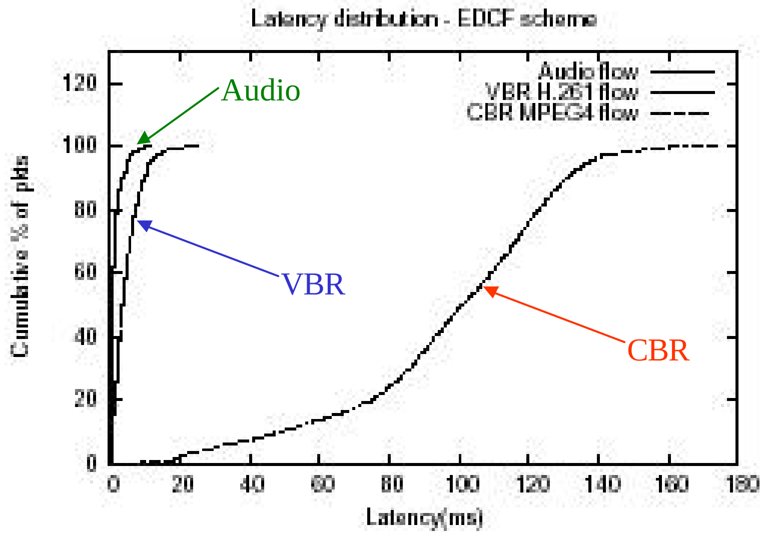
Number of lost packets

	Audio	VBR	CBR
FHCF	0	0	204
HCF	0	513	204
EDCF	1	3	8443




Latency distribution - FHCF scheme
Audio flow
VBR H.261 flow
CBR MPEG4 flow
Cumulative % of pkts
Latency(ms)
0
20
40
60
80
100
120


Latency distribution - Standard HCF scheme
Audio flow
VBR H.261 flow
CBR MPEG4 flow
CBR
Audio
VBR
Cumulative % of pkts
Latency(ms)
0
200
400
600
800
1000
1200
1400
1600
1800
2000


Latency distribution - EDCF scheme
Audio flow
VBR H.261 flow
CBR MPEG4 flow
Audio
VBR
CBR
Cumulative % of pkts
Latency(ms)
0
20
40
60
80
100
120
140
160
180

Conclusion

- HCF simple scheduler is good for periodic CBR (Constant Bit Rate) traffic, but not good for VBR (Variable Bit Rate) traffic (such as Poisson, bursty traffic)
- We proposed a fair scheduler which uses queue length estimations to tune its time allocations to stations
- Simulation results show that fair scheduler provides good fairness while supporting bandwidth and delay requirements for a large of network loads