Call Admission Control in EDCA-based WLANs (Initial Steps)

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Situation....

- Meeting event.
- IEEE 802.11 WLAN (WiFi).
- People uses their handbook to access Internet:
  - •Web pages.
  - •Mail.
  - •Message applicattions.
  - •Upload/Download files.
  - •VoIP?
  - •Video streaming?
  - •Video conference?

VoIP + TCP Performance

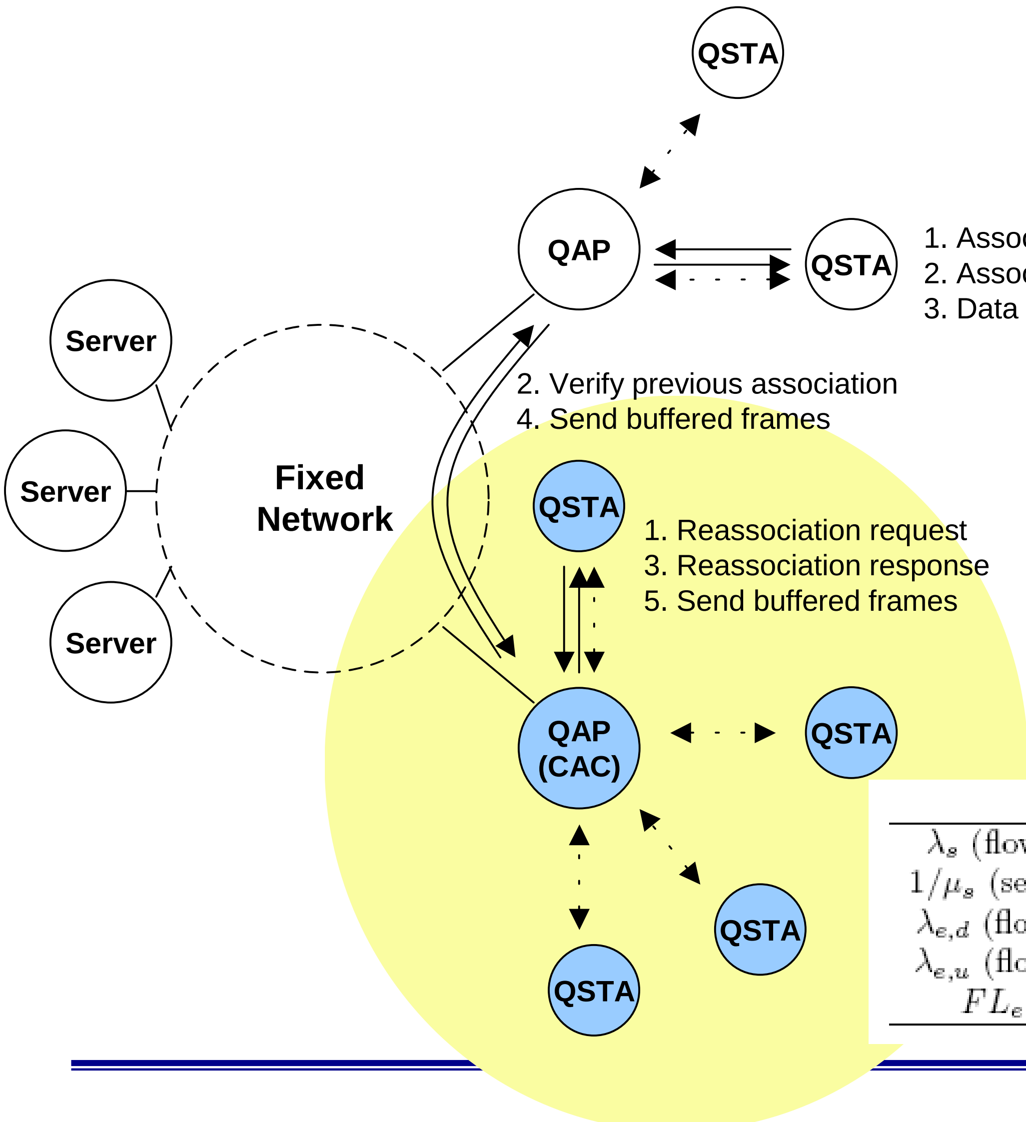
- Current limitations:
  - Only best-effort services (no QoS mechanisms).
  - Performance problems (not efficient use of resources) with simultaneous TCP-like and UDP-like traffic flows.
- <u>Example</u>: R_{data} = 2 Mbps, R_{basic} = 1 Mbps, RTS/CTS
  - Downlink TCP flows ↑ **à** simultaneous VoIP calls ↓.
  - A single TCP uplink flow "blocks" all current active calls!

	No TCP flows	TCP Downlink			TCP Uplink		
VoIP calls (G.729)		1	5	10	1	5	10
1	0.024	0.023	0.023	0.022	0.018	0.008	0.006
2	0.048	0.047	0.045	0.043	0.026	0.014	0.014
3	0.072	0.071	0.066	0.062	0.029	0.023	0.021
4	0.096	0.094	0.088	0.081	0.030	0.029	0.031
5	0.120	0.114	0.106	0.102	0.029	0.030	0.028
6	0.127	0.126	0.126	0.118	0.127	0.027	0.016

Table 5: Downlink throughput (at MAC layer) for VoIP calls in presence of TCP flows (Mbps)

- IEEE Solution: EDCA (Enhanced Distributed Channel Access).

Scenario



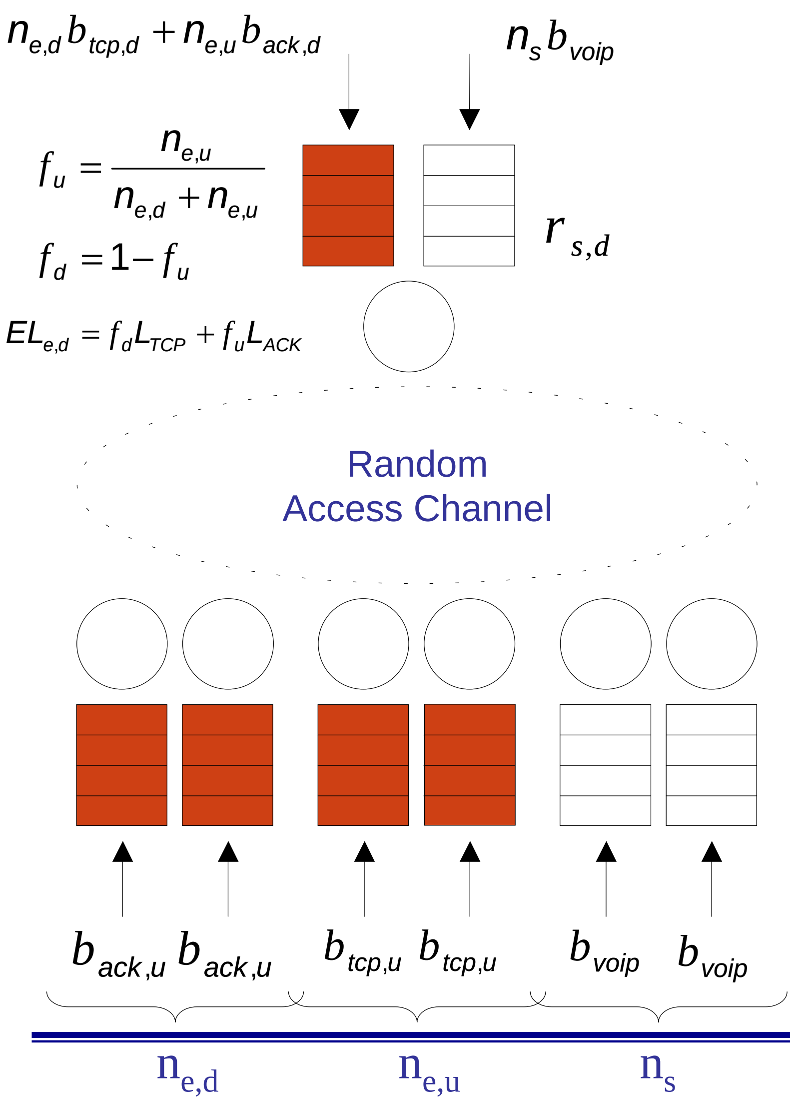
CAC schemes

- CWmin
- TXOP
- AIFS
- Combined

- Single BSS (single cell)
- Two traffic classes:
  - VoIP + TCP (up/down)
- No HO (future work)

	Scenario 1	Scenario 2	Scenario 3
λ_s (flows/second)	*variable*	0.0083	0.0083
$1/\mu_s$ (seconds/flow)	240	240	240
$\lambda_{e,d}$ (flows/second)	0.5	0.5	0.5
$\lambda_{e,u}$ (flows/second)	0.5	*variable*	0.5
FL_e (Mbits)	1, 2	1, 2	*variable*

BSS (cell) Model

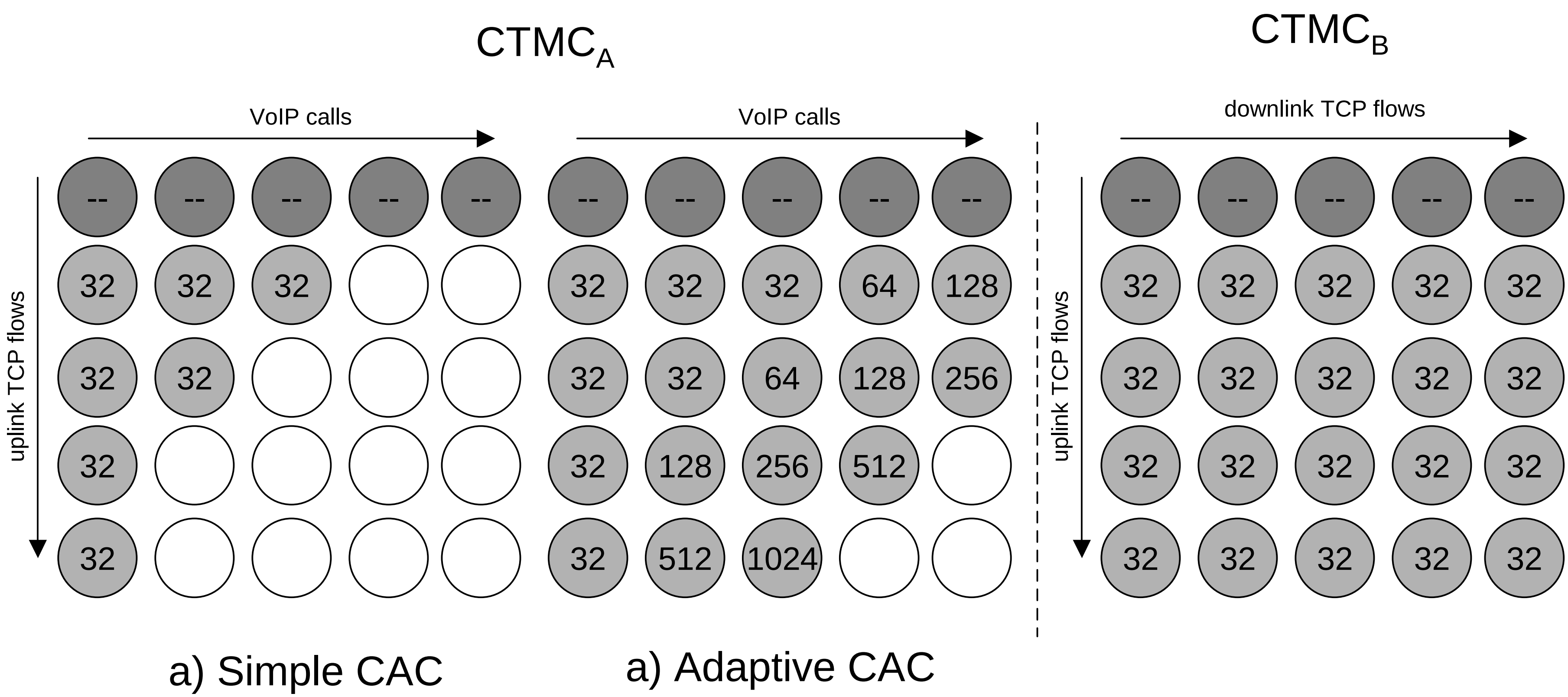


- All TCP (ACK) nodes are modelled as saturated sources
- A VoIP flow is modelled as a Poisson source.

- Model of a cell using 2 bi-dimensional CTMC.
- Decoupling assumption ($\rho_{s,d}$):
  - VoIP with only uplink TCP flows ($CTMC_A$)
  - Bi-directional TCP flows simultaneously ($CTMC_B$).

CAC description

- Modifies the CWmin parameter of elastic uplink TCP flows.



EDCA Model

- Each user is modeled as a $M/M^{[TXOP]}/1$ queue (bulk service time queue)
- TXOP (Burst length): consecutive number of frames transmitted at each successful attempt.

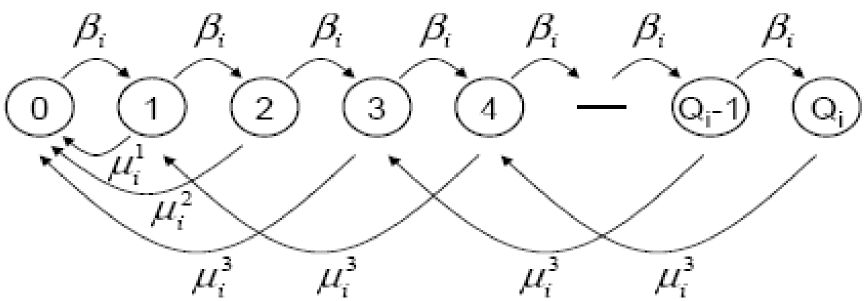


Figure 1: $M/M^{[TXOP_i]}/1/Q_i$, $TXOP_i = 3$

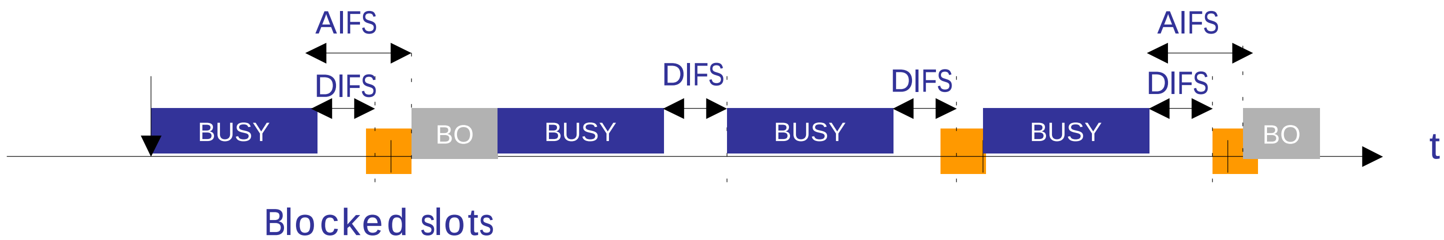
$$\begin{cases} \mu_i^{s_i} = 1/X_i^{s_i}, & s_i < TXOP_i; \\ \mu_i^{TXOP_i} = 1/X_i^{TXOP_i}, & s_i \geq TXOP_i. \end{cases}$$

$$\begin{cases} \nu_i = \beta_i \sum_{k=0}^{Q_i} \pi_{k,i} X_i^k, \\ \rho_i = \sum_{k=1}^{Q_i} \pi_{k,i} = 1 - \pi_{0,i}, \\ S_i = \sum_{k=1}^{TXOP_i} \pi_{q,i} \frac{k \cdot L_i}{X_i^k} + \sum_{k=TXOP_i+1}^{Q_i} \pi_{q,i} \frac{TXOP_i \cdot L_i}{X_i^{TXOP_i}} \end{cases}$$

$$\begin{cases} P_{b,i} = \pi_{Q_i,i}, \\ EQ_i = \sum_{k=1}^{Q_i} k \cdot \pi_{k,i}, \\ ED_i = \frac{EQ_i}{\lambda_i (1 - P_{b,i})} \end{cases}$$

EDCA Model

- Service Time $X_i^{TXOP_i} = (M-1)\left(AEB_i\alpha_i + ET_{c,i}^{ba||rts}\right) + AEB_i\alpha_i + T_{s,i}^{TXOP_i,ba||rts}$
- Arbitration Expected Backoff (AEB) $AEB_i = (EB_i + A_i) + p_{tr,i}\cdot EB_i \cdot A_i$



- Av. Slot duration $\alpha_i = p_{e,i}\sigma + p_{s,i}(ET_{s,i}^{TXOP_i,ba||rts,*} + \sigma) + p_{c,i}(ET_{c,i}^{ba||rts,*} + \sigma)$
- Channel Prob. $p_{e,i} = \prod_{j\neq i}(1-\tau_j)$ $\quad p_{s,i} = \sum_{z\neq i}\tau_z \prod_{j\neq z\neq i}(1-\tau_j)$ $\quad p_{c,i} = 1 - p_{e,i} - p_{s,i}$

EDCA Model

- Expected BackOFF slots

$$EB_i = \frac{1 - p_i - p_i(2p_i)^{m_i}}{1 - 2p_i} \frac{CW_{min,i}}{2} - \frac{1}{2}$$

- Cond. Collision Probability

$$p_i = 1 - \prod_{j \neq i} (1 - \tau_j)$$

- Transmission Probability

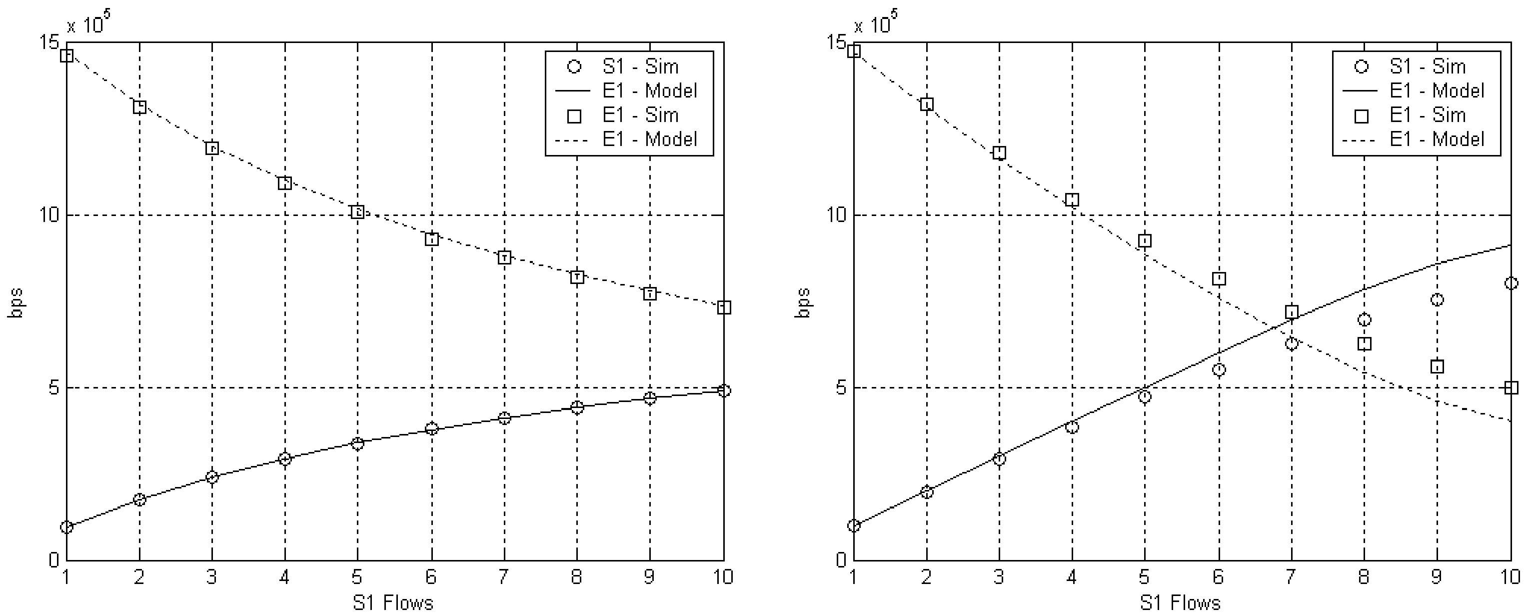
$$\tau_i = \frac{E[Pr(Q_i(t) > 0)]}{AEB_i + 1} = \frac{\rho_i}{AEB_i + 1}$$

Prob to access the channel = f(CWmin,TXOP,A)

EDCA Model (validation)

Traffic Flow	Bandwidth	Frame Length
Sat. ($E1$)	*max. avail.*	1500 B
Unsat. ($S1$)	100 $Kbps$	400 B

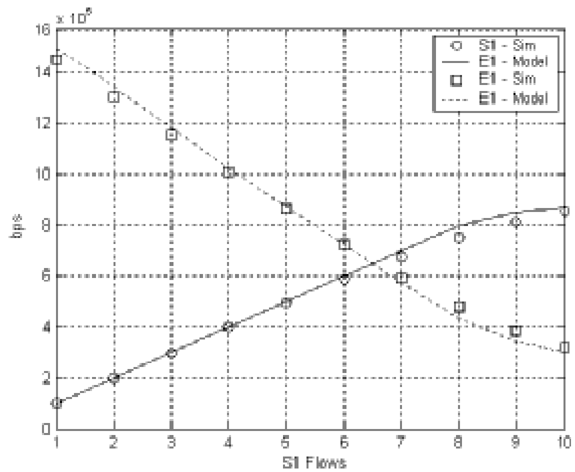
- 4 E1 flows (fixed)
- Variable S1 flows



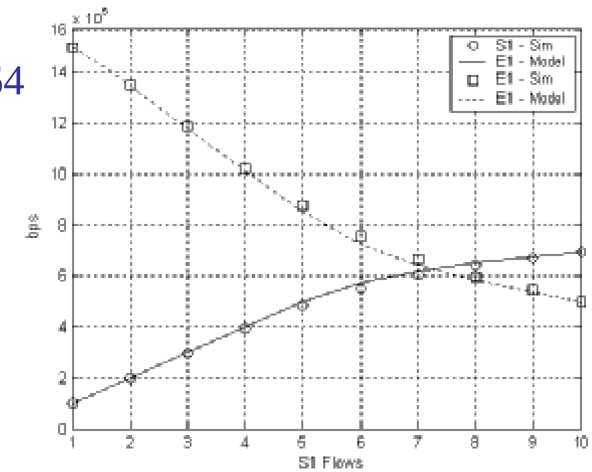
TXOP$_{S1}$=4

EDCA Model (validation)

$AIFS_{E1}$=3

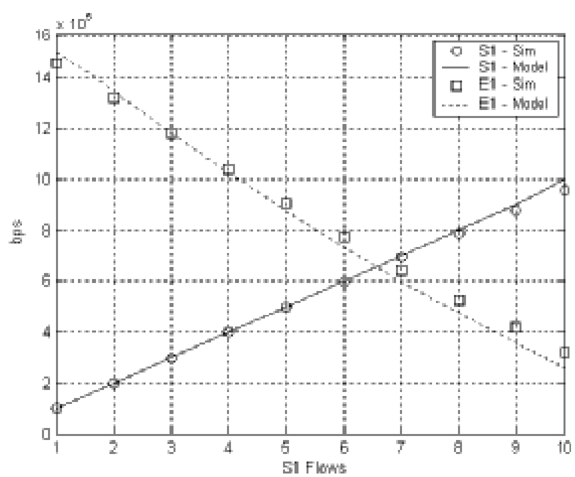


$CWmin_{E1}$=64



$AIFS_{E1}$=3

$TXOP_{S1}$=4



$AIFS_{E1}$=3

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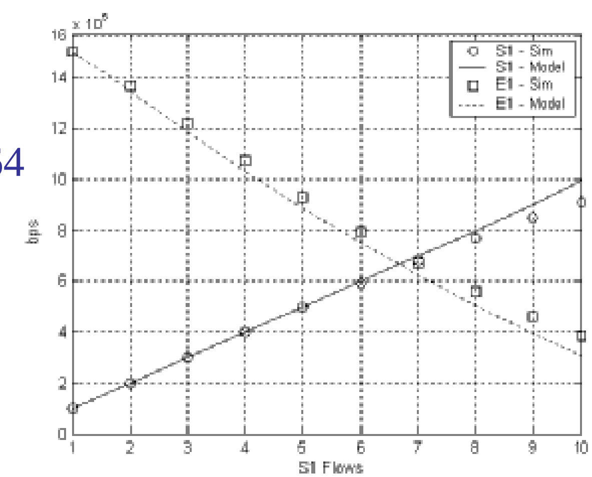


Results. DCF – CAC: CWmin

Parameters

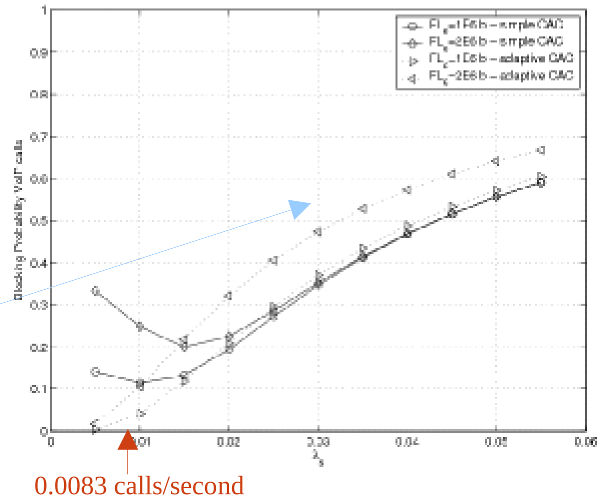
- simple (CWmin = 32)
- CAC:CWmin
  - TCP:CWmin adaptive (32 – 1024)

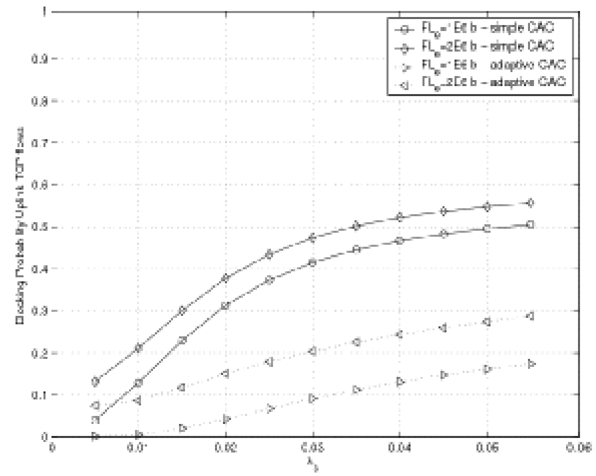
CAC: worst results?

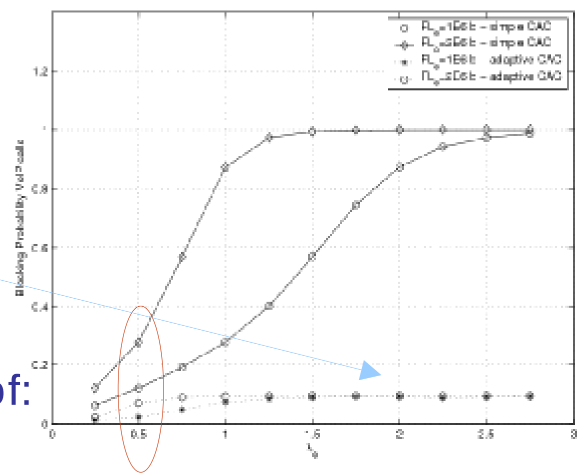
- TCP:CWmin ↓
- CWmin (Max) = 1024
- Fle à $1/\mu_{e,u}$ ↑
- No preemption of active flows

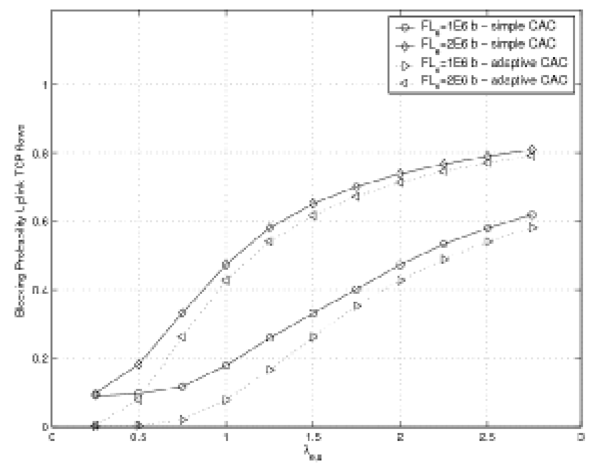
Ø High blocking Prob VoIP!

- Low sensibility to increments of arrival rate of uplink TCP flows.
- Improves the performance of:
  - VoIP calls.
  - TCP uplink flows.









Future (current) Work

- Traffic Differentiation: AIFS, CWmin.
- TXOP ↑ reduce the congestion of a node when:
  - it is overloaded by its own traffic.
  - can achieve enough channel access to avoid starvation.

- Understanding the benefits / drawbacks of tuning the different EDCA parameters.
- A CAC algorithm able of finding the optimal parameters in run-time.

- A more accurate user and MAC model:
  - $G/G^{[TXOP]}/1/Q$
  - AIFS (blocked slots).
  - Non ideal channel conditions (BER, FER)
- Consideration of HO (HO prioritization).
- Enhance the MAC simulator to include CAC algorithms (flow level behaviour).