Admission Control Scheme in 802.11e Networks

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Seminar History

- 2005. 6. ‘A Survey of Quality of Service Enhancements for IEEE 802.11 Networks’
- 2005. 8. ‘An Efficient Scheduling Scheme for IEEE 802.11e WLAN based on Fuzzy Prediction’
- 2005. 10. ‘An Efficient Scheduling Scheme for IEEE 802.11e WLAN - Fuzzy AR approach’
- 2005. 12. ‘Admission Control Scheme in 802.11e Networks’ - Paper

http://folk.uio.no/paalee/
Contents

- **Introduction**
  - Importance of the issue
  - Existing results & their limitations
  - Problem statement

- **Preliminaries**

- **Proposed algorithm**

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Introduction

- IEEE 802.11e standard
  - MAC procedures to support real-time services with QoS requirements
  - Multimedia applications (e.g. voice, audio, video)

- Admission control in IEEE 802.11e
  - To ensure that admittance of a new flow does not violate parameterized service
  - Important component for the provision of guaranteed QoS
Introduction

Related work & their limitations

1. Markov chain model-based admission control [1]
   - Based on the predicted achievable throughput for each flow
     \[ S_i = \frac{P_{si} \times E[P]}{P_c \times T_c + P_{idle} \times aSlotTime + P_s \times T_s} \]
   - Admission control algorithm

        if(request_bw[i] > achievable_throughput[i]) {
            reduce CW or increase TXOP;
            re-estimate achievable throughput;
        }

        if(CW or TXOP limit is reached) {
            reject new flow;
            restore to original parameters;
            exit program;
        }

        admit new flow;
Introduction

- Related work & their limitations
  - 1. Markov chain model-based admission control
    - Analytical model is not accurate at all - Bianchi’s model
    - No consideration of delay
Introduction

Related work & their limitations

2. Contention window based admission control \textsuperscript{[2]}

- Dynamic CW values adjustment for each STA

- CW set \( \{CW_1, \ldots, CW_n\} \)
- Throughput requirements set \( \{R_1, \ldots, R_n\} \)
- \( r_i \): actual throughput of STA \( i \)
- A new station \( (n+1) \) with \( R_{n+1} \) accepted when

\[
\forall \ i \in \{1, \ldots, n+1\}, \quad r_i' \geq R_i
\]

- Inaccurate analytic model (virtual collision), no consideration of delay
Introduction

Related work & their limitations

3. Admission control to provide guaranteed delay \cite{3}

- Analysis of delay distribution

\[ E[W] = \frac{w_0(1-p-2^m p^{m+1}) + 2}{2(1-p)(1-2p)} \left( \sigma(1-P_{tr}) + T_s P_{tr} P_d + T_c P_{tr} (1-P_d) \right) \]

- QoS requirement \([d, p_g]\) (e.g. \([d = 40\text{ms}, p_g = 0.95]\) )

- Admission control based on MAC service time

\[ \text{Prob}(\tau < d) \geq p_g \]

- No consideration of queueing delay, throughput requirements
Introduction

- **Problem statement**
  - Design admission control scheme for IEEE 802.11e networks
    - Consider QoS requirements such as throughput, delay
    - Algorithm based on closed-form solution

- **Assumption**
  - Saturation condition: worst-case
IEEE 802.11e contention based channel access

- QoS parameter
  - $CW_{min}[AC]$
  - $CW_{max}[AC]$
  - $AIFS[AC]$
  - $TXOPLimit[AC]$

- Virtual collision handling
Preliminaries

- **AIFS differentiation**

- **TXOP (transmission opportunity) management**
Preliminaries

- QoS requirements & performance metrics
  - Throughput
  - Packet loss
  - Average transmission delay
  - Delay jitter
    - Fluctuation/variation of end-to-end delay from one packet to the next packet
Proposed Algorithm

- **Throughput of AC₃ (voice), AC₂ (video)**
  - Transmission probability \( \tau \) of AC₃, AC₂ are given by [4]
    
    \[
    \tau_3 = \frac{2}{W_{3,0} + 1}
    \]
    
    
    \[
    \frac{1}{\tau_2} = \frac{(1 - 2\tau_3)}{2(1 - \tau_3)} + \frac{W_{2,0}(1 - (2\tau_3)^{m_i})}{2(1 - 2\tau_3)(1 - \tau_3^{L_i+1})} + \frac{W_{2,0}(2\tau_3)^{m_i}(1 - \tau_3^{L_i-m_i+1})}{2(1 - \tau_3)(1 - \tau_3^{L_i+1})}
    \]

- Throughput received by STA of AC \( i \)
  
  \[
  r_i = \frac{\tau_i (1 - \tau_i)^{n_i-1} \prod_{j \in \{1,\ldots,N\} \setminus i} (1 - \tau_j)^{n_j}}{T_{\text{slot}}} l
  \]
Proposed Algorithm

**Access delay of \( AC_3 \)(voice), \( AC_2 \)(video)**

- Access delay of 802.11e can be obtained from modification of the result of [5]
- [5] models access delay phase-type distribution using absorbing Markov chain
- Expected channel delay conditioned on a Backoff value

\[
E[D_{\text{access}} | B] = \frac{B(1 + P_c (L_c - 1) + P_d (L_d - 1))}{1 - P_c - P_d} = B \cdot \bar{t}_B
\]

\[
p_d = (N - 1) \cdot \tau_c (1 - \tau_c)^{N-2} \quad p_c = 1 - (1 - \tau_c)^{N-1} - p_d
\]

\[
L_{d_{\text{RTS}}} = L_{\text{RTS}} + L_{\text{SIFS}} + L_{\text{CTS}} + L_{\text{SIFS}} + L_{\text{DATA}} + L_{\text{SIFS}} + L_{\text{ACK}} + L_{\text{AIFS}[AC_i]}
\]

\[
L_{d_{\text{noRTS}}} = L_{\text{DATA}} + L_{\text{SIFS}} + L_{\text{ACK}} + L_{\text{AIFS}[AC_i]}
\]
Proposed Algorithm

- **Access delay of AC₃(voice), AC₂(video) - cont’**
  - Expected MAC layer access delay conditioned on contention window $w$
    \[
    E[D_{access} \mid w] = \sum_{b=0}^{w-1} \frac{1}{w} \cdot b \cdot \bar{t}_B = \frac{w-1}{2} \cdot \bar{t}_B
    \]
  - Unconditional expected MAC layer access delay conditioned on contention window $w$
    \[
    E[D_{access}] = \sum_{i=1}^{M} \frac{w_i - 1}{2} \cdot \bar{t}_B \cdot \pi_{w_i} = \frac{\bar{W} - 1}{2} \cdot \bar{t}_B
    \]
    \[
    \pi_{w_i} = \begin{cases} 
    (1 - p_c - p_d) \cdot (p_c + p_d)^{i-1}, & i = 1, \ldots, M - 1 \\
    (p_c + p_d)^{i-1}, & i = M 
    \end{cases}
    \]
Proposed Algorithm

- **Overall delay of AC₃(voice), AC₂(video)**

\[
D = D_{queueing} + D_{access} + D_{transmission}
\]

- **Transmission delay**

\[
D_{transmission} = \frac{L_{DATA}}{R}
\]

- **Queueing delay in case of G/G/1**

\[
D_{queueing} \leq \frac{\lambda(\sigma_a^2 + \sigma_b^2)}{2(1 - \lambda(D_{access} + D_{transmission}))}
\]

- \( \lambda \): avg. packet interarrival time
- \( \sigma_a^2 \): variance of packet interarrival times
- \( \sigma_b^2 \): variance of delays
Proposed Algorithm

- Admission control

if new traffic is voice or video, \( N_Q = N_Q + 1 \)

Estimate \( r_i, E[D_i] \) for each traffic \( i \) (\( 1 \leq i \leq N_Q \) )

\[
\text{for } i = 1 \text{ to } N_Q ,
\]

\[
\text{if } r_i \leq R_i \text{ or } E[D_i] \geq \text{Delay Bound}_i
\]

reject the request

exit

end if

end for

accept the request; update \( \tau_3, \tau_2 \)
Conclusion & future work

- Design admission control scheme for IEEE 802.11e networks
  - Consider QoS requirements such as throughput, delay
  - Algorithm based on closed-form solution

- Future work
  - Consideration of TXOPlimit
  - Ns-2 simulation
References


