Analytical Model for IEEE 802.11 DCF Supporting Service Differentiation (Extended Abstract)

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Abstract: - This paper considers the problem of providing relative service differentiation in IEEE 802.11 Wireless LAN by using different Medium Access Control (MAC) parameters for different service classes. An analytical model is presented which predicts the saturation throughput of IEEE Distributed Coordination Function with multiple service classes. Though the model considers almost all MAC parameters for service differentiation, the influence of Distributed InterFrame Space is our main concern in this paper. With help of the analytical model, system performance can be evaluated easily. Simulation results are shown to validate the analytical model.

Key-Words: - 802.11 WLAN, Media Access Control, Quality of Service, Network Performance

1 Background
In recently years, IEEE 802.11 Wireless Local Area Network (WLAN) has achieved great commercial success. Today’s 802.11 WLAN can be considered as a wireless version of Ethernet, which supports best-effort service. However, the interest in wireless networks supporting QoS has recently grown. The IEEE 802.11 Working Group established an activity to enhance the current 802.11 MAC protocol to support applications with QoS requirements. In the upcoming new standard IEEE 802.11e [1], Mac parameters, such as Contention Window (CW), Distributed InterFrame Space (DIFS), Persistence Factor (PF) and maximum backoff stage, are all changeable for service differentiation use. Some mechanisms providing service differentiation in Distributed Coordination Function (DCF) have been proposed. But nearly all of them are investigated only by simulation. Little has been done on theoretically analyzing how to implement services guarantee and bandwidth management in the WLAN system. The challenge is to predict the service level for different service classes in the presence of random access channels.

2. Issues
Most of existing schemes to support service differentiation in 802.11 WLAN are investigated only by simulation [1][2]. So the issue of service guarantee and management is hard to be considered. To address this issue, a distributed admission control scheme is proposed in [3] for service guarantee in IEEE 802.11. In this scheme an additional Virtual Media Access Control (VMAC) module is needed to run in each wireless station to predict the traffic load and service quality, which is time consuming and may be impractical in a large WLAN. In [4], an analytical model is proposed, but it is only for single service class and the influence of DIFS is not considered. If we have a precise analytical model of 802.11 DCF for multiple service classes, the system performance could be well predicted and relatively service differentiation in MAC layer for different service classes could be achieved with ease.

2 Proposed Analytical Model
DIFS is a parameter that can be used to distinguish different service classes. A station with shorter DIFS means it will access the channel earlier statistically. We assume two service classes for simplification. For class 1, the DIFS₁ is shorter than DIFS₂ for class 2. That’s to say, class 1 has higher priority than class 2 to access the random channel.

In legacy DCF, DIFS is a constant, which equals to the value of Short InterFrame Space (SIFS) plus double slot time. We use the number of added slot time to denote the value of DIFS. So in legacy DCF, DIFS equals to 2.

We first generalize the Markovian model in [4] to the multiple service class case. For a given station in i'th service class, let \( b(i,t) \) denote the state of the
backoff time counter at the beginning of time slot $t$. Note that $b(i,t)$ is non-Markovian because of its dependence on transmission history. Let $s(i,t)$ be a stochastic process which represents the backoff stage $[0,...,m_i]$ of a station in the $i$th service class at time $t$. Let $d(i,t)$ denote the DIFS counter value for $i$th service class at time $t$. In this model, the 3-dimension process $(b(i,t),s(i,t),d(i,t))$ forms a discrete time Markovian chain. For example, state $(2,3,0)$ means the station is in its backoff stage 2 with backoff counter value 3, and the backoff process of this station is active since the DIFS counter value is 0. One-step transition probabilities of the Markov chain can be obtained. Use the chain regularities and physical definition, and the transmission probability in a slot time of each service class can be solved. The saturation throughput then can be calculated.

The key part of our analytical model is to model the backoff frozen state, where influence of different DIFS expresses well.

### 3 Main Results

A set of simulations was run by OPNET software to validate our analytical model. The simulation results and analytical results of saturation throughput for each service class (denoted by S1 and S2) are drawn in the same figure. The station number of each class is set to be $n_1$ and $n_2$. DIFS$_1$ is set to be 2, and DIFS$_2$ is changed from 3 to 5. From the figures, we conclude that our analytical is accurate. The model can be used to facilitate and simplify bandwidth management in future WLANs.

### References:


