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An Evaluation of Performance Analysis for IEEE 802.11 DCM as A Discrete Time Markov Chain

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ABSTRACT: *In this paper, considers a single-hop wireless LAN, where the channel conditions are idle. Let n be the number of stations. We consider the third case of non-saturation condition, so that the station does not generate flows while the station has a flow in service. After completion of a flow's transmission in a station, that station goes to idle state and it takes exponential duration with rate λ for a station to generate a new flow. An inter-arrival time of flow is exponentially distributed with rate λ.*

I. INTRODUCTION

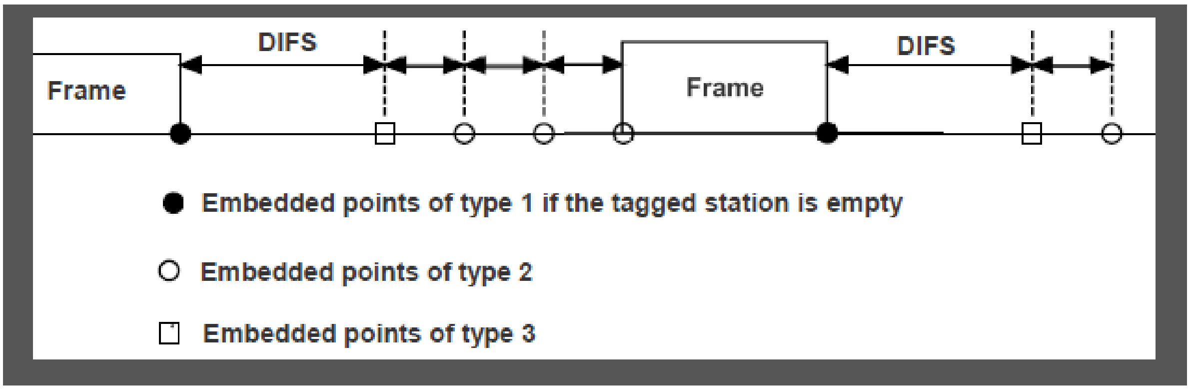
We assume that each flow consists of geometrically distributed number of packets with mean $\frac{1}{1-\varphi}$ i.e, the distribution for the number L of packets in a flow

$$p(L=k)=\varphi^{k-1}(1-\varphi) \tag{1}$$

We note that an arrival of a flow consisting of geometric number of packets with mean $\frac{1}{1-\varphi}$ mathematically equivalent to the station generates a new packet with probability immediately after a previous packet has been transmitted or goes to the idle state with probability $1-\varphi$. We adopt the second way of thinking in order to make our model to be a Markov chain. The buffer size is infinite. It is assumed that all packets have the same payload length.

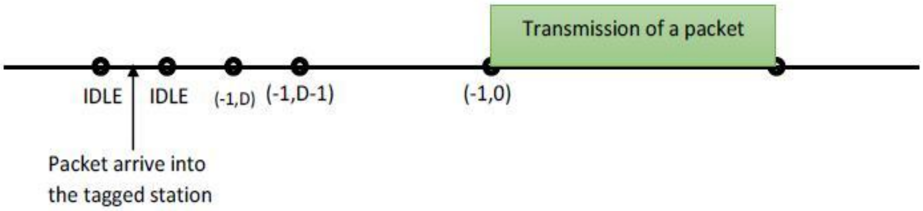
II. MATHEMATICAL MODEL PERFORMANCE S FOR IEEE 802.11 DCF

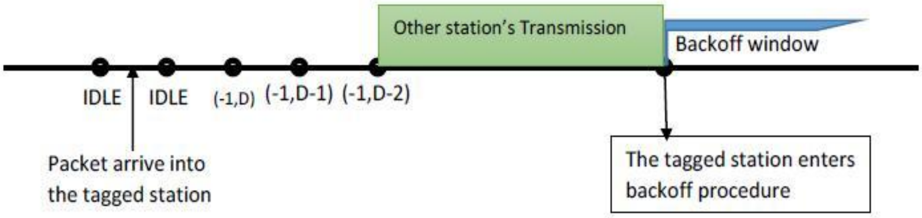
The stochastic behaviour of the tagged station is modeled by the discrete time markov chain. The backoff counter decrement is freezed when the channel is sensed busy. The state of a tagged station of the non saturated DCF is analyzed in three types of embedded points.



Type 1: the end of each time period during which the channel is busy due to packet transmissions, regardless of success or collision, if the tagged station is empty at that time.
Type 2: DIFS after each time period during which the channel is busy due to packet transmission, regardless of success or collision.
Type 3: every slot times after the embedded points of type 2 until the channel is sensed to be busy.

Embedded points of the Markov chain are epochs where the back off counter of the tagged station decrements and so a slot can be classified an idle slot, a successful transmission slot and a collision slot. Therefore the time interval between two consecutive slot times may be much longer than the idle slot time size σ, as it could be duration of a packet transmission. Let us denote $W = CW_{min}$, for convenience, adopt the notation $W_i = \min\{2^i W, 2^N W\}$ where N is the maximum back off stage. The state space of our Markov chain is as follows. Idle: the state in which the station does not have any packet to transmit $(-1, d)$, $1 \le d \le 3$: the states in which the station monitors the channel activities during DIFS when the first packet of of a flow arrives. Since $DIFS = SIFS + 2 \cdot \sigma$, $(-1, 1)$ is the state of sensing channel during SIFS, $(-1, 2)$ and $(-1, 3)$ denote the states of two slot next SIFS period. (i, k) : the states in which the station is in the back off procedure. i denotes the back off stage with $0 \le i \le M$ where M is retransmission limit excluding initial attempt. So, a packet can be experienced $M + 1$ transmission attempt. If a packet is not successfully transmitted at the $(M + 1)^{th}$ attempt, the packet is discarded. The back off stage is reset to 0 and the contention window is reset to CW_{min} after every successful packet transmission or packet discard. k denotes the back off counter with $0 \le k \le W_i$. Specially, all cases of back off procedures that the first packet of a flow can experience. The values under the lines in and 4.4 mean the states of the tagged station in our Markov chain. Figure 4.2 describes the situation that the first packet arrived at the idle station is immediately transmitted without back off procedure after it senses the channel being idle during DIFS period.





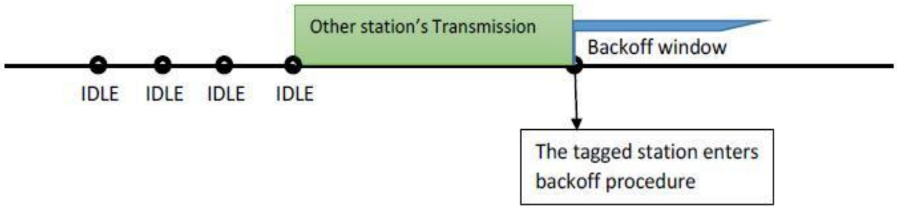


Figure 4.3 represents the situation that the channel is occupied by other stations during which the tagged station sense channel during DIFS period after packet arrival.In this case ,the tagged station starts a back off procedure after DIFS period following the other station's transmission.vs

Figure4.4 displays the situation that the packet of the station arrives during busy slot.The tagged station postpones a back off procedure until the channel is idle during DIPS period.On the other hand, the ordinary packets are always transmitted through back off procedure.

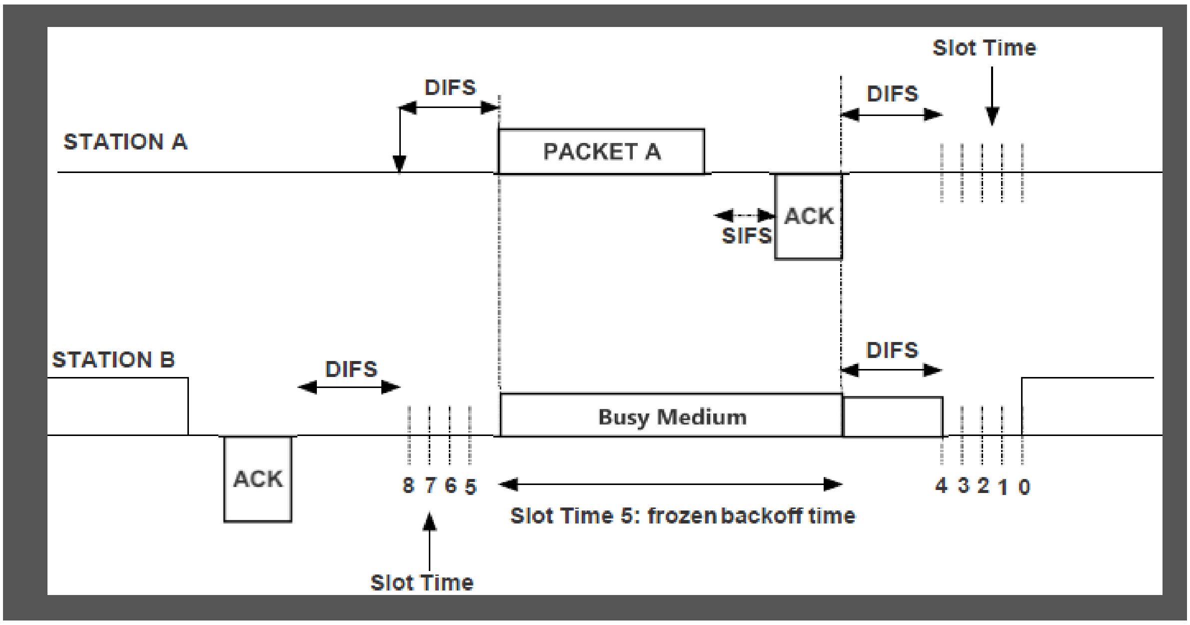


Figure 4.5 represents the diagram of one-step transition probability of the Markov chain model describing back off procedures for the tagged station in non-saturation condition.

p is the conditional collision probability which is assumed as constant regardless of the backoff stage. Let P_0, P_1 and P^* be the conditional probabilities that a randomly chosen slot is an idle slot, a successful transmission slot and a collision slot, given that the tagged station has no packets to transmit, respectively. Then

$$P_0 = (1-\tau)^{n-1} \tag{4.1.2}$$

$$P_1 = (n-1)\cdot\tau\cdot(1-\tau)^{n-2} \tag{4.1.3}$$

$$P^* = 1 - P_0 - P_1 \tag{4.1.4}$$

where τ is the probability that the tagged station transmits in a randomly chosen slot. Let P_a and P_b be the probabilities of packet arrival in an idle slot and a busy slot of channel when the tagged station has no packet to transmit, respectively. Since inter-arrival time of flows is exponentially distributed with rate λ . as mentioned, P_a and P_b are calculated as follows.

$$P_a = P_0(1-e^{-\lambda\sigma}) \tag{4.1.5}$$

$$P_b = P_1(1-e^{-\lambda T_s}) + P^*(1-e^{-\lambda T_c}) \tag{4.1.6}$$

Where T_s and T_c are the durations that the channel is sensed busy during a successful transmission and a collision, respectively, and calculated by

$$T_s = T_0 + T_p + SIFS + T_a + DIFS \tag{4.1.7}$$

$$T_c = T_0 + T_{p^*} + DIFS \tag{4.1.8}$$

Where T_0 and T_a denote the durations to transmit overhead (PHY overhead+MAC overhead) and ACK packet, respectively. T_p is the average transmission time of data payload and T_{p^*} is the average transmission time of the longest data payload involved in a collision. Since we assume that all packets have the same payload size, $T_{p^*} = T_p$. Let b_{idle}, $b_{-1,d}$ and $b_{i,k}$ be the stationary probabilities of this Markov chain. We will evaluated as follows We compute the stationary probabilities namely b_{idle} , $b_{-1,d}$ and $b_{i,k}$

III. CONCLUSION

In this paper we have presented the mathematical analysis in evaluating performance along for the non-saturated condition. In the non-saturated condition where there is no generation of flow while the previous flow is in service and the number of packets in flow is geometrically distributed, the first packet arriving at the idle station is transmitted without entering into backoff procedure. The stochastic behavior of one station as a discrete time Markov chain is analyzed in IEEE 802.11 DCF in non-saturation condition.

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