行政院國家科學委員會專題研究計畫　期中進度報告

無線區域網路提供區別服務之媒介存取控制機制研究與實現(1/2)

計畫類別：個別型計畫
計畫編號：NSC92-2213-E-009-110-
執行期間：92 年 08 月 01 日至 93 年 07 月 31 日
執行單位：國立交通大學電信工程學系

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報告類型：精簡報告

處理方式：本計畫可公開查詢

中　華　民　國 93 年 5 月 27 日

一、中文摘要

本年度計畫主要研究現有的無線區域網路下於媒介存取控制層所提供之區別服務頻寬保證演算法。在研究中，我們將保證使用此演算法的無線工作站在現有通道頻寬的許可之下獲得所需的頻寬。此演算法將能將控制的部分分散到各個工作站，並避免對現有的標準做額外的改變。此演算法的效能將經由適當的模擬驗證。驗證的結果顯示了此演算法將能適當的運作於現有的網路條件。

關鍵詞：無線區域網路，媒介存取控制層，服務品質保證，區別服務

Abstract

This project proposes an enhanced through guarantee mechanism with differential service for MAC layer of IEEE 802.11 Wireless LANs. With the mechanism, we can provide guaranteed throughput by evaluating and designing the suitable parameters for enhanced stations. With the use of enhanced mechanism, the service of control will be fully distributed and differentiated services will be achieved by minimizing migration effort on current standard. The performance of proposed mechanism has been evaluated by simulation. Simulation results show that the mechanism behaves well in present network architecture.

Keywords: IEEE 802.11, MAC, QoS, DiffServ

二、計劃緣由與目的

In wireless communication, because of the variant environment of wireless media, the impact of packet collisions, hidden terminals, fading, and interference lends itself harder to provide service assurances rather than deterministic ones. There are two principal approaches to support better than best-effort services for Internet-based services in a future wireless network. One is Integrated Services, and the other is Differentiated Services (DiffServ). The first approach begins with the conventional circuit switched paradigm and extends it with datagram services. Another increasingly popular approach is based on an important Internet design principle that only minimal control and signaling is viable, since only simple mechanisms can accommodate the variety of applications in the Internet. The Differentiated Services architecture is to span instead of end-to-end path such as from a server to a mobile user, thus the wireless hop has to be compatible with the Differentiated Services model as well. These approaches enable the fast installation of simple wireless access networks, with minimum management and maintenance costs. Similar distributed algorithms are analyzed and compared in [1]. Each of these components performs well and can be implemented in a fully distributed manner, without the need for a centralized controller. Service differentiation is based on the IEEE 802.11 DCF. Support better than best-effort service over a shared wireless network with distributed control algorithms.

Many authors investigated the enhancement of the IEEE 802.11 DCF MAC protocol to increase the performance. Branchi presented an analytical model in [2] for throughput analysis, where the relationship between throughput and station number was considered. In [3], service differentiation will be achieved by analyzing a simple Markov model. A method of dynamically estimating the optimized contention window size for throughput maximization is presented in [4]. In [5] and [6], Virtual MAC and Virtual Source mechanism are introduced. Virtual MAC mechanism monitors the capability of the radio channel. Virtual Source mechanism utilizes VMAC to estimate application level service quality. In [7], a throughput guaranteed mechanism is introduced. Finally, the use of black burst mechanism is discussed in [8], [9] and [10].

三、研究方法與成果

We propose and evaluate our enhanced algorithm for providing throughput guarantee in the IEEE 802.11 DCF network. IEEE 802.11 DCF network is fair with transmit opportunity, and each station will get channel with the same probability. As a result of fair opportunity, the original IEEE 802.11 DCF stations will transmit packet with best effort. At first, we want the algorithm can perform well when joining an original IEEE 802.11 network. That is, we must achieve backward compatibility if not all of the stations perform the mechanism. Figure 1 shows an example of enhanced guaranteed algorithm in our project. After the end of a previous transmission, the enhanced stations will compete with different length of black burst if the transmission rates are under the guaranteed bandwidth. These stations will access wireless media first. Best effort stations and enhanced stations which achieve guaranteed bandwidth will use the backoff mechanism in IEEE 802.11 standard. With the choice of IEEE 802.11 backoff mechanism, our architecture provides backward compatibility. Note that enhanced stations which transmit black burst will wait for DIFS the same as DCF mode. This property makes sure that the PCF mode will get the highest service class the same as in IEEE 802.11 standard.

Figure 2 shows the mechanism of token bucket filter which can provide different service. The token bucket is maintained by token rate R, this means service of the station is guaranteed to R (Mb/s). The token bucket will be limited by a maximum depth D. By choosing large depth, we can maintain throughout precisely to the guaranteed bandwidth but need large buffer. If the token length is deeper than the maximum length, the token will be discarded and the throughput will not be guaranteed. However, in our simulation shown below, the case happens when sum of throughput committed to guaranteed bandwidth is larger than total throughput available in the wireless media. In our simulation, we define one token as one bit for precise result. The bucket threshold K_H defines how urgency the black burst mechanism should switch on. The higher K_H will get larger variance relative to the guaranteed bandwidth, and will get lower probability to transmit black burst.

By using the enhanced guarantee mechanism, the station can determine packet transmission mechanism depending on the token bucket depth. If the token bucket depth does not exceed threshold, the station will transmit packet by backoff mechanism as in IEEE 802.11 standard. The scheme of enhanced guarantee mechanism is shown in Figure 3. When a station joins wireless network, the guaranteed throughput R, is maintained by token bucket. If the station starts to transmit packet, the decision engine will choose appropriate transmit mechanism. If the bucket depth exceeds threshold K_H, black burst will be transmitted. Otherwise, the station will access wireless media by backoff mechanism in IEEE 802.11 standard. After station transmits black burst according to L, it should sense the channel to ascertain that there is no longer black burst. If there is longer burst in the wireless media, the station fails to access wireless media in this round, and it should wait until the wireless media becomes idle. After wireless media becomes idle, the station which loses in last round will transmit black burst with updated L.

$$p' = f(L) \tag{1}$$

$$P_J(f) = \begin{cases} p'^{f-1} \times (1-p'), & 1 \le f \le W \\ p'^{W-1}, & f = W \end{cases} \tag{2}$$

Equation (1) shows that p’ will be the function of exceeded length L. Equation (2) shows the truncated geometric distribution with parameter p’. The probability of i enhanced stations generating longest black burst of f slot when there are N enhanced stations is given in (3).

$$P_J(N, f, i) = \binom{N}{i} P_J(f)^i \left(\sum_{j=1}^{f-1} P_J(j)\right)^{N-i} \tag{3}$$

Therefore, the channel utilization is given by:

$$utilization = \frac{success\ probability \times Payload\_t}{success\ probability \times T\_time_{success} + \ failure\ probability \times T\_time_{failure}}$$

$$= \frac{Payload\_t}{\frac{\sum_{f=1}^{W}\sum_{i=1}^{N}(P_J(N,f,i) \times \ f) + Pkt\_time_{failure}}{\sum_{f=1}^{W} P_J(N,f,1)} + (Pkt\_time_{success} - Pkt\_time_{failure})}$$

$$= \frac{Payload\_time}{\frac{W + Pkt\_time_{failure}}{\sum_{f=1}^{W} P_J(N,f,1)} + (Pkt\_time_{success} - Pkt\_time_{failure})} \qquad (4)$$

We can find that the cost of collision at basic access mode is much higher than RTS/CTS mode. If we need to achieve maximum throughput at specific *W*, we should get maximum value of:

$$\sum_{f=1}^{W} P_J(N,f,1) = N \times P_J(f) \times (\sum_{j=1}^{f-1} P_J(j))^{N-1} \qquad (5)$$

Thus, for a specific *W*, we can get the best *p'* to achieve maximum throughput. We find the optimal value of *W* = 9 and *p'* = 0.45 by numerical analysis. To test the performance of our enhanced mechanism, we simulated it on a network consisting of a number of wireless terminals in a 2 Mbps Wireless LAN. The channel is assumed to be error free. We evaluate performance by assuming each STA always gets a packet to transmit. Figure 4 shows that different classes of service can be achieved with number of best effort stations. Figure 5 shows the channel utilization with different number of enhanced stations and is compared with the channel utilization of IEEE 802.11 standard. We can find that channel utilization will be impacted if enhanced station exists. Actually, channel utilization increases when there are enhanced stations. Moreover, the increase is higher when there are fewer enhanced stations. The reason is that, with no enhanced stations, the network is underloaded owing to too long idle times. Having one enhanced station with guaranteed throughput, the load increases and achieves to a higher utilization. However, channel utilization decrease with number of enhanced stations. This is because having more than one enhanced stations will lead to more collision by black burst. Note that by choosing optimal parameter in our mechanism, collision probability of black burst is much smaller than best effort when number of best effort stations gets large.

四、結論

In this project, we have proposed enhanced throughput guarantee mechanism for providing guaranteed service in Wireless LAN. The design goals of our mechanism have been keep the MAC protocol fully distributed, provide backward compatibility, and minimize the migration effort from current standard. We use numerical analysis to determine proper parameters in our mechanism to maximize channel utilization. The simulations show that our approach will guarantee throughputs well and DiffServ will be achieved. The enhanced stations will get demanded throughputs and leftover bandwidth is equally shared to best effort stations.

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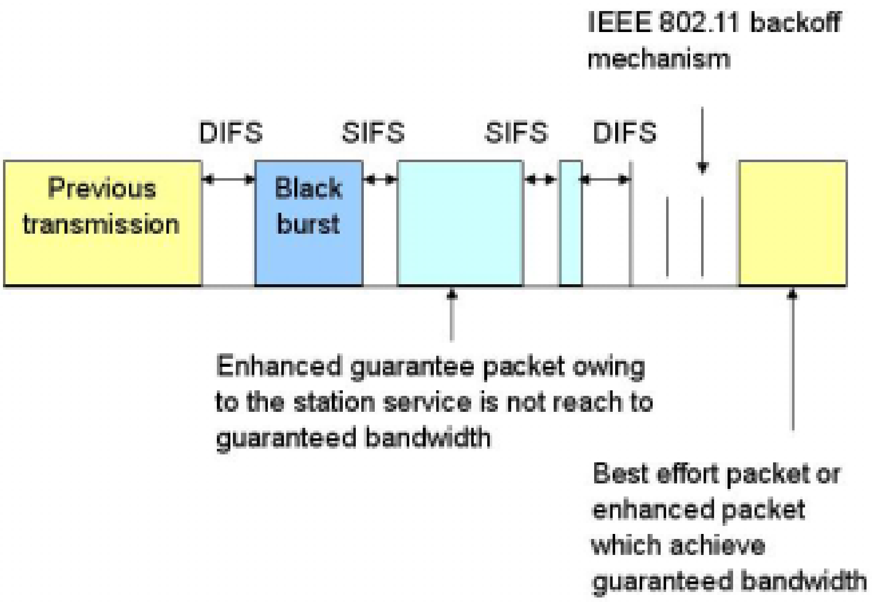

Figure 1: Protocol Operation

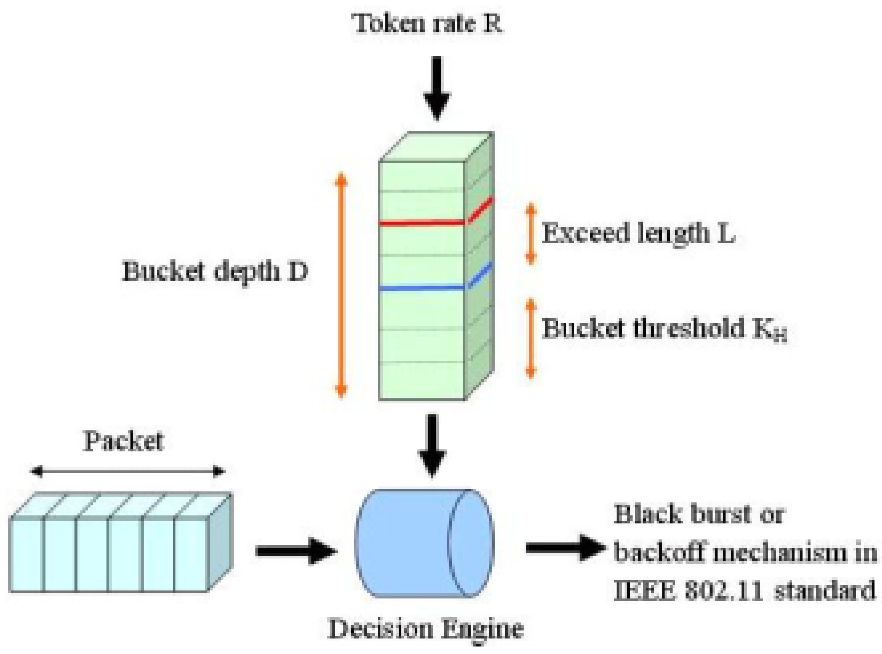

Figure 2: Token bucket filter for DiffServ

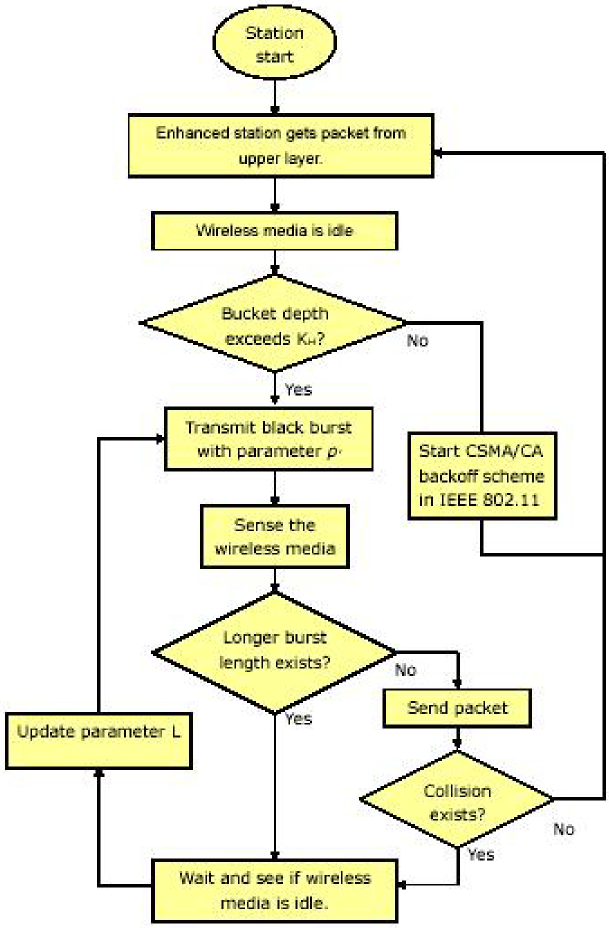

Figure 3: Scheme flow

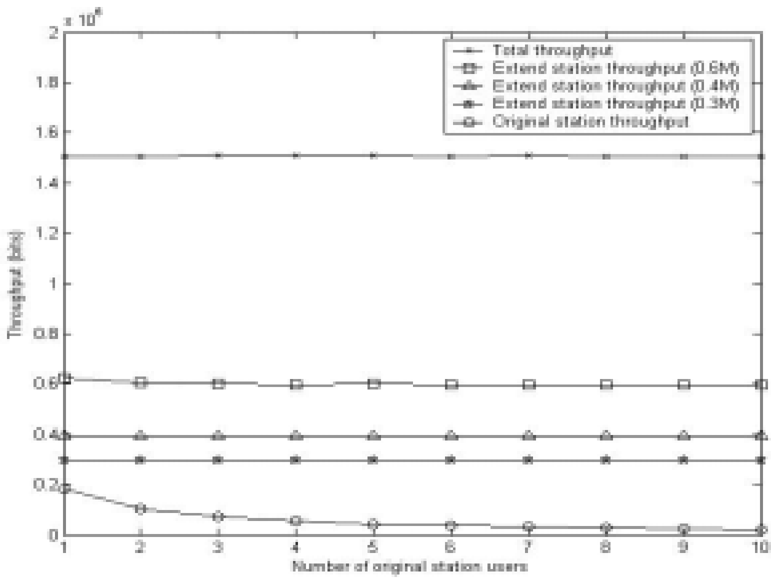

Figure 4: Different service classes vs. number of best effort stations

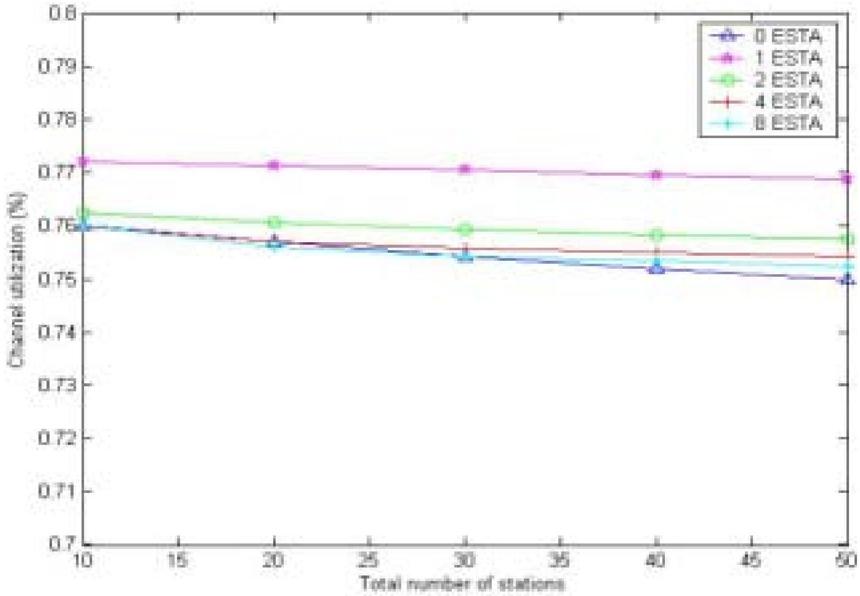

Figure 5: Number of enhanced stations vs. number of total stations