無線區域網路結合速率調整與功率控制於廣義多路徑衰減通道之研究

Joint Rate and Power Adaptation for Wireless Local Area Networks in Nakagami Multipath Fading Channels

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摘　　要

本論文旨在針對無線區域網路 (wireless local area networks, WLANs) 於廣義多路徑衰減通道的環境，提出一個快速的結合速率調整與功率控制的機制。並且也提出一個分析的方法，藉由媒介存取控制層與實體層的觀點分析 IEEE 802.11a 無線區域網路在廣義多路徑衰減通道下的實際資料吞吐量 (goodput) 與能量效能 (energy efficiency)。

對於無線區域網路的速率調整與功率控制設計，最主要的挑戰在於實際資料吞吐量與能量效能是兩個互相對立的目標。為了達到較高的實際資料吞吐量，須調整使用較高階的調變技術與較少的編碼冗餘位元，因此要求以較高的傳送功率去維持其位元錯誤率 (bit error rate)。所以如何在實際資料吞吐量與能量效能這兩個互相對立的目標下，使 IEEE 802.11a 無線區域網路決定適當的調變編碼機制與傳輸功率以期達到最佳的系統效能是一件值得的研究課題。

我們為無線區域網路系統發展了一套快速的通道驅策傳輸速率與功率調適 (channel-driven rate and power adaptation, CDRPA) 技術。同時考量實際資料吞吐量與能量效能這兩個互相對立的目標，我們提出了兩個速率調整與功率控制的機制。功率優先的通道驅策傳輸速率與功率調適技術會先控制傳輸功率來提高能量效能，再調整傳輸速率來增加實際資料吞吐量。而速率優先的通道驅策傳輸速率與功率調適技術會先調整傳輸速率還增加實際資料吞吐量，再控制傳輸功率來提高能量效能。之後我們會在進一步考慮到以 RTS/CTS 機制設計的通道驅策傳輸速率與功率調適技術並結合權重移動平均通道品質預測機制 (weighted moving averaged channel quality prediction) 來改進系統效能。最後由我們的分析結果發現，速率優先的通道驅策傳輸速率與功率調適技術能提供較佳的實際資料吞吐量，並且維持和功率優先的技術相當的能量效能。因此，我們建議以速率優先的通道驅策傳輸速率與功率調適技術當作無線區域網路的結合速率調整與功率控制的機制，可以兼顧到實際資料吞吐量與能量效能這兩個互相對立的目標。

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ABSTRACT

This thesis aims to propose a fast channel-driven joint rate and power adaptation (CDRPA) algorithm for wireless local area networks (WLANs) in Nakagami fading channels to simultaneously enhance the goodput and energy saving. Furthermore, we develop analytical methods to evaluate the performance of the Institute of Electrical and Electronics Engineers (IEEE) 802.11a WLAN from both the medium access control (MAC) layer and physical (PHY) layer perspectives.

The main challenge for power and rate adaptation in WLAN lies in the fact that energy efficiency and goodput enhancement are indeed two contradictory goals. To achieve higher goodput, it is necessary to operate in a higher level of modulation with fewer redundant bits in coding, thereby requiring higher transmitted power to maintain the bit error rate (BER) performance. How the IEEE 802.11a WLAN selects a suitable modulation and coding scheme (MCS) and decides appropriate transmitted power to optimize the performance tradeoff between energy efficiency and goodput becomes a difficult but important task.

To investigate the tradeoff between energy efficiency and goodput enhancement, we propose and compare two joint rate and power adaptation schemes: the power-first CDRPA scheme and the rate-first CDRPA scheme. The power-first CDRPA scheme first selects the transmitted power aiming to enhance energy efficiency and then the data rate to improve goodput. On the contrary, the rate-first CDRPA scheme first selects data rate aiming to boost goodput and then the transmitted power to save energy consumption. Then, we extend the CDRPA algorithm to the multiple user contention following carrier sense multiple access with collision avoidance (CSMA/CA) MAC protocol with RTS/CTS. From our numerical results, we find that the rate-first CDRPA scheme can provide best goodput performance, while maintaining comparable energy efficiency as the power-first CDRPA scheme. We further suggest a weighted moving-average approach to predict the channel condition, which can help improve the energy efficiency of the rate-first CDRPA scheme. Here,

we suggest that the rate-first CDRPA scheme can be an appropriate joint rate and power adaptation for WLANs that can optimize the performance tradeoff between goodput enhancement and energy saving.