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# Enhanced statistics-based rate adaptation for 802.11 wireless networks

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ABSTRACT

Rate adaptation is a common technique to exploit channel diversity in wireless networks. Despite the many rate adaptation algorithms proposed for 802.11 networks, statistics-based schemes remain the most widely adopted approaches in commercial 802.11 products due to their simplicity and practicality. However, statistics-based schemes suffer some disadvantages. Our previous research effort revealed the rate avalanche effect that could significantly degrade the network performance of heavily loaded 802.11 networks. In this work, we propose RADAR (Rate-Alert DynAmic Rts/cts exchange), a novel enhanced rate adaptation system that can effectively alleviate the impact of the rate avalanche effect. RADAR detects rate avalanche through maintaining a dynamic range-based mapping between rates and RSSI (received signal strength indicator) measurements. It judiciously exploits dynamic RTS/CTS exchanges to effectively suppress the rate avalanche effect while at the same time minimizes the transmission overhead of RTS/CTS exchanges. Being fully compatible with current 802.11 standards, RADAR can be readily implemented in the NIC driver. Through extensive simulations using realistic channel propagation and reception models, we demonstrate that RADAR is a practical and efficient performance enhancement approach for multi-rate 802.11 networks.



## 1. Introduction

The highly volatile nature of wireless medium poses special challenges to the protocol design for wireless networks. Supporting multiple transmission rates at the physical (PHY) layer that use different modulations and coding schemes is a nature solution to exploit wireless channel diversity. While many current wireless networking standards support multi-rate transmissions, the rate adaptation schemes that guide the rate selection to match the time-varying channel conditions are left undefined in the standards. Recently, a number of rate adaptation schemes have been proposed for 802.11 networks in the literature (Bicket, 2005; Chen et al., 2007; Haratcherev et al., 2004; Holland et al., 2001; Kamerman and Monteban, 1997; Kim et al., 2006; Lacage et al., 2004; Sadeghi et al., 2002; Wong et al., 2006). These schemes could be roughly divided into two categories: SINR (signal to interference plus noise ratio)-based (Chen et al., 2007; Holland et al., 2001; Sadeghi et al., 2002) and statistics-based (Bicket, 2005; Haratcherev et al., 2004; Kamerman and Monteban, 1997; Kim et al., 2006; Lacage et al., 2004; Wong et al., 2006).

SINR-based approaches, where data rates are chosen based on SINR measurements, are theoretically ideal for rate adaptations. However, they are hard to implement in practice due to their dependencies on some assumptions that are usually too strong to hold in reality (Zhang et al., 2009). SINR-based approaches have not been applied in practice so far.

As an alternative to SINR-based approaches, statistics-based schemes estimate link conditions through maintaining statistics about the transmitted data such as the achieved throughput (Bicket, 2005), consecutive transmission successes/losses (Haratcherev et al., 2004; Kamerman and Monteban, 1997; Kim et al., 2006; Lacage et al., 2004), and short-term lose ratio (Wong et al., 2006), etc. For example, as the representative statistics-based approaches, ARF (auto rate fallback) (Kamerman and Monteban, 1997) and AARF (adaptive ARF) (Lacage et al., 2004) adjust data rates by keeping the track of acknowledged and unacknowledged transmissions. (A brief description of these two algorithms is given later in Section 2). However, statistics-based schemes suffer some disadvantages. For example, they are slow to adapt to fast-changing channel conditions (Holland et al., 2001). On the other extreme, when channel condition is static (does not change), statistics-based schemes often fail to stay at the optimal rate, i.e., they always try to probe the next higher rate every once in a while. Despite these disadvantages, ARF, the first documented rate adaptation scheme, remains the most widely implemented rate adaption scheme in the 802.11 market (Kim et al., 2006) due to its simplicity.

Aiming at practical solutions, we focus our effort on statistics-based schemes with the objective of enhancing their performance

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