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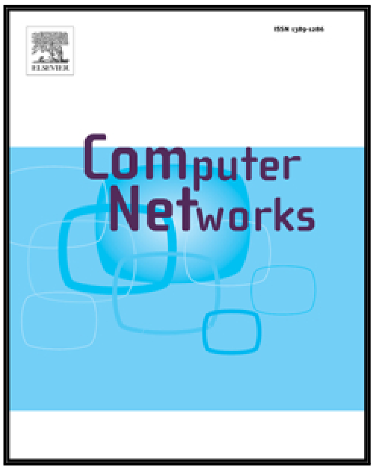

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Michele Luvisotto, Federico Tramarin, Stefano Vitturi

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A Learning Algorithm for Rate Selection in Real–Time Wireless LANs

Michele Luvisotto

Department of Information Engineering, University of Padova, Via Gradenigo 6/B, 35131, Padova, Italy

Federico Tramarin, Stefano Vitturi

National Research Council of Italy, CNR–IEIIT, Via Gradenigo 6/B, 35131, Padova, Italy

Abstract

To achieve a real–time behavior in wireless communication systems, the multi–rate support (MRS) provided by the IEEE 802.11 Wireless LAN standard may reveal particularly advantageous. Unfortunately, the most widespread rate adaptation algorithms designed for general purpose applications proved to be unsuitable for the challenging real–time scenario. This has led to the definition of purposely designed algorithms such as RSIN, a rate adaptation technique based on the SNR measurement, which showed very good performance in terms of timeliness and reliability. The goal of this paper is to propose an improvement of RSIN that extends its applicability to a wider range of applications. To this aim, we introduce RSIN–E, an enhanced version of RSIN based on an estimation of the SNR obtained through a learning algorithm. In detail, this paper first provides an exhaustive description of both the proposed learning algorithm and the relevant estimation procedure. Then it presents an extensive performance assessment of RSIN–E carried out via both experimental sessions and simulations. The obtained results confirm the effectiveness of the proposed technique and highlight that its performance figures are comparable with those of RSIN, and significantly better than those of Minstrel, a widespread rate adaptation algorithm adopted by most general purpose applications.

Keywords: Real–time WLANs, Learning Algorithm, SNR estimation, Rate selection

1. Introduction

Real–time communication systems are requested to provide performance figures that are quite different from those of general purpose communications [1]. Significant examples, to this regard, are represented by networks deployed in factory automation systems as well as in motion control applications. Indeed, the typical industrial traffic is characterized by the cyclic transfer of small data amounts, as well as by the transmission of short acyclic messages, generated by alarms, with very tight deadlines. Similarly, networks adopted by motion control applications may have cycle times (i.e. the duration of the intervals in which a controller carries out a complete polling of a set of sensors/actuators) as low as some hundreds of microseconds, with very low jitters, while an alarm message should be notified within a deadline of the same order of magnitude. Furthermore, the appearance of real–time multimedia industrial applications, such as video surveillance and remote tracking, has led to the introduction of another type of traffic, characterized by the exchange of greater data amounts that, nevertheless, maintains tight timing requirements.

To deal with such kinds of traffic, different communication systems have been deployed in the years, specifically, fieldbuses [2], real–time Ethernet networks [3] and, more recently, real–time (industrial) wireless networks [4]. Among the different wireless technologies that can be adopted, the IEEE 802.11 Wireless LAN (WLAN) [5] represents an important opportunity, since it can be adequately tailored to achieve performance figures almost comparable with those of the wired real–time counterparts [6]. A feature of IEEE 802.11 that significantly contributes to its adoption in this context is multi–rate support (MRS). Basically, MRS allows to dynamically change the transmission rate to adapt to the possible fluctuations of the channel status. Thus, since low rates use more robust modulations, they can be selected when the channel is in a bad state (i.e., when the signal–to–noise–ratio, SNR, is low), whereas higher rates can be used for better channel states. This kind of strategy is implemented by suitable rate adaptation (RA) algorithms that, however, are not explicitly specified by the IEEE 802.11 standard. The design of effective RA algorithms is hence an interesting and widely targeted research topic [7]. The most popular ones nowadays adopted are arguably the Automatic Rate Fallback (ARF) [8] and Minstrel [9]. These algorithms aim at maximizing the throughput, irrespective of the number of transmission attempts carried out at the Medium Access Control (MAC) layer [10]. Such a behavior, unfortunately, results unsuitable for the majority of real–time applications, since the random backoff waiting times introduced between subsequent transmission attempts clearly impair the communication timeliness. As a consequence, some RA algorithms specifically tailored for real–time industrial com-

Email addresses: michele.luvisotto@dei.unipd.it (Michele Luvisotto), federico.tramarin@ieiit.cnr.it, stefano.vitturi@ieiit.cnr.it (Federico Tramarin, Stefano Vitturi)

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