Poster Abstract: Exploiting the LQI Variance for Rapid Channel Quality Assessment

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ABSTRACT

Communicating over a reliable radio channel is vital for an efficient resource usage in sensor networks: a bad radio channel can lead to poor application performance and higher energy consumption. Previous research has shown that the LQI mean value is a good estimator of the link quality. Nevertheless, due to its high variance, many packets are needed to obtain a reliable estimation. Based on experimental results, we show instead that the LQI variance is not a limitation. We show that the variance of the LQI can be used as a metric for a rapid channel quality assessment. Our initial results indicate that identifying good channels using the LQI variance requires an order of magnitude fewer packets than when using the mean LQI.

1. INTRODUCTION

Channel quality estimation is a critical task in sensor networks. When communicating over a bad radio channel, applications suffer from high network latency, poor packet delivery, and increased energy consumption. Link quality estimation is typically based on information retrievable from the radio, for example the Received Signal Strength Indicator (RSSI) and Link Quality Indicator (LQI) from the CC2420 radio chip [1]. It is commonly agreed that the LQI mean value has a more linear correlation with the Packet Reception Rate (PRR) than the RSSI. However, the research community considers it as unattractive for fast link quality estimation, because of the high number of packets needed to obtain a reliable estimation. Srinivasan and Levis [2] show that the LQI mean value provides an accurate link estimation, but only when averaging more than 120 packets. This large amount of packets is required because of the high variance of the LQI that has been pointed out as a big limitation also by Srinivasan et al. [3], Holland et al. [4] and Rein [5].

We show that instead of being a limitation, the LQI variance can be used to obtain a faster channel quality assessment, compared to the LQI mean value. The LQI variance computed over received packets is low with good channels, whereas a high variance identifies unreliable channels. Our initial experimental results suggest that we can quickly identify channels with a high PRR.

2. CONTRIBUTION

Experimental setup. We carry out our experiments indoors, both in office and residential environments. We used the Sentilla Tmote Sky platform with the transmission power set to approximately -5 dBm. A sink node collects data from nodes situated at distances ranging from 1 to 6 meters. All nodes run the Contiki operating system [6]. The sink node triggers the sender to send 256 consecutive packets on a specific channel. Each packet has a payload length of 8 bytes. The sink node collects RSSI, LQI and noise floor readings for each received packet. We iterate the same procedure over all the 802.15.4 radio channels in the 2.4 GHz band.

Experimental results. Our results show that the link quality can be accurately estimated using the LQI variance. Figure 1 shows the LQI variance of the best and the worst channels during our experiments, which are channel 22 and 16 respectively. The average PRR is 87% for channel 16 and 99.9% for channel 22. The LQI variance is around 100 for channel 22 and about 1600 for channel 16, i.e. it is an order of magnitude higher for the bad channel.

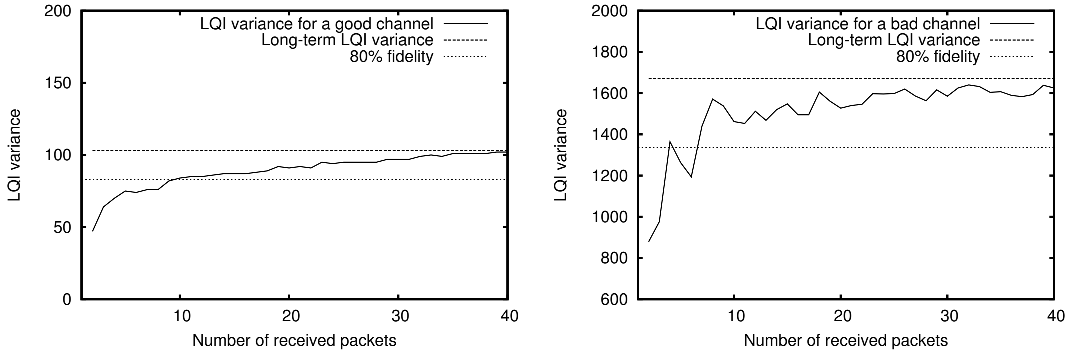

Figure 1: LQI variance for a channel with high PRR (good) and a channel with a lower PRR (bad). The left figure shows the good channel (PRR of 99.9%) with LQI variance of about 100, while the LQI variance of the bad channel (PRR of 87%) in the right figure is around 16 times higher.

Since the LQI variance depends on the number of samples on which it is computed, it is inapt to define a rigorous threshold to distinguish good and bad channels. Our results indicate, however, that a good channel's LQI variance is in the order of hundreds, whereas an unreliable channel's LQI variance is usually above 1000. Our experiments also show that the LQI variance increases logarithmically when the LQI mean value decreases.

Our findings are confirmed by experiments of Rein [5], Srinivasan et al. [3], and Xiao et al. [7], although they focus on the LQI mean. Measurements of Rein (Fig. 5-12(a), [5]) and Xiao demonstrate that when the PRR is very high, i.e. 95-100%, the LQI variance is very low, whereas the variance is much higher with a lower PRR. The LQI variation is lower on high quality links also in measurements by Srinivasan, supporting our thesis.

Figure 1 further shows that the variance of the LQI quickly converges to the long-term value. The LQI variance estimation is 95% close to the long-term value after 30 packets are received and greater than 80% after only 10 received packets, as highlighted by the dashed line.

Given the large difference between the LQI variance of good and bad channels, it seems possible to rapidly identify good channels using the LQI variance, substantially reducing the number of packets compared to the LQI mean-based approach.

3. CONCLUSIONS AND FUTURE WORK

We have taken the first steps towards a fast reliable estimation of the channel quality. Our preliminary evaluation suggests that the variance of the LQI is not a limitation as previously assumed. Instead, it can be used as a channel quality assessment metric to quickly identify channels with a high packet reception rate. Our results indicate that link quality assessment based on the LQI variance can be performed with fewer packets than the conventional approach based on the LQI mean. We plan to carry out further experiments in different environments to determine the scenarios where the rapid channel quality assessment based on the LQI variance is reliable.

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