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Improving Packet Delivery Ratio in Ubiquitous Sensor Networks

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Abstract— Wireless sensor networks (wsns) have emerged as a promising low-cost technology to establish flexible networks unlicensed band for monitoring and control applications. the main threats to the communication reliability of wsns are interference from coexisting wireless systems and frequency selective fading This paper presents packet delivery ratio is to improve the communication in ubiquitous sensor network usn. A simple yet effective PDR estimation method based on passive channel measurements is proposed to rank the candidate channels in wireless sensor networks

Keywords— Wireless Sensor Networks(WSN), Ubiquitous Sensor Networks(USN), Packet Delivery Ratio(PDR)

I. INTRODUCTION

Wireless sensor networks (wsns) have emerged as a promising low-cost technology to establish flexible networks unlicensed band for monitoring and control applications. the main threats to the communication reliability of wsns are interference from coexisting wireless systems and frequency selective fading. the communication reliability in such hostile environment can be enhanced by adjusting the network operation on favourable channels determined by a channel ranking scheme. the channel ranking is the ordering of the available wsn channels according to a performance metric such as interference strength and/or activity factor, packet delivery ratio (PDR). we develop a PDR estimation method for channel ranking in wsns. the PDR as a performance metric for channel ranking is appreciated since it combines the effect of temporal and spatial dynamics of the co-existing systems. the PDR estimation by counting the successfully received probe packets is energy inefficient for channel ranking. theoretically, PDR is defined as a function of snr, sinr and collision-time distribution of a sensor link. the collision time distribution depends on the traffic pattern; the packet sizes and packet inter-arrival distributions of two co-existing systems under study.

The PDR estimation, using this model, requires finding the signal and interference level estimates, and the collision-time distribution. this model is used to estimate PDR[1] at a wsn receiver using channel energy measurements. however, PDR is estimated by assuming traffic patterns which set bounds on the channel ranking error, whereas, the effect of traffic pattern on PDR estimation. the existing channel ranking schemes are based on the identification and utilization of the interference characteristics, activity factor and/or interference level estimates. these interference characteristics are determined by channel energy measurements. in channels are ranked only based on the activity factor estimate. in ranking scheme is based on a heuristic combination of activity factor and interference level estimates. in channel ranking is based on PDR estimation. however, instead of estimating the exact PDR, a traffic pattern setting up the upper bound on ranking error is utilized for ranking the channels. instead of channel ranking, the first channel satisfying a certain PDR target is selected. moreover, by assuming the sensor link strength is the same over all channels, the cited previous studies only consider the interference characteristics for ranking. there is a significant frequency selective fading in bandwidth. in this situation, a least interfered channel might not provide the best channel quality. PDR estimation method for channel ranking is designed such that:

- Interference characteristics are taken into account using limited channel energy measurements such that traffic pattern estimation is avoided.
- The effect of multi path fading on the interfering signal is considered.
- Signal level variations in the sensor link across available channels are considered. in order to bypass the traffic pattern estimation, we design a spectrum measurements scheme in which a sensor node collects energy samples from a channel according to the intended packet size and inter-arrival distribution of the sensor link.

All of these studies measured early mote platforms whose data-link stacks resided primarily in software. Researchers showed that packet collisions, hidden terminals, link asymmetries, and the broadcast storm problem make flooding a problematic approach for building trees. [4]Demonstrated that frequency shift keying (FSK) radios, such as those on the mica2 platform, can recover from packet collisions where the stronger packet starts later by constantly looking for a start symbol. Took one step further and measured a precise RSSI envelope for when mica2 packets can be recovered. They showed that if the signal to interference plus noise ratio (SINR) is above a threshold, PRR is very high (> 99.9%), and that this threshold varies for different nodes. These results suggest that SINR may be a good way to understand PRR more generally. If noise behaves in a simple fashion and RSSI values are stable over time, then RSSI might be a good determinant of packet delivery success or failure. Researchers showed that PRR rates can change significantly over time, so that long-term PRR calculation can lead to very inaccurate results, suggesting instead that an instanteous measure of RNP – “required number of packets” – was preferable to a long-term PRR.

This approach also introduced the idea of using conditional probabilities in link estimation, an idea which we extend when considering the correlation between packet failures[2]. Observed similar packet delivery behaviours in a 38-node long haul urban mesh network, but concluded that they were most likely due to multipath effects as there was little correlation between PRR and SINR. However, they consider average SINR ratios over second-long periods rather than on a per-packet basis. Nevertheless, the differences in conclusions between the efforts are interesting.

II. MODEL

We consider a single wireless sensor link established between two sensor nodes acting as transmitter (S_{tx}) and receiver (S_{rx}). These nodes can be assumed to be a part of a WSN operating at unlicensed band partitioned into K channels. The same spectrum is used by co-existing WLAN with overlapping but different channel partitioning. The WLAN communication on these channels induces interference[2] to the sensor link. Where,I_c and Pe are the perceived interference level and activity factor at the WSN receiver, and Se is the sensor link strength on channel c. The receiver node estimates the Se with some probe packets since the received signal level on each channel may be different due to frequency selective fading. The WSN receiver ranks the available channels based on the PDR estimates achieved using S_c and channel energy measurements.

2.1 Channel Measurements and PDR Estimation

In order to estimate PDR without estimating the interference traffic distribution, we set the channel measurements time according to the intended traffic from the transmitter node. We assume that S_{tx} intends to send N -bit packets periodically at a rate of P packets/sec. Each packet is transmitted at a fixed data rate of R bits/sec. This is a typical WSN traffic model where sensors periodically report data to the sink.

A receiver collects L macro-samples $X_c^1, X_c^2, .., X_c^L$ on a channel with time spacing of T_I = 1/P in order to identify the noise and interference characteristics. Each macro-sample consists of l micro-samples uniformly distributed over the packet transmission time Ts = N / R. channel measurement scheme where $x_c^{i,j}$ indicates the j^{th} collected micro-sample in i^{th} macro-sample on channel c. These channel samples are collected by using the default energy detector (ED) of the sensor radio chip. The ED provides the received energy on a channel regardless of the signal type. In the absence of WLAN interference, the reported energy sample contains pure noise, otherwise, it contains the WLAN signal embedded in noise.

The PHY layer uses offset quadrature phase shift keying modulation with half sine pulse shaping, which is equivalent to MSK modulation. The bit error rate of OQPSK modulation in additive white [3]Gaussian noise channel is Q, where k is 0.85 and E_b/N_o is the ratio of the average energy per information bit to the noise power spectral density at the receiver input. The E_b/N_o is equivalent to SNR = S_c/P_N or SINR = $S_c/(I_c+P_N)$depending on interference absence or presence respectively, where P_N is the noise power.

Given that the bit errors occur independent of each other, for aN-bit packet the PDR can be calculated by considering the probabilities of receiving all the individual bits correctly

$$PDR = \prod_{i=1}^{N}(1 - Q(\sqrt{2kSINR^i}))$$

where $SINR^i$ is the SINR corresponding to the ith bit of the packet. Assuming the link strength on a given channel (S_c) is known, we can define $\mathrm{SINR}_c^{i,j}$ in dB as the difference between Se and energy sample $x_c^{i,j}$ as,

$$\mathrm{SINR}_c^{i,j} = S_c - x_c^{i,j}$$

As per the assumptions, $\mathrm{SINR}_c^{i,j}$ represents the SINR at the receiver corresponding to the jth bit belonging to the ith packet. If the interference is changing slowly within the timegap between two consecutive micro-samples, the SINR for N / l consecutive bits can be assumed to be the same. In this case, the PDR considering only the i^{th}macro-sample the PDR estimate can be obtained by averaging over L collected macro-samples. We designed an experimental setup to assess the accuracy of PDR estimation model under WLAN interference. The experimental setup measures the empirical packet delivery of a sensor link under the emulated indoor multi-path propagation conditions of the interfering signal. In the same environment, the receiver node collects channel samples to estimate the PDR.This network performancemetric is defined as the ratio between the number of datapackets successfully delivered to the destination and thenumber of packets transmitted by the source.

$$PDR = \frac{Number\ of\ received\ packets}{Number\ of\ transmitted\ packets}$$

III. EXPERIMENTATION

High value for PDR indicates that wireless channel has a good condition, while low value for PDR presents that wireless channel is not in a proper condition and packet retransmissions are required to compensate packet drops. Consequently, power consumption and delay in system are increased and result in low network performance. Naturally, wireless link quality is subject to environment changes and prone to distortion, channel fading, noise and interference. These parameters make PDR to change dramatically over time. In order to obtain a reliable estimate of channel condition with achieved PDR criterion, packet transmissions should be performed with large number of packets, during a long period of time compared to coherence time of the channel.

The coherence time is a statistical measure of the time duration over which the channel can be considered constant. In other words, coherence time is the time duration in which any two received signals have a strong correlation. On the other hand, since sensor nodes are mostly powered by batteries and are expected to operate for a long period of time, calculating PDR with transmitting and receiving a large number of packets would consume too much energy. However, we use this empirical method in experiments as a reference to compare with PDR estimation results and explore how much the estimates are accurate.

The physical layer of most wireless networking stacks has two simple functions: framing and bit error detection or correction. These two functions are affected by many different factors. First, environmental characteristics can cause multi-path signal reception, or signal attenuation. Second, the spatial separation between sender and receiver can determine the received signal strength. Finally, minor variations in receiver and sender circuitry or in battery levels can adversely affect these functions of the physical layer. To measure packet delivery at the physical layer, we use the following general setup. The precise pattern of node separation in this chain topology is discussed later. There is a single sender: the node at the head of the chain sends out a message periodically, and all other nodes receive. This simple setup measures the impact of the environment and the spatial separation between sender and receiver. It does not measure individual receiver or sender diversity; in fact, we are interested in the collective behaviour or distributions of performances. We show that these distributions are not qualitatively affected by sender or receiver variations.

IV. RESULTS

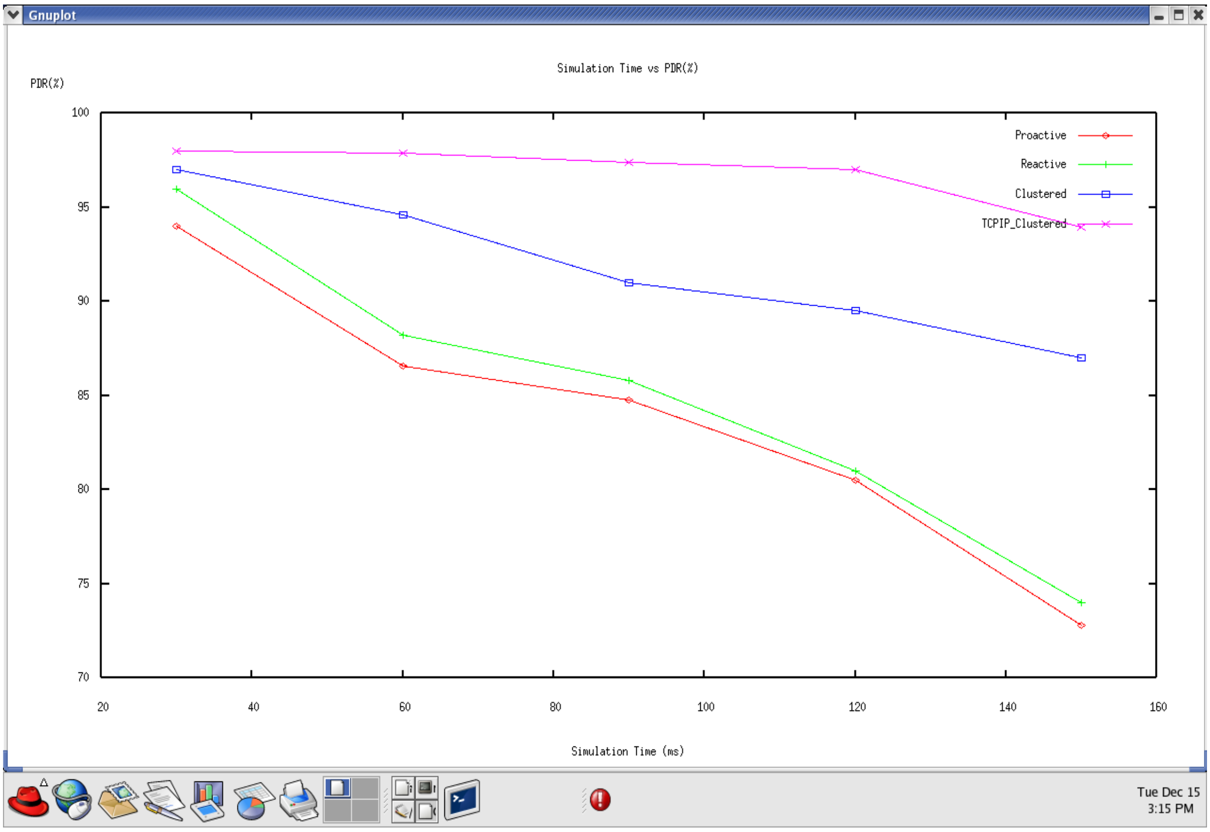

Fig. 1 Simulation Time vs Packet Delivery Ratio

Table 1.1 PDR Comparisons in Different Methods

	Time (Seconds)	TCP/IP Clustered	Clustered	reactive	Proactive
Case1	30	98	97	96	94
Case 2	60	97.9	94.6	88.2	86.6
Case 3	90	97.4	91	85.8	84.8
Case 4	120	97.0	89.5	81	80.5
Case 5	150	93.95	87	74	72.8

The execution results for PDRexaminations at time 150sec, TCP/IP clustered attains the highest percentage of PDRof value 93.95 percentage compared to clustered of 87 percentage, reactive of 74 percentage and Proactive of 72.8 percentage.

V. CONCLUSIONS

A simple yet effective PDR estimation method based on passive channel measurements is proposed to rank the candidate channels in wireless sensor networks. The proposed method does not rely on the prior knowledge or estimation of the traffic patterns of other competitive users, instead the channel measurements are adjusted according to the sensor link traffic. The optimum number of channel samples is determined to minimize the energy consumption providing the required accuracy. The PDR estimates in emulated and realistic channel conditions are in good agreement with the empirical PDR results suggesting that the proposed method can be effectively used for channel ranking. In a large sensor network with the same traffic pattern for all nodes, a particular receiver node needs to perform the channel measurements procedure only once for each channel to determine PDR estimates for different links. By using the link strengths from neighbour nodes and a single set of energy measurements, the PDR estimates on a channel for all the links can be determined.

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