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Concurrent Wireless Channel Survey on Dual Band Sensor Network Testbed

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***Abstract*—Researchers have proposed many multi-channel and dual-band communication systems to address the limitations of single-channel hardware and software. The most common dual-band communication for sensor network applications use 900 MHz and 2.4 GHz radios. There are now some testbeds such as Flocklab and Twonet that allow experimentation with dual-radio systems. However, there is no widely accepted efficient and comprehensive mechanism to survey all the channels of the dual band systems during networking experiments. In this work, we evaluate two mechanisms that can survey the RF environment in multiple channels in both the bands concurrently. We implement these two mechanisms on Twonet and evaluate them. We find that the channel scanning methodology is generally sound but sometimes static channel assignment may be attractive due to its simplicity.**

I. Introduction

Single-channel platforms and protocols have widely-known limitation: we cannot take advantage of wireless channels with much lower noise even when they exist. Many researchers have proposed multi-channel protocols to address this limitation. Lately, there has been research also on dual-band hardware and software to bring even more frequency diversity to the communication system. Getting information about the state of all the channels from all the areas of the testbed during an experiment has been a challenge.

It is important to address this challenge because the capability to sample all the channels concurrently will help establish the baseline for multi-channel experiments. Testbed evaluation of dual-band protocols require knowledge of the state (for example, noise) in all the channels so we know if the proposed dual-band multi-channel protocol is making optimal use of the channels.

The problem of sampling all the channels simultaneously in all the parts of a testbed is challenging because the radios used in low-power wireless sensor networks can sample only one channel at a time. Further, we do not want to use all the nodes for channel sampling nor install additional expensive spectrum analyzer everywhere on the testbed. We want to use as few nodes as possible for channel sampling while cover all the channels and space. Thus, the problem of efficiently gaining comprehensive knowledge about the state of wireless channels across space and time is challenging.

Researchers have mostly used two techniques to understand the channels in which they perform multi-channel experiments. They either use multiple receiver radios or wireless spectrum analyzer in one location to get an approximate idea of channel states. They have also used a node to sample noise cycling through all the channels, like described in Jamlab [1]. These methodologies, however, did not attempt to uncover the spatial channel conditions during the experiments nor applied the methodologies on dual radio platforms.

In this paper, we describe and evaluate two methodologies that attempt to survey multiple channels covering the entire testbed in space and time. The first technique designates different snooper nodes in the testbed to sample statically assigned channels. The second technique makes the nodes cycle through the channels they sample. We deploy the two methodologies on a testbed with dual-radio nodes and evaluate the effectiveness of these techniques. We find that the channel scanning approach deployed on key strategic locations on the testbed gives good spatial and temporal coverage while using only a fraction of nodes on the testbed.

II. Related Work

Researchers have used different techniques to sample multiple channels on wireless sensor networks. One of the earlier attempts to do this used a USRP platform to decode packets sent on multiple channels [2]. They implemented a tool to debug and analyze the packet loss in wireless sensor network in multiple channels. In our work, we compare different ways of concurrently sampling multiple channels using single-channel radios.

Researchers have also used various hardware, software, or deployment techniques to get an idea of the environment in multiple channels using a single-channel radio. Liang et al. report on their work on protocol that can sense and use four channels [3]. Srinivasan et al. perform extensive wireless channel measurement studies [4]. However, they sample one channel at a time for 11 hours and move to the next channel. This large time gap between the measurements on different channels does not allow us to make comparisons across the channels because the channel condition could have been different when different channels were sampled. Hauer et al. introduced the methodology for iterating over the 16 channels of 2.4 GHz band to investigate the packet transmission quality [5], which also did not perform concurrent channel sampling. In our work, we design and evaluate methodologies that can concurrently sample all the channels and provide coverage over space and time.

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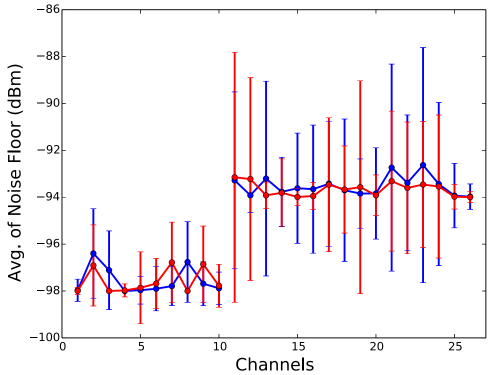

Fig. 1. Noise Floor Fluctuations from Static Channel Assignment.

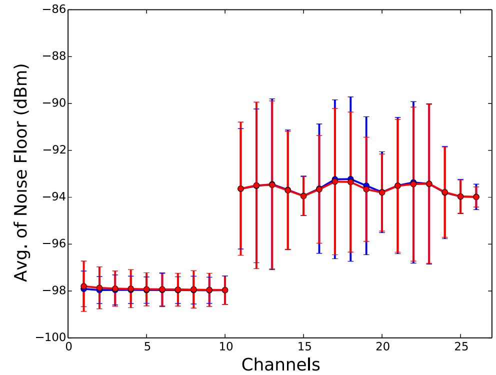

Fig. 2. Noise Floor Fluctuations from Channel Scanning.

III. Methodologies

We now describe two methodologies that can scan all the channels of both the bands at the same time.

Static Channel Assignment: In this methodology, we assign a fixed channel to scan to each node. In case of a node that supports dual band communication, we assign two channels to sample to each node. Thus, different nodes on the testbed sample different channels. While simple, the main limitation of this methodology is we cannot sample a given channel in all the node locations.

Channel Scanning: In this methodology, we program a node to iterate through all the channels and sample them. Thus, each node on the testbed samples all the channels but at different times. With this methodology, the spatio-temporal coverage of channel survey is more complete than with static channel assignment.

IV. Evaluation

We test the two methodologies on the Twonet testbed [6]. The testbed has Opal nodes, which has AT89RF231 and AT89RF212 radios operating at 2.4 GHz and 900 MHz bands respectively. We program the nodes with a TinyOS application to sample RSSI with both the radios at 250Hz selecting the channel depending on the methodology being used. We use a transmit power of 3 dBm in all measurements.

To evaluate the effectiveness of static channel assignment to perform multi-channel sampling, we designate 16 nodes on the testbed as snooper nodes. We statically assign two channels to each node, one for each radio. The nodes sample those assigned channels. We then redo the experiment assigning the nodes to sample different channels. Figure 1 shows the average noise obtained from these experiments. The average difference in noise levels from the two measurements is 0.495 dBm for 900 MHz channels and 0.279 dBm for 2.4 GHz channels. We find that the noise levels reported depends on the channel assignment. Thus, this methodology may cause different interpretation of the channel condition when performed by different researchers.

The next methodology we evaluate is channel scanning. We select two different sets of 16 nodes on the testbed. Each set runs channel scanning independently. Figure 2 shows the result from this experiment. The average difference in noise levels from the two measurements is 0.045dBm for 900 MHz channels and 0.039dBm for 2.4 GHz channels. This small difference suggests that channel scanning from two independent sets result in similar conclusions about the channel condition. Thus, we conclude that channel scanning provides a more reliable indication of channel states across the testbed.

V. Conclusions

In this work, we describe and evaluate two methodologies that can be used for concurrent wireless channel survey on dual band wireless sensor network testbed. Although channel scanning provides a more consistent result, sometimes static channel assignment may be preferred because of its simplicity. The main limitation of channel scanning is non-contiguous sampling because it takes some time for the radio to switch between channels. However, deployment of multiple scanning nodes partly addresses this problem. Overall, we find that the channel scanning methodology is suitable for concurrently tracing all channels on both 900 MHz band and 2.4 GHz band.

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