Adaptive Channel Assignment Testbed on MICAz

Junjie Zhu, Bo Chai, Jiming Chen
State Key Laboratory of Industrial Control Technology, Zhejiang University, China
{junjiezhu,chaibozju}@zju.edu.cn, {jmchen}@iipc.zju.edu.cn

***Abstract*—To fully evaluate and compare the performances of channel assignment algorithms, we design a MICAz-based testbed system with GUI interface, which is suitable for most kinds of algorithms. In the proposed system, we can download different algorithms, observe the performance through the GUI interface, and compare the results with simulations. In the demonstration, regret matching based channel assignment algorithm (RMCA) [1] is chosen as an example.**

I. Introduction

Wireless sensor network (WSN) is widely used in daily life, e.g., environment monitoring, medical care, target tracing. Due to the low-cost and limited capacity, the WSN nodes cannot provide reliable high data-rate communication. Moreover, limited spectrum utilization and crowed channel condition will degrade the Quality of Service (QoS) of WSN dramatically. Especially, in some urgent cases, e.g., in tsunami or earthquake disaster monitoring, the low QoS of wireless communication would be fatel. Thus, the fact that single channel MAC protocols cannot handle the interference efficiently is obvious. Therefore, it is necessary to enhance QoS with multiple channel utilization and the researchers have proposed plenty of channel assignment algorithms to improve the QoS.

Generally, the existing channel assignment algorithms can be categorized into three classes: static, semi-dynamic and dynamic with different adjusting interval: a) Static: the assignment can only be done once at the network initialization, e.g., TMCP [2], MCRT [3]. b) Semi-dynamic: the assignment can be done periodically or event-based. e.g., RMCA [1], MMSN [4]. c) Dynamic: the assignment is done frequently, typically before each transmission, e.g., Y-MAC. [5]

It is noteworthy that some of the existing algorithms are still only simulated but not conducted on testbed due to huge challenge for practical testbed design and debugging. However, simulations cannot firmly verify the performance, since they do not consider the errors in the modeling process and the unreliability of wireless communications in WSN. Therefore, the developed test system in the demo is necessary as it can validate more persuasive results in the practical environment than simulations. Furthermore, we can test and compare different channel assignment algorithms under the same conditions to decide which one is better. In addition, further improvement of the algorithms can be done based on the observation of results in the real scenarios.

Research was supported by 863 High-Tech Project under grant 2011AA040101-1.

II. System Description

The proposed testbed system consists of two parts, including the MICAz nodes and the main local server. Fig. 1 depicts the structure diagram of the testbed and Fig. 2 shows the real system.

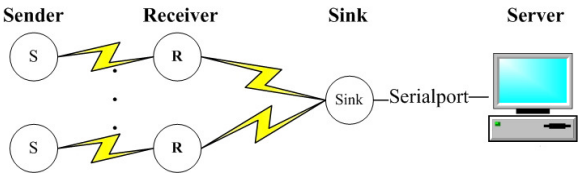


Fig. 1. The structure of the testbed system

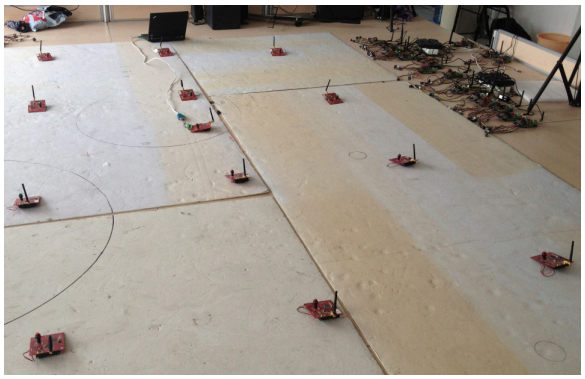


Fig. 2. A picture of the real system

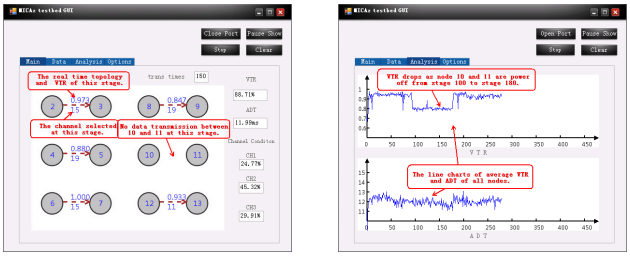
A. Hardware and operation system

The experiments are conducted with MICAz nodes equipped with CC2420 RF chips, which provides 16 available channels on 2.4 GHz frequency band (from 2405 MHz to 2480 MHz). Moreover, the average channel switching time delay is tested to be 0.34 ms, which qualifies it for most channel assignment algorithms. The operation system we choose is TinyOS, which is a well-known operation system specially designed for wireless sensor networks. It provides functions to support channel switching and data transmission on different frequencies.

B. Experiments

1) ***Nodes:*** In the experiments, the nodes can be classified into two types: data node and sink node. Data nodes transmit data packets periodically following the given topology. The sink node acts like a basestation. It broadcasts the time

978-1-4673-1017-8/14/$31.00 ©2014 IEEE



(a) The main page of the GUI (b) The line charts in the GUI

Fig. 3. The graphical user interface (GUI)

synchronization frame periodically and collects the packets from all the data nodes and delivers them to the PC through the serial port.

*2) **Main local server**:* We choose a Thinkpad X61 laptop as the main local server, which is used for collecting and analyzing the packets. A Graphical User Interface (GUI) is developed with C# to present a straight view of performances under different channel assignment algorithms. As shown in Fig. 3, the GUI shows the real time topology, current traffic condition and the overall performance of the certain algorithm. Here, both Valid Transmission Ratio (VTR) and Average Delay Time (ADT) are significant parameters in measuring the QoS of wireless communication under channel assignments algorithms.[1]

*3) **Procedure& Coding**:* The testbed is programed to work as the following steps. Firstly, sink node broadcasts a beacon frame at the begining of each stage in the control channel (in this demo, control channel is selected as channel 25). After all the data nodes hear the beacon frame in the control channel, they begin to exchange their channel information and start data transmission in their own arranged channel. At the end of every stage, the sink node ask each data node for their VTR and ADT. Then, all the information is reported to the server through serial port. Finally, after analyzing the reports, we can know how the algorithm works.

However, When the scale of nodes becomes large (e.g., 50 nodes), traffic jam of the control channel merges. As a solution, retransmission and allocating the time slot for each data node is introduced into the testbed. With the help of this schedule, the QoS of control channel has been improved dramatically.

For the convenience of user experience on coding, a general template source code file is built with four independent programme blocks: parameter block, procedure block, message block and algorithm block. The first three blocks are prewritten, so we just need to transfer and insert the certain channel assignment algorithm into the algorithm block and add the necessary parameters into parameter block. In order to suit more kinds of algorithms, the procedure can be adjusted flexibly in the procedure block by changing the interval of exchanging channel information. The message block is responsible for the pattern and length of the control message or data packets.

III. Demonstration

In this section, we demonstrate our testbed by testing RMCA [1] and MMSN [4] under the same environment.

Firstly, RMCA rules should be transfered into nesC code and inserted into algorithm block. Then, the parameters (e.g., the parameters of RMCA, the time interval of transmission, the times of transmission) can be easily set in the parameter block. Next, the source file can be downloaded into the nodes through serial port. After switching on all the nodes, we can watch the GUI to obtain the real time information, which are shown in Fig. 3. If the performance cannot reach the expected goal during the experiment, we can immediately reset the parameters and redo the experiment.

After a few attempts, RMCA always performs better than MMSN in terms of VTR and ADT. Compared with the simulation results in [1], the proposed system achieves a similar result that RMCA acts excellent in both VTR and ADT, which is shown in Fig. 4.

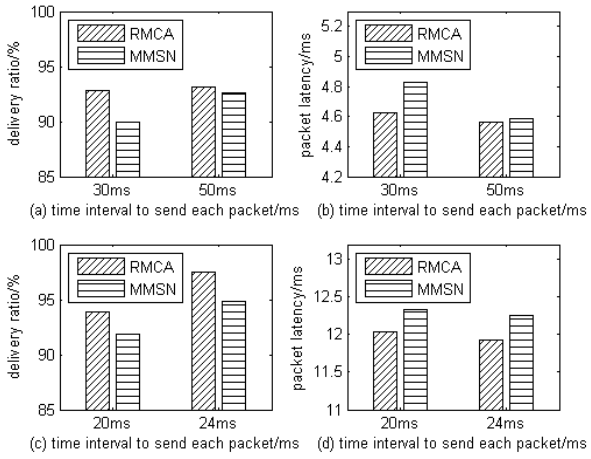


Fig. 4. Comparation of simulation and testbed results, (a) and (b) are the simulation results, (c) and (d) are the testbed results

After further analysis of the results, some improvements can be put forward for RMCA. Despite of the better performance of RMCA, the strong dependence of proper parameters may cause less robustness and worse performance. As a solution, the ADT at the first few stages is recorded to adaptively reset the parameters.

References

[1] Q. Yu, J. Chen, Y. Sun, Y. Fan, and X. Shen, "Regret matching based channel assignment for wireless sensor networks," in *Proc. IEEE ICC 2010*, pp. 1–5, 2010.

[2] Y. Wu, J. Stankovic, T. He, and S. Lin, "Realistic and efficient multi-channel communications in wireless sensor networks," in *Proc. IEEE INFOCOM 2008*, 2008.

[3] X. Wang, X. Wang, X. Fu, G. Xing, and N. Jha, "Flow-based real-time communication in multi-channel wireless sensor networks," in *Wireless Sensor Networks*, pp. 33–52, Springer, 2009.

[4] G. Zhou, C. Huang, T. Yan, T. He, J. A. Stankovic, and T. F. Abdelzaher, "Mmsn: Multi-frequency media access control for wireless sensor networks.," in *Proc. IEEE INFOCOM 2006*, pp. 1–13, 2006.

[5] R. Soua and P. Minet, "A survey on multichannel assignment protocols in wireless sensor networks," in *Proc. IEEE WD 2011*, pp. 1–3, 2011.