Throughput Enhancement By Multi Channelling IEEE 802.15.4 For Multimedia Applications

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Abstract— In this paper, we propose a new multichannel allocation protocol for ZigBee/IEEE 802.15.4 networks. The main goal is to improve the global throughput which is basically insufficient to satisfy high bandwidth requirements for applications like monitoring or traffic control. The solution is based on the availability of multiple channels on current low-cost, low-energy radio transceivers, which can be easily tuned dynamically to different frequencies. This possibility can be exploited to increase the number of simultaneous transmissions on adjacent links. The allocation of the different channels is centralized and distributed by the coordinator thanks to a function designed to compute the channel offset between two successive children routers. In the nodes, the switching process between the transmission and the reception channels is triggered starting from the PHY primitive available on the transceiver. We have implemented the multichannel capability foe 802.15.4 MAC with multichannel interface to aodv protocol. The channel allocation conditions are observed by considering different scenarios. The performance is compared with single channel 802.15.4. The simulation results shows that the proposed protocol improves the global throughput by a factor between 2 and 5, depending on the scenario, compared to the single-channel solution or a random channel allocation.

Keywords— 802.15.4, Multi Channel, Throughput Enhancement, Multimedia Applicaition.

I. Introduction

The bandwidth available in Wireless Sensor Networks (WSN) is generally insufficient to satisfy greedy applications such as low/medium resolution video monitoring. For instance, the theoretical throughput in prevalent WSN standards such as ZigBee or 6LowPan is upper-bounded to250kbps. As wireless sensor networking evolves toward multimedia sensing, it becomes necessary to find new mechanisms to transmit more efficiently audio or video flows.

We are interested here only on single interface solutions as multiple interface schemes are not adapted to ZigBee devices because of their energy consumption limitations. In WSNs standards, much smaller packet sizes are used (e.g. ~100 bytes for IEEE 802.15.4) compared to those in wireless ad hoc networks (e.g. 1500 bytes in IEEE 802.11).
The solutions with control packets like RTS/CTS in IEEE 802.11will not be adopted as they can lead to an important overhead.

Current low-cost, low-energy radio transceivers, can be tuned dynamically to different frequencies allowing PHY protocols to operate on different radio channels. The availability of multiple channels on the wireless medium can be exploited to increase the number of simultaneous transmissions between different pairs of transmitter/receiver. Thus, the global network throughput can potentially be increased. However, no channel switching protocol is proposed in IEEE 802.15.4 standard. That is why, in this paper, we propose a new protocol for the channels assignment called MASN - short for Multichannel Access for Sensor Networks - based on an offset function comparable to the one used in the hierarchical ZigBee addressing. Channels on the different links are successively allocated by the coordinator after the association process, starting from the first child router and toward the end terminals. The proposed protocol ensures that two neighboring links will not use the same channel. In addition, the protocol introduces a switching process between transmission and reception channels. This process is triggered by the PHY primitive available into the transceiver.

Insofar as the protocol does not modify the medium access method but only adds channel allocation and channel switching process in the nodes, it can be easily implemented in IEEE 802.15.4 device. The MASN protocol is thus designed in accordance with the 802.15.4/ZigBee networks standard which is not the case of many proposed solutions in literature.

In Section II we have mentioned technique used for establishing multichannel capability for 802.15.4 and methodology. In section III we shown simulation based results and finally in section IV we conclude the paper.

II. Material and Methodology

As suggested in mutlichannel in 802.11 and multichannelling in 802.15.4 we have considered some basic aspects of multichannelling the 802.15.4 starting from physical layer to network layer including MAC. For creating multichannelling in 802.15.4 we have modified 802.15.4 MAC file in ns2. The figure1 shows

the conceptual idea for network layer model strictly in ns2 point of view for multichanelling the 802.15.4.

To provide multiple channels we have considered 5MHz bands of frequencies extending from 2.45GHz basic carrier frequency of 802.15.4. Figure 2 indicates the channelling concept extending from 2.45GHz frequency. For simulation purpose we have considered only 6 channels which are considered as maximum mossible channels for 802.15.4.

Figure 1 indicates multichannel interface with network which has full duplex capapbilities upto network layer. The instances can be recalled as objects whenever new node is created. As six channels are considered we are sticking with the maximum six channels utilization based scenarios while writing tcl script for experimentation.

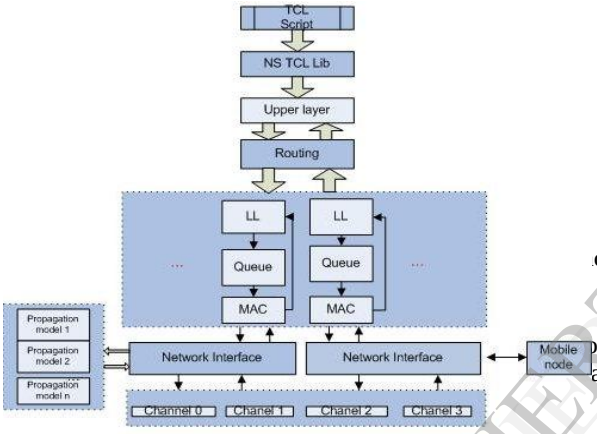


Figure1: Multichannel Architecture of 802.15.4

Figure 2: Channelling

As mentioned above, this study takes into consideration the technical characteristics of existing WSNs and relates to sensor networks with high bandwidth demand in which data are destined to aunique sink. Such context imposes some assumptions for the network and its components:

1. Static nodes limited to 50 and distributed in an area less than 100x100m (current deployments of ZigBee networks in home automation or monitoring contexts are generally composed of less than 50 nodes).
2. Hierarchical clustered topology with a single sink;
3. ZigBee/IEEE 802.15.4 technology for routing, MAC and PHY layers;
4. Hierarchical ZigBee routing for many-to-one transmissions (different from a reactive ad hoc routing for many-to-many communications which is the case of many studies on the subject [6-11]);
5. One radio per node, except for the ZigBee coordinator which serves as sink.

For experimentation we have smulated the network scenario consist of 6 nodes. Node0 is set as coordinator of star topology. The traffic has been establishe initialy for only one node and then it is increased by assigning it to more than one nodes. The ramaining simulation parameters are set as shown in Table 1.**Table 1. Simulation parameters**

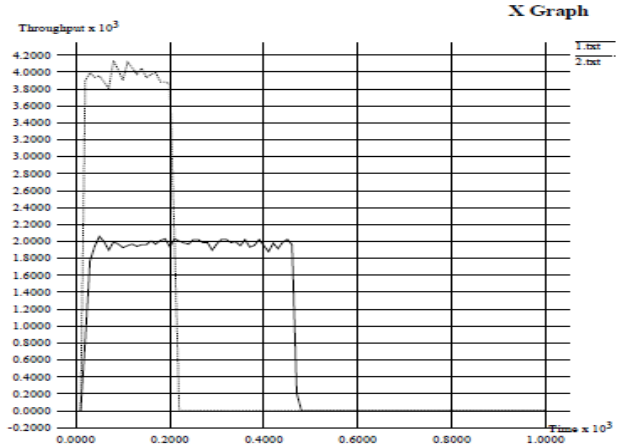
Physical Channel	802.15.4
CBR Interval	0.045454546 Sec
Reception range	10m
Detection range	15m
Number of Nodes	6
Routing Protocol	AODV
Simmulation Time	1000 seconds

For analysis we have compared the onochannel scenario with multichannel scenario.

III. Results and Tables

For performance evaluation we have onsidered two cases:

ase 1:

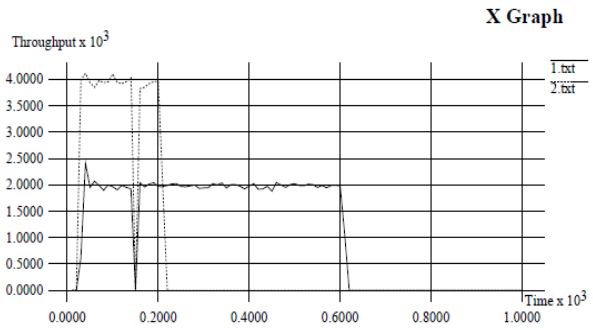


Graph 1: Comparison of 1st case

Analysis: Graph shows that as multichannels are been alloted throughput has been increased and due to which the same amount of data is deleivered in short period. For throughput analysis only data packets count is considered. For case 1 we are considering only one node as traffic generator. In total 10,000 data packets are sent. Using monochannel it takes approximately 450 seconds where as using multichannel it takes approximately 200 seconds. Instantaneous throughput for multichannel is almost twice of monochannel.

Case 2:

Graph 2: Comparison of 1st case



Analysis: For case 2 we are considering two nodes as traffic generator. In total 10,000 data packets are sent. Using monochannel it takes approximately 600 seconds where as using multichannel it takes approximately 200 seconds. Instantaneous throughput for multichannel is almost twice of monochannel.
The analysis is tabulated as below:

Table 2: Analysis of results

	Parameters	Monochannel	Multichannel
Case1	Total Packets	10000	10000
	Time taken to send all Packets	450seconds	200seconds
	Number of Nodes generating traffic	1	1
	Instantaneous Throughput	2000	4000
Case 2	Total Packets	10000	10000
	Time taken to send all Packets	600 seconds	200 seconds
	Number of Nodes generating traffic	2	2
	Instantaneous Throughput	2200	4100

IV. Conclusion

From the experimentation we conclude that using multichannel scenario 802.15.4 can be used for multimedia applications where more bandwidth requirements are essential. Multichannel 802.15.4 improves the bandwidth in terms of utilization.

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