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A Hybrid Model for Fast Converge Cast in Tree-Based WSN

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***Abstract* – In Wireless Sensor Networks sensor nodes and a common sink node are involved. Data is collected from a set of sensor nodes towards the sink. Various routing topologies can be used to achieve the data collection. This paper explores the data collection over a tree based routing topology. For guarantee of delivery it is important to follow an efficient approach for data collection. Recently Incel et al. explored various approaches for fast data collection over tree-based routing topology. The many to one communication over such topology is known as converge cast. They explored different schemes such as node-based and link-based channel assignment schemes to eliminate interference. In this paper we improve their scheme further by combining the two channels and also experimenting with variable amount of data. We also build a prototype application to demonstrate the proof of concept. The empirical results revealed that the proposed scheme is robust in fast data collection in tree – based WSN.**

***Keywords* – Convergecast, Multiple Channels, Tree Based Routing Topology, WSN.**

I. INTRODUCTION

In Wireless Sensor Networks data is collected from multiple sensor nodes to sink. This kind of many to one communication is known as “Convergecast”. This process is known as data collection. However, in many real time applications, it is essential to collect data from sensor nodes faster with guaranteed delivery for quick decision making. For instance in machine critical installations such as monitoring gas leakage, or any damage, it is essential to the WSN to respond in given dead line [1]. Failure of WSN to deliver its services ontime can lead to a cascade of problems. Incel et al. [2] focused on the fast data collection techniques. They considered two models for fast data collection. They are known as aggregated convergecast and raw-data convergecast. In case of aggregate convergcase the packets area aggregated at each hop. In case of raw-data convergecast, packets are sent to sink individually. When there is spatial correlation aggregate convergecast is suitable. When the correlation is minimal and individual data is important raw-data convergecast is suitable. For periodic traffic it is important to have MAC protocols such as TDMA (Time Division Multiple Access) that support contention – free transmission. These protocols avoid collisions and improve communication problems. Constructing conflict-free TDMA schedules is not easy. There are problems in data collection. The problems include interference in the medium and sensor nodes having half-duplex transceivers and underlying topology of network.

Recently Incel et al. [2] combine transmission power control with scheduling schemes such as node independent and link independent channel assignment schemes. Totally three schemes are tested by them. They are RBCA, TMCP and JFTSS. The RBCA and JFTSS show better performance when compared with TMCP.

In this paper we combine both node independent and link independent channel assignment schemes besides testing those using variable amounts of data for fast data collection. The results revealed that the proposed approach outperformed the individual schemes for channel assignment.

II. RELATED WORK

Fast data collection is essential in WSN in order to take quick decisions as this network is used in applications where fast information is important. The data when collected from multiple nodes to the sink in WSN, it is known as converge cast. This has been studied by many researchers in [3], [4], [5], [6], [7]. Impact of transmission power control is investigated in [3] on schedule length with channels of multiple frequencies. Another type of convergecast known as raw-data convergecast was studied in [8], [9] and [10]. In order to reduce the schedule length of TDMA protocol over a single channel, experiments are made on a schme known as distributed time slot assignment. Moscibroda [5] studied on the problem of combining the transmission power control and joint scheduling. This resulted in uniform traffic demands. The work done byIncel et al. [2] is different in which they evaluated the transmission power control, node-based and link-based channel assignment schemes. They also compared the results with different interference and channel assignemt models on tree based roiuting topology in WSN. They also did experiments on both aggratd convergecast and also raw-data convergecast.

Annamalai et al. [6] studied the use of orthogonal codes for the purpose of eliminating interference. In the experiments they assigned time slots in tree based topology in such a way that parents wait until data is collected from children before sending the data to the sink.

One shot convergecast of raw-data type has been addressed by Chen et al. [7]. Low latency was the problem observed in their experiments due to the increasing hops in the tree. In order to minimize the latency, bounded diameter tree and bounded-degree tree construction has to be considered. In tune with this another study came from Pan and Tseng [11] where a beacon period was assignmed to each node by them and the experiments were done on Zigbee network. With respect to raw-data convergecast, Song et al. [8] proposed anenergy efficient and time optimal scheduling algoihtm that ensures periodic traffic being flown between the sensor nodes to the sink. Their algoihtm achieved expected results provided the elimination of interference. They also proposed a 3-colored scheme for channel assignment to eliminate intefgerence. However, their assumption is on single interference model in which each node exhibits a circle range for transmission. It also avoids from concurrent sender nodes the cumulative interference. Incel et al. [2] proposed multiple frequencies and experimented with three different schemes of channel assignment. They also tested the effects of transmission power control along with link based, node based channel assignments. Moreover the channel models and interference models they used are realistic in nature. TDMA based protocol with high data transmission range in WSS was proposed by Song et al. [8], [12]. Their work is named as TreeMAC which have differentlevels of routing as per the hop count, depth, and nodes in the tree and so on. However, only single channel is supported by TreeMAC for achieving maximum throughput which is similar to the technique presented by Gandham et al. minimizing the schedule length is of given much importance by Choi et al. [9]. Throughout maximizing in convergeecast through conflict free schedule with shortest length is presented by Lai et al. [10]. They used a strategy named as greedy graph coloring. Impact of routing trees on the scheduling mechanism was studied by them. They observed that sink is a bottleneck there is no possibility of sending data from different paths. Minimal spanning tree can be used to overcome this problem with respect to raw-data covergecast. In both ad hoc and cellular networks, multiple frequencies are studied considerably in WSN domain. There are few studies on multiple channels [13], [14], and [15]. Incel et al. [2] also evaluated different schemes of channel assignment at various levels.

In this paper we combine the node based and link based channel assignment schemes to improve the fast data collection further. We also built a prototype which demonstrates the proof of concept besides facilitating experiments on various amounts of data.

III. Scheduling of Convergecasts

We used inference aware TDMA protocol. We tested the tree – based routing topology as an underlying topology for WSN. Our aim is to improve convergecast or achieve fast data collection. The algorithms used for node and link independent channel assignment schemes are combined and then experiments are made using various amounts of data. The two models such as node independent and link independent are taken from Incel et al. [2]. We built a new scheme that combines these two and allows testing the WSN for fast data collection. The next section provides details of our protocol implementation.

IV. Prototype Implementation

The prototype implementation is a custom Java simulator that demonstrates the concept of convergecast as per the proposed approach. The nodes and sink in the WSN are simulated and the proof of concept is demonstrated. Fig. 1 shows multiple sensor nodes communicating with single sink. The converge cast is demonstrated.

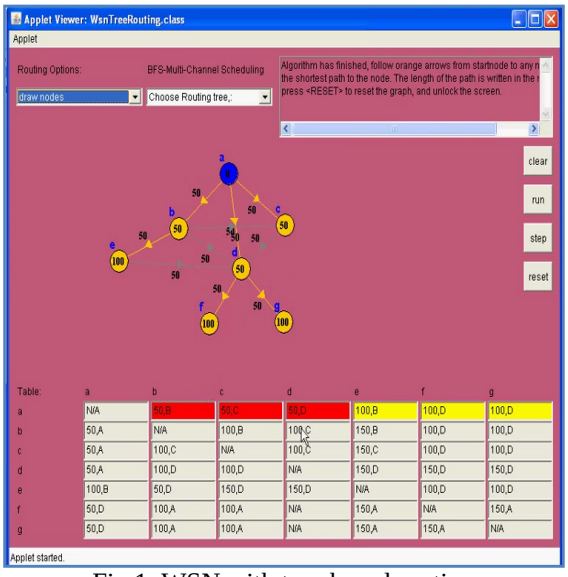

Fig.1. WSN with tree-based routing

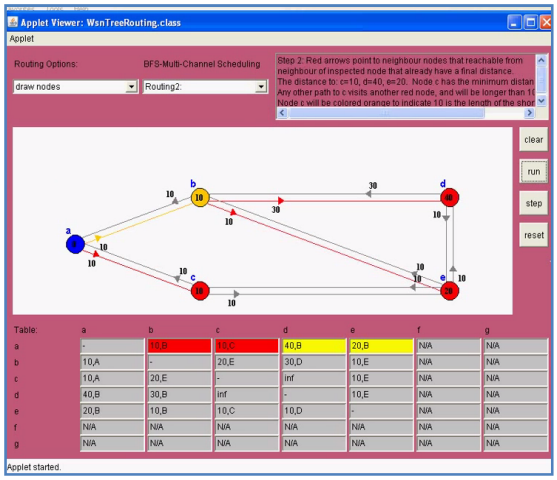

Fig.2. Sample scheduling

As can be seen in fig.1, a WSN is shown with multiple sensor nodes and single sink. The topology is tree based and the convergecast takes place. It does mean that data is collected from multiple sensor nodes towards sink node. There is routing table also presented.

As can be seen in fig.2, as scheduling algorithms run the changes are visible on the screen. The routing table and the scheduling paths can be viewed. The red arrows point to neighboring nodes that are reachable from the inspected nodes.

V. Experimental Results

The experimental reuslts of convergecast using diffent channel assignemt approches such as RBCA, JFTSS, and the combine approch. The experiments are done in terms of number of time slots, side length, percentage of incorrectly scheduled links and son on.

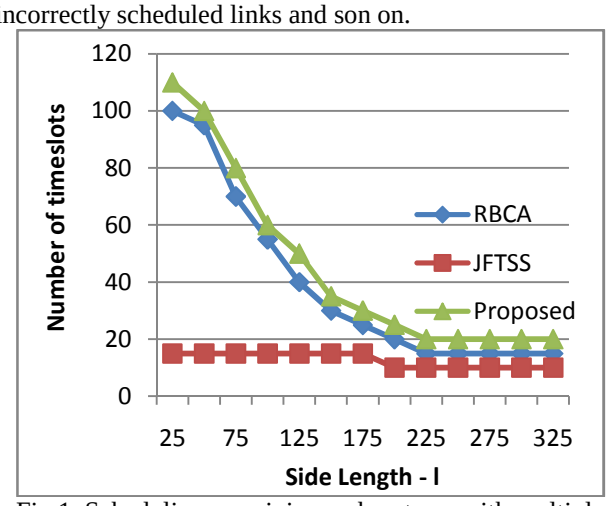

Fig.1. Scheduling on minimum-hop trees with multiple channels (Aggregated convergecast)

As shown in above figure 1 the horizontal axis represents side length while vertical axis represents number of time slots.As results are shown the proposed approach outperforms the existing approaches.

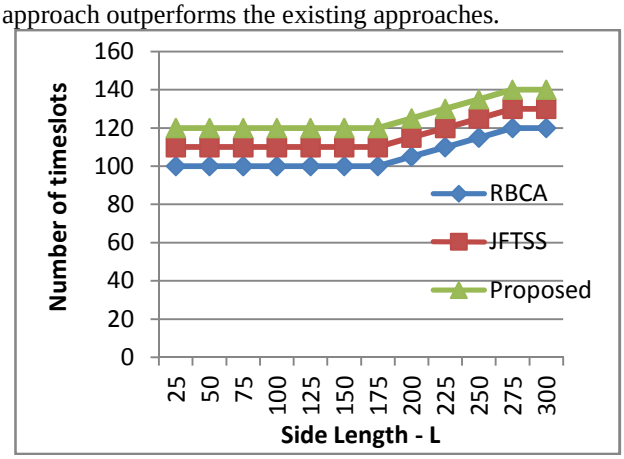

Fig.2. Scheduling on minimum-hop trees with multiple channels (Raw-data convergecast)

As shown in above figure 2 the horizontal axis represents side length while vertical axis represents number of time slots. As results are shown the proposed approach outperforms the existing approaches.

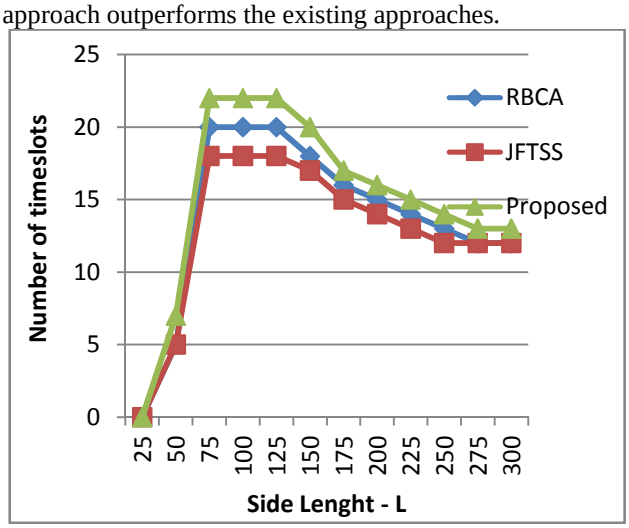

Fig.3. Bounds on the number of frequencies

As shown in above figure 3 the horizontal axis represents side length while vertical axis represents number of time slots. As results are shown the proposed approach outperforms the existing approaches.

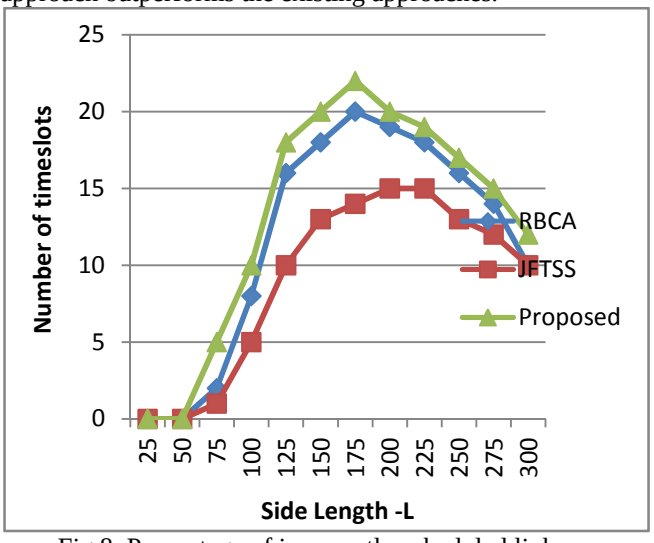

Fig.8. Percentage of incorrectly scheduled links.

As shown in above figure 4 the horizontal axis represents side length while vertical axis represents number of time slots. As results are shown the proposed approach outperforms the existing approaches.

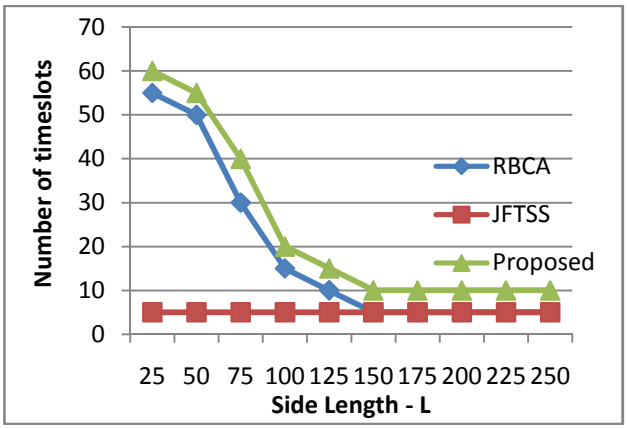

Fig.5. Scheduling on degree-constrained minimum-hop trees

As shown in above figure 5 the horizontal axis represents side length while vertical axis represents number of time slots. As results are shown the proposed approach outperforms the existing approaches.

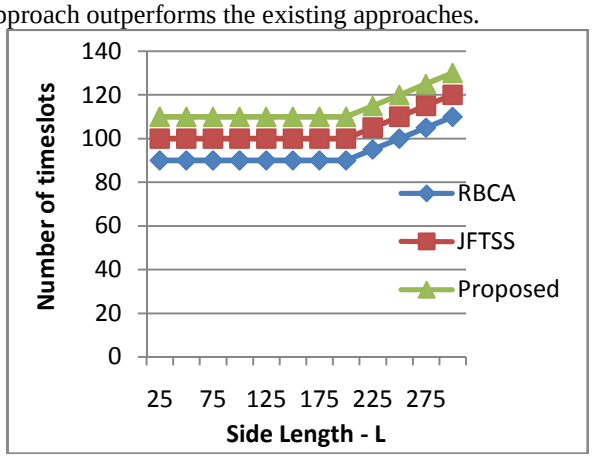

Fig.6. Scheduling on CMST

As shown in above figure 6 the horizontal axis represents side length while vertical axis represents number of time slots. As results are shown the proposed approach outperforms the existing approaches.

VI. Conclusions

In this paper we implemented the node based and link based channel assignment schemes proposed by Incel et al. [2]. Moreover we combine both the schemes and explored the fast data collection with variable amount of data. We also built a prototype application that simulates the proposed scheme. We made various experiments with node based and link based channel assignment schemes over a tree based topology in WSN for fast data collection. The empirical results revealed that the proposed scheme is robust and results in faster data collection besides eliminating interference.

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