Congestion Control with Network Design Strategy to Optimize Energy Efficiency in IWSNs

Gaspard Gashema, Godwin Brown Tunze, Jae-Min Lee and Dong-Seong Kim
Networked Systems Lab., Dept. of IT Covergence Engineering,
Kumoh National Institute of Technology, Gumi, South Korea,
Email: {ggas05, gbtunze, ljmpaul and dskim}@kumoh.ac.kr

***Abstract*—This paper proposes the approach to control the packet traffic in wireless communication networks (WCNs). The approach omits contention within the sensor nodes in network during executing operation by alternatively improving the energy efficiency of the sensor nodes, hence ensuring the lifetime of the network through energy management of the nodes. The communication between nodes is executed under IEEE 802.15.4 AN1066 MiWi protocol. The performance evaluation was conducted under MATLAB simulating environment. It was shown that the proposed approach outperforms reliable, efficient, fair and interference-aware congestion control (REFIACC) protocol energy efficient.**

***Index Terms*—IEEE802.15.4 MAC (AN1066 MiWi), congestion control, energy efficiency.**

I. INTRODUCTION

SINCE the development of wireless sensor sector, wireless sensor nodes have becomes paramount to various applications. They are deployed in a particular environment; are also connected wirelessly under radio frequency (RF) communications to form wireless sensor network (WSN) for a specific application. WSNs optimally render services such as seismic detection, medical and process, smart spaces, inventory tracking, military surveillance, acoustic detection, environmental/habitat monitoring, etc. Despite the above aforementioned applications of WSNs organized through those sensor nodes, they face several challenges due the security, i.e., to be easily hacked [1], high energy consumption [2], lower data rate communication and the most crucial challenge of these kind of network is being vulnerable to interference due to the distraction of other elements such Bluetooth which can cause drastic communication among nodes, hence high energy consumption.

In fact, the data are collected from sensor nodes in order to process and send them to intermediate neighbor nodes for further transmission to the base station by using the designed routing process [3], [4]. Since sensors are interconnected wirelessly with limited power, the radio links within the network to connect each node and its adjacent to communicate to the base station may fail due to either big gap connectivity or low energy nodes which can result serious problem, leading to the operating failure. This performance degradation can be explained by when the load traffics exceed the available capacity assigned to the link between nodes in the network, hence convey traffic congestion during packet transmission. This paper evaluates and figures out how to control transmission congestion due to link-level in multi-hop communication. The problem is handled by proposing a novel approach " *Congestion Control with Network Design Strategy to optimize the energy efficiency* in IWSNs. As the name indicates, the approach consists of controlling congestion in sensor network for the purpose of reducing packet delivery delay from source node to base station, energy consumption of sensor nodes and tackling interference in the links within network leading to the balance of transmission from one node to its neighbor, hence ensuring optimum energy efficiency.

Sensor nodes in the network are arranged such that, they are operating only in case of the need performing tasks, otherwise they keep being in inactive mode, hence energy efficiency. Microchip wireless network protocol knows as MiWi protocol was employed for energy efficient during the transmission of packets. Moreover, MiWi employed in the network is designed based on the principle on the IEEE.802.15.4 MAC standard for Wireless Personal Networks (WPANs). The beneficial for MiWi, is open source protocol, i.e, does need license if used with microcontrollers and the Microchip MRF24J40 transceiver. Through the simulation results under MATLAB environment tool, it was shown that, there is a signification outperformance in both energy consumption compared to [5].

II. SYSTEM MODEL

Consider Fig. 1 to represent the topology of the sensor network composed by sensor network, base station, external internet and control center/ data storage management center. The sensor network consists of a number of sensor nodes distributed in coverage area. The function of sensors is to sense even in industrial complex, generates packets, processes them to be transmitted to the base station under multi-hope propagation routing for further procession in control center. Herein, the base station plays the role as network coordinator; and consists of receiving data from sensor network, processes and stores these data into control center. The network has the structure of

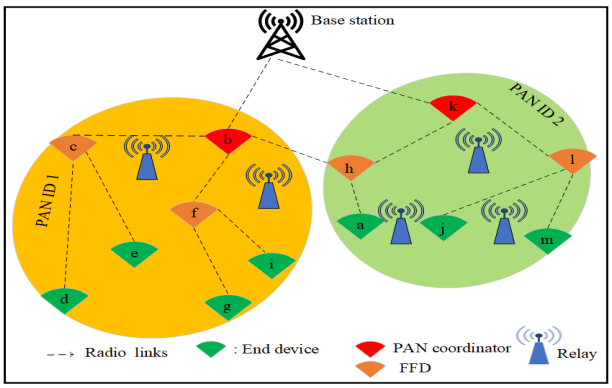

Fig. 1. Network topology: tree topology.

a tree (tree-topology) where the base station emulates its roots while the sensor nodes which are at the farthest distance from base station represent the leaves; and they assure transmission of data to the base station via intermediate nodes. To make the network flexible and reliable, the whole tree is subdivided into sub-trees and every PAN coordinator imitates the root of sub-tree with a particular PAN ID to facilitate transmission of data to the base station. In other words, PAN coordinator starts the network and consists of selecting the perfect path as well as PAN ID of the network. The other devices attached to PAN in sub-tree must respect its instructions. As we have already evoked, the main aim of this work is to optimize energy efficiency of sensor nodes in the network by controlling congestion and mitigating inter-link interference which can occur during communication of the nodes (when nodes tend to send packed data to its neighbor towards the base station).

A. Expression of Energy consumption

Since the active nodes require high energy specially during transmission, we can make analysis in energy consumption by considering the current drop with respect to the time taken for every operating mode. Therefore, putting I_T as the current consumed by transceiver in the state represented by T[1]. On the other hand, in case the transceiver is in the sleep mode, it becomes disable until the coordinator which is in its communication range addresses the message to it. By letting I_s as the current consumed in the sleep mode represented S as the fraction time in which the transceiver is in sleep mode. The following condition must be satisfied:

$$T \times I_T + S \times I_S \leq I_{max}. \quad (1)$$

Since S=T, (1) can be expressed as:

$$T \leq \frac{I_{max} - I_S}{I_T - I_S}. \quad (2)$$

On the other hand, the energy consumption for the PAN coordinator during the broadcast message transmission in corresponding sub-tree can be expressed as:

$$E_L = P * E_S + P * E_C * d^2 = P * (E_S + P * E_C * d^2), \quad (3)$$

with P, E_S, E_S are the number of transmitted bits of data packets from leaf, the energy dissipated per P by transceiver and the energy consumed by leaves during transmission of P to the designed PAN coordinator receptively while the d is the distance separating transmitting leaf to the corresponding PAN coordinator.

III. Performance Evaluation

In this work, the performance was evaluated under MATLAB simulation environment. We present the result by comparing the proposed approach with that is in [5]. The simulation was conducted in the closed area of 10×10 m^2. The IEEE802.11 MAC (AN1066 MiWi) was introduced as the preferable protocol due to its merits as already mentioned in the network design. The number of sensor nodes 30 which form 3 sub-tries. Each sub-tree is composed of different number of sensor nodes. Recall that: the sub-tree has FFD which is set as a coordinator to further transmit packet to the base station. All nodes in the network are static.

Fig.2 depicts the energy consumption in the network with respect to the packets transmission rate. As shown, in both

[1]The fraction of time in which the transceiver is turned on.

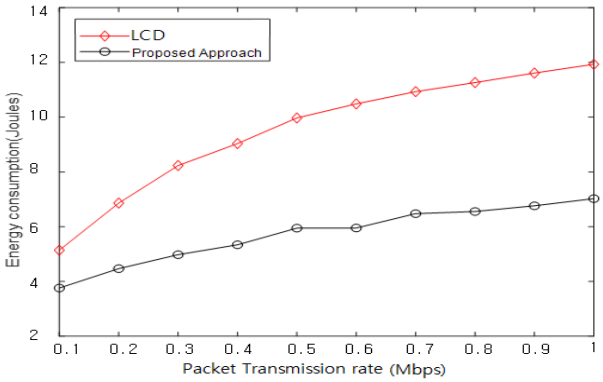

Fig. 2. Energy consumption vs Packet transmission rate.

curves the energy increases with the of packets transmitted. This increment in energy consumption in both schemes is due to the fact that that nodes in the network in the active active when they are generating, processing transmitting and receiving/ forwarding data. However, it is clear that they is lesser energy consumption for the proposed approach compared to REIACC.

IV. Conclusion and Future works

This paper proposes a novel approach for congestion control during data transmissions in sensor network. It symmetrically arranges sensor nodes in tree topology; then subdivided into sub-trees for the purpose of reliable and flexible network. The sub-trees are controlled by PAN coordinator to render the network flexible and reliable. Moreover, IEEE802.15.4 MAC (AN1066 MiWi) based energy efficient protocol was employed to link sensor nodes (RF transceivers). After performance evaluation under MATLAB environment, it was shown that the proposed approach outperforms REFIACC in terms of energy efficiency.

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