Minimization of Packet Congestion in Wireless Sensor Networks

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***Abstract*:** *Wireless Sensor Networks (WSNs) technology is the exciting network that solves variation of the applications in networks and it has more efficient towards delivering of sensed information that benefits society in many ways. WSNs have been identified as one of most important technology for the 21st century compared to other wired network. This technology consists of collections of nodes organized into corporate network, where we find that each node consists of processing capability for one or more fries, which may maintain multiples types of functions within a network. However, this technology experience packet congestion when transmitting packets among each other nodes from source node to destination node, which leads to end-to-end delay, low throughput, packets loss and reduce the Quality of Services (QoS) within a network. As a result, in this dissertation we are going to design an algorithm that will minimize the collision that occurs in WSNs. Network Simulator-2 (NS-2), will be used to test the proposed solution.*

Keywords: *wireless sensor networks, packet congestion, packet loss, QoS.*

1. Introduction

IN recent years, Wireless Sensor Networks (WSNs) have been approaching as the key in technology for upcoming generation of the current wireless networks system. WSNs consist of a large number of small sensor nodes and these nodes are very cheap in terms of cost [1, 2]. This is mostly, because wireless networks processes the authority of services for long-distance communication was wires cannot be implemented [3, 4]. Therefore, WSNs can also be assimilated with other communication channel such as the IEEE 802.11, Internet, cellular and etc. Network users who make use of WSNs can move freely and change their position any time while still connected to a network. Sensor nodes are capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. Hence, WSNs are self-organized and make use of an ad hoc network to automatically establish the wireless connectivity and nodes.

However, WSNs communicate with other nodes by sending data packets or information over multiple wireless hops using the bandwidth and enable the deployment of multi-hop wireless network to access the packets. The nodes of wireless sensor networks can have many wireless interfaces in order to increase the capacity of wireless network [5]. There is different ways that can cause the packet congestion in WSNs, such as link interference, limited bandwidth that cannot accommodate the entire network user at the same time and also other execution of data amount to be sent to other nodes. Furthermore, in WSNs congestion can happen anytime anywhere in the intermediate node and lead to poor network performance or quality of services (QoS).

Furthermore, packet congestion mostly happens when the load on the network is more than the capacity of the network. The information in wireless sensor network is transferred using the greatest route to the destination using the greatest path which determines the routing protocol. Hence, the packet congestion occurs when there is a routing protocol which determines the same greatest path over other path due to traffic load that occurs on the same path when other path are not often used and it lead to packets loss, end-to-end delay and poor network throughput [6]. Wireless network is most considered to be good and successful if it offers good QoS [7, 8].

This paper focuses on minimizing packet congestion using the new algorithm. In order to achieve our goal, we designed and implemented new algorithm by integrating different algorithms which are: Packet Scheduling Algorithm (PSA) and History-Based Increment Backoff (HBIB) Algorithms and Transferable bandwidth allocation. The new algorithm we come up with is Packets Bandwidth Scheduling (PBS) algorithm

The remainder of this paper is structured in the following way: In Section II, we presented the overview of exiting algorithm. In Section III, we presented the related work. In Section IV, we presented the proposed network architecture. In Section V, we presented the proposed algorithm.

2. Overview of Exiting Algorithm

In order to achieve the goal of minimizing the packets congestion and improve the quality of services (QoS), we integrate three algorithms which are as follows: Packets scheduling algorithm (PSA), and History-Based Increment Backoff (HBIB).

Packets scheduling algorithm was used to minimize the congestion in wireless network. A packets scheduling algorithm is one of the good algorithm that used to improve the QoS in wireless network. The fundamental notions of defining the packet scheduling are based on the transmission of packets when are from source to destination. Packets scheduling [9] consist of the set of packets in the nodes. Packets start when delivering the packets to instantaneously after complete its step [10]. The coalition value can be in different ways which include the graph form, characteristic form and partition form [11]. Therefore, our study focuses on characteristic form, because a decision that it takes it checks based on the traffic type and even checks the size of the bandwidth in the network. In characteristic form, the value of coalition is the value which assigned to a node after all nodes have communicated and made a decision based on the available bandwidth and the size of packet that user want to send at the time [3, 11].

History-Based Increment Backoff (HBIB) Algorithms improves the end-to-end delay and throughput of wireless sensor network by regulating the Contention Window (CW) size based on the current status of packets transmission and the available bandwidth. HBIB algorithm idea is to pair the CW upon a collision until the frame which is transmitted is successful or reached, which determined the number of retransmission. Therefore, it will reset the CW and have a new transmission, which minimize the packet collision. However, their algorithm improved end-to-end delay and throughput, the problem of arranging the packets in network before it can be transmitted still remain as a problem.

As a result, there is high interference and poor utilization of the available spectrum as it is not shared cooperatively. In interweave mode, simultaneous transmission is not allowed. In this paper, interlay mode was used to allow wireless sensor network to share spectrum cooperatively in order to all users roam between the different networks without services i.e., VoIP being interrupted. In interlay mode, both PUs and SUs can transmit concurrently in the same area, without limiting the transfer power of SUs in the PN. In the proposed algorithm PUs and SUs cooperatively share the spectrum provided by PN [3, 10-14, 18-20].

3. Related Work

Over the past years a lot of work has been conducted in this area and many researches have contributed in the field of wireless networks based on packets congestion and provided their solutions.

Grover et al. [1] proposed to use Congestion Control Algorithms based on AODV routing protocol to overcome the congestion in the network. The author use AODV routing protocol to implement routing in the network. The congestion control algorithm is responsible for preventing the occurrence congestion and also lessening the impact on network congestion throughput if occurs. Network Simulator -2 was used to implement and test their solution.

Mani [12] proposed Congestion Aware Ant Colony Optimization algorithm to achieve the efficient congestion avoidance and routing algorithm framework in wireless sensor networks. The author use the CACO algorithm for biologically inspired agents to route the packets in WSNs. CACO use nodes, to distributed interference-aware data forwarding algorithm which allow nifty ants to concurrently perform the routing and data forwarding. Therefore, it evaluates the load within the network in order to correctly qualify the outgoing links.

https://doi.org/10.15242/DiRPUB.DIR1017025

Ramesh [13] proposed Congestion Adaptive AODV routing Protocol (CA-AODV) to cope up with congestion condition effectively and increase the performance of the network. The author used this protocol to ensure the availability of the primary route as well as the alternative routes. Therefore, if there is any type of congestion at the primary route and affect the node it will notify its previous node about the congestion and packets will be retransmitted from alternate route until it reaches its destination node.

Li, et al. [14] proposed the spectrum of sharing the packets between primary and secondary systems by using two-phase spectrum sharing protocol with Analogy Network Coding (ANC). The connectivity of secondary user acts as a relay to assist with the bidirectional primary transmissions. When ANC is employed for two-way relaying between the two primary users and spectrum sharing is achieved by superimposing the secondary signal on the network-coded primary signals at the secondary relay. The simulation results showed that two-phase spectrum sharing protocol with Analogy Network Coding (ANC) can achieve higher (or at least equal) outage performance for the primary system than direct transmission without spectrum sharing. In paper, interlay mode is used in order to cooperatively share the available spectrum.

Rad et al [15] proposed to use the Joint Optimal Channel Assignment and Congestion Control (JOCAC) to overcome the capacity of user increased in multiple channels in wireless sensor networks. The author used JOCAC algorithm to assign the non-overlapping and partially-overlapping channels within the IEEE 802.11 frequency bands to decentralize the utility maximization problem with the constraints that ascend from the interference of the packets transmission. The simulation of the proposed algorithm shows the higher aggregated good put by 40% than the previous proposed algorithm which have 20% when all 11 partially-overlapping channels are been used.

Gupta et al. [16] proposed the dynamic routing algorithm which will provide the optimal performance on all possible traffic demands. The author determined the traffic alongside the pre-determined paths and shows as ineffective in coping with unreliable and unpredictable in wireless medium. They use NS-2 for their simulation results and results show that the proposed method performs competitively.

He et al. [17] proposed the multipath routing optimization algorithm for allocating the bandwidth resource to nodes that subjected to interfere the flow in the parts of the network. The author used routing metric for path section and load distribution during the flows in the network. They use computers for simulations to evaluate the performance and effectiveness of the proposed routing method.

4. Proposed Algorithm

The developed algorithm below demonstrates how the altered equations and variables are being executed in order to produce a successful algorithm that will be implemented in the system

```
Initialization
dist[source]        := 0
L[source]           := 0
L_i[source]         := 0
P_n                 := 0
for each vertex v in Graph
if  v ∉ source
    dist[v]     := infinity
      L[v]      := infinity
      L_i[v]    := inifinity
    previous[v] := underfined
  endif
  add v to q
end for
for each neighbour  v to u
D_n   := dist [u] + length [u, v]
L_n   := L[u] + L[u, v]
L_N   := L_i[u] + L_i[u, v]
if D_n  < dist[v]
  dist[v] := D_n
    previous[v] := u
  else if  L_n  < L[v]
  L[v]  := L_N
      previous [v]  := u
    else  L_N  < L_i[v]
  L_i[v]   := L_N
  previous [v] := u
  endif
endif
return dist[], L[], L_i[], previous[]
endfor
```

Algorithm 1: Packets Bandwidth Scheduling (PBS) algorithm

5. Simulation Results

To measure the influence of the proposed algorithm before the exact network were observed using the Network Simulator 2 (NS-2) version 2.35. NS-2 was installed in a virtual machine running Linux 14.04 operating system with 512 RAM. 10 randomly placed nodes with UDP traffic type with 512 packet size was configured and APs supports 2.4 GHz and 5 GHz. The APs used supports 802.11 and CSMA/CD. The performance metrics analysed during simulations include:

- End-to-end delay
- Number of packet loss
- Network throughput

- **End-to-end delay**

The average end-to-end delay that occurred during packet transmission is demonstrated using Figure 1. The three algorithms' performance was monitored from 1 packets/s to 550 packets/s.

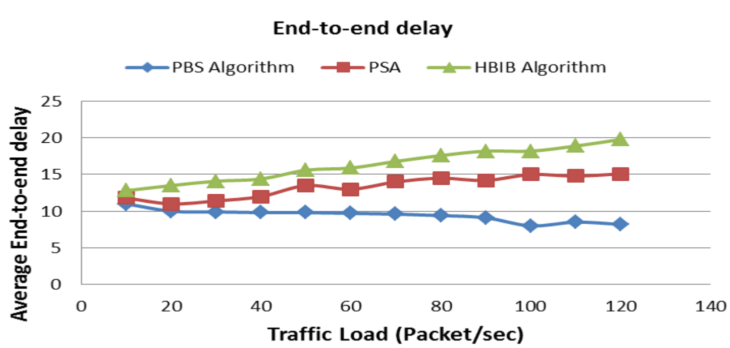

Fig 1: Average end-to-end delay

When traffic load increases, the PBS algorithm executed better than PSA and HBIB algorithm by decreasing the end-to-end delay. Therefore, the Packets Bandwidth Scheduling algorithms outperform the other two algorithms, because the packets were spread over reliable path while high priority traffic had high priority over the low priority traffic.

- **Number of packet loss**

Packets loss happen when packet from source node does not reach its destination node. However, if the bandwidth is available and properly allocated between the commutation users and the path is consistent selected, then the QoS is guaranteed and there will be less chances of packet loss within a network. See figure 2.

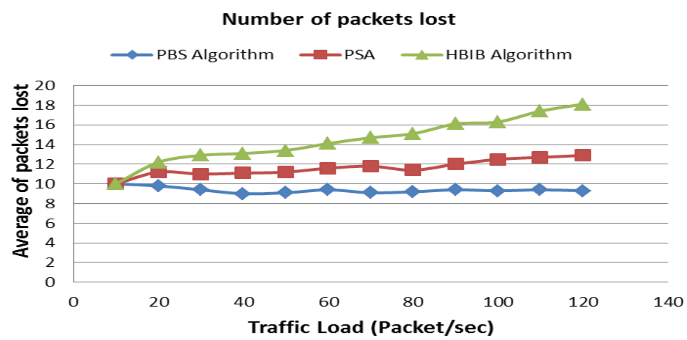

Fig 2: Average percentage of packets lost

When the traffic load increases, PBS algorithm produced the lower average percentage of the packet lost, while the other two algorithms (PSA and HBIB algorithm) produce high average percentage of the packets lost during the transmission of packets. Therefore, this gives better QoS that the network produced, because number of packets that lost within the wireless network was few.

- **Network throughput**

Figure 3 demonstrate the average network throughput of the compared algorithms. We examine the three algorithms when the network throughput it's for 25 nodes.

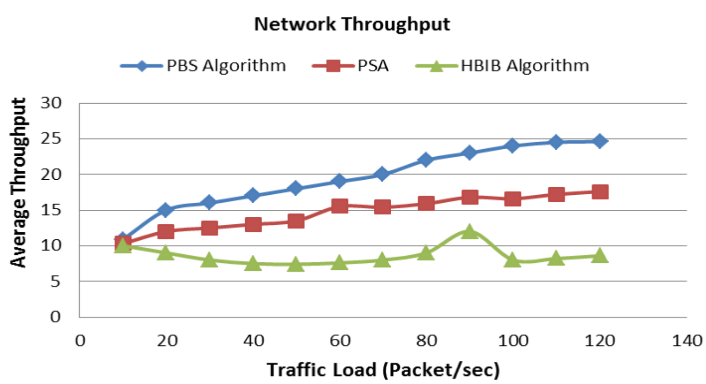

Figure 3: Average Network Throughput

The Packets Bandwidth Scheduling algorithm outperforms both Packet Scheduling algorithm and HBIB algorithm, when the traffic loads upturn. The Packets Bandwidth Scheduling algorithm reduced the end-to-end delays and packet congestion, because the high bandwidth traffic had the high implication over low bandwidth, and it results in a better quality of service (QoS) and high network throughput.

6. Conclusion

Wireless network technology is growing every time and the wireless devices that support the wireless connection is finding more and more loaded connections of devices in lot of areas, meaning lot of network users who use mobile devices are connecting to network using wireless connection than wired connection. Furthermore, the QoS is required when transmitting the packets from the wireless node.

7. Acknowledgement

The authors would like to thank Tshwane University of Technology for financial support. The authors declare that there is no conflict of interest regarding the publication of this paper.

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