ENERGY-AWARE VIRTUAL BACKOFF ALGORITHM FOR IMPROVED NETWORK LIFETIME IN WIRELESS SENSOR NETWORKS

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ABSTRACT: Medium Access Control (MAC) takes a vital role in the wireless communication networks for making efficient utilization of bandwidth, fairness among the nodes, latency management, and scalability. Unlike other networks, sensor networks required dedicated MAC protocols to consider the energy efficiency to improve the life time of the node along with efficient bandwidth utilization. In this paper, energy aware virtual back off algorithm (EAVBA) is proposed for successful channel access over the medium. In this method overall network energy consumption is managed by maintaining the details of transmission energy and receiving energy of a node. The simulation performed by considering the delay, packet delivery ratio and energy consumption factors to identify the performance of the proposed algorithm.
KEYWORDS: MAC, virtual backoff algorithm, sensor networks, energy, optimization.

1. INTRODUCTION

The recent practices in wireless communications enabled the development in low- cost, multi-functional and low power sensors nodes. The wireless sensor nodes are equipped with smart sensing devices, communication and processing and communication capabilities. These type of nodes communicate with each other in the network via sensors to use the data and we formally called as data sink [Q+06]. In the past decade, the medium access control (MAC) protocols have received major attention in area of wireless sensor networks. The MAC techniques developed for WSNs can be divided into two types: TDMA based protocols and Contention based protocols [Cek08]. The TDMA based MAC protocol is implementing IEEE 802.15.4 for low data rates in WSNs, and energy based model is used for cluster based mechanism [***02, V+10]. These are managing energy constraints in constraint based protocols by adding the additional complexity to the wireless sensor networks. V. Rajendran et al. presented a collision free model for MAC protocol based on energy constraints. It manages the all nodes information based on theirs loads and follows the time slot allocation procedure. The election based mechanism is introduced here to use the node appropriately [ROG03, F+11]. The contention based protocol is used in SMAC [YHE02, MKS11]. The CSMA collision avoidance is the mechanism which is employed in the protocol. The energy aware and self-adaption are the primary goals employed for the node. There are fairness, energy efficiency, latency, scalability, bandwidth efficiency and throughput as the parameters to be considered while designing the MAC protocol [K+11, LK14, Kha11]. But when the wireless sensor networks are considered, energy efficiency and the scalability are the major aspects to be considered as the sensor nodes are powered on battery and is difficult in managing these batteries and the network is not stable because of the mobility of the nodes in the network. Hence MAC protocols for sensor networks are designed in order to increase the life time of the nodes in the network. There are four reasons where energy is getting wasted. They are due to the collisions, overhearing, idle listening, and control packet overhead [RKR14].

This paper employs the energy aware virtual back off algorithm for successful channel access over the medium. It uses the node transmission energy and receiving energy for calculating overall network energy consumption. The proposed approach has the special property it can sense the channel by multipath routing mechanism.

Section 2 explains about the general discussion of existing protocols in WSNs. Section 3 implements the network and energy models for virtual backoff algorithm, and state transition diagram shows the node mobility model. Section 4 explains about the energy aware virtual backoff algorithm and section 5 deals with simulation setup and experimental analysis. Finally the conclusion is drawn in section 6.

2. LITERATURE SURVEY

The major interest in WSNs made the medium access control protocols to become efficient in energy constraints. Haidong W and Guizhong L tried to enhance the quality of real time video transmission when compared to IEEE 802.11e in [HG14] where they proposed the Priority and Delay Aware Packet

Management Framework. The video packets are forwarded based on the estimated delay and its significance. The number of packets dropped is reduced while saving the required significant video packets and hence the authors attempted to enhance quality with which the video is being received. The authors in [MK13], proposed a novel procedure semi-distributed backoff algorithm which shifts from random backoff to deterministic backoff algorithm where channel access is assured. The collisions are avoided to be consecutive in nature for critical applications. Here, besides the backoff on sender-side, the backoff on receiver-side also is employed. The deterministic backoff mechanism is shifted to random backoff mechanism when the transmission is successful and vice-versa. Shan et al. [SR02] proposed optimal path routing to increase the lifetime of the network. The probability function is used for path selection, and majorly it concentrated on energy consumption. The parameter which evaluates the proposed model is network stability. The approach justifies that using always the path with minimum energy consumption decreases the energy of nodes in that path. So, using the multipath will increase the lifetime of the network. In [YYA02], Younis et al. proposed a routing algorithm with hierarchal model which is three-tier architecture. The cluster mechanism is employed to track the nodes location in wireless sensor networks. Gate ways are part of the routing mechanism which maintains the details of each node like energy, location cluster head. In [KKK11, H+13], the authors discussed two channel access scheduling algorithms based on STDMA in order to accomplish the bandwidth efficiency and enhance the throughput of the wireless mesh networks which are based on spatial – TDMA (STDMA). The key concept in this paper is that the channel access procedure utilizes the information related to the Optimized Link State Routing (OLSR). Four different cases like OLSR aware centralized scheduling, non-OLSR aware centralised scheduling, OLSR aware distributed scheduling and non-OLSR aware distributed scheduling algorithms are simulated and tested. The authors proved the throughput is enhanced with no added overhead. A protocol for an energy efficient collision free channel in wireless sensor networks called the traffic adaptive medium access (TRAMA) is proposed in [HCB00, HLD12, T+13]. TRAMA is based on TDMA and the nodes move to the low power idle mode during the absence of transmission and reception and thereby minimize the power usage and guarantee the success of transmission of packets without any collision. In [YVM08, SK11, K+11], an optimized MAC protocol is proposed. The duty cycle of the sensor nodes depend on the density of the network traffic. The duty cycle is high for the heavy traffic and the low for the less traffic. The number of packets waiting in the queue of a specific sensor is used determine the traffic in the network. The number of control packet and also the size is decreased which reduces the network overhead when compared to the S-MAC protocol.

3. ENERGY AWARE NETWORK MODEL

3.1 NETWORK MODEL

In order to design the wireless sensor networks, we assume that there are N nodes participating in the area of M x M size. The transmission of packet from a node at a particular time is given as P(a). The probability of packet transmission is given as P(st), and it is calculated under the assumption that no other node is sending the packets at the same time. Therefore (1-P(a)) is the no transmission probability of the remaining nodes in the network.

$$P(st) = P(a) \times (1 - P(a)) \tag{1}$$

If there are N nodes participating in the packet transmission then the transmission probability is given as

$$P(st) = (N \times P(a)) \times (1 - P(a))^{N-1} \tag{2}$$

3.2 ENERGY MODEL

Let us consider that two nodes i and j are connected by a link with less energy consumption when compared to other linking nodes in the network. Then the distance between the two nodes is calculated by using ϑ(i, j).

$$\vartheta(i, j) = ((\alpha(i) - \alpha(j)) + ((\beta(i) - \beta(j)) \tag{3}$$

Here α and β are the arbitrary variables from the location of two nodes participating in the communication. The energy consumption of sending L-bit packet information for a distance of ϑ is given as

$$T_{Energy}(L, \vartheta) = \varepsilon \times L + \vartheta^2 \tag{4}$$

where ε is energy consumed by each packet. The receiving energy at node j is calculated as

$$R_{Energy}(L) = \varepsilon \times L \tag{5}$$

3.3 STATE TRANSIONAL MODEL

In the proposed model, the nodes have various operations to perform at different levels of activation

and different level of energy consumption. In this model, every node is considered with 6 operations such as sleeping, sensing, transmitting, receiving, listening and log sleep. Figure 1 explains about the behaviour of each mode and the channel access of each mode. The node in the sleeping state means it is not participating in the communication. The node in the transmitting state means it can move to the long sleeping or it can remain in the transmitting state.

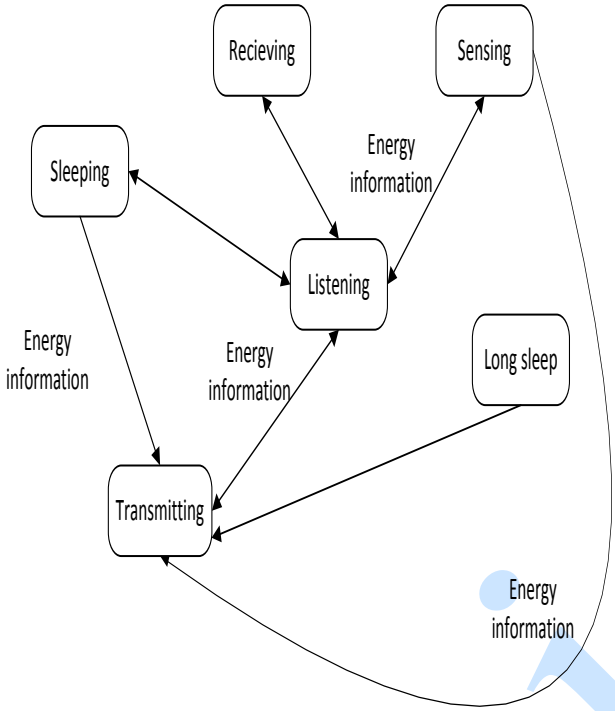

Figure 1: State Transition model for a node

4. ENERGY AWARE VIRTUAL BACKOFF ALGORITHM

In this paper, we consider wireless sensor networks with in the range of M x M size area. The nodes with in the specified range can communicate. The major concern in the wireless sensor networks is energy consumption. We proposed a model for energy consumption of each node based on their distance they are positioned. The calculation of transmitting and receiving energy plays crucial role in overall network energy consumption. In the energy aware-VBA algorithm the i_{energy} is introduced to calculate the energy of contending nodes for channel access. Two different types of counters referred as $N_{attempt}$ and N_{access} for each node. These two counters are initialized with 0 for all the contending nodes for the first time or it can be said as a node joins the network, it's both counters are initialized to 0. When a node requests for a channel access, then $N_{attempt}$ of the corresponding node is incremented irrespective of the node acquiring the channel. N_{access} is incremented only when the node acquires a channel to access. When 'n' nodes are contending for a channel access, then the channel is allotted to the node for which N_{access} is low and $N_{attempt}$ is high, provided that the N_{access} is less than its corresponding sequence number. Otherwise the access is denied. The algorithm 1 explains about the energy aware model of virtual back off algorithm.

Algorithm 1: Energy aware-VBA (EAVBA)

Input: N nodes
Output: channel Access
Begin
$K_{attempt}$= 0
i_{energy}= 0
K_{access} = 0
If (channel = busy)
$K_{attempt}$= $K_{attempt}$+1
K_{access}=K_{access}+1
Calculate energy consumption of each node participating in the node access by equation 4.
Change the channel access path
If (channel =free)
Find the minimum energy consumption nodes Min(i_{energy}).
Find the minimum access nodes Min (N_{access}).
If (Num(Min(N_{access})) >1)
Choose the node with Min (i_{energy}).
If (Num(Min(i_{energy}))>1)
Choose the nodes with Max($N_{attempt}$).
If (Num(Max($N_{attempt}$))>1)
Choose node randomly.
Allocate the channel to the node.
Else
Discard the channel access and wait for backoff time
End

5. SIMULATION ANALYSIS

The proposed algorithm, EAVBA is simulated and tested using ns-2 [***]. The simulation is carried out for 20 runs in order to get more appropriate values. NS-2 simulation parameters used for simulation are shown in Table 1. The simulation is carried out with 40 nodes and bit rate of 15kbps.

Table 1: Simulation Parameters

Parameter	Value
Routing	AODV
size	300x300
Bandwidth	4 Mbps
Max Packet Length	2000 bytes
Frame size	25 slots
Packet length	250 bytes
Traffic type	CBR
MAC	802.11

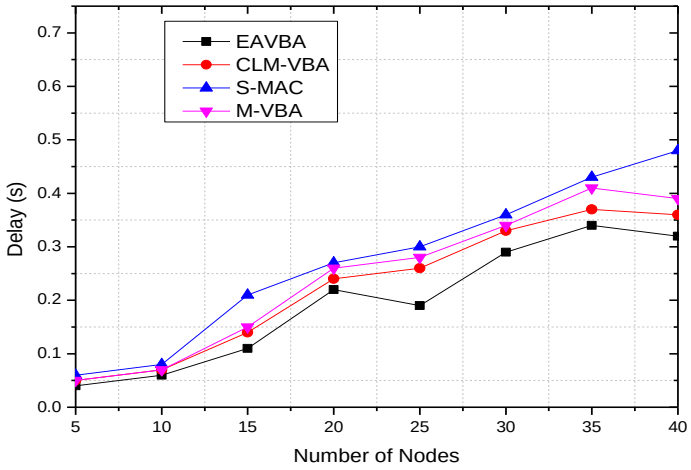

Figure 2: Performance of EAVBA compared with CLM-VBA, M-VBA and S-MAC in terms of delay

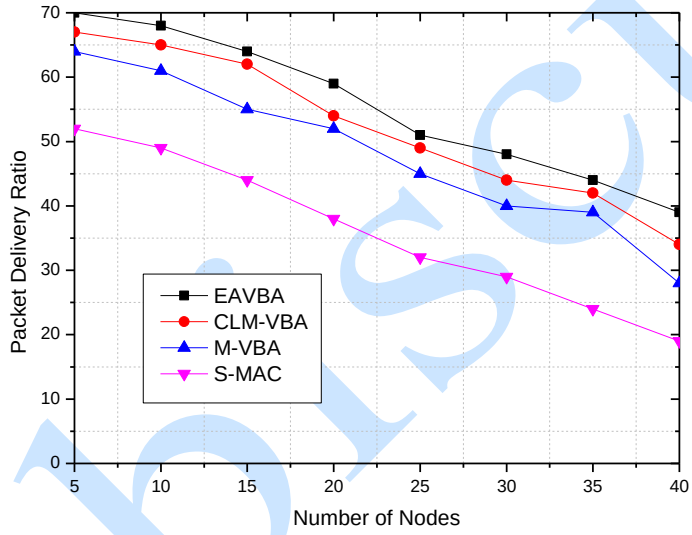

Figure 3: Performance of CLM-VBA compared with VBA, S-MAC and M-VBA in terms of packet delivery ratio

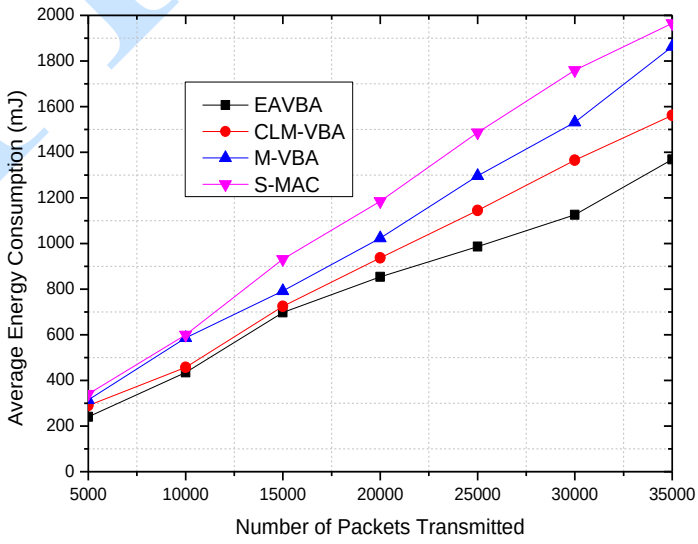

Figure 4: Performance of CLM-VBA compared with VBA, S-MAC and M-VBA in terms of Average Energy Consumption

The parameters used to test the performance of the proposed algorithm EAVBA are:
Energy Consumption: The quantity of energy consumed by each node for transmitting a packet.
Packet Delivery Ratio: This is the ratio of number of packets received to the number of packets transmitted.
Delay: The time taken for the packet to transmit from the source to the receiver.

CONCLUSION

In this paper, Energy aware virtual backoff algorithm has been proposed to improve the life time of a network by considering the transmitting and receiving powers of each node in the sensor network. Latency, Packet delivery ratio and average energy consumption factors are evaluated by comparing with other existing backoff algorithms such as CLM-VBA, M-VBA and S-MAC. The simulation analysis of EAVBA outperforms the existing algorithms and given considerable improvement in the network.

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