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Bottleneck Zone Analysis in Wireless Sensor Network Using XOR Operation and Duty Cycle

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ABSTRACT: Wireless sensor network consist of autonomous sensor, which are having only limited power supply. Nodes which are present near the centralized gathering point will be in demand of more power which limits the network life time. This work archive to enhance the energy efficiency of the bottleneck zone which leads to overall improvement of the network lifetime by considering an adaptive duty cycled WSN. The node which adapts the sleep time to the traffic change dynamically by considering the queue length at a fixed value. Linear Network coding is not simply relaying the packets of information they receive, the sensor nodes of a network take several packets and combine them together for transmission and applied in bottleneck zone. By applying the above techniques the overall life time of the node will eventually increases. This proposed system investigates Performance improvements namely, packet delivery ratio and packet latency.

KEY WORDS: Wireless sensor Network, Adaptive Duty Cycle, Linear Network Coding, Network Lifetime, Energy Efficiency

I. INTRODUCTION

Wireless sensor Network Consist of distributed autonomous sensor node that can be deployed to monitor the inaccessible and accessible areas such as Forest fire deduction, Deserts, Air pollution monitoring, Land slide deduction, Water Quality monitoring . Each sensor network node generally equipped with a Radio Transceiver with an internal or external antenna ,Memory Unit, Micro controller, and each node having own battery with limited energy to reducing the power consumption of each node is a difficult task

Wireless sensor Network the node transmitting the data to the central gathering point (i.e. called as sink). There is a large amount of data flow near the sink so the nearer node's taking more power than the other node. The area nearer the central gathering point is called as bottleneck zone. The sensor nodes in the bottle neck zone vacate their energy very quickly, It is called as energy hole problem in WSN. Failure of sensor node in bottleneck region leads to wastage of network energy, bandwidth, and reduction network reliability. The bottleneck zone needs special cognizance for decrement of traffic which improves the network lifetime of the WSN.

In WSNs the entire node in active condition is not practical for energy constraint. The senor nodes are saving the energy by active and sleep states. The total time of sensor nodes are active and dormant state is called Duty cycle. The duty cycle depends on the network coverage and connectivity. Usually for a crowded WSN the sleep time of a node is very low

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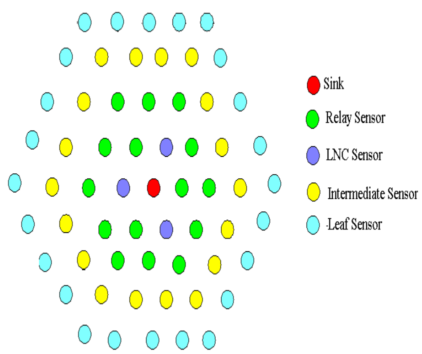

Fig. 1 Roles of Sensor in typical WSN.

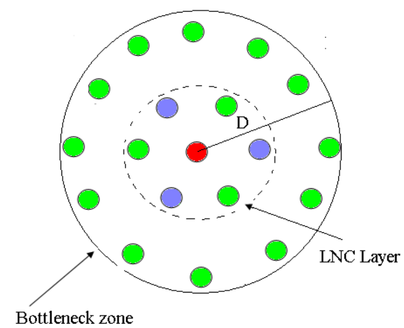

Fig. 2.Bottelneck Zone in typical WSN.

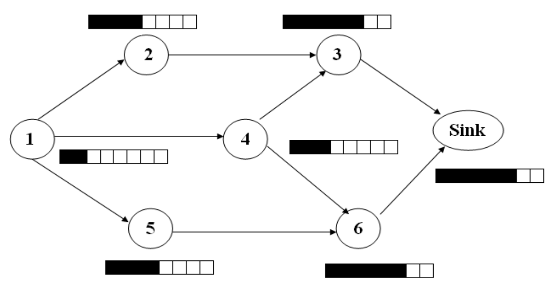

Fig. 3 Adaptive Duty Cycle in a typical WSN.

A duty cycle WSN can be loosely categorized into three main types: random duty-cycled WSN [1], co-ordinated duty-cycled WSN [2], Adaptive duty-cycle WSN [3], in random duty –cycle the sensor nodes can be turned active or sleep state independently in random fashion. The random duty-cycle WSNs are simple to design as no additional overhead is required, but the disadvantage of random duty cycled WSN will not go to the sleep state based on their network condition. It will be generating the heavy traffic. It will not use better utilization of bandwidth. In coordinated duty cycle the sensor node coordinates among themselves through the communication and message exchange However, it requires additional information exchange to broadcast the active sleep schedules of each node. It will generate the heavy traffic and overhead. We propose an adaptive duty cycle control mechanism based on the queue management with the aims of power saving and delay reduction. The proposed scheme does not need explicit state information from the neighbouring nodes, but only uses the possessive queue length available at the node. The network condition or traffic variations changes implicitly occurs because the queue states having possibility or power of the network states Using the queue length and its variations of a sensor node, we present a design of distributed duty cycle controller. Therefore the adaptive duty-cycled based WSN has been considered for its design. Specifically the problem of reduction of traffic in bottleneck zone has been considered.

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The network coding technique can be used to improve the network throughputs, ability, and scalability. This can be used to production from attacks and eavesdropping. This can be used for better utilization of bandwidth. The intermediate node was implementing with network coding. It can receive their multi hop data before forwarding their data to the sink. It will encode the packet. In the sink is performing decode operation. This technique also improves the reliability of the network.

A. LINEAR NETWORK CODING

Network coding is a technique which allows the intermediate node to encode the packet before forwarding to the neighbour node. The encoding and decoding methods described below.

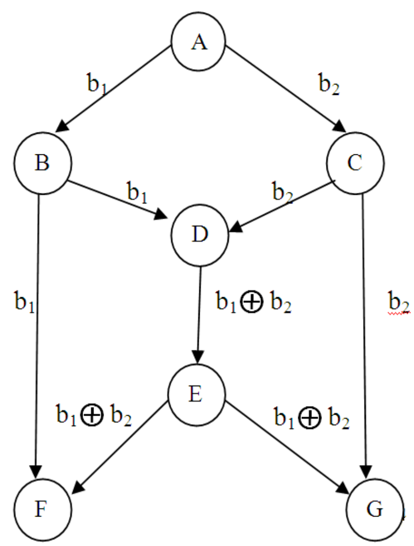

Fig 4: Encoding and Decoding operation of sensor node

Encoding operation: A node wants to transmit the encoded packets, choose a sequence of bits b_1, b_2 from Nodes N_i (i =1, 2, 3 …n). The output of encoding packet is given by

$$Y= N_i (b_1 \oplus b_2) \quad 1$$

Where i = 1, 2,……….n

The encoded packets are transmitted with k coefficient in the network.

Decoding operation: A node receives encoded packets, and it will get bits either b_1 or b2 based on the bit. It will performing decoding operation

$$b_2= Y \oplus b_1$$
$$b_1= Y \oplus b_2$$

The b1 and b2 using {0, 1} information's

Decoding operation: A node receives encoded packets, and it will get bits either b_1 or b_2 based on that it will performing decoding operation A source node A send the information to the destination F and G , the node A will be generating information b_1={0101101} and b_2={1011011} and it should be multi casted . The node D receives the information of b_1, b_2 and it will perform XOR operation. The result will be {1110110}. The Destination F receiving the b1 bit and also get XOR result. It will again perform XOR operation $b_1 \oplus (b_1 \oplus b_2)$ for getting b_2 bit.

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II. RELATED WORK

Random Duty cycle facilitates in reduction of energy consumption in a crowded WSN. Furthermore, Linear network coding technique has been drawn its attention for improvement of throughput, energy efficiency and better utilization of bandwidth in Wireless Sensor Networks.

There have been studies on the network life time in WSNs. The Adaptive Duty cycled with queue management in WSN has been estimated by Heejung Byun et al [1]. The network lifetime upper Bounds has been derived in Rashmi Ranjan Rout et al [2]. Bharadwaj et al [2]. Wang et al [3] proposed a Bottleneck zone analysis to improve the performance of the whole network. The information theoretic aspects of Linear Network coding aspect introduced by Yeung et al [4]. Aggregating data using spatial correlation in cluster-based networks introduced by Lee et al [5]. The network life time upper bound in cluster based WSN has been estimated by Habib M Ammari et al [6]. Sachin Katti et al [7] proposed a scheme that uses XOR on the air of packets for practical network coding. Bo Jiang et al [9] proposed a sleep scheduling protocol for improvement of energy efficiency. Jurdak et al [10] proposed a cross-layer mechanism for power saving a node based on the local topology information

III. PROPOSED SYSTEM

A . System model

A system is considered with N sensor nodes scattered uniformly in area A. The area A is shown in Fig 1. The bottleneck zone B with radius D is shown in Fig 2. Adaptive Duty Cycled in typical WSN in Fig 3. All the N sensor nodes are Adaptive Duty Cycle Enabled (i.e. switching between active and dormant state based on their Queue value) in the zone B, the nodes are differentiating into two groups such as relay sensor and Linear Network Coder Sensor nodes. The active relay sensor nodes(R) transmit the data which are generates outside as well as inside the bottleneck zone. In the bottleneck zone the relay nodes can communicate to the sink using a single hop communication, the relay node communicate to the another relay node and Liner network coder node using a multi hop communication. The active Linear Network Coder sensor nodes encode the relay node data before transmission to the sink. It will use the single hop to communicate with the sink. The leaf sensor nodes periodically sense the data and transmit them to the neighbouring nodes towards the sink. The intermediate sensor nodes periodically sense the data and it will relay the sensed data and received data in the direction of sink S.

Each sensor node has a number of Received queue and sensed Queue attached to it, one or more to other nodes, more to the sink. On each sensor node the packets are arrived and depart except the Leaf (or) Terminal node and Sink node. The proposed approach is to dedicate the buffer at each node to a single FIFO queue. When the buffer occupancy exceeds a threshold the switch begins to the sensor node as an active state to do so until buffer occupancy falls below the threshold. If the buffer size below the threshold means the sensor node going to the dormant (sleep) state

B. Duty Cycle control and Network Modeling

To model the network, we first introduce the following notations:

- G=(N,L), a WSN where N is the node set and L is the link set of the network
- $l_{n,}$ the outgoing wireless link of node N ($0 \le n \le N-1$) where N is the cardinality of N
- B, channel Bandwidth
- q_{ln} , Current queue length of the link
- q_{old} , old queue length of the link
- q^{th}_{ln}, the queue threshold of link l_n.
- S_n, Sleep time of node n
- SE_n ,Sense node to generating a traffic
- AC_n, Active time of a sensor
- $A_{n,}$ The number of packets arrive to the receive Queue

The current Queue Length of the link l_n mathematically represented as following

$$q_{ln} = [q_{old} + SE_n + A_n - B*(AC_n)]$$

The sensor, active time is of fixed size whereas the length of sleep time depends on a q_{ln} value. If the q_{ln} value below the q^{th}_{ln} value means. The sensors gone to sleep state otherwise it should be active state. At every time, each node computes its sleep time using the local queue length $q_{ln.}$ When the queue threshold is low, a node increase the active periods, the queue threshold becomes larger, Increases the sleep time to buffer the packets until the queue length reaches the queue threshold.

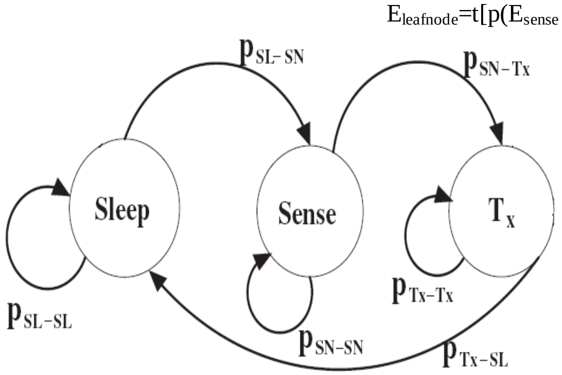
C. Energy Consumption Model with Duty Cycle

The sensor node absorbs energy at five different states, such as, sensing and producing a data, transmitting, receiving and sleeping state. Energy savings are done at the node level through switching between active and dormant state Energy consumption by a source node per second across distance d is

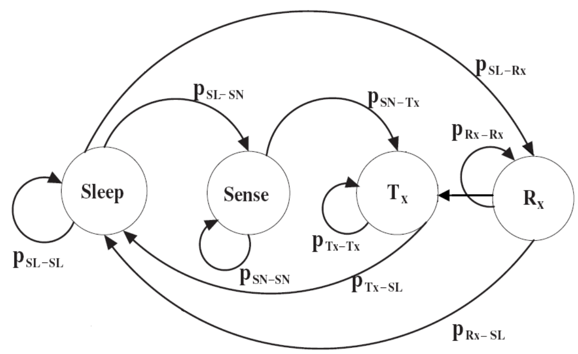
$$E_{trans} = R_d\,(a_{11} + a_2 d^n)$$

R_d is the transmit and receive data rate, a_{11} is the transmitter electronics consumed the energy per bit and a_2 is the energy consumed by the operational amplifier. The total energy consumption of a Leaf node in time t is

$$E_{leafnode}=t[p(E_{sense} + E_{trans}) + (1-p)E_{sleep}]$$



5.a



5.b

Fig 5 a:State transition diagram of a node acting as a Leaf node with transition probabilities in aWSN.

Fig 5 b. State transition diagram of node acting as a relay node and a node acting as a source node Fig 5 .a with the transition probabilities of WSN. $P_{SL\text{-}SL}$ TP from sleep state to sleep state, $P_{SL\text{-}SN}$ TP from sleep state to sense state, $P_{SN\text{-}SN}$ TP from sense state to sense state, $P_{SN\text{-}Tx}$ TP from sense state to transmission state, $P_{Tx\text{-}Tx}$ TP from transmission state to transmission state, $P_{RX\text{-}RX}$ TP from receive state to receive state, $P_{SL\text{-}Rx}$ TP from sleep state to receive state, $P_{Rx\text{-}SL}$ TP from receive state to sleep state, $_{PRx\text{-}SL}$ TP from receive state to sleep state.

Where p is the probability of active time of sensor node, E_{sense} is the energy consumed by the sensor to sense a bit, (1-p) is a Sensor node remains in sleep state till time t. The number of active sensor node, a, out of N nodes, in a monitoring area follows the Binomial Distribution

$[(N! / ((a!)(N-a)!)p^a (1-p)^{N-a}]$ The state transition diagram of a source node is shown in Fig.5. The energy consumption of intermediate and relay node is given by

$$E_{trans} = R_d\,(a_{11} + a_2 d^n + a_{12})$$

Where a12 is the energy consumed by the sensor node to receive a bit. The total energy consumption of Relay and Intermediate sensor is

$$E_{Relay}=t[p(E_{sense} + E_{trans}) + (1-p)E_{sleep}]$$

D. Upper bounds of a network life time using network coding and Adaptive Duty Cycle

In this section the network life time has been estimated with a proposed network coding algorithm for a adaptive duty cycled WSN. A Linear Network Coding layer (Ref Fig2.) Containing Linear network Coder nodes has been placed around the sink. The network Coding layer is the most excessive load in bottleneck region. So, the reduction of energy consumption of the network coding layer leads to higher network life time. The group of relay nodes in the bottleneck region simply forward the data to sink. This relay node helps the Sink to decode the encoded packets. Whenever a node in the WSN, it will check the queue. The node follows the Algorithm to process packets.

Adaptive Duty cycling and the packet processing in the Linear Network Coding Layer of the bottleneck zone has been given in algorithm.

Each node in the network maintains the received queue (receiveQueue ()) And a sensed queue (senseQueue()). On sensing a information a node put the packet in the senseQueue(P_j). On receiving a packet p_i a node put the packet in the receiveQueue(P_i). The node check the queues length whether it is below the threshold or above. If the threshold is below means the node gone to sleep state otherwise It should be active state. If the received packet already processed by the node than it is discarded, otherwise node processes the packets further. The node check the role from the Nodeset(), whether it is Relay node or Linear Network Coder node. If the node is relay node in Linear Network coding Layer it will forward the packet to the sink otherwise forward the packet to the Linear Network Coding layer. The node is an encoder if the packet received non coded packet then it performs the XOR operation. On successfully generating encoded packets, the LNC node transmits the encoded packet to the Sink. The processed packets inserted into Transmitted set Transmitset(). This stores the transmitted packet and helps restricting further redundant transmission. However the received packet Pi is already processes then it is discarded by node.

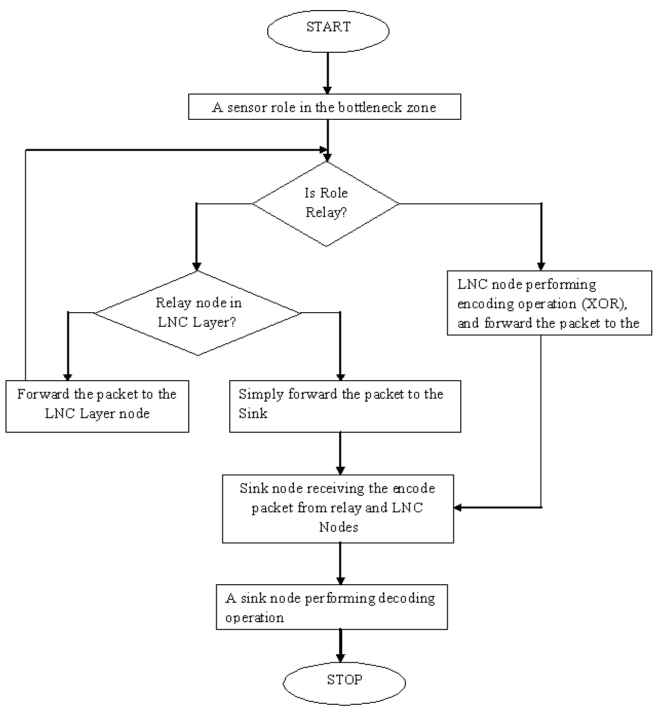


Fig 6: Flow chart of sensor node in bottleneck zone.

Algorithm 1: Packet process (Pi, Pj): Packet processing at a node inside the network coding layer

Requirement: Packet transmission and reception starts, sensed packets inserted into the senseQueue() and receiveQueue()

Ensure: The node will be active state or not

1 if(Threshold < (ReceiveQueue().Length+ sense Queue().Length))

2 The sensor node going to sleep state
3. else
4. The sensor node going to active state
5. Pick a packet P_i from the receiveQueue()
6. if node N in Relay node set() continue
7. Node act as a relay node and transmit the packet P_i to the Sink or Network coding layer
8. else
9. Performing XOR operations
10. if senseQueue() is not empty and receiveQueue() is not empty then
11. Pick a packet P_i from the head of receiveQueue()
12. Pick a packet P_j from the heat of the senseQueue()
13 Computing $P_x=P_i \oplus P_j$
14 else
15 if senseQueue() is empty and receiveQueue() is not empty then
16. Pick a two packets P_i and P_{i+1} from the receiveQueue()
17. Computing $P_x=P_i \oplus P_{i+1}$
18.else
19. Pick a two packets P_j and P_{j+1} from the SenseQueue()
20. Computing $P_x=P_j \oplus P_{j+1}$
21. end if
22. if(receiveQueue()!=empty&&senseQueue()!=empty)
23. goto step10
24. if(receiveQueue()!=empty&&senseQueue()==empty)
25. goto step17
26. if(receiveQueue()==empty&&senseQueue()!=empty)
27. goto step20
28 else exit
29. end if
30. end if

Decoding packet at the sink: The sink node receive the packet from the relay nodes and encoded packets from the LNC node. The decoding procedure is executed at the sink which processes the gathered data in WSN. The sink maintains a packet storage in which it stores the relayed packets. And the sink receives an encoded packet containing of k relayed packet, the sink retrieves the relayed packet one by one from the packet storage. The sink XORs the received encoded packet with the k-1 native packets to retrieve the missing packet.

IV. SIMULATION RESULTS

The simulation work has been carried out using a NS2 (Network Simulator). The network life time in a WSN with (a) Duty Cycle (b). Random duty Cycle and Network coding have been shown in fig.7.

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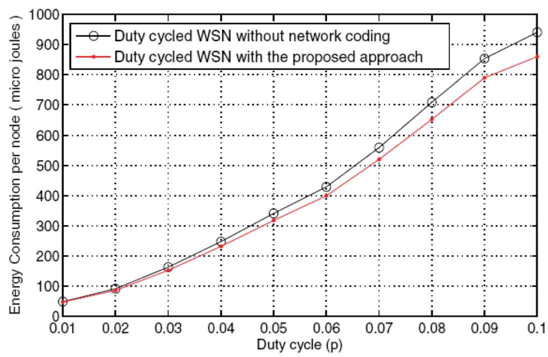

V. CONCLUSION

In a wireless sensor network the area near the central gathering point forms the bottleneck zone where the traffic flow maximum, so reducing the power consumption . In this paper, we propose adaptive duty cycle control for WSN and Liner Network Coding. The proposed approach controls the Adaptive duty cycle through the queue management to achieve high performance under network condition changes. The sensor node save the energy by dynamically changing the sleep time based on the predetermined value of queue length. These results in minimum power consumption and faster adaptation to traffic changes. The proposed scheme only requires the local queue length for computing the duty cycle, which adds good scalability, improved efficiency to the system. In addition, we propose a Linear Network Coding approach which is used to improve the capacity of information flow with the better utilization of bandwidth in a multi hop communication. That the proposed algorithm improves significantly both energy efficiency and delay performance by adapting the duty cycle properly under network changes.

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