International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 10 | Oct-2016 www.irjet.net p-ISSN: 2395-0072

LIFETIME IMPROVEMENT OF WIRELESS SENSOR NETWORK USING CO-ORDINATED DUTY CYCLE AND QUEUE DETECT TECHNIQUE

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Abstract*- Wireless sensor networks (WSNs) are made of very low cost, low energy consuming devices with sensing capability, signal processing module and wireless communication systems. Minimizing energy consumption and maximizing network lifetime are important problems in the design of protocols for wireless sensor networks.*

Wireless sensor network consists of automatic sensors, which have a limited power battery. Nodes which are present near the centralized collecting point will be in demand of much power which restricts the overall network life time. The active area near to the sink node makes a bottleneck zone because of large traffic-flow which minimize the network lifetime in wireless sensor network. In this project, we introduce an queue detect technique, co-ordination duty cycle and encoding technique for reducing power consumption in the bottleneck area .A low power consuming communication technique has been adopted in the bottleneck zone by combining queue detect duty cycle and encoding technique. Energy efficiency of the bottleneck zone increases due to more volume of data will be transmitted to the cluster head with the same number of transmitters. Hence the lifetime of wireless sensor network is enhanced. This work archive to enhance the energy efficiency of the bottleneck zone which leads to overall improvement of the network lifetime by considering a network coded queue detect duty cycle WSN. Queue detect with network coding is not simply transmitting the packets of information they receive, the sensor nodes of a network take several packets and add all of them with each other for transmission and applied in bottleneck area. By applying the above techniques the overall life time of the node will finally increases. This proposed system investigates life time improvement approximately 8.4% - 14.8%, and minimizing energy consumption.

Key Words: WSN, Co-ordinated Duty Cycle, Queue Detect, Network Coding, Network Lifetime, Upper Bound.

1. INTRODUCTION

The huge advancements in technology generally and in wireless communications have specifically provide America the aptitude to fabricate tiny, cheap sensors which will connect with one another wirelessly. The sensors once deployed, whether or not during a random or a pre-engineered method can connect with one another in system and type a wireless sensing element network (WSN), that area unit product of an outsized range of sensors deployed during a predefined space. The sensors would remodel physical knowledge into a type that might create it easier for the user to know. WSN technology is growing quickly, turning into cheaper and easier to afford, and permitting completely different varieties of application usage of such networks. WSNs are often used for a large style of applications managing observation (health environments, seismic, etc.), management (object detection and tracking), and police work (battlefield surveillance) [4-7].

Wireless sensing element Networks consists of range of sensing element nodes that area unit deployed in observation areas comparable to deserts, Forest fires, glaciers etc. including industrial observation system and military applications every sensing element nodes consists of a microcontroller, microchip, ARM processor, frequent transceivers exploitation that they method the information. Xbee protocols are often used as RF based mostly communication. In every sensing element node battery energy is restricted that sweetening of energy consumption becomes major challenge. The quantitative relation between active mode and sleep mode is termed duty cycle they save energy between active and sleep mode. During this WSN accommodative duty cycled methodology has been adopted, these sensing element nodes turned on and off during an affected fashion. The coding network technique that provides higher utilization of information measure and additionally encodes the incoming knowledge packets and so transmits the encoded packet towards the sink node the network computer programmer nodes uses single hop for communication and different varieties of sensing element nodes use multihop communication.

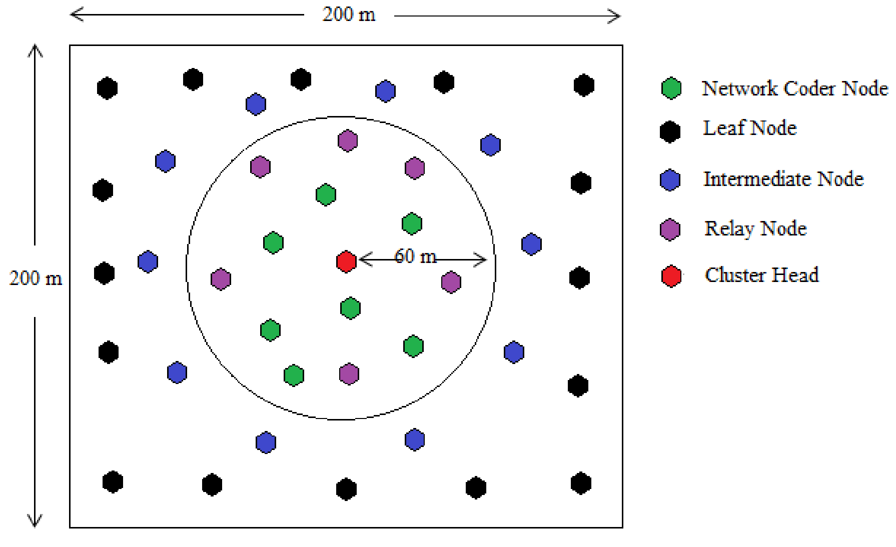

Fig- 1: Sensors Position in WSN

A duty cycle WSN is loosely categorised into 3 main types: random duty-cycled WSN [1], co-ordinated duty-cycled WSN [2], accommodative duty-cycle WSN [3], in random duty –cycle the sensing element nodes is turned on or off state severally in random manner. The random duty-cycle WSNs square measure straightforward to style as no further overhead is needed, however the disadvantage of random duty cycled WSN won't visit the sleep state supported their network condition. It'll be generating the significant traffic. It'll not use higher utilization of information measure. In coordinated duty cycle the sensing element stuff communicates among themselves through the communication and message exchange.

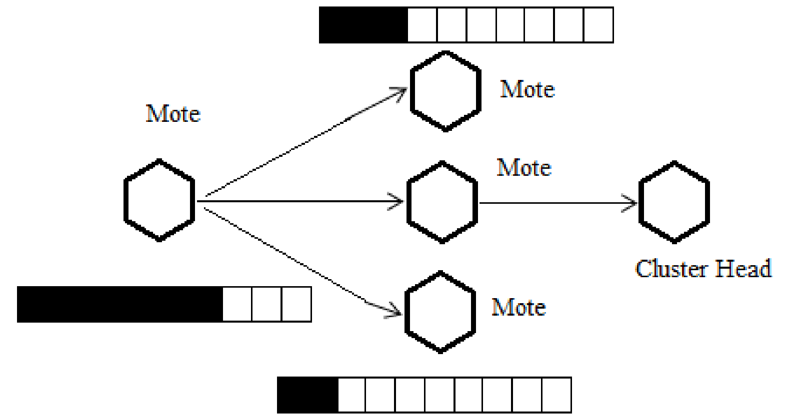

Fig- 2: Queue Detect Technique in a typical WSN

However, it needs further info exchange to broadcast the active sleep schedules of every node. It'll generate the significant traffic and overhead. We tend to propose a queue detect and co-ordinated duty cycle management mechanism supported the queue management with the aims of power saving and delay reduction. The projected theme doesn't would like specific state information from the neighbour nodes, however solely uses the possessive queue length obtainable at the node. The network condition changes implicitly happen as a result of the queue states having risk or power of the network states. Victimization the queue length and its variations of a sensing element node, we tend to gift a style of distributed duty cycle network controller. Thus queue detect and co-ordinated duty-cycled primarily based WSN has been thought of for its style. Specifically the matter of reduction of traffic in bottleneck zone has been thought of.

2. RELATED WORK

Responsibility cycle allows in discount of vigour consumption in a denser WSN. Adaptive responsibility cycle with community coding process has been drawn its concentration for development of sensor community lifetime and power efficiency in useful resource constraint wireless networks. There have been reports on the network lifetime in WSNs. The network lifetime upper bounds have been derived in [10][11][9]. Bhardwaj et al. [11] and Wang et al. [9] have derived upper bounds on network lifetime for a non-responsibility cycle centered WSN. The network lifetime higher bounds in a cluster centered WSN has been estimated by way of Lee et al. [10]. Zhang et al. [12] have also derived network lifetime for a non-responsibility cycle centered WSN. A lifetime-awared routing scheme has been proposed with the aid of Karkvandi et al. [13]. There are also more than a few works in the literature on broadcasting, connectivity and protection in responsibility cycle centered WSNs. An obligation cycle founded broadcasting scheme with right reliability has been proposed by using Wang et al. [14]. A recent work which considers duty cycle with respect to communiqué in an vigour harvesting WSN has been proposed by using Gu et al. [15].A random responsibility cycle established WSN has been used for dynamic protection via Hsin et al. [21]. Furthermore, Lai et al. [16] have additionally proposed an effective broadcasting scheme in duty cycled WSNs. The coverage and connectivity of low duty cycled WSN has been studied by means of Kim et. Al.[17]. The information theoretic facet of community coding used to be presented through Ahlswede et al. [20] for know-how networks. A random linear community coding situated scheme that provides packet-level ability for each single unicast and single multicast connections had been proposed by using Lun et al. [18] for wireless networks. Rout et al. [19] have also presented a community coding established probabilistic routing scheme which supplies beneficial properties of community coding in a WSN.

3. ENERGY CALCULATION AND MODELLING

A device node consumes energy at completely different states, such as, sensing and generating knowledge, sending, receiving and sleeping state. During this work, the radio model [22] has been changed for a requirement cycle primarily based WSN. Energy savings area unit done at the node level through shift between active and sleep states.

Energy consumption by a supply node per second across a distance d with path loss exponent n is,

$$E_{tx} = R_d(\alpha_{11} + \alpha_2 d^n) \quad (1)$$

Where R_d is the data rate of transceiver relay, α_{11} is the energy consumption per bit by the transmitter and α_2 is the energy consumption per bit in the transmit op-amp [22]. Total energy consumption in time t by a source node (leaf node) without acting as a relay (intermediate node) is,

$$E_s = t[p(r_s e_s + E_{tx}) + (1-p)E_{sleep}] \quad (2)$$

where E_{sleep} is the idle mode energy consumption of a sensor node per second, r_s is the sensor's average sensing rate and it is equal for all the nodes, e_s is the energy consumption of a mote to sense a bit, the probability p is the average proportion of time t that the sensor node use in active mode. Thus, p is the duty-cycle. A sensor node remains in the idle state with probability (1-p) till time t. The energy consumption per second by an intermediate node which act as a relay mote is given by [23]

$$E_{txr} = R_d(\alpha_{11} + \alpha_2 d^n + \alpha_{12}) \quad (3)$$

Where α_{12} is the energy consumption by the sensor node to receive a bit. Total energy consumed till time t by an intermediate (relay) node is

$$E_r = t[p(r_s e_s + E_{txr}) + (1-p)E_{sleep}] \quad (4)$$

The total energy consumption in the bottleneck zone in time t for a p duty-cycle WSN is given by [23]

$$E_d = E_{agd} + E_{2gd} + E_{3gd} + (1-p)tN\tfrac{B}{A}E_{sleep} \quad (5)$$

$$E_d = \left[\tfrac{m+1}{2}\right] Npr_s t\tfrac{A-B}{A}\left(\alpha_1 \tfrac{D}{d_m}\tfrac{n}{n-1}\right) + Npe_s r_s t\tfrac{B}{A} + pr_s\tfrac{N}{A}t\iint\left(\alpha_1\tfrac{x}{d_m}\tfrac{n}{n-1} - \alpha_{12}\right)d_s + (1-p)tN\tfrac{B}{A}E_{sleep} \quad (6)$$

When p=1 (all-nodes-active) and m=1 the energy consumption in the bottleneck zone to relay the data bits that are generated inside as well as outside the bottleneck zone becomes same as in a general or non-duty cycle based WSN [5]. Thus, the equation (6) also covers the general network scenario without considering duty cycle of nodes.

The lifetime of a WSN is significantly depended on the energy consumption at the node level. Let E_b is the initial battery energy available at each sensor node. In a network of N nodes, the energy reserve at the start is $N \cdot E_b$.

The performance of a WSN strictly depends on the failure statistics of the sensor nodes. The failure pattern of sensor nodes depends on the rate of depletion of energy. The network lifetime demands that the total energy consumption is no greater than the initial energy reserve in the network. The upper bound on network lifetime can be achieved when the total battery energy (N.E_b) available in a WSN is depleted completely. The following inequality holds to estimate the upper-bound of the network lifetime for a duty cycle based WSN [23].

$$E_D \le \frac{NB}{A}E_b$$

$$t \le \frac{d_m B E_b}{S_x} = T_u D \quad (7)$$

where the term S_x is given by

$$S_x = p\alpha_1\tfrac{n}{n-1}r_s\left[D(A-B)\tfrac{m+1}{2} + \int\int x d_s\right] + Bd_m[p - r_s(e_s - \alpha_{12}) + (1-p)E_{sleep}] \quad (8)$$

and $T_u D$ is the lifetime upper bound of the WSN with duty cycle (p). The amount of energy consumption is maximum when *p=1* (i.e. all node active condition) and the lifetime minimizes in a WSN. The energy efficiency of the network increases with low duty cycle which enhances the lifetime of the network. r_s is defined as

$$r_s = \frac{H}{(A-B)\frac{N}{A}}$$

Where H =960 bits, B is πD^2,

4. QUEUE DETECT & CO-ORDINATED DUTY CYCLE

A system is taken into account with N device nodes scattered uniformly in space A. All the N device nodes are adaptive Duty Cycle Enabled i.e. switching between active and sleep state supported their Queue value within the zone B, the nodes are differentiating into two teams reminiscent of relay device and Linear Network computer programmer device nodes. The active relay device nodes(R) transmit the info that are generates outside similarly as within the bottleneck zone. Within the bottleneck zone the relay nodes will communicate to the sink employing a single hop communication, the relay node communicate to the another relay node and Liner network computer programmer node employing a multi hop communication. The active linear network computer programmer device nodes write in code the relay node information before transmission to the sink. It will use the one hop to speak with the sink. The leaf device nodes sporadically sense the info and transmit them to the neighbouring nodes towards the sink. The intermediate device nodes sporadically sense the information and it'll relay the detected information and received data within the direction of sink S.

Upper bound of network lifetime for Queue Detect is defined as

$$t \le \frac{d_m B E_b}{S_x} = T_u D \quad (7)$$

where the term S_x is given by

$$S_x = p\alpha_{31}\tfrac{n}{n-1}r_s\left[D(A-B)\tfrac{m+1}{2} + \int\int x d_s\right] + Bd_m[p - r_s(e_s - \alpha_{12}) + (1-p)E_{sleep}] \quad (8)$$

Each device node encompasses a variety of Received queue and detected Queue hooked up thereto, one or a lot of to alternative nodes, a lot of to the sink. On every device node the packets are arrived and depart except the Leaf (or) Terminal node and Sink node. The planned approach is to dedicate the buffer at every node to one inventory accounting queue. Once the buffer occupancy exceeds a threshold the switch begins to the device node as a vigorous state to try to thus till buffer occupancy falls below the brink. If the buffer size will below the threshold then the device mote progressing to the sleep state.

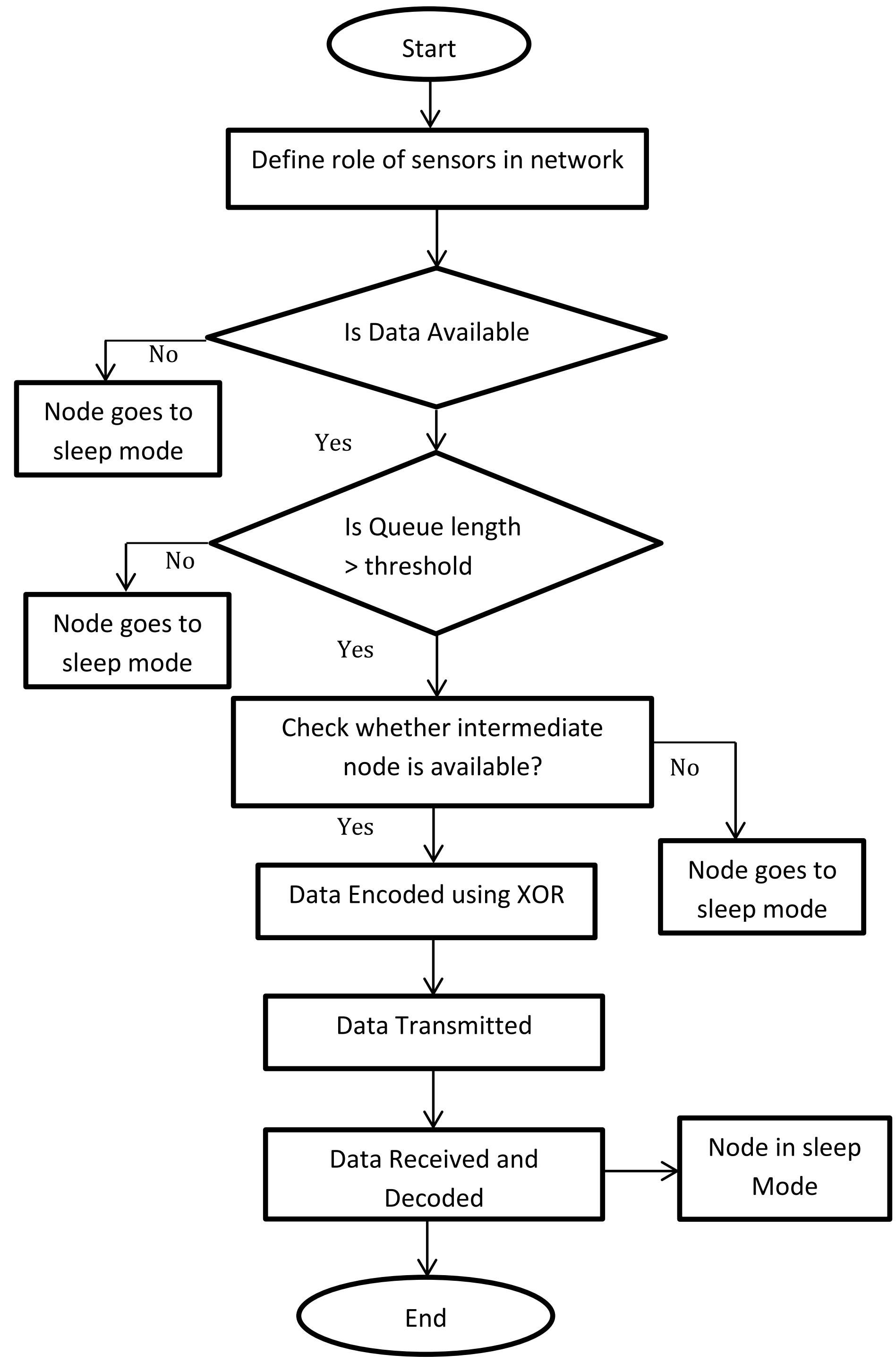

Fig- 3: Flow chart of project

5. SIMULATION & RESULTS

5.1 Network Lifetime using Random Duty Cycle

In this paper area of wireless sensor network is considered 200x200 square meter, diameter of bottleneck zone 60m, number of nodes 1000, battery energy 25kj, sleep energy 30uj,hop length 2, number of bits 960 and threshold 12 bit are considered.

Fig 4 shows energy consumption per node in wireless sensor network with change in duty cycle. When duty cycle value is 0.01, energy consumption is minimum i.e. 30.1uJ, and duty cycle 0.1, energy consumption is 1000uJ. With increase in duty cycle increases energy consumption decreases.

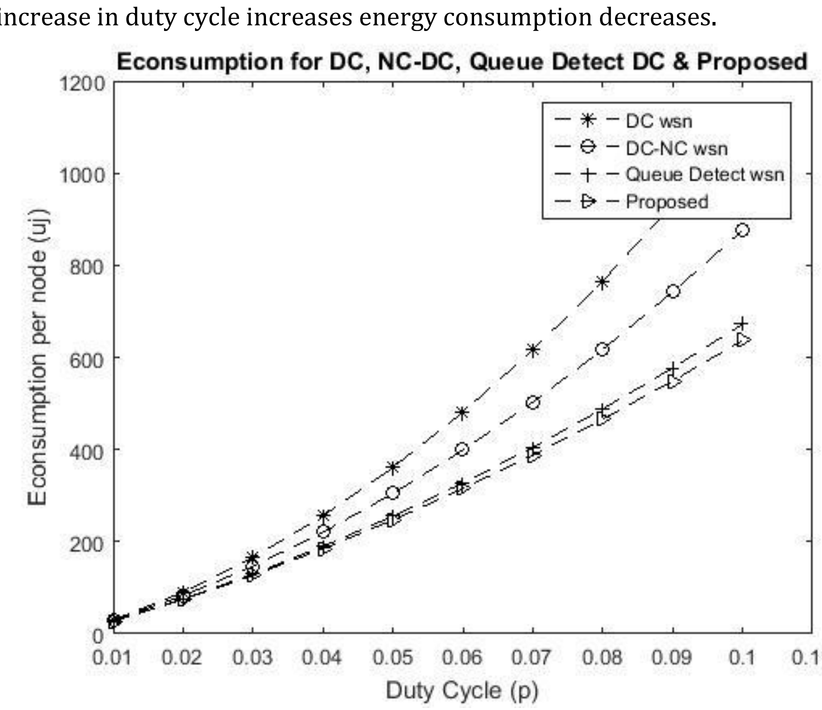

Fig- 4: Lifetime of Sensor Network using Random Duty Cycle

From the figure it is observed that energy consumption is maximum for random duty cycled wsn and minimum for queue detect with co-ordinated duty cycled network. Table 1 compares energy consumption for different techniques.

Table- 1: Energy Consumption for different Techniques

WSN Techniques	Energy Consumption for p=0.01	Energy Consumption for p=0.1
Random Duty Cycle	30.1	1110.5
Network Coded Duty Cycle	28.59	876.31
Queue Detect with Network Coding	27.26	672.10
Proposed (Queue detect and co-ordinated duty cycle)	27.04	637.12

5.2 Network Lifetime for Co-ordinated Duty Cycle and Queue Detect Technique

Fig 5 shows lifetime variation in wireless sensor network with change in duty cycle. When duty cycle value is 0.01, lifetime for m=1 is 8.31x10^8 seconds. With increase in value of duty cycle lifetime decreases and with the increase in value of m (traffic density) lifetime again decreases. For m=9 and p=0.01 lifetime is 8.0051x10^8 seconds.

From the graph it can be observe that when traffic density is higher lifetime of wireless sensor network is lower. Using Co-ordinated Duty Cycle and Queue Detect Technique, lifetime is improved in case of higher traffic density as compared to lifetime achieved in random duty cycled wireless sensor network and network coded random duty cycled wireless sensor network.

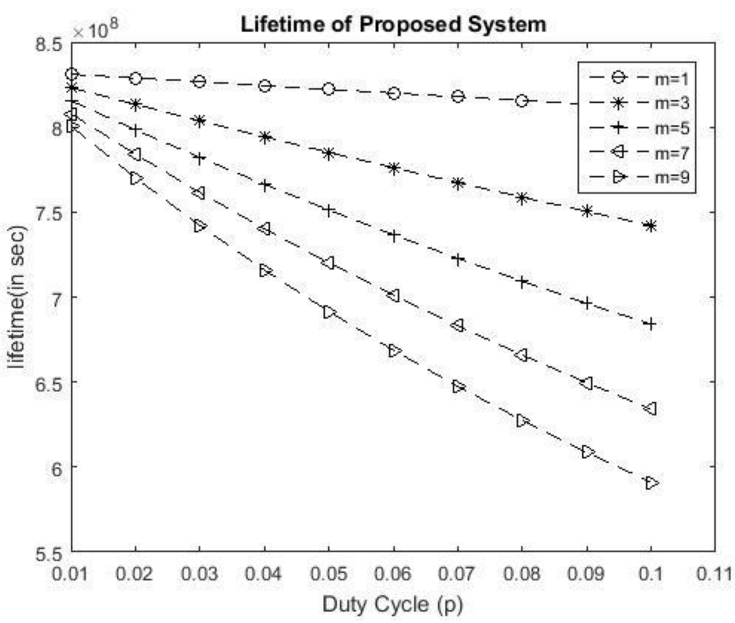

Fig- 5: Lifetime of Sensor Network for Proposed wsn at different values of m

Table2 shows lifetime of proposed wsn for variable traffic density. After analysis it can be conclude that lifetime for low traffic density is maximum and for high traffic density lifetime is minimum.

Table- 2: Lifetime Comparison for Proposed WSN

	Lifetime for p=0.01	Lifetime for p=0.1
m=1	8.31x10^8	8.11x10^8
m=2	8.23 x10^8	8.11 x10^8
m=3	8.15 x10^8	7.42 x10^8
m=4	8.08 x10^8	6.34 x10^8
m=5	8.01 x10^8	5.91 x10^8

5.3 Dependence Network Lifetime for Co-ordinated Duty Cycle and Queue Detect Technique on h parameter

Fig.6 shows, how network lifetime is depends on h parameter. It can be observe that with increase in value of h lifetime decreases. For higher values of h lifetime is almost constant.

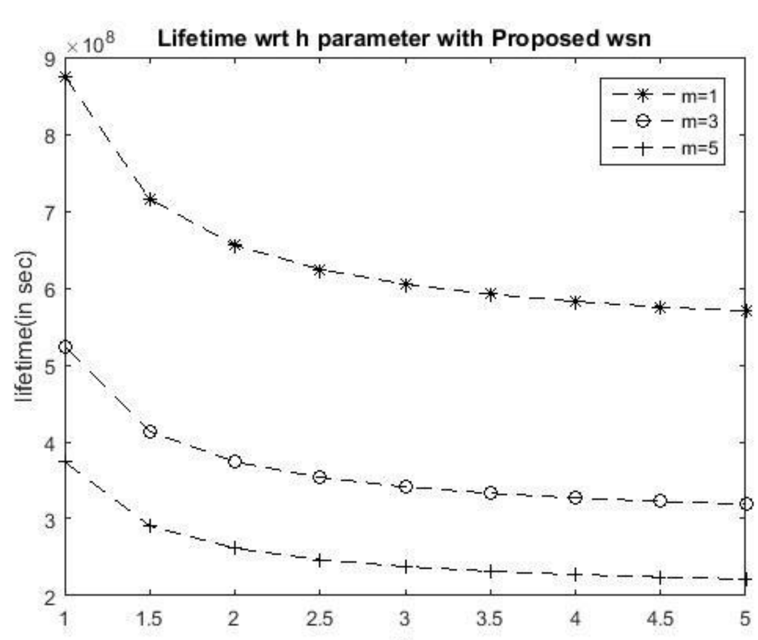

Fig- 6: Lifetime of Sensor Network for Proposed wsn at different values of m for different h parameters

Table- 3: Lifetime for variable traffic density

	Lifetime for h=1	Lifetime for h=5
m=1	8.31x10^8	8.11x10^8
m=2	8.23 x10^8	8.11 x10^8
m=3	8.15 x10^8	7.42 x10^8

5.4 Network Lifetime using Network Coded Adaptive Duty Cycle

Fig 7 shows comparison of lifetime for random duty cycle, network coded duty cycle, network coding with queue detection technique and queue detection with co-ordinated duty cycled wsn. Form table4 it can be concluded that queue detection with co-ordinated duty cycled wsn is best technique for lifetime improvement of network.

Table- 4: WSN Parameters

Number of Nodes (N)	1000
Sensor Network Area (A)	200 m2
Bottleneck Zone Radious	60m
Path Loss Exponent	2
Alpha11	0.937uj
Alpha12	0.787uj
Alpha2	0.0172uj
Sleep	30uj
Alpha32	1.2uj

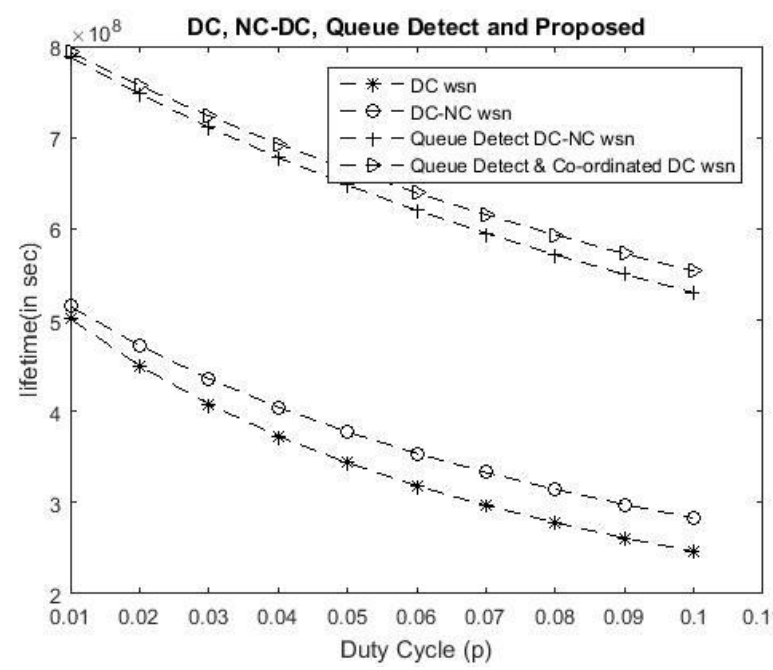

Fig- 7: Lifetime of Sensor Network using Random Duty Cycle, Network Coding with Duty Cycle, Queue Detect Technique and Proposed System

Table- 5: Lifetime comparison for different techniques

	Lifetime for p=0.01	Lifetime for p=0.1
Random Duty Cycle	5.01 x10^8	2.46 x10^8
Network Coded Duty Cycle	5.15 x10^8	2.82 x10^8
Queue Detect with Network Coding	7.88 x10^8	5.29 x10^8
Proposed (Queue detect and co-ordinated duty cycle)	7.93x10^8	5.53 x10^8

6. Conclusion

In a wireless sensor network (WSN), the area around the Sink forms a bottleneck zone where the traffic flow is maximum. Thus, the lifetime of the WSN network is dictated by the lifetime of the bottleneck zone. The lifetime upper bounds have been estimated with (i) adaptive duty cycle, (ii) network coding and (iii) combinations of co-ordinated duty cycle and queue detect technique. It has been observed that there is a reduction in energy consumption in the bottleneck zone with the proposed co-ordinated duty cycle and queue detect technique. This in turn will lead to increase in network lifetime. Simulation results reveal that there is an increase of 3.8% to 11.25% of network lifetime by using the proposed co-ordinated duty cycle and queue detect based algorithm, and an increase of 8.4% to 14.8% lifetime of wireless sensor network as compared with duty cycled WSN.

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