Life Span Enrichment of Wireless Sensor Networks via Duty Cycle and Network Coding: A Survey

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***Abstract*— Wireless sensor networks (WSNs) essential confront is to Enrich the network lifetime. The area something like the sink forms a bottleneck zone. There is stirring a heavy traffic –flow. This Survey works attempts to develop the life time of wireless sensor networks by in view of Duty Cycle and Network Coding. A competent communication exemplar has been adopted in the bottleneck zone by the amalgamation of Duty Cycle and Network Coding. The aspiration of our Survey is discussed get better energy competence and raises the throughput in WSN. Exhaustive speculative analyses have been provided to demonstrate the efficiency of the proposed approach besides discussed.**

Index Terms-Wireless Sensor Networks, network lifetime, energy efficiency, duty cycle, network coding.

I. INTRODUCTION

An elementary dispute in the design of wireless sensor networks **(WSN$_s$)** is to augment the network life time. In the region of sink form a bottleneck zone appropriate to heavy traffic – flow which restrictions the network existence in WSN. The sensor node in the bottleneck zone is alienated in to two groups: simple relay sensor and network coder sensor. The relay node just forward the received data, the network coder nodes convey using the network coding based algorithm [1].

Energy competence of the bottleneck zone increases because more degree of data will be transmitted to the sink with the same number of broadcast. Wireless sensor networks consist of sovereign sensor node that can be deployed for monitoring unfeasible areas, such as glaciers, woodland areas, deserts, deep bushel etc [2]. Sensor nodes are generally outfitted with a radio transceiver, a micro controller, a reminiscence unit, and a set of transducer using which they can obtain and process data from the deployed regions. These nodes can self systematize themselves to form multi-hope network and transmit the data to a sink. In a emblematic WSN, the network traffic exposure at the sink swelling S. (Fig.1).

There is a momentous amount of data flow near the *Sink*. The area near the *Sink* is known as the bottleneck zone.

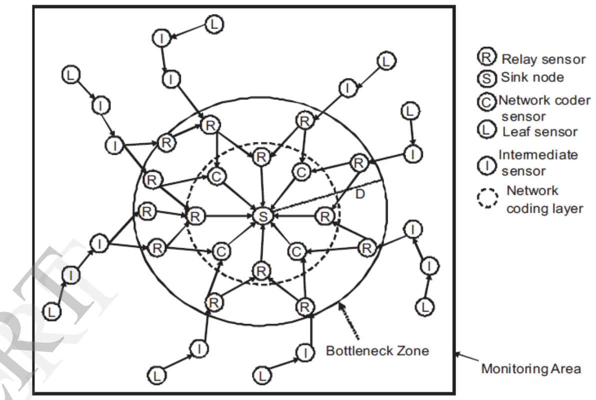

Fig.1. Traffic Flow, Bottleneck zone and role of sensor in a typical WSN.

Profound traffic load imposes on the sensor nodes near the *Sink* node. The nodes in the bottleneck zone diminish their energy very quickly, referred as energy hole problem in WSN. Collapse of such nodes inside the bottleneck zone leads to expenditure of network vigor and reduction of network steadfastness. The bottleneck zone needs extraordinary consideration for diminution of traffic which improves the network existence of the whole WSN.

II. ARBITRARILY DUTY CYCLE WSN ENERGETIC OF EXPOSURE.

Wireless sensor networks that maneuver in low duty cycles, deliberate by the entitlement of time a feeler is on or active. The energetic change in topology as a result of such duty-cycling has potentially disorderly consequence on the concert of the network. We perimeter our concentration to a class of scrutiny and monitoring applications and unsystematic duty-cycling schemes, and scrutinize certain coverage chattels. Here deems exposure strength distinct as the prospect sharing of durations contained by which an intention or an event is revealed/unmonitored. Originate this allocation using a partially-Markov model, constructed using the superposition of discontinuous rejuvenation processes. The psychotherapy using the partially-Markov model serves as a tool with which we can unearth apposite arbitrary duty-cycling schemes gratifying a given recital prerequisite and also show that there is a close rapport among coverage passion and the appraise of lane accessibility, defined as the prospect division of durations inside which a path vestiges existing. Thus the consequences presented here are voluntarily pertinent to the cram of path accessibility in a short duty-cycled sensor group.

A. *Coverage Passion*

In this slice will sculpt the on/off schedules of individual sensors as sporadic Markov revitalization processes (MRP), and scrutinize the superposition of numerous such processes. While revitalization theory is a well-reputable subject [3], there are moderately less outcome on sporadic revitalization Processes. In [4] the superposition of sporadic revitalization processes was deliberate with a relevance to arithmetical multiplexing of fracture traffic sources. In this part occupy the approach used in [6] to obtain coverage passion. We too there a beginner's partially-Markov model with a linear state space, while the model based on [4] has an exponential state liberty.

- Markov revitalization Processes

We will presume distinct time, and thus the on and off periods are integer-valued and selected from certain prospect mass functions (pmf) (having finite support) *f*on *i* (*k*) and *f*off *i* (*k*), *k* = 1, 2…*K*, for some *K*, correspondingly. The same loom can be applied to nonstop time in a similar manner. Consider *n*, $n \geq 2$sovereign discrete-time MRPs. Each MRP has only 2 states off (denoted as state 1) and on (denoted as state 2). The *i*-th MRP is characterized by a partially-Markov essence *Gi*(*k*) = [*gi*(*x, y, k*)] defined over the set of states *{*1, 2*}*, where *gi*(*x, y, k*) is the prospect that the *i*-th process goes from state *x* to state *y* in *k* slots where *x*, *y* $\in \{1, 2\}$. Thus we have.

$$\mathbf{G_i} = \begin{bmatrix} g_i(1,1,k)g_i(1,2,k) \\ g_i(2,1,k)g_i(2,2,k) \end{bmatrix} = \begin{bmatrix} 0 & fioff(k) \\ f_p on(k) & 0 \end{bmatrix} \quad (1)$$

The superposition of *n* sovereign MRPs is modeled as a partially-Markov process. Communication that this is a guess since the future superposed state may depend not only on the present state and the time the superposed process has spent in the present state, but also on past states2. Delineate the state transition of the superposed process to arise at time instants when one or more of the constituent processes familiarity a state transition.

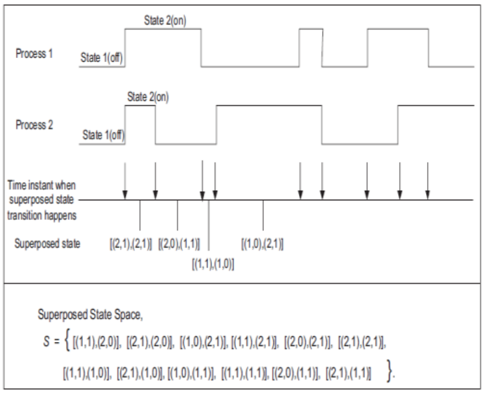

Fig. 2. A circumstances transition example when there are *n* = 2 MRPs. State ½ is the off/on state.

A superposed state is given by the *n*-tuple

$$[(x1, t1), (x2, t2),\dots,(xn, tn)],\ xi \in \{1, 2\},\ ti \in \{0, 1\} \qquad (2)$$

where *xi* is the state of the *i*-th process pragmatic immediately *after* a transition occurs in the superposed process, and *ti* indicates whether the *i*-th process has untouched state when this transition occurs, with *ti* = 1 iff process *i* has changed state and *ti* = 0 otherwise. Symbolize by *S* the state space of the superposed process. The state space consists of all possible combinations of *n* pairs except when *ti* = 0, $\forall i$, in which case no component process has a state transition and then the superposed process cannot have a state transition. The total number of states is thus 2*n* (2*n* − 1). Figure 2 exemplify a model of the superposition of two component MRPs (*n* = 2), and the equivalent state space *S*.

A state *u* ∈ *S* is given by *u* = [(*x*1(*u*), *t*1(*u*)),(*x*2(*u*), *t*2(*u*)),… , (*xn*(*u*), *tn*(*u*))], where the *i*-th pair defines the state of the *i*-th component process when the superposed process changeover to state *u*. accordingly we will also refer to the *i*-th pair (*xi*(*u*), *ti*(*u*)) as the *state* of the *i*-th component process when the state of the superposed process is *u*. For example, if the superposed states are *u* = [(2, 1), (2, 0)] and *v* = [(1, 0), (1, 1)], then we have (*x*1(*u*) = 2, *t*1 (*u*) = 1) and (*x*1(*v*) = 1, *t*1 (*v*) = 0).

Toward attain the allotment of the time the superposed process expend in state *u* before transitioning to state *v*, *u*, *v* ∈ *S*, we begin with the following notations.

gi(*x*, *y*, *k*): the probability that the *i*-th component process stays in state *x* for *k* slots before transitioning to state *y*, where *x* and *y* signify the individual on/off states, *x*, *y* ∈ {1, 2*}*. This was formerly agreed in Equation (1).

III. NETWORK INFORMATION FLOOD

Network Information Flood (NIF) introduces a new class of tribulations called network information flood which is stirred by computer network applications. Regard as a point-to-point communication network on which a number of information sources are to be multicast to influenced sets of goals. Presuppose that the information sources are reciprocally independent. The problem is to characterize the permissible coding rate province. This model includes all formerly premeditated models along the same line. In this paper, learning the problem with one information source, and we have attain a simple characterization of the permissible coding rate province. Our result can be staring as the Max-flow Min-cut Theorem for network information flood [8].

Divergent to one's insight, our work divulge that it is in general not optimal to regard the information to be multicast as a "fluid" which can simply be running scared or imitation. Fairly, by employing coding at the nodes, which we refer to as network coding, bandwidth can in general be saved. This verdict may have momentous impact on future design of switching systems [8].

In obtainable computer networks, each node functions as a switch in the sense that it moreover relays information from an input link to an output link, or it replicates information received from an input link and sends it to a certain set of output links. From the information-theoretic point of view, there is no reason to hamper the function of a node to that of a switch. fairly, a node can function as an encoder in the sense that it receives information from all the input links, encodes, and sends information to all the output links. Commencing this point of view, a switch is a special case of an encoder. In the continuation, we will refer to coding at a node in a network as network coding.

Let R_{ij} be a nonnegative real number allied with the edge (i,j), and let $R=[R_{ij},(i,j)\in E]$. For a fixed set of multicast requirements, a vector **R** is admissible if and only if there exists a coding scheme rewarding the set of multicast requirements such that the coding rate from node i to node j is less than or equal to R_{ij} for all $(i,j) \in E$. In graph theory, R_{ij} is called the aptitude of the edge (i,j). Our goal is to characterize the tolerable coding rate province, R i.e., the set of all admissible **R**, for any graph G and multicast requirements a,b and h.

The model we have described includes both multilevel assortment coding (without deformation) [5], [6] and distributed source coding [7] as special suitcases. As an illustration, let us show how the multilevel miscellany coding system in Fig. 1 can be formulated as a special case of our model. In this system, there are two sources, X1and X2. Decoder 1 renovates X1 only, while all other decoders renovate both X1 and X2. Let r_i be the coding rate of Encoder i,i=1,2,3. In our model, the system is represented by the graph G in Fig. 2. In this graph, node 1 represents the source, nodes 2, 3, and 4 represent the inputs of Encoders 1, 2, and 3, respectively, nodes 5, 6, and 7 represent the outputs of Encoders 1, 2, and 3, respectively, while nodes 8, 9, 10, and 11 represent the inputs of Decoders 1, 2, 3,and 4, respectively. The mappings and are precise as

a (1)=1 a (2)=1
and
b (1)= {8,9,10,11} b(2)-{9,10,11}

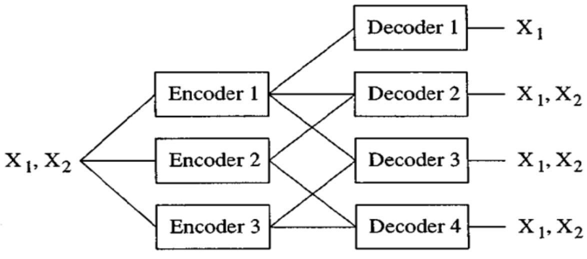

Fig.3. A multilevel diversity coding system

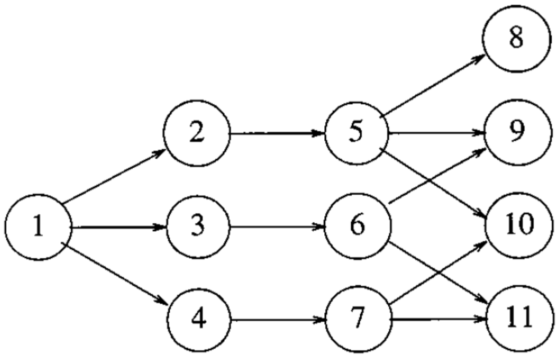

Fig.4. The graph G representing the coding system in Fig.3.

And h = $[h_1h_2]$ represents the information rates of X1 and X2. Now all the edges in G except for (2, 5), (3, 6), (4, 7) match to straight connections in Fig. 3, so there is no constraint on the coding rate in these edges. Therefore, in order to influential R, the set of all permissible R for the graph G (with the set of multicast requirements precise by a,b and h), we set $R_{ij}= \alpha$ for all edges in G except for (2,5), (3,6), (4,7) to obtain the permissible coding rate region of the quandary in Fig. 3.

A major pronouncement in this paper is that, dissimilar to one's suspicion, it is in general not optimal to consider the information to be multicast in a network as a "fluid" which can simply be routed or pretend at the middle nodes. Fairly, network coding has to be employed to accomplish optimality.

In the respite of the paper spotlight our debate on problems with m=1, which we collectively refer to as the single-source problem. For problems with $m \geq 2$, we refer to them communally as the multisource problem. The respite of the paper is structured as track.

A. A Max-Flow Min-Cut Theorem

In this part propose a theorem which characterizes the permissible coding rate district for the single-source problem. For this problem, we let a (1) =s, and b (1) = {t1, Tl} In other words, the information source X_1 is generated at node and is multicast to nodes. We will call the source and t_1, Tl the sinks of the graph G.

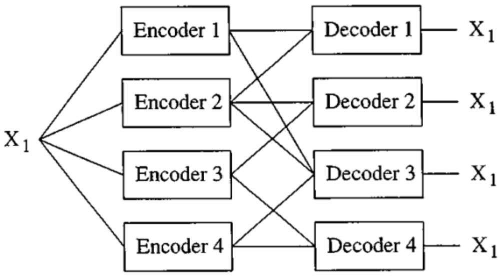

Fig.5. A single-level diversity coding system

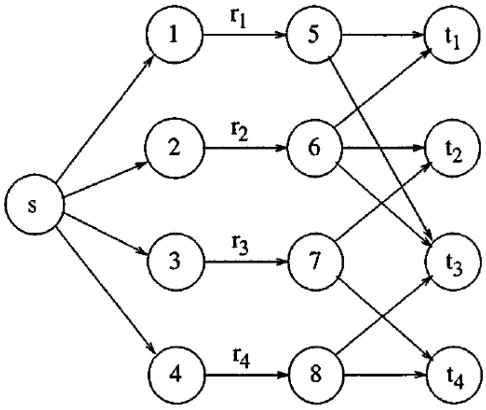

Fig.6.The graph representing the coding system in Fig.3

For a explicit L, the problem will be referred to as the one-source L-sink problem.

Let us first identify some notations and terminology which will be used in the respite of the paper. Let G= (V, E) be a graph with source and sinks t_1... tL. The capability of an edge (i,j)$\in$E is given by R_{ij}, and let R=[Rij, (i,j) $\in$E]. The sub graph of G from s to *tl*, *l*=1, refers to the graph G*l*= (V,E*l*), where

$E l=\{(i,j) \in E$: (i,j) is on a directed path from s to $tl\}$.

$F=[F_{ij}, (i,j) \in E]$ is a flow in G from s to t*l* if for all $(i,j) \in E$.

$$0 \le F_{ij} \le R_{ij}$$

Such that for all $i \in V$ except for s and *tl.*

$$\sum_{i':(i',i)\in E} F_{i'i} = \sum_{j:(i,j)\in E} F_{ij}$$

i.e., the total flow into node is identical to the total flow out of node *i*. F_{ij} is referred to as the value of F in the edge (*i*,*j*). The value of F is distinct as

$$\sum_{j:(s,j)\in E} F_{sj} - \sum_{i:(i,s)\in E} F_{is}$$

This is equal to

F is a max-flow from s to t1 in G if F is a floe form s to tl whose value is greater than or equal to any other flow from s to tl. Manifestly, a max-flow from s to tl in G_i is also a max-flow from s to tl in. For a graph with one source and one value of a max-flow from the source to the sink is called the capacity of the graph.

IV. TAILBACK ZONE

In WSN nodes roughly the sink devour more vitality than those further disappeared. It is not unusual that limited energy resources available at the nodes around the sink befall the bottleneck which limitations the routine of the intact network. In this epistle initially present our measured bottleneck zone in a general sensor network circumstances. Then, the effect of the bottleneck zone on network performance is scrutinized by construe performance bounds compulsory by the energy resources available indoors the bottleneck precinct. In this epistle, both the concert hurdle in stipulations of network existence and the performance hurdle in terms of information collection are discovering.

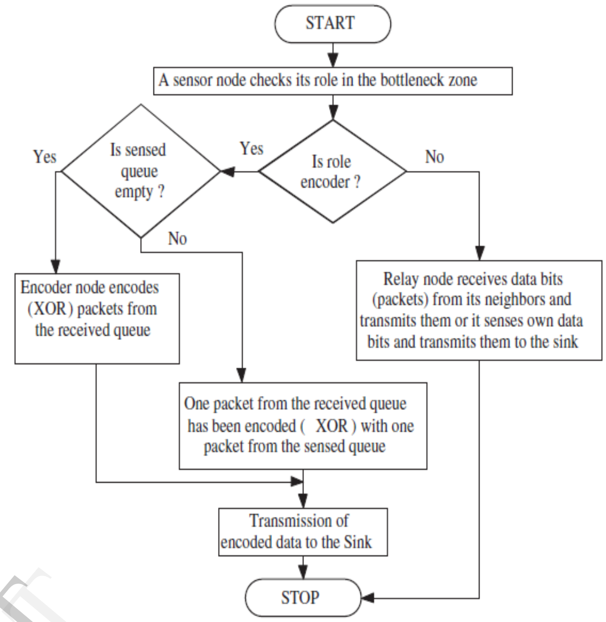

Fig.7. Functionalities of the sensor nodes in the bottleneck zone.

A. *Network coding.*

Network coding is a technique which allows the intermediate nodes to encode data packets received from its adjoining nodes in a network. The encoding and decoding process of linear network coding are depicting underneath. [1].

- Encoding maneuver

A node, that desires to transmit encoded packets, prefer a progression of coefficients q = (q1, q2... qn), called encoding vector, from GF (2^s). A set of n packets Gi (i = 1, 2, 3, 4... n) that are customary at a node are linearly encoded into a solitary output packet. The output encoded packet is prearranged by

$$Y=\sum_{i=1}^{n} q_i G_i \quad q_i \in GF\,(2^s) \qquad (3)$$

The coded packets are conveying with the *n* coefficients in the network. The encoding vector is used at the receiver to decode the encoded data packets.

- Decoding maneuver

A receiver node decipher a set of linear equations to salvage the original packets from the received coded packets. The encoding vector q is received by the receiver sensor nodes with the encoded data. Let, a set (q^1, Y^1)... (q^m, Y^m) has been received by a node. The cipher Y^j and q^j denote the information pictogram and the coding vector for the j^{th} received packet respectively. A node solves the go after set of linear equations (4) with m equations and n unknowns for decoding progression.

$$Y^{j} = \sum_{i=1}^{n} q^{ji} G_i, \qquad j = 1 \dots m \qquad (4)$$

As minimum n linearly independent coded packets must be received by the recipients for apposite decode of the inventive packets. The merely unknown, *Gi*, restrain the original packets that are transmitted in the network. The *n* number of original packets can be retrieved by decipher the linear system in equation (4) after getting *n* linearly independent packets. The XOR network coding, a special case of linear network coding has been used in this exertion. The coded packets that are transmitted in the network are rudiments in $GF(2) = \{0, 1\}$ and bitwise XOR in $GF(2)$ is used as an operation.

B. Duty Cycle

The sensor nodes accumulate energy by switching between active and quiescent (i.e. sleep) states. The quotient between the time during which a sensor node is in energetic state and the totality time of active/quiescent states is called duty cycle. The duty cycle depends on the node solidity of the scrutinize area for better exposure and connectivity. Habitually for a intense WSN the duty cycle of a node is very stumpy [10].

A duty cycled WSN can be droopily categorized into two main types: random duty-cycled WSN [10] and co-ordinate duty cycled WSN [11]. In previous the sensor nodes are crooked on and off separately in random trend. In afterward the sensor nodes synchronize amid themselves via communication and control message interactions. They are potentially proficient for communication. Conversely it requires additional information replace to propagate the active / snooze agenda of each lump.

The random duty-cycled WSNs are simple to blueprint as no additional slide is required. The principally goal is to gain certain systematic understanding on the upper-bound of the network lifetime. Consequently, the random duty cycle based WSN has been measured for its effortlessness in design. Expressly, the problem of lessening of passage in the bottleneck zone has been painstaking [10].

V. UPPER BOUND OF NETWORK LIFETIME USING DUTY CYCLE.

The system model has been depicting in this sector. Based on the system replica, an energy utilization model for duty cycle based WSN has been urbanized. The upper bound of the network life span has been anticipated and energy savings due to duty cycle has also been exposed [13].

A. System Model

A system is painstaking with *N* sensor nodes sprinkled unvaryingly in vicinity *A*. The area *A* with a traffic jam zone *B* with radius *D* is exposed in Fig. 1. All the *N* sensor nodes are duty cycle enabled (i.e. switching between active and dormant states). The nodes are named based on their roles in the network as shown in Fig. 1. In the zone *B*, the nodes are discriminate into two groups, such as, relay sensor and network coder sensor nodes. [13] The (active) relay sensor nodes (*R*) transmit data which are generated outside as well as inside the traffic jam zone. The (active) network coder sensor nodes (*N*) encode the unprocessed native data which are coming from faint the zone *B* before transmission.

B. Energy Expenditure Model with Duty Cycle.

A sensor node devours energy at different states, such as, sensing and generating data, transmitting, receiving and sleeping state. In this work, the radio model [13] has been personalized for a duty cycle based WSN. Energy investments are done at the node level through switching between active and snooze states. Energy expenditure by a source node per second across a distance *d* with path loss proponent *n* is,

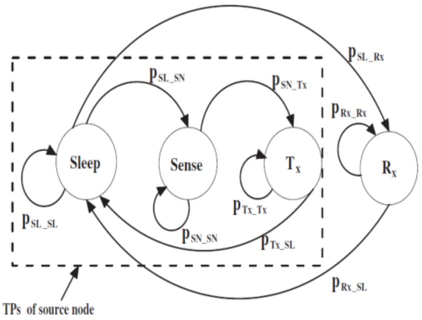

Fig.8. State transition diagram of a node substitute as a source (only inside the rectangle) and a node substitute as a relay (the whole state diagram) with transition probabilities (TPs) in a WSN. *PSL SL*: *TP* from sleep state to the same state, *PSL SN*: *TP* from sleep to sense state, *PSN SN*: *TP* from sense state to the same state, *PSN Tx* : *TP* from sense to transmit (*Tx*) state, *PTx Tx*: *TP* from *Tx* to the same state, *PTx SL*: *TP* from *Tx* to the sleep state, *PSL Rx*: *TP* from sleep to receive (*Rx*) state, *PRx Rx*: *TP* from *Rx* to *Rx* state and *PRx SL*: *TP* from *Rx* to sleep state.

$$E_{tx} = R_d\,(\alpha_{11} + \alpha_2 d^{n}) \qquad (5)$$

Where *Rd* is the transceiver relay data rate, $\alpha 11$ is the energy addicted per bit by the transmitter electronics and $\alpha 2$ is the energy extreme per bit in the transmit op-amp [11]. Besides, the total energy utilization in time *t* (i.e. duration [0, t]) by a source node (leaf node) lacking acting as a relay (intermediate node) is

$$E_S = t\,[p\,(r_s e_s + E_{tx}) + (1 - p)E_{sleep}] \qquad (6)$$

somewhere E_{sleep} is the sleep state energy utilization of a sensor node per second, r_s is the average sensing rate of each sensor node and it is same for all the nodes, e_s is the energy utilization of a node to sense a bit, the probability *p* is the average quantity of time *t* (in the duration [0,t]) that the sensor node devotes in active state. Thus, *p* is the duty-cycle.

C. Energy utilization and Upper Bound of Network life span.

Total energy utilization in the bottleneck zone are scrutiny as three parts, namely, energy utilization (i) to relay the data bits which are received from outside of the bottleneck zone (*E*1) (ii) due to sensing maneuver of the (relay) nodes inside the bottleneck zone (*E*2) (iii) to relay the data bits which are spawn inside the bottleneck zone (*E*3).

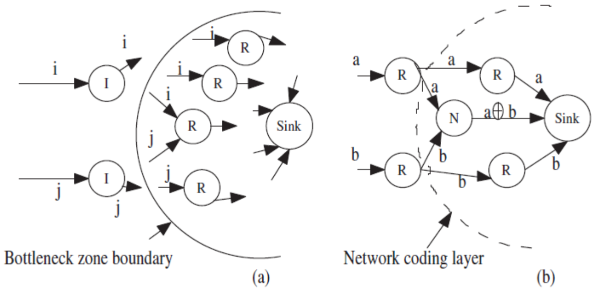

Fig.9. (a) Reception of redundant data bits by the boundary relay nodes in the bottleneck zone (b) A scenario of *XOR-network coding* in the network coding layer of the bottleneck zone.

As shown in Fig. 9, sensor nodes in the bottleneck zone may receive multiple copies of the same data bits transmitted from exterior of zone *B*. So, the superfluous bits which affect the network life span are transmitted within the zone *B*.

The performance of a WSN austerely depends on the failure information of the sensor nodes. The failure pattern of sensor nodes depends on the rate of depletion of energy. The network life span demands that the total energy utilization is no greater than the primary energy reserve in the network. The upper bound on network life span can be realize when the total battery vigor (N ·*Eb*) obtainable in a WSN is exhausted completely. The following unfairness holds to conjecture the Upper-bound of the network life span for a duty cycle pedestal WSN.

$$E_D \leq \frac{NB\,E_b}{A} \Rightarrow_t \leq \frac{d_m\,BE_b}{Q_x} = T_u D \qquad (7)$$

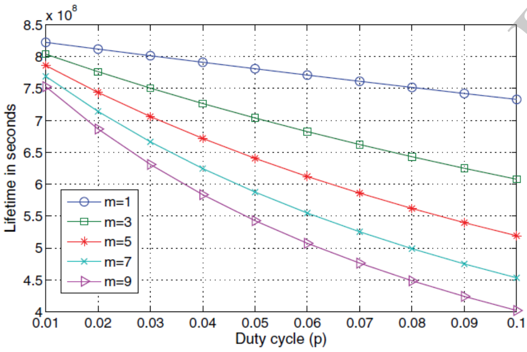

Fig.10. Network lifetime upper bounds in duty cycle based WSN.

VI. UPPER BOUNDS OF NETWORK LIFE SPAN VIA NETWORK CODING AND DUTY CYCLE

The network life span has been anticipated with a proposed network coding algorithm for a non-duty cycled WSN. Besides, network coding and random duty Cycles have been combined to guess the network life span in a duty cycled WSN. Here, the lifetime upper bounds have been resultant while consider a fraction of total passage flows during the network coder nodes in the bottleneck zone.

A network coding layer (refer Fig.1 and Fig. 9 (b) containing network coder nodes has been initiate around the Sink. The network coding layer is the most congested region (i.e. vulnerable region) of the bottleneck zone. So, diminution of energy utilization of the coding layer leads to higher network life span. A group of unarmed nodes (i.e. the nodes which are nearest to the Sink and diminish their energy quickly) in the bottleneck zone transmits using network coding based announcement. The other group of nodes in the bottleneck zone acts as simple relay nodes. These relay nodes help the Sink to decode the encoded packets. Every time a node in the bottleneck zone receives a packet, it checks its role (refer Fig. 7). The node follows the Algorithm-1 to process a packet.

The packet processing process of a node in the network coding layer of the bottleneck zone has been given in Algorithm-1. Each node in the network coding layer maintains a established queue (RecvQueue()) and a sensed queue (SensQueue()). On receiving a packet Pi, a node put the packet in RecvQueue(Pi). If the packet is already processed by the node than it is discarded, otherwise the nodes process the packet auxiliary. The node prove its role from EncoderNodeSet(), whether it is an encoder or a simple relay node. If the packet is a native (non-coded) packet and the node is an encoder, the node invokes the method XorEncode(). Specify method of encoded packet making is given in Algorithm-2.

A. *Algorithm 1*

Packet practice (Pi): Packet processing at a node inside the network coding layer.

Require: Packet transmission and reception starts, received packets inserted into the *RecvQueue ()*

Ensure: Encoded packet transmitted or discarded

```
1.  Pick a packet $p_i$ from RecvQueue($P_i$)
2.  If Packet $P_i \in$ ForwardPacketSet($P_i$) exit;
3.  If Node n $\in$ EncoderNodeSet() continue;
4.  If native($P_i$) then
5.  $C_N$ =XorEncode();
6.  Node n transmits the coded packet $C_N$ to Sink
7.  Insert the processed packet $P_i$ to
    ForwardPacketSet();
8.  Else
9.  Discard($P_i$);
10. Endif
11. Else
12. Node n acts as relay and transmits the packet $P_i$ to the
    Sink;
13. Endif
14. Endif
15. If (RecvQueue() _= empty)
16. goto step 1;
17. else exit;
18. endif
```

B. *Algorithm 2:*

XorEncode() : Encoding algorithm

Require: A received queue *RecvQueue()* and a sensed queue *SensQueue()* is maintained at an encoder node.

Ensure: Invention of network coded packet *CN*.

```
1.  If SensQueue() is not empty then continue;
2.  Pick a packet $P_i$ from head of the RecvQueue();
3.  Pick a packet $P_j$ from head of the SensQueue();
4.  $C_N = P_i \oplus P_j$ ;
5.  Else
```

```
Pick next packet $P_i$+1 from the RecvQueue();
$C_N = P_i \oplus sP_i+1$;
endif;
return $C_{Ns}$
```

A portion of the traffic engender inside traffic jam zone may also relay through the network coder sensor nodes. Imagine that the traffic engender inside the bottleneck zone are not encoded and the network coder sensor node functions as a common relay node. So, the energy utilization in the traffic jam zone to relay the data bits engender inside the zone is given by

$$E_{3NC} = \frac{N \quad r_s}{A} t \iint_B \quad l(x)dS$$

$$\Rightarrow E_{3NC} \geq = \frac{N \quad r_s}{A} t \iint_B \quad \alpha \left(\frac{n}{} \; \frac{x}{n-1} \right) \frac{dS}{d_m} \qquad (8)$$

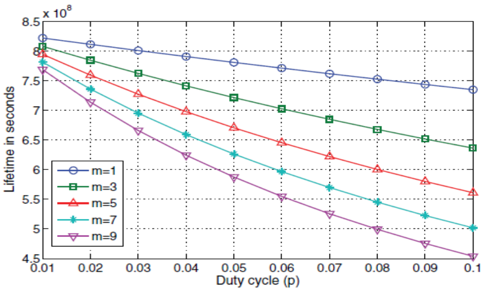

Fig.11. Lifetime upper bounds by combining network coding and duty cycle.

VII. RECITAL SCRUTINY AND PONDERING

The routine metrics other than the energy competence are packet delivery ratio (PDR) and packet latency (PL) [15][16]. Thus, the metrics PDR and PL are used to appraise the recital of the network with the proposed network coding based algorithm in a duty cycled WSN. Packet delivery ratio (PDR) is the ratio of the successfully distribute packets to the total number of packets sent to the Sink [15]. Lest of multi-hop communication with multi-path forwarding tactic, multiple nodes or link dislodge paths survive connecting a pair of source and the Sink [17] [18] to afford definite dependability.

VIII. CONCLUSIONS

We comprise survey in this paper in a wireless sensor network (WSN), the region roughly the *Sink* forms a traffic jam zone where the traffic flow is ceiling. Thus, the life span of the WSN network is utter by the life span of the traffic jam zone. The lifetime upper bounds have been predictable with (i) duty cycle, (ii) network coding and (iii) amalgamation of duty cycle and network coding. It has been pragmatic that there is a lessening in energy utilization in the traffic jam zone with the planned approach. This in twirl will lead to enlarge in network life span. The packet delivery ratio and packet latency for the planned approach have also been scrutinize with packet wounded at the *Sink*. As a conservatory of the current exertion, life span time analysis can be complete. Auxiliary, the planned scrutiny and approach too confer in this appraisal.

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