An Enhancement of Lifetime Duty Cycle using Genetic and Sine Cosine Algorithm and Network Coding in WSN

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ABSTRACT

Wireless Sensor Network (WSN) consists of autonomous sensor nodes which are equipped with limited battery and requires energy management for enhanced Network Lifetime. The area around the sink forms a bottleneck zone due to heavy traffic-flow will be in demand of more power which limits the network lifetime. This work attempts 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 process of a sensor network is to control by a big number of parameters, such as the wireless duty cycle, the frequency of neighbor discovery inspirations, and the rate of sample sensors. In this Thesis, we propose a reduced-complexity Genetic Algorithm (GA) and Sine cosine for optimization of multi-hop sensor networks in two stages such as randomized and circular bottleneck network node scheduling. The goal of the system is to generate optimal number of sensor clusters with Cluster-Heads (CHs). The GA is used to adaptively create various components such as cluster-members; Performance improvement by using GA namely; packet delivery ratio, reduced cost and energy efficient have also been investigated. A full theoretical analysis and simulation results have been providing to display the efficacy of the proposed approach improved x-OR using GA showing efficiency better as compare to basic X-OR method and producing maximum packet delivery ratio. Furthermore, it was proved that the use of *xor* operation with GA could satisfy most of the network topologies.

Keywords*: Duty cycle, network coding, network lifetime, GA, SCA, Wireless sensor networks etc.*

1. INTRODUCTION

Wireless Sensor Networks (WSNs) consist of distributed autonomous sensor node that can be deployed to monitor the inaccessible and accessible areas such as forest fire, deserts, air pollution monitoring, deep oceans water quality monitoring, glaciers. 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.

Energy is a scarce resource in wireless sensor networks and conservation of energy has been the subject of extensive research. While a variety of solutions have been proposed, duty cycling and network coding have proven to be two of the most successful techniques in this field. In most applications of sensor networks, the sensing information is transported only to a sink node, where information that is helpful for users is conveyed to users of the applications. The sensor nodes near a sink node suffer from the heavy traffic load imposed on them and their energy is depleted strongly. This phenomenon is called the energy hole problem. In a typical WSN, the network traffic converges at the Sink node S (Fig. 1.1). The area near the Sink is known as the bottleneck zone. The nodes in the bottleneck zone vacate their energy very quickly, referred as energy hole problem in WSN. Failure of such nodes inside the bottleneck zone leads to wastage of network energy, bandwidth and reduction of network reliability. The bottleneck zone needs special attention for reduction of traffic which improves the network lifetime of the whole WSN.

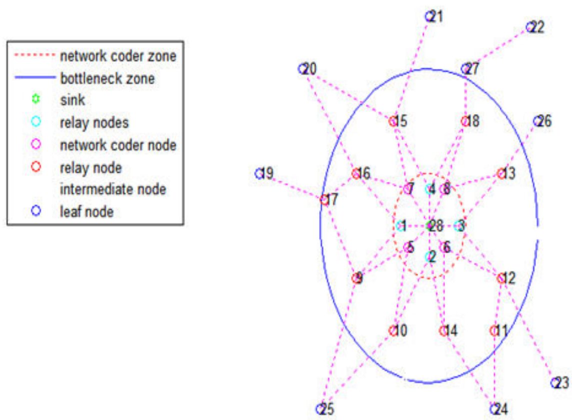


Fig.1.1 Heavy traffic-flow and roles of sensor nodes in WSN

The all-node-active condition is not practical for energy constraint WSN. 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 dense WSN the duty cycle of a node is kept very low. A duty cycle WSN can be loosely categorized into three main types: random duty-cycled WSN, coordinated duty cycled WSN, Adaptive duty-cycle WSN. This paper proposes 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 neighboring nodes, but only uses the possessive queue length available at the node. Using the queue length and its variations of a sensor node, it presents 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.

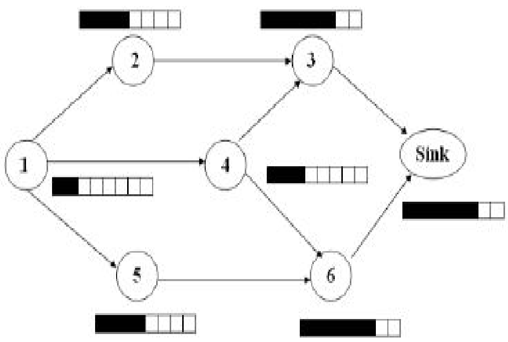


Fig 1.2: Adaptive duty cycle in a WSN

In this work, the primarily goal is to gain certain analytical understanding on the upper-bound of the network lifetime and comparative studies carried out to estimate upper bound of the network lifetime between adaptive duty cycle WSN without network coding and adaptive duty cycle WSN with network coding technique.

1.1 Network Coding

Network coding is used to enhance a network's throughput, efficiency and scalability. This technique improves the capacity of a network with better use of bandwidth. The nodes of the wireless network take several packets and send them together for transmission to attain maximum possible information flow. Intermediate nodes encode data packets received from neighboring nodes. Whenever a node enters into the bottleneck zone, network coding layer maintains received queue and a sensed queue. Whenever it receives a packet a node put the packet in received queue. Encoded (XOR) packet is generated by packets from sensed queue and received queue. If received packet is already processed then it is discarded by the node. If the node is not an encoder node, it acts as relay node and transmit packet to the sink. Duty cycle and network coding technique can be combined to use the network resources effectively. The benefits of network coding are increasing multicast throughput, reducing resources usage and enhanced system robustness.

1.2 Duty Cycle

The most effective energy conserving operation is to put the radio transceiver in low power mode i.e. sleep mode whenever communication between nodes is not necessary. The radio should be switched off as soon as there is no data to transfer or to receive and should be made active as soon as a data packet becomes ready. The switching between active and sleep mode can save energy utilization. In this way, nodes alternate between active and sleep periods.

2. PROPOSED WORK

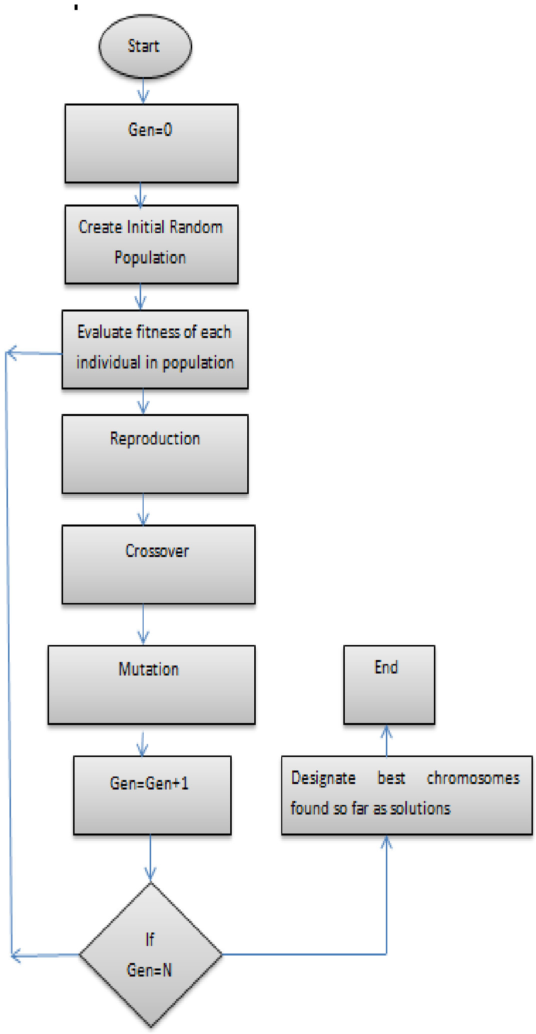
Procedure of proposed algorithm:

The process of the algorithm founded on Genetic Algorithm is existing in Flow chart. The procedure of algorithm is nearly a standard Genetic Algorithm procedure portrayed in classic literature. But the performance of network coding resources optimization based on Genetic Algorithm be contingent on the improved genetic operations, which are exemplified by italics in Flow chart.

1) initialization population (add all-one vector and special vector ψ)
2) calculate the fitness value
3) while (the stop condition is not true)
4) {
5) selection operation (add new individuals and retain elite individual)
6) crossover operation (uniform crossover)
7) mutation operation
8) compute the fitness value
9) }
10) end while
11) output the final solution

Genetic algorithm is usually collected of two procedures. First process is selection of separate for the production of next generation and second process is operation of the selected individual to form the next group by crossover and mutation methods [2].

The selection device controls which individual are chosen for imitation and how many offspring each designated individual produce. The main principle of selection strategy is the better is an individual; the higher is its chance of being parent. Fig.1 GA Flow chart [3]



Flow chart 2.1: Flow chart of GA

The GA has subsequent steps: -

1. Initialization: genetic algorithms are [4] usually start with a first population that is made randomly some research has been showed using special method to produce an advanced quality initial population. Thus, a method is intended to elasticity the GA a good start and speed up the evolutionary process.
2. Selection: It choice the two-parent chromosome from a population according to their fitness better the fitness bigger the accidental to be selected.
3. Reproduction: It first-rate the two chromosomes affording to current selection process achieve crossover on them and get one or two children, maybe apply mutation as well and install the result back into that population, the least fit of populace is destroyed.
4. Crossover: With a crossover probability crossover, the parental to form new descendants (children).
5. Mutation: After a crossover [5] this operator is achieved. Mutation is a genetic worker used to maintain genetic diversity from one generation of a population of chromosomes to next.
6. Replacement: Usage new produced population for a further run of algorithm.

XOR METHOD

The Network Coding Duty cycle and the packet processing in the Linear Network Coding Layer of the block region has been given in algorithm.

1. Every node in the network conserves the conventional line (accept Queue ()) and a identified queue (sense Queue ()). On sensing information, a node place the packet in the sense Queue (Pj). On getting a packet of pi and a node place the packet in the obtain Queue (Pi).
2. In network, nodes form the lines length where it is beneath the threshold or overhead. If when threshold is less possession the node away goes to sleep condition then sits should be energetic formal.
3. If the established packet previous handled through the node than it is cast-off, or else node developments the packets more. The node checked the part after the Nodes (), where its Communicate node or Lined Network Coding node.
4. Whether node is communicating node in Linear Network coding, the Layer will onward the packet to the base then advancing the packet or container to the Linear Network Coding layer.
5. Here, node encoder if the packet conventional non-implicit packet before it does the XOR process. On positively making programmed packets, the LNC node conveys the programmed packet to the Sink. The administered packets implanted into Conveyed set.
6. This provision the conveyed packet and assistances confining more dismissed broadcast. Though the established packet Pi is now procedures formerly it is rejected by node.

SINE COSINE ALGORITHM (SCA)

SCA is population based optimization technique, found the optimization process with a set of random solutions. These random solutions are repeatedly calculated over the course of iterations by an objective function. The probability of finding global optima is increased, with the sufficient number of random solutions.

$$X^{t+1}_i = X^t_i + r_1 \times \sin(r_2) \times r_3 P^t_i - X^t_i. \quad (2.1)$$

$$X^{t+1}_i = X^t_i + r_1 \times cos(r_2) \times r_3 P^t_i - X^t_{ii}. \quad (2.2)$$

Where X^t_i is the position of current solution in i-th dimension at t-th iteration, r1/r2/r3 are the randomnumbers, Pi is position of the destination point in the i-th dimension

$$X^{t+1}_i \quad X^t_i + r_1 \times \sin(r_2) \times r_3 P^t_i - X^t_i \quad r4 < 0.5 \quad (2.3)$$

$$X^t_i + r_1 \times cos(r_2) \times r_3 P^t_i - X^t_{ii} \quad r4 > 0.5 \quad (2.4)$$

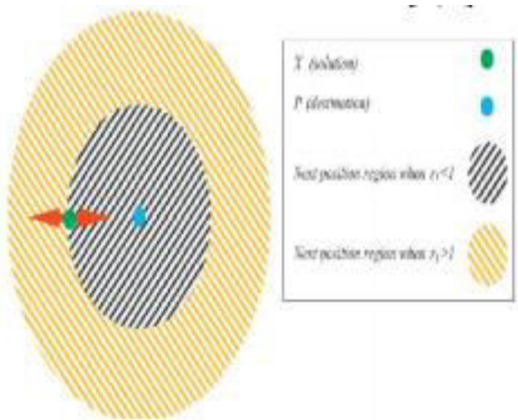


Fig.2.1 Effect of sine cosine in eqn. (1) and (2)

In the above equations there are four main parameters r1, r2,r3 and r4. The parameters r1 states that the next position region between solution and destination or outside it. Parameter r2 tells how far the movement should be towards or outwards the destination. The parameter r3 brings the random weight for destination in order to stochastically force (r3 > 1) or deemphasize (r3 < 1) the effect of destination in defining the distance. And parameter r4 equally switches between sine and cosine component in eqn. (2.4) Fig. 2.1 shows that in the search space how the proposed equations define space between the two solutions. The cyclic pattern of sine and cosine function describes the position of solution around another solution. Also, this can give guarantee exploitation of the space between two solutions. We can explore the search space by changing the range of sine and cosine function.

Figure 2.2 sine cosine with ranges of [-2,2]

The Sine Cosine function [-2,2] operation is illustrated by conceptual model as shown in the fig. 3. By changing the ranges of Sine Cosine function we can find the promising region in the search space. Also, it ensures the exploration and exploitation of search space. To make balance between exploration and exploitation, the range of sine and cosine in eqn. (2.1) to (2.3) is changed adaptively using the below equation:

$$r_1 = a - t\,a/T$$

where t is current iteration, T is maximum number of iterations and a is constant. SCA explores the search space when ranges of sine and cosine function are in [-2, -1] and (1,2] and exploits the search space when ranges are in [-1,1].

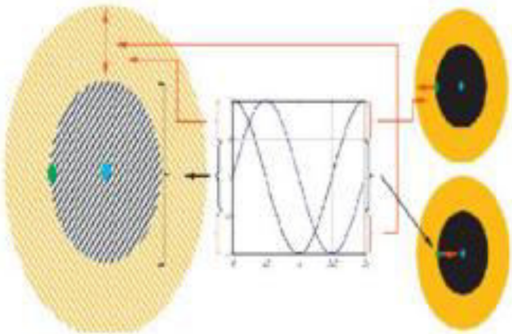


Fig.2.3 Sine and Cosine with the ranges in [- 2,2] to go around the destination General steps of the SCA Algorithm

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Initialize a set of search agents (solutions) (X)
Do
Evaluate each of the search agents by the objective function
Update the best solution obtained so far (P=X*)
Update r1, r2, r3, and r4
Update the position of search agents using Eq. (3)
While (t< maximum number of iterations)
Return the best solution obtained so far as the global optimum

Unit commitment problem formulation

The main objective of unit commitment is to find the optimal schedule for operating the available generating units to regulate the total operating and generation cost of electric power utilities. Total operating cost of power generation includes fuel cost, shut down and startup costs. The fuel costs are calculated using the data of generating unit characteristics such as fuel price information, turn-on status of unit, heat rate of generating utilities, turn-off and initial status of units, which is mathematically, a non-convex, quadratic and non-smooth equation of power output of each generator at each hour and can be determined by Economic Load Dispatch (ELD), as illustrated as following:

$$FC_i(P_{ih}) = \sum_{i=1}^{NG} \alpha_i P_{ih}^2 + \beta_i P_{ih} + \gamma_i \qquad (2.5)$$

Where, αi ($/MW^{2}h), βi ($/MWh) and iγ ($/h) are fuel consumption coefficients of ith unit the total fuel cost over the given time horizon ‘H’ is TFC.

$$Cost_{NH} = \sum_{h=1}^{H} \sum_{i=1}^{NG} [FC_i(P_{ih}) * U_{ih} + STC_{ih} * (1 - U_{i(h-1)}) * U_{ih}] \qquad (2.6)$$

where Uih is the position or status of ith unit at hth hour. Startup cost is warmth dependent. Startup cost is that cost which takes place while bringing the thermal generating unit online. It is expressed in terms of the time (in hours) for which the units have been shut down. On the other hand, shut down cost is a fixed amount for each unit which is shut down. Mathematically, startup cost can be expressed as:

$$STC_{ih} = \begin{cases} HSC_i, & if \quad MDT_i \leq DT_i < (MDT_i + CSH_i) \\ CSC_i, & if\ DT_i > (MDT_i + CSH_i) \end{cases} \quad (2.7)$$

where CSCi and HSCi are cold startup and hot start-up cost of ith unit respectively and MDTi is the minimum down time of ith unit, MDTONi is the number of hours that ith unit has been on-line since it was turned ON earlier and CSHi is the cold start hour of unit i.

- SCA creates and improves a set of random solutions for a given problem, so it intrinsically benefits from high exploration and local optima avoidance compared to other single-solution-based algorithms.
- Different regions of the search space are explored when the sine and cosine functions return a value greater than 1 or less than -1.
- Promising regions of the search space is exploited when sine and cosine return value between -1 and 1. • The SCA algorithm smoothly transits from exploration to exploitation using adaptive range change in the sine and cosine functions.
- The best approximation of the global optimum is stored in a variable as the destination point and never get lost during optimization.
- Since the solutions always update their positions around the best solution obtained so far, there is a tendency towards the best regions of the search spaces during optimization
- Since the proposed algorithm considers optimization problem as black boxes, it is readily incorporable to problems in different fields subject to proper formulation of the problem. The next section employs a wide range of test problems and one real case study to investigate, analyse, and confirm the effectiveness of the proposed SCA algorithm

3. RESULTS AND CNCLUSION

Network coding and duty-cycling are two popular techniques for saving energy in wireless sensor networks. In this work, we demonstrate that although they achieve energy efficiency by conflicting means, they can be combined for more aggressive energy savings. To achieve these energy savings, we propose Duty-Code, a network coding friendly MAC protocol which implements packet streaming and allows the application to decide when a node can sleep. Through analysis and real system implementation we demonstrate that Duty-Code does not incur higher overhead, and that it achieves 20-30% more energy savings when compared with network coding-based solutions that do not use duty-cycling. The proposed scheme requires minimal changes to existing network coding applications.

Genetic Algorithm provides a valuable problem solving method. The proposed approach demonstrates how GA can be used to solve a very general version of shortest path problem. A SCGA encoding along with the genetic operators is defined. The performance of the algorithm is better than previous work. For the practical application of the proposed work Coding of the algorithm is also comprised. This method can be very beneficial to appraise the straight path in various networks. This research work obtains a genetic algorithm for solving the shortest path routing problem. The crossover and the mutation operations work on variable-length chromosomes. The crossover is simple and independent of the position of crossing site.

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