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# Bottleneck Zone Analysis in WSN Using Low Duty Cycle in Wireless Micro Sensor Network

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**Abstract -** In Wireless Sensor Network (WSN) to enhance the network lifetime it's a fundamental challenge. To enhance the network lifetime, the area around the sink node forms a bottleneck zone due to the heavy traffic flow which limits the network lifetime in WSN. To improve the energy efficiency of the bottleneck zone which leads to overall improvement of network lifetime by considering low duty cycled WSN For efficient communication paradigm has been adopted in the bottleneck zone by low duty cycle. The sensor nodes are generally classified into two groups: simple relay sensors and network coder sensors. The relay nodes simply forward the received data, whereas, the network coder nodes transmit using the network coding algorithm. More volume of data will be transmitted to the sink hence due to this energy efficiency of the bottleneck zone increases. This improves the overall lifetime of the network.

**Keywords -** *Wireless Sensor Networks, Low Duty Cycle, Network Coding, Network Lifetime, Energy Efficiency.*

## 1. Introduction

Wireless Sensor Networks (WSNs) consist of distributed autonomous sensor nodes that can be deployed to monitoring unattainable areas, such as, glaciers, forest fires, deserts, deep oceans etc.[1]. 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 [2]. A wide range of WSN applications have been proposed such as habitat monitoring, environmental observations and forecasting etc. Many low power and inexpensive sensor nodes are deployed in this type of application. In an energy constraint WSN, each sensor node has limited battery energy for which enhancement of network lifetime becomes a major challenge [1]. The senor nodes are saving the energy by active and dormant states. The ratio between the time and the total time of active/dormant states is called Duty cycle. The duty cycle depends on the network coverage and connectivity. The sleep time of a node is very low for a crowded WSN [2].

A duty cycled WSN can be loosely categorized into two main types: random duty-cycled WSN [7] and co-ordinated duty cycled WSN [8]. In the former, the sensor nodes are turned on and off independently in random fashion. In the later, the sensor nodes co-ordinate among themselves via communication and control message exchanges. Therefore, the random duty cycle based WSN has been considered for its simplicity in design. Specifically, the problem of reduction of traffic in the bottleneck zone has been considered.

Low-duty-cycle wireless sensor networks in which nodes stay asleep most of the time and wake up asynchronously. A broadcasting packet is rarely received by multiple nodes in this type of network. There are two features in low-duty-cycle networks challenging [3]. First, a packet is unlikely to be received by multiple nodes simultaneously as in always-awake networks. To broadcast a packet, a sender has to transmit the same packet multiple times if its receivers do not wake up at the same time. Second, unlike wired networks, wireless communication is notoriously unreliable. A transmission is repeated if the previous transmissions are not successful due to wireless loss [3]. Wireless sensor networks are emerging applications of pervasive computing, consisting of many small, low power, and intelligent sensor nodes and one or more base stations. In these networks, the individual sensor data per se is not necessarily important to the end user. Sensor nodes gather information in diverse settings including natural ecosystems, battlefields, and manmade environments and send the information to one or more base stations. Sensor nodes work under severe resource constraints such as computing power, limited battery power, memory, wireless bandwidth, and communication capability, while the base station has more computational, energy and communication resources. The base station acts as a gateway between sensor nodes and the end user.

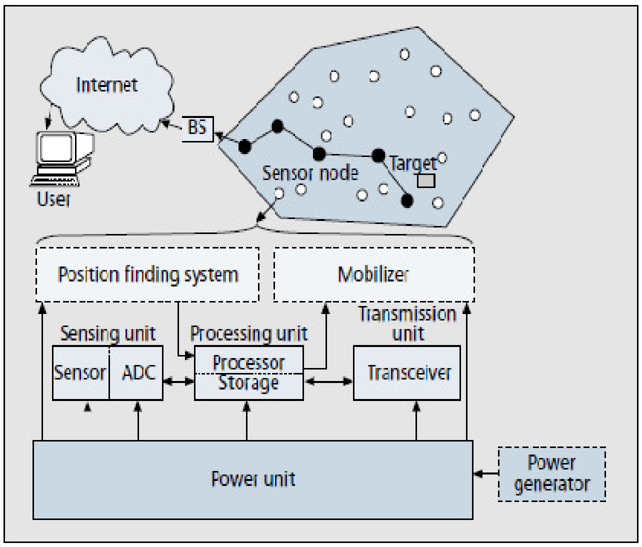


Fig. 1.The components of a sensor node

Figure 1 shows a schematic diagram of the components of a sensor node. Generally, each sensor node consist of sensing unit, processing unit, transmission unit, power unit, mobilizer, and position finding system, (mobilizer is an optional component). The same figure shows the communication architecture of a WSN. In a sensor field, sensor nodes are usually scattered and in this area the sensor nodes are deployed. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment. Each sensor node, its decisions is depending on its mission, information and its knowledge of computing. It is mostly depend on communication. Each of the scattered sensor nodes has the capability to collect and route data either to other sensors or back to an external base stations (BSs). A base station may be a fixed or mobile node capable of connecting the sensor network to an existing communications infrastructure or to the Internet where a user can have access to the reported data. The remaining paper is organized as follows: Section II describes the previous work. Section III presents the proposed work. Section IV describes the expected outcome of the proposed system. Lastly section V presents the conclusion.

## 2. Related Work

Rashmi Ranjan Rout, Soumya K. Ghosh[1], focused on the upper bounds of network lifetime in WSN, considering random duty cycle, network coding, and combinations of the duty cycle and network coding. A network coding based communication paradigm has been proposed. Network coding is a technique which improves the capacity of an information network with better utilization of bandwidth. In a multi-hop communication with network coding, the intermediate nodes of a network can appropriately encode the incoming data packets before forwarding the coded packets to the next node. The network coding technique also improves reliability of the network. Network coding is a technique which reduces the number of transmitted packets. Network coding proposed for wired networks to solve the bottleneck problem and to increase the throughput.

P. Dhivakar, K. Sindhanaiselvan[2], focused on the network life time with a network coding algorithm for a adaptive duty cycled WSN.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. An adaptive duty cycle control mechanism based on the queue management with the aims of power saving. From the neighboring nodes the proposed scheme does not need explicit state information, but only uses the possessive queue length available at the node.

Liang He, Bo Jiang, Shuo Guo, Tian He[3],focused on opportunistic flooding, a flooding method specially designed for low-duty-cycle wireless sensor networks, which reduce redundancy in transmission while achieving fast dissemination. There are two features that make flooding in low-duty-cycle networks challenging. First, a packet is unlikely to be received by multiple nodes simultaneously as in always-awake networks. To broadcast a packet, a sender has to transmit the same packet multiple times if its receivers do not wake up at the same time. Thus flooding in such networks is realized essentially by multiple unicasts. Second, unlike wired networks, wireless communication is notoriously unreliable. A transmission is repeated if the previous transmissions are not successful due to wireless loss. The combination of low-duty-cycle operation and unreliable links necessitates the design of a different flooding mechanism than those found in wired networks and always awake wireless networks.

Chih-Min Chao, Lin-Fei Lien, and Chien-Yu Hsu[4], focused on the staggered scheduling protocol (SS). SS operates in a slots synchronize environment in which time slots are aligned providing synchronization in WSN is not trivial. In this paper, we design a new awake/sleeping scheduling mechanism that enables a sensor node to determine its own duty cycle independently and guarantees a node to meet any of its neighbor nodes. To achieve this goal, we propose the staggered scheduling protocol (SS). Fortunately there exist several synchronization schemes. Instead of always using the same duty cycle as most of the existing protocols suggested, SS adjusts each node's instantaneous duty cycle in a staggered way.

H. R. Karkvandi, E. Pecht, and O. Y. Pecht[5], focused on the network layer of a WSN and proposes an efficient routing algorithm to optimize the lifetime and sensing coverage of the network. In this paper wireless sensor networks are facing two main challenges in general, i.e., Lifetime-aware routing and the desired Sensing Spatial Coverage of the field of interest. To increase the WSN's lifetime, they have proposed an algorithm called flow redirection (FR) which extends the lifetime of the WSN nodes by redirecting portions of the information portions of the information to paths with longer length. They have shown that the FR algorithm has a better lifetime performance.

Q. Wang and T. Zhang[6], focused on deploying a wireless sensor network is collecting interesting information from its environment, the total number of collectable information after a network is deployed. Since energy constraint is usually a big problem for a wireless sensor network and the network often fails to function because of its exhausted energy, the operational lifetime of a wireless sensor network is widely used to measure the network performance.

## 3. Proposed System

In dense wireless sensor network reduction of energy consumption is most important factor and low duty cycle facilitates to perform this task, network coding technique is used to improve the throughput, bandwidth and energy efficiency in resource constraint wireless networks. Low duty cycle wireless sensor networks in which nodes stay a sleep most of the time and wake up asynchronously. In this type of network, a broadcasting packet is rarely received by multiple nodes. Simultaneously, a unique constraining feature that makes existing solutions unsuitable. There are two features in low duty cycle networks challenging. First, a packet is unlikely to be received by multiple nodes simultaneously as in always-awake networks. To broadcast a packet, a sender has to transmit the same packet multiple times if its receivers do not wake up at the same time. Second, unlike wired networks, wireless communication is notoriously unreliable. A transmission is repeated if the previous transmissions are not successful due to wireless loss.

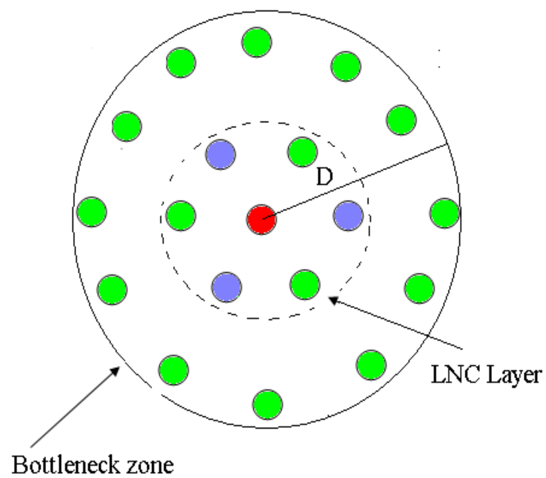


Fig. 2. Bottleneck zone in typical WSN

### 3.1 The Need for Low-Duty-Cycle Operation

The energy used in communication can be optimized using physical-layer transmission rate scaling or link-layer optimization for connectivity, reliability, and stability. With a comparable current draw and a 3-4 orders of magnitude longer duration waiting for reception, idle listening is a major energy drain that accounts for the communication energy cost. To reduce the energy penalty in idle listening, a node has to run at a low duty cycle state and turn off its radio most of time.

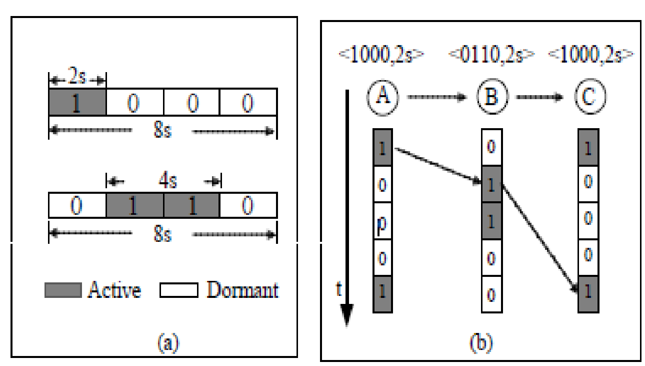


Fig. 3. Low duty cycle network model

Suppose there is a wireless sensor network of N sensor nodes. Each sensor node has two possible states: an active state and a dormant state. An active node is able to sense an event, transmit a packet or receive a packet. A dormant node turns all its function modules off except a timer to wake itself up.

### 3.2 Bottleneck Zone In A Wireless Sensor Network

In Wireless Sensor Network (WSN) Multi-hop routing strategies are widely used. From multi-hop routing strategy, a sensor node which is deployed far away from the sink which is possible to communicate with the sink through sensor nodes deployed. The dominating communication pattern in a sensor network is dispersed sensor nodes forwarding their sensed information to the sink; multi-hop routing strategies inevitably lead the nodes closer to the sink to suffer more energy consumption than those further away. To classify wireless micro sensor network according to different communication functions, data delivery models and network dynamics. This taxonomy will aid in defining appropriate communication infra-structure for different sensor network application subspaces. It allows network designer to choose the protocol architecture. According to their application this taxonomy will enable new sensor network models to define for use in further research in this area. The overall communication behavior in a wireless micro sensor Network is application driven.

Wireless micro sensor networks lend themselves to trade-offs in energy and quality. In these networks, the individual sensor data per se is not necessarily important to the end user. By allowing the algorithms and protocols to adapt the quality of this description, with a corresponding change in energy dissipation, sensor networks can be flexible to the end-user's requirements. By ensuring that the system operates at a minimum energy for each quality point, the system can achieve both flexibility and energy efficiency, allowing the end-user to maximize system lifetime. Wireless micro sensor networks consist of battery-operated sensor nodes that work together to achieve a desired goal. WSN consist of many applications that include home security, medical monitoring, and a variety of military application. The goal of a sensor network is very different than that of a traditional wireless network. A group of vulnerable nodes (i.e. the nodes which are nearest to the Sink and deplete their energy quickly) in the bottleneck zone transmits using network coding based communication. The other group of nodes in the bottleneck zone acts as simple relay nodes.

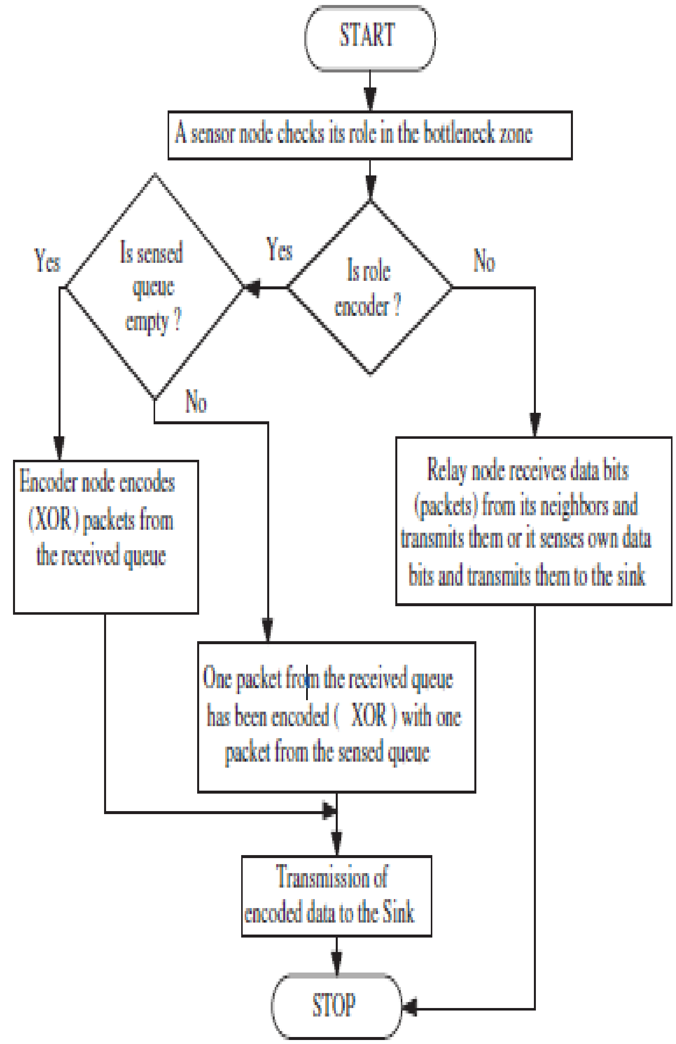


Fig. 4. Flow chart

These relay nodes help the sink to decode the encoded packets and accordingly the bottleneck zone node as shown in flowchart.

## 4. Proposed Solution

From the idea of the proposed system we are clear with the sensor nodes in the bottle neck zone vacate their energy very quickly, it is called as energy hole problem in WSN .The bottleneck region leads to bandwidth, wastage of network energy, and reduction network reliability in the failure of sensor node. The bottleneck zone improves the network lifetime of the WSN which needs special cognizance for decrement of traffic. We can reduce the power consumption of source due to low duty cycle. In addition, reduce the congestion in bottleneck zone.

## 5. Conclusion

In a wireless sensor network the area near the central gathering point forms the bottleneck zone where the traffic flow maximum, so we can reducing the power consumption of source. The proposed scheme only requires the local queue length for computing the duty cycle, which adds good scalability, improved efficiency to the system.

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