An Efficient Mechanism Protocol for Wireless Sensor Networks by using Grids

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***Abstract*—Multilevel short-distance clustering communication is an important scheme to reduce lost data packets over the path to the sink, particularly when nodes are deployed in a dense WSN (wireless sensor network). Our proposed protocol solves the problems of single hop paths in the TDTCGE (two-dimensional technique based on center of gravity and energy) method, which addresses only single-hop problems and does not minimize distances between nodes by using multi-hop nodes with multilevel clustering grids to avoid dropped packets and to guarantee reliable paths without failures. In multilevel clustering grids, transmitted data are aggregated from lower-level grids to upper-level grids. In this paper, the proposed protocol obtains the optimal path for data transmission between cluster heads and the sink for heterogeneous WSNs. The cluster head nodes play an important role in forwarding data originating from other normal nodes that aggregate data to upper clusterheads. This routing approach is more efficient than other routing approaches, and it provides a reliable protocol for avoidance of data loss. In addition, the proposed protocol produces sleep and wakeup signals to the nodes and cluster heads via an MD (mediation device), thereby reducing energy consumption. Simulation results demonstrate the efficiency of the proposed method in terms of fewer dropped packets and high energy efficiency. The network environment overcomes the drawbacks of failure paths and provides reliable transmission to the sink**.

Keywords—Multilevel; WSN; reliable; heterogeneous; routing

I. Introduction

Wireless sensor networks (WSNs) have many applications in fields such as agriculture, medical care and health care depending on the type of sensors installed. WSNs are crucial for gathering information necessary for smart devices that are part of pervasive computing, which is utilized in buildings, transportation and industrial systems. A pervasive sensor network consists of individual nodes (sensors) that can interact with the environment by sensing certain physical parameters. All sensor nodes generally have the same task. To complete their tasks, collaboration among nodes is required. Given that sink nodes can occasionally be outside the network, the data collected by sensors are transmitted to sink nodes that are part of the network. Sensors and sinks exchange packets through wireless communication.

Nodes cannot be connected easily to a wired power supply in many WSN applications; the nodes instead depend on onboard batteries [2]. In such cases, the energy efficiency of communication protocols is a crucial concern (i.e., figure of merit) because extended operation time is necessary. In other applications, power supply may not be a problem; consequently, other metrics (e.g., the accuracy of the delivered results) may be more relevant than energy efficiency.

A sensor is equipped with a radio transceiver or another wireless communication device that transmits and receives data over a wireless channel. A sensor also has a controller for manipulating data and memory for storing software and temporary data. A sensor commonly uses a battery as its energy source.

The concept of a WSN is based on a simple equation [3]: Sensing + CPU + Radio = many applications. However, to create an effective WSN, the combination of sensors, radios, and CPUs requires in-depth understanding of the capabilities and limitations of hardware components and networks. WSNs face several problems that may not occur in other types of networks. Power constraints are a major concern. Communication is the most energy-intensive task a node performs. Nodes must compete for a share of the limited bandwidth available. Networking protocols attempt to reduce energy consumption by two means: neglecting certain communication tasks or turning off the radio transceiver when communications are unnecessary [1].

WSNs combine the latest advances in low-power micro-sensors and short-range wireless radios to yield an attractive new technology. WSNs enable a number of sensing and monitoring services in vital areas such as industrial production, home security +and in traffic and environmental monitoring. In addition, some of nodes be in sleep mode most of time to save energy as B-Mac [19].

The proposed protocol is an efficient Clustering Protocol for Heterogeneous energy nodes which divided into levels. There are many examples of Heterogeneous Oblivious Protocols, some of these examples Sep Protocol, ECHERP Protocol, Evolutionary Algorithms (EAs) and EECB (Energy-Efficient Chain-Based routing protocol) [13]-[18].

The rest of the manuscript provides some of the related works and describes the methodology of the proposed protocol then discusses the results with conclusions.

II. Literature Review

The proposed protocol is compared with the TDTCGE [7] protocol.

- Two-Dimensional Technique based on Center of Gravity and Energy (TDTCGE) [7].

This protocol uses two-dimensional techniques. The centers of gravity and energy for each grid are computed. The optimal node is selected to be the cluster head (CH) because this node is the nearest to one of the centers. The TDTCGE protocol addresses the distance problem, particularly the distance of the CH from the BS. However, the problem of idle listening is overlooked. The results of this protocol indicate that both the lifetime and energy consumption are enhanced.

- In CRCWSN [8] this protocol uses two different techniques for selecting cluster head (CH) that has been initially used by genetic algorithm and re-clustering technique.

A. Network Model

For this study, we randomly deploy N sensor nodes in a monitored area and assume that the sensor network has the following characteristics:

1) The position of the BS in the sensor network is fixed.

2) All nodes are heterogeneous and stationary and have different initial supplies of energy.

3) All the nodes are randomly deployed in the target area, and each can establish a connection with the sink.

B. Energy Consumption

LEACH [4], [5] includes a first-order radio model that can be utilized for calculating hardware energy dissipation. For comparative purposes, this paper uses the same model. In this model, the energy consumptions of radios for sending and receiving data are both expressed as Eelect; the free space and the multi-path fading channel models with respective amplifying indexes ε fs and ε mp are used; the energy consumption of data fusion is denoted by EDA [9]-[11]. The energy spent by a node that transmits an l-bit packet over distance d is calculated using the Heinzelman model. This model states that for each node to transmit L bits of data a distance d from itself, Et energy is consumed:

$$Et = L * Eelect + L * \in mp * d4 \quad d \geq d0. \tag{1}$$

$$else$$

$$Et = L * Eelect + L * \in fs * d2 \quad d < d0. \tag{2}$$

The energy required to receive L bits of data equals.

$$Er = L * Eelec. \tag{3}$$

The parameters are defined as follows:

*d*0: crossover distance
∈*elect*: energy necessary for activating electronic circuits
∈*mp*, ∈f *s*: sensitivity and noise in the receiver, respectively.

III. Proposed Protocol

In the proposed protocol, the target area is divided into grids, with each grid consisting of a cluster. Using grids reduce distance between nodes within cluster. Each cluster has a CH and connected member nodes. A mediation device (MD) node also exists which is intelligent device [6]; this node schedules and manages the nodes and CH. After performing its task, the MD node synchronizes the nodes and the CH. This node mostly keeps the CH and other nodes in sleep mode. The CH is awakened only for a short time to receive packets. The CH aggregates the data from the nodes and transmits them to the BS (see Fig. 5). Nine grids are established to ensure a high transmission data rate and to minimize the overall overhead.

The WSN environment is separated into 9 grids in the proposed protocol. Each grid consists of two dimensional centers (centers of gravity and energy). These two points are computed in each grid using the following two formulas (center of gravity and energy center) (see (1), (2), (3), (4)):

$$Xgc = (x1m1 + x2m2) / (m1 + m2) \tag{1}$$

$$Ygc \ (y1m1 + y2m2) / \ (m1 + m2). \tag{2}$$

If there are more than two object masses, then the formulas are represented as follows:

$$Xgc = sum \, (X - coordinate(node) * node - mass) \, / \, all \, Mass. \tag{3}$$

$$Ygc = sum \, (Y - coordinate(node) * node - mass) \, / \, all \, Mass. \tag{4}$$

The center of energy for each grid is obtained by calculating the center of energy for the two (or more) points.

a) sum (X-coordinate(node) * node-mass) / node-count

b) sum (Y-coordinate(node) * node-mass) / node-count

The proposed protocol has the following rules:

CH: a super node that organizes all the nodes and aggregates data.

Centers of gravity and energy: center points used for reducing the distances between the nodes and CH to choose the optimal CH.

MD node: inelegant node that synchronizes the nodes and CH.

By calculating the formulas for each center, the dimensional centers are included in each grid.

The center of gravity pertains to the average point of the object weight [17] (see Fig. 1).

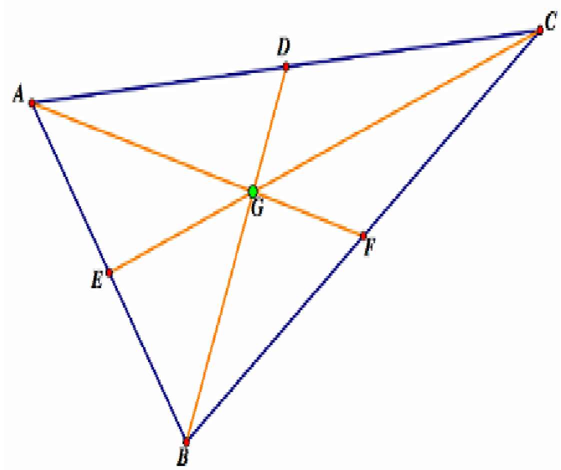

Fig. 1. Center of gravity.

The proposed GMD protocol has two phases: setup and steady state. In the former, the network is divided into nine grids that result in four clusters. Each cluster has two centers (gravity and energy), one CH, and undetermined nodes with different energies. An MD node is also present in each grid (see Fig. 2).

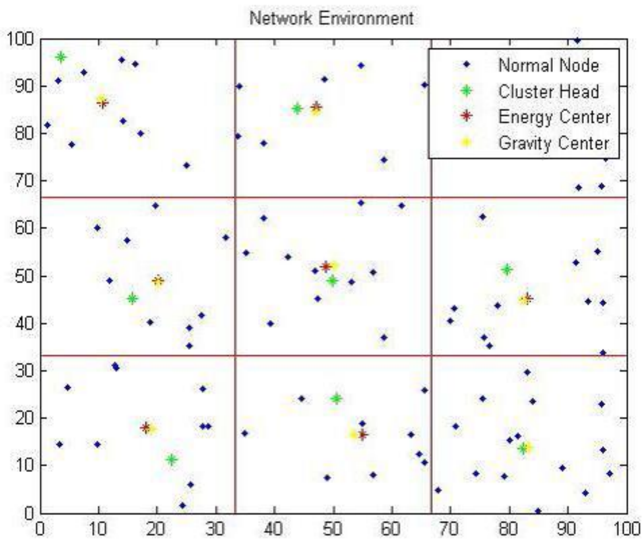

Fig. 2. Network environment.

A. Setup Phase

In the setup phase, the nodes are distributed randomly in the grids. After setup, the sink and centers are identified along with the CH. The node closest to the sink and the energy center is selected as the CH. The center of gravity should also be the closest to the BS for the node to be the CH. If the node is far from the center of gravity but is the closest to the center of energy, it can be the CH. If this center is also the nearest to the BS, then the node that has the most energy is the CH. The proposed Protocol has three types of CHs in each level: normal, advanced, and super CH's. The ranking of CHs is according to the distance of the nodes from the BS and how close the heterogeneous nodes are to the energy center; the node that has the most energy is the CH. The weights of normal CHs are accordingly less than the weights of advanced CHs and super CHs.

B. Steady-State Phase

In the steady-state phase, the BS broadcasts the address and ID number of each node. An MD node that works as a node mediator is present in each grid. This node is responsible for scheduling, managing the suggested routing protocol, and treating the synchronization operations between the nodes and the CH. The MD node performs its operations in the grids in two cases: when the nodes have no data and when they have data.

Case 1: If nodes in each grid have no data to send to the CH, then the MD node keeps the nodes and the CH in sleep mode most of the time by transmitting a sleep signal (see Fig. 3).

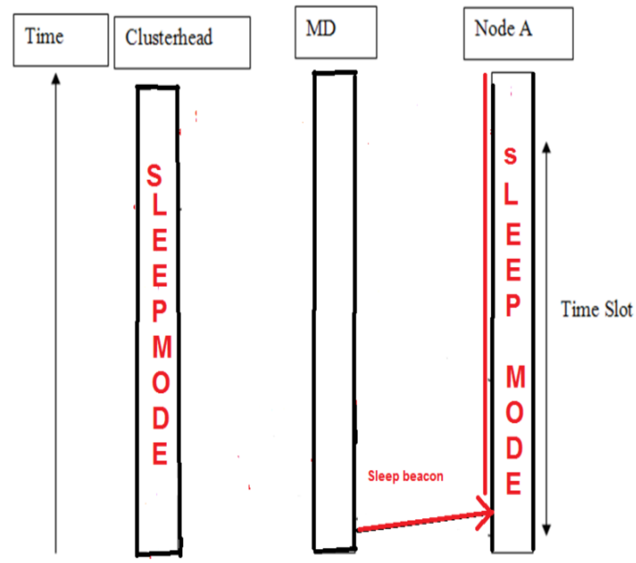

Fig. 3. Case 1: No Data.

Case 2: If new data must be received, the MD node sends a wake-up signal to the nearest node. The wake-up signal is also sent to the CH. The CH and the nodes are in sleep mode most of the time. To receive data, they wake up for a short time. The MD node produces a binary digit "0" for sleep to nodes which doesn't have data and "1" for wake up to nodes have data notify that MD node is intelligent device. The nodes then wait for their time slots to transmit data on their time-division multiple accesses (TDMA) [12] schedule. In this schedule, the nodes that have data when the binary digit is "1" are prioritized. Accordingly, the MD node transmits a wake-up signal to the nearest node up to the farthest one to minimize the delay in sending data and simultaneously save energy (see Fig. 4).

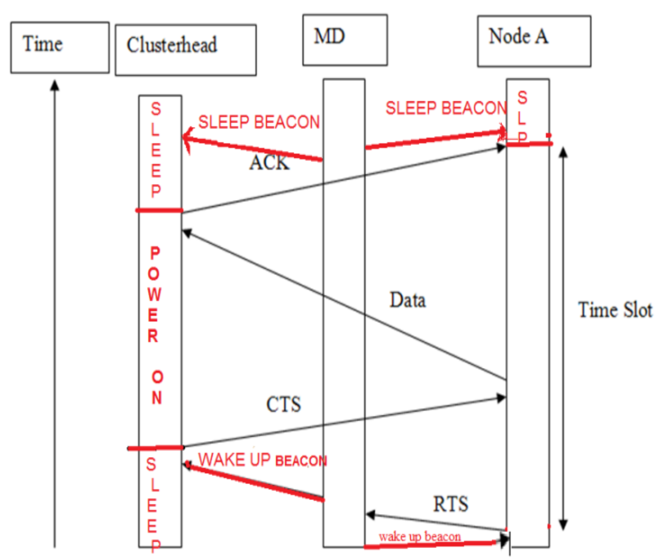

Fig. 4. Case 2: With Data.

The MD node creates a wake-up signal containing the address of the node that must transmit a packet. The signal is passed to the CH, which in turn responds by transmitting a clear-to-send (CTS) signal to the source node. The source node then transmits the data directly to the CH. After receiving the data, the CH sends an acknowledgment back to the source node A, thus signaling that the transmission is completed. According to Fig. 3, in this proposed study there is multilevel clusterheads and Multilevel MD (see Fig. 5).

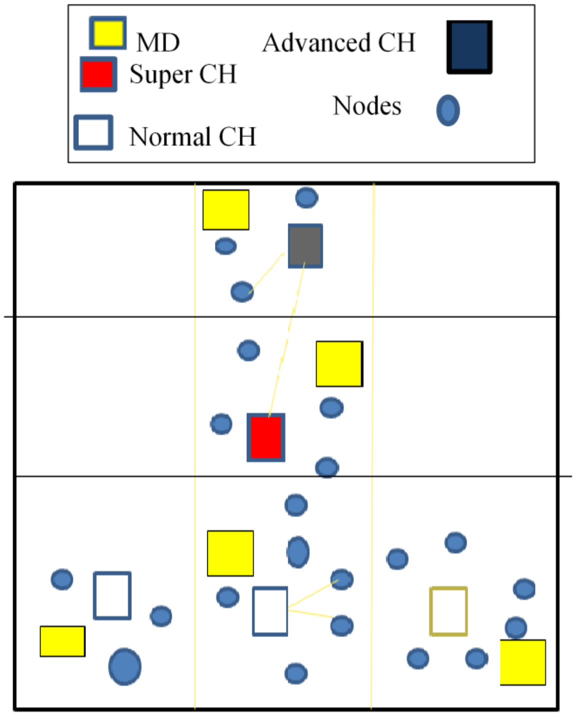

Fig. 5. Multilevel clusterhead grids.

In the first level, the normal CH aggregates the transmission data from normal nodes; this occurs after the MD node lets the nodes sleep most of time unless they have data. When the nodes have data, the MD will wake them up and refer them to the normal CH. All normal CHs will forward the data to the advanced CH; this also aggregates data from its cluster nodes. The MD node then lets normal CHs return to sleep mode. The advanced CH will then forward the aggregated data to the super CH, which will transmit them to the BS. To overcome the above problem, an efficient multi-hop heterogeneity protocol is proposed to obtain an optimal path with no failures or dropped packets between the CHs and the BS during data transmission. This will reduce the transmission path instead of transmitting directly from a normal CHs to the BS, as in the TDTCGE protocol. The second level advances cluster head nodes, which are allowed to communicate with the third level super cluster head node in its TDMA time slot; the same is followed for level 1 nodes to level 2 CHs. In level 2, the advanced CH node performs data aggregation to remove replicate data. In level 2 node sends, the aggregated data advance to the level 3 CH in its TDMA time slot. In level 3 super CH nodes, the data use network coding; they are forwarded to the sink. Owing to a multi-hop link [20] between level 3 CHs, data forwarded to the sink increase the network traffic. The network environment overcomes the disadvantages and provides reliable transmission to the sink.

SETUP PHASE

Algorithm:

Divide the network into two grids.
Find the center of gravity for each grid.
1. If node-count = 1
a. The node that is nearer to BS participates in the grid computation.
2. If node-count > 1
a. allMass = calculate sum of the masses of all nodes in grid b.
b. sum (X-coordinate(node) * node-mass) / allMass
c. sum (Y-coordinate(node) * node-mass) / allMass
3. Find the center of energy for each grid.
1. If node-count = 1
a. The node that is nearer to BS participates in grid computation.
2. If node-count > 1
a. sum (X-coordinate(node) * node-mass) / node-count
b. sum (Y-coordinate(node) * node-mass) / node-count
4. If Distance (normal nodes) <= distance(center of energy, BS),
A. select most energetic node as Normal CH
5. else If (Advanced nodes< Advanced CH)
A. Select Advanced node as Advanced CH.
Else
B. Select Advanced node as Super CH

STEADY PHASE:

Algorithm:

Steady State Phase: Algorithm

Repeat 1. If the node is normal
MD broadcasts IP address and ID number to all nodes
If node = data
MD produces wake-up signal
If Distance(node<=CH)
Node sends RTS to CH
CH sends CTS to node
Node sends data to CH
CH sends acknowledgment to nodes
Flag=1
a. node-energy = node-energy – consumed energy when sending a message
2. Otherwise
a. node-energy = node-energy – aggregated energy – consumed energy)when sending a message until no node has energy(
B. (Advanced-CH) = Node-energy+ Normal CH-energy
C. (Super-CH)=(Advanced-CH)+(Advanced-Nodes-energy)

IV. PERFORMANCE MEASUREMENT

The performance of the proposed protocol can be evaluated with a number of metrics.

A. Performance Evaluation

- Energy Consumption: The total numbers of energy consumed for packets transmitted and packet received during the rounds.
- Throughput: It measures the total data rate sent over the network, including the data rate sent from CHs to the sink node and that sent from the nodes to their CHs.
- Packet loss: Many causes of data loss would be bit errors in an erroneous wireless network or collisions due to network congestion when the channel becomes overloaded or large distance path to base station.

B. Results and Discussion

TABLE I. SIMULATION PARAMETER

Parameter	Value
Network size	100*100 m
Ee	50nJ/bit
Tevent_all	(randi(9,1,m)+1)*1*10^{-3}m
T	10
Pactive	6*10^{-3}mw
Tdown	1*10^{-3}m
Psleep	1*10^{-3}mw
L	1000 bit
Do	87m
Grids Number	4
Mp	0.0013 *10^{-9}
Fs	10*10^{-9}
Position of BS	(75,125)
Number of nodes	100

We use these parameters from Table I in matlab simulation to evaluate the MD Multilevel Proposed Protocol with MD one level and TDTCGE Protocol.

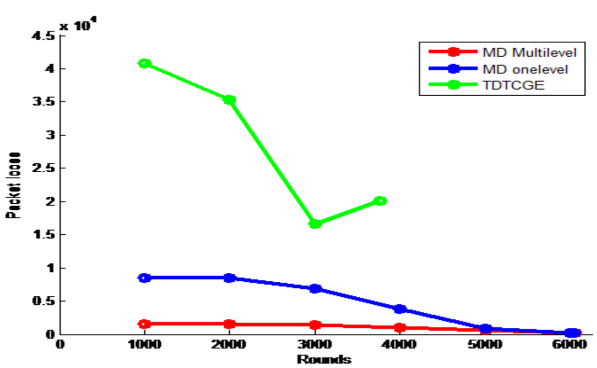

Fig. 6. Drop packets during rounds.

From Fig. 6, we can observe that the Proposed MD multilevel protocol is more reliable than MD onelevel protocol and TDTCGE which is the least of dropping packets between these two existing protocols. The percentage of errors with dropping packets during rounds for each protocol is 35% to MD Multilevel, 45% to MD one level and 65% to TDTCGE. The MD multilevel obtain the optimal path for data transmission to reach the base station to avoid loose date and guarantee reliable paths without failures.

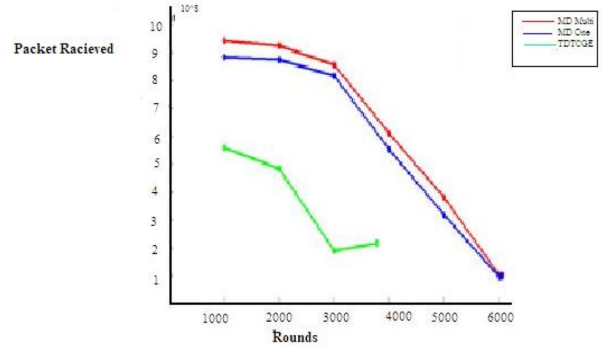

Fig. 7. Number of messages received during rounds.

From Fig. 7, we can observe that the Proposed MD multilevel protocol is more efficient than MD onelevel protocol and TDTCGE. The large volume of successfully messages received to BS by MD multilevel protocol more than these two existing protocols. The received successfully messages by MD-multilevel is 9.5*104, MD-onelevel is 8.7*104. The MD multilevel obtains the optimal path for data transmission to reach the base station.

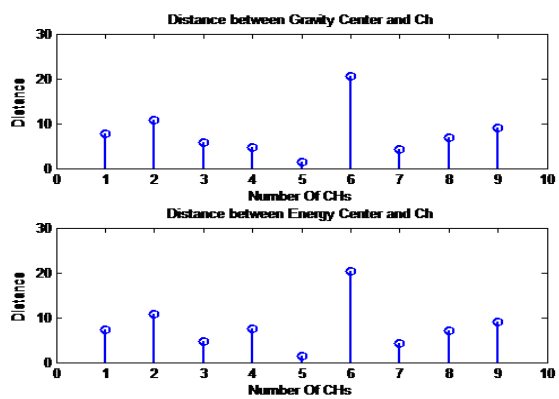

Fig. 8. Distance for MD (multi).

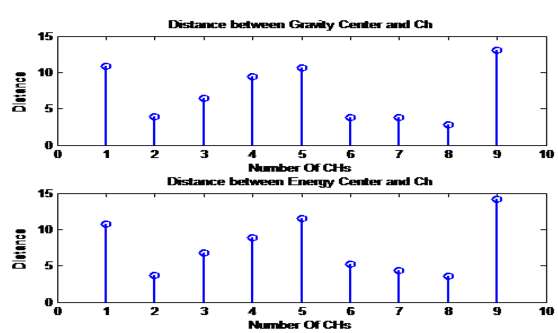

Fig. 9. Distance for MD (one level).

We observe from Fig. 8 and 9 above that for the MD multilevel protocol, all the clusterhead candidates were near the energy center points except for one candidate, CH6. However, in the MD-one level protocol, all clusterhead candidates were near except three: CH1, CH5 and CH9. Thus, the MD-multilevel protocol was more precise in choosing an efficient clusterhead.

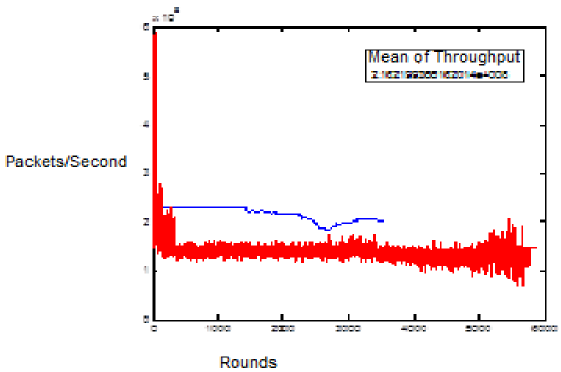

Fig. 10. Mean of throughput.

Fig. 10 compares the throughput values of the MD-one level protocol and the proposed MD multilevel protocol using nine grids for both. A long transmission time implies a low throughput. A large throughput represents a large number of messages delivered per unit time, regardless of whether the delivery was successful, i.e., Throughput = (Size of the packet / Transmission time). The TDTCGE protocol requires a long time to send data to the BS, and it uses nine grids that result in a small throughput. This is due to the small number of nodes in each grid. The time required to reach the BS is thus reduced. The number of data packets received by the BS per unit time in the proposed MD protocol is greater than that received by the BS per unit time in the MD-one level protocol. The proposed protocol exhibits a higher mean throughput than the TDTCGE protocol. The mean throughput of the latter is 2.1621*108, whereas that of the former is $2.5*10^8$ (see Fig. 11).

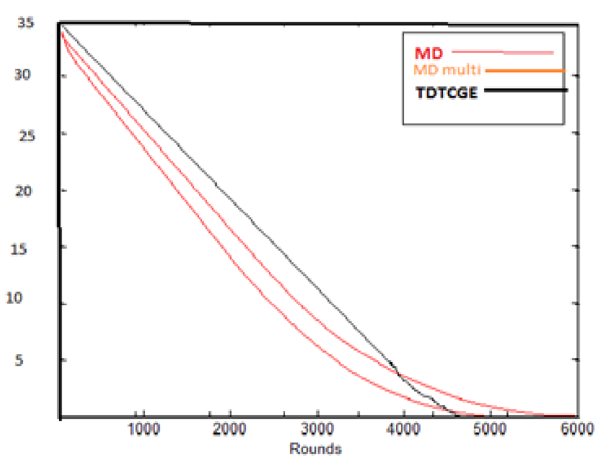

Fig. 11. Energy consumption.

Fig. 11 reveals that the proposed MD-multilevel protocol conserves more energy than the TDTCGE protocol. The former consumes 34 Joules in 5900 rounds, whereas the latter consumes 35 Joules in 4880 rounds. However, the MD-one level protocol saves more energy than the MD-multilevel and TDTCGE protocols; it consumes 33 Joules in 6050 rounds.

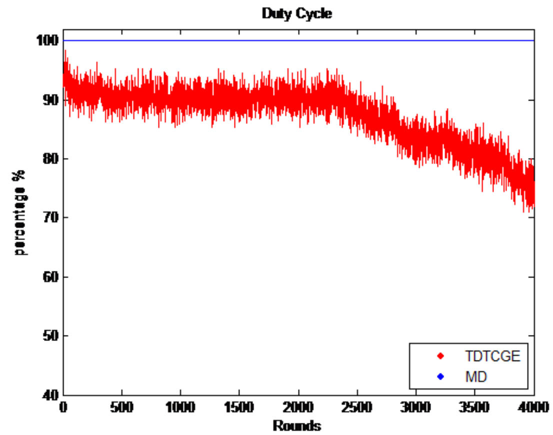

Fig. 12. Duty cycle.

The duty cycle in Fig. 12 pertains to the ratio of time, a node is in the active mode to the entire operational time. WSNs are typically engineered with low duty cycles to guarantee long node and network lifetimes. Therefore, most of the time, the nodes are in extended sleep modes with their radios turned off. Duty cycling limits the number of nodes that synchronously overhear a packet. Thus, the spatial reuse in the forwarding process is restricted. For the proposed and TDTCGE protocols, the resulting duty cycle for the given nodes was 80%–90% during all rounds (see Fig. 12). The average duty cycle for all nodes was 85%. The average duty cycle was 100% and 95% for the first 400 rounds and for rounds 401–2300, respectively. This percentage then decreased from 95% to 75% at 4000 rounds.

V. CONCLUSIONS

The proposed protocol is more reliable than existing protocols for multilevel heterogeneous WSNs. Comparing TDTCGE, MD-one level and MD-multilevel protocols, the proposed protocol was evaluated in terms of the messages received by the sink and the network lifetime. The proposed MD-multilevel protocol is well organized in establishing multi-hop communication within grids using link path correlation along with the TDMA time slot. Moreover, multi-hop communication between cluster heads is well controlled by the MD node. Because heterogeneous nodes are usually chosen as clusterhead candidates, incorporating energy-consuming tasks on those nodes increases the number of messages received by the network sink. The simulation results illustrate the efficiency of the multilevel MD protocol compared with the existing protocols in terms of reducing both the energy consumption and the number of dropped packets and hence guarantee the reliability of the proposed multilevel protocol to deliver data without failure.

VI. FUTURE WORK

In the future Research Plans that how to mix fuzzy logic system with MD node and adding grids and Centres. We highlight some interesting on the future research directions:

- Currently, the proposed protocols designed mainly to solve this problem as idle listening and delay with throughput by adding MD node alone also adding Mathematical model will improve the lifetime of the network 90% than TDTCGE.
- In addition, in the Proposed Schemas we will add fuzzy logic with three criteria's to the grids and Centers that the proposed schema minimize the distance and saving more energy which give us a better energy efficiency than TDTCGE Protocol.
- Furthermore, when we plan to mix Fuzzy logic with MD node and adding mathematical model to the grids and Centres which that solve all the problems in this research .in addition, solving the problems of reliability and collisions.

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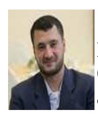

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