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Improvement of Energy-Efficient and Reliable Mechanism by node Classification based Functionality in WSNs

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Abstract: **The designing of WSN is affected by mainly energy efficiency and reliability. In this paper, energy efficient & reliability are parameters of WSN outline. The clustering structure has been used to decrease the energy consumption in WSNs. The cluster head is an important component in WSNs. There is a need to design a SCH which guarantees the reliability of data propagation. Sensor nodes have been classified into five categories i.e. (i) BN (Branch Node) (ii) CH (Cluster Head) (iii) SCH (iv) IN (Intermediate Node) (v) NN (Normal Node). These divisions are based on different functionalities of WSNs. The different MAC (Medium Access Control) protocol and network strategies have been adopted for different categories of node to reduce the consumption of energy. In this way, the reliability of data is increased. The simulated results show that the proposed mechanism improves the energy efficiency and reliability.**

Keywords: Node Classification, MAC protocols, cluster head, wireless sensor networks, multipath routing algorithm

I. INTRODUCTION

WSNs consist of many sensor nodes. The sensor nodes are found generally homogeneous. The resource-rich base stations are the mediums among the outside information source and WSNs. The special scales of environment are temperature, humidity and wind speed. The works of the sensor nodes are to collect the data through sensing the environment parameters and then to propagate them to BS for next clearing. WSNs have applications in healthcare, security and surveillance, environment monitoring, vehicle tracking, detection, control and automation and agricultural precision.

The constraints of WSNs are their small sizes, price and energy consumption. These affect processors, communications, and memory size energy capability. Energy saving is a research matter, which needs attention in design of WSNs protocol. Several problems are known for saving energy in communication of WSNs. The reliability of sensor nodes performance is affected by some energy Constraints. The energy depletion in Hardware restricts the regularity of work.

The normal operation of sensor nodes is affected by their deployment. The environment factors take the major role in affecting the wireless radios of sensor nodes. The interference causes the communication faults in WSNs. Thus main highlighted challenge for real life applications is the reliability of WSNs. It needs high fault tolerance.

The energy in WSNs can be saved by hierarchical structure. Hierarchical structure enables to reduce the direct communication between base station and sensor nodes. The consumption of energy of the C.H. is more than N.N. during extra works. Energy consumption can be reduced by selecting cluster heads in rotation. Consequently total energy is significantly reduced so that the lifetime of network is extended. Thus the clustering hierarchical structure has been utilized. IN spite of the hierarchical structure, energy efficient MAC protocols help in energy saving by reducing the radio sleep/wake. The MAC for WSNs are divided in following categories:

(i) S.B. protocols
(ii) C.B. protocol

Using the above categories of MAC protocols, the energy saving may be maximized.

The role of the C.H. is major principal in hierarchical WSNs. The reliability of cluster head has been considered by few researchers. The cluster head is associated with formation of cluster, data collection, aggregation & propagation. In case of failure of cluster head, the cluster working is stopped and major part of cluster's data may be lost. In such circumstances, reliability of C.H. plays important role in WSNs.

One of the objectives of this research paper is to propose an approach so that a SCH may be chosen. SCH should work properly if the cluster head fails suddenly. A non-cluster head requires less energy consumption than SCH (substitute cluster head). By neglecting consumption of energy in one node, the reliab. C.H. is improved the process of WSNs. Inspite of this, the average energy consumption may be reduced by selection of SCH in rotation.

The fault tolerance in routing is observed in case of multiple node disjoint paths. Alternative path is selected neglecting an

unavailable path with broken links. The multipath routing paradigm helps in fault tolerance and reliable data propagation. It provides an alternative path to each sensor node to reach the destination. The W.C. is unstable and fault liberality is necessary for data processing. The multipath discovery algorithm is considered to increase the reliability when the transfer of data from C.H. to B.S.

The S.Ns. have been classified into following groups based on their role in WSNs:

(i) B.N.
(ii) C.H.
(iii) S.C.H.
(iv) I.N.
v) N .N.

In addition to each category alternative network and MAC protocol are considered. Following parameters have important role in WSNs:

(i) Schedule generation
(ii) Data aggregation
(iii) Radio control
(iv) Energy alarm
(v) Route discovery
(vi) Data transfer

The energy efficiency and energy reliability are main issues in the design of standard WSNs.

The objectives of this research paper are as under:

(i) To propose the power coherent and reliable WSN mechanism.
(ii) To classify the S.Ns. into groups based on their role.
(iii) To consider mechanism of SCH.
(iv) To consider phases including C.F., D.T. etc.
(v) To use global parameters to improves the performance of CH and routing discovery.

For (i), S.Ns. are divided into 5 groups as per their functionalities. Flexible MAC protocol is designed to help each category of sensor nodes.

This helps in reducing E.C. and in enhance lifespan.

In (ii), the SCH is liable for the transmission of data in the situation of sudden failure of cluster heads. If a path fails, the multiple discovery schemes solves the problem. Thus, there is surety of reliability and robustness durability of the WSNs. Finally, For (iii), the phases including C.F., multiple path transmission and D.T. are arranged in such distributed manner that they guarantee for the major of WSNs. Finally, in (iv) parameters of T.E. and node sum are to be used to better route discovery and performance of CH as well as the selection of SCH. In our proposed mechanism, parameters are to be renovated after each round through calculation by B.S. to control the quality of network. This is a significant achievement of this research paper.

2. Energy Saving Mechanism (E.S.M)

2.1 Hierarchical Structure

Main issue of H.S. is to decrease use up of energy in WSNs. The cluster structure helps this matter.

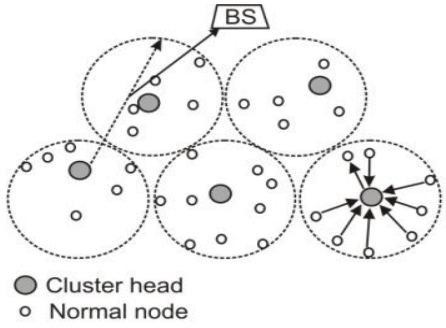

Fig. 1 : Clustering structure in WSNs.

In fig. (1), the network has been partition into clusters. Nodes are grouped into clusters having cluster head. The cluster head takes the responsibility of routing from cluster to B.S. During a process, periodical data is taken by N.N. The C.Hs. take from S.Ns. They send an aggregate data to the B.S. It is also possible that cluster heads may choose a multi hop path for communication. This path should be based on R.R. of C.Hs. and network major.

There is one demerit of cluster heads is because they consume more energy in comparison to none cluster head nodes. There is need of more loads for cluster heads to handle.

The network lifetimes and energy consumption are enhanced by LEACH. It is observed that LEACH is not measurable if the WSNs size is large. It is considered that node may have sufficient energy to transmit other sensor nodes. It is not a realistic phenomenon if WSNs are large in size. LEACH protocols improve the capability of C.H.D. Consumption of energy of WSNs is decreased & L.T. of the system is increased. The limitations of H.Ps. are mentioned below:

(i) It improves only the algorithm of C.F.
(ii) It provide total on average D.T.

Role of total data is very useful in WSNs and hence the reliability of data transmission should be considered as guarantee.

3. MAC Protocols

The main factors of energy wastage are as under:

1. Data collision
2. Overhear
3. Idle listening
4. Control packet overhead.

40% energy waste is due to idle listening in WSNs. The major part of the energy is saved due to turning of the radio if avoidable. The energy efficient MAC protocols control the energy wastage by following procedures:

1. Controlling radio step;
2. Arranging access schedule.

There are two types of MAC-layer protocols i.e.

1. S.B.Ps.
2. R.A.P.

In first type, the assessment of channel depends on the agenda of MAC-layer protocols. At a time, only one node of WSNs is accessed by schedule based MAC-protocols. The advantage of random access protocols is that they are flexible than S.B.Ps. It also avoids pre allocation of resources to nodes in WSNs. There

are collisions during the process of communications. The R.A.Ps. minimize happening of concussion.

T.D.M.A. is considered as a difficult schedule based MAC solution. At first, radio frequency is divided into time slots, and then each communicating node is allocated unique time slot to obtain schedule based MAC solution. TDMA is one of the media access control protocols used in shared media networks. In this protocol, several stations can share the same channel for transmitting data by dividing signals into number of time slots and allocating each time slot to one of the sending station. If any one of the stations connected to the channel fails to send data in its time slot then the slot gets wasted. In this way, bandwidth of the signal is not used efficiently.

In T.D.M.A., number of stations and time slot allotted to each station is fixed which makes T.D.M.A. less flexible and scalable in comparison to contention based methods/protocols like CSMA. Although stations do not have any coordination among them in both protocols TDMA and CSMA, in TDMA, if a station does not have anything to send in its time slot then that slot will never be utilized by any other station. This situation can be effectively handled by CSMA. CSMA is highly flexible because before sending data onto shared channel it first senses the channel and if it finds the channel free then only it sends data onto channel. S-MAC (Sensor MAC) reduces energy consumption caused by overhearing of channel idle listening and collision. In this protocol, every node can be in either of two states-sleeping states and active or listening state. These states come on regular intervals of time. S-MAC adopts periodic wake-up scheme and synchronization phase. In synchronization phase, listen period of every node gets synchronized by their neighbor nodes. But S-MAC results in low throughput and collision avoidance cannot be handled efficiently in content M.A.C.Ps. In LEACH protocol, TDMA and M.A.C.Ps. are applied on phases of its functioning.

4. Reliability Mechanisms

4.1 Multipath Routing Algorithm

Using M.R., fault liberality of node failure along the root increases & the reliability of WSNs are improved. The construction of node disjoint paths plays a role in design. Multipath routing algorithm provides a way to route data through various paths in order to ensure fault tolerance, increase bandwidth and have better security. It provides alternative paths when node failure occurs along single path and promises fault tolerance and so reliability of network increases. Enabling node disjoint alternative paths gives zero probability for the same failure node will be present on the alternative path. The idea of SPREAD algorithm is to divide whole message into multiple small parts and delivering these parts via node disjoint multiple paths. It deals with faults tolerance problems more effectively, because if node failure occurs on any of the paths then only a small portion of message is compromised, and since paths are node disjoint, it ensures that failure of node will have the impact on only one part of the message. For finding node disjoint multiple paths from every sensor node to the common sink node, H-SPREAD adopts N-to-1 multiple discovery algorithm. This algorithm consists of two phases. Phase one, branch aware coding, introduces the mechanism of finding node disjoint multiple path of each sensor node which is entirely dependent on the topology of the network. Phase two, multiple extension of coding, allows sensor nodes to share paths obtained in phase one to the nodes of other branches in order to get more paths at the cost overhead of more data interchange. The algorithm of branch-aware coding is shown in Fig.(2). The one H.Ns. of the BS is known B.N. If a neighbor with different BN value sends a message to a node then an alternative path may be considered. For example, the hexagon (ABCDEF) represents BNs.

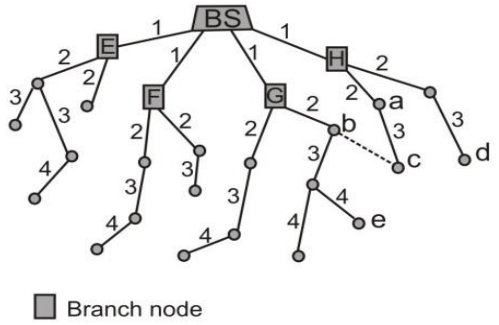

Fig. 2: B.F.A

A R.P. is considered that is similar to previously discussed protocol. Previously, store alternative paths are considered. In this paper, a F.P.D.A. has been utilized.

Nodes closer to B.S. and branch node transmit more packets and related participate during communication. Thus, more energy has been expanded by concerned nodes and consequently failure prone occurs due to loss of power. The conservation of power in nodes is an issue when they are exhausted and all paths to the B.S. are not active. To the best of our knowledge, there is no literature to avoid E.E.C. in neighbours of B.S. Hence, this problem has been considered in our proposed mechanism.

4.2 Fault Tolerant Mechanism for Clustering

C.P.E.Q. is one of the cluster based routing protocols. It considers the data reliability of communication within clusters. The data D.P. is multihop within C.Ns. The situation of cluster head failure is not in account during data transmission. A few literatures is available for C.Hs. CHs help in exchanging the S.M. after every cycle for detecting the miscarriage of CH. In case of detecting of miscarriage, the nodes having fault CH are allocated to nearer cluster for further circle at once. Throughout this process, CHs exchange a lot of observations which result more overhead. Furthermore, after assignment, it also creates node isolation case.

5. Mechanism for Node Classification

5.1 Network Model

This mechanism is applicable for a wide dense range in WSN. Two or more stations exist as the gateway between WSN and the exterior information of the system. All sensor nodes except base station have similar components which are mentioned below:

1. Initial energy
2. Sensing processing and communication capabilities

Nodes **can** change their radio range **based on** their **needs**. Communication between nodes is unidirectional and asymmetric. The residual energy of each **nodes**:

1.

Communication between normal **and** CH **nodes** is **a leap into** a cluster**.**

2. The communication for cluster heads to base station is multihop.

The advantages of this approach are mentioned below:

1. It is more suitable for the applications where sensed data is periodically collected.

2. Due to the demand of MAC protocol, synchronization is very important among sensor nodes.

5.2 Energy Efficient and Reliable Mechanism

This protocol consists of following three stages:

1. At first stage, each node retrieves the information regarding the neighbours and the network. This stage is called initialization phase.

2. The second phase is cluster formation phase. In this phase, clusters are formed in a distributed way.

3. The third phase is data propagation phase this final phase consists of two steps i.e. (a) the sensed data is transmitted among clusters. (b) The aggregated data is transmitted from cluster heads to base station. The hybrid MAC protocols have been utilized for different phases in our scheme. Figure (3) shows the entire WSN for different categories of sensor nodes.

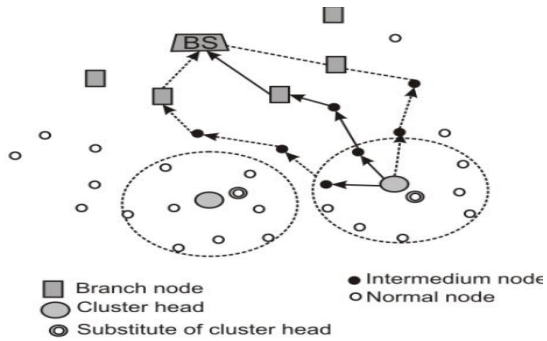

Figure 3: Node classification mechanism

5.2.1 Initial Broadcasting

This phase initiates with a request from the base station broadcasting .

The message is the following format:

{INI, RID, BID, SID, E_{re}, H_{count} (H_1, H_m), E_{to} , N, T_1 }

where

INI shows the type of message is initialization.

RID is the round identifier generated by the B.S., BID is the branch node identifier

SID is the sensor node identifier

E_{re} is the residual energy of the sensor node;

H_{count} is the hop count from the sensor to the B.S.

E_{to} is the total energy of all nodes and it is determined by base station

N is the sum of nodes after last stage;

T_1 illustrate timestamp for the ending of phase 1 and the starting of the further phase.

The node collects the broadcast text hop by hop. It rebroadcast the message after updating the information regarding message. The sensor node is regarded as parent who sends the first message. After this phase, every node takes decision in the following steps:

(i) To work as branch node

(ii) To store the parameters of whole energy Eto

(iii) The knowledge of the whole number of nodes n for the further phase

(iv) The construction of the table of neighborhood information

(v) To discover many paths in the data provocation phase.

This mechanism is very helpful to the broadcast nature of WSNs. Each node rebroadcasts only one time. The table 1 shows the neighbor information.

Table 1:

Neighbour ID	Is Parent	BID	Residual energy	Hop count	RSSI

In this phase, node stores following information;

(i) The neighbor node I.D., which may be parent node;

(ii) The branch I.D. of this neighbor;

(iii) Residual energy

(iv) Hop count of B.S. RSSI. It is proportional to the distance between them.

Here, branch aware flooding algorithm is applied. There are some chances of node failure and link conflicts that cause the loss of some message. The nodes may obtain network parameters by the help of their neighbors to construct approximate impress around the neighbors. During this case, all sensor nodes should be kept awake until the end of this phase. Suppose time T1 is required to complete the smooth functioning of WSNs.

5.2.2 Second Phase: Cluster Formation

After completion of first phase, total energy Eto is assigned to each node and sum of nodes N is observed. After time T1 phase 2 is to be started and then each node decides to be a cluster head in a manner of distribution.

If a node works as a cluster head, then using CSMA MAC protocol, it broadcasts the information which is to be advertised. This is a little message containing IDs of node and cluster as well as an ADV header. Nodes would decide the cluster head that requires the minimum communication energy. The basis of this is the received signal strength of the advertisement message from cluster heads. If each node decides its membership in a particular cluster head, then it transmits a JOIN-REQ (JOINT-request) message in reverse direction to the chosen cluster head applying CSMA MAC protocol. This message has the following components:

(i) ID of the node

(ii) ID of joining cluster heads

(iii) Residual power and

(iv) The hop count to base station of the node

The TDMA schedule is to be organized by the cluster head node and it broadcasts this schedule to the nodes in the cluster. At the same time CH selects a node as a SCH considering the following facts:

(i) The parameters of the residual power

(ii) Hop count

(iii) RSSI

SCH is informed in the same message as per TDMA schedule.

During this phase, the communication collision is avoided by utilizing CSMA MAC protocol . The branch nodes do not join any other cluster for the sake of conservation of energy. They become inactive in the complete phase where as another sensor node keep awake at the time of formation of cluster.

5.2.3 Third Phase Transmission of data

There are following two steps of this phase :

(i) **Spreading data in** a cluster**.** (ii) Data propagation from the CHs to the base station. This is a multihop transmission along multipaths.

First step : In the first step, nodes comply with the JDMA MAC protocol. The cluster head receives data from the nodes atmost once per frame. This is performed during allocated transmission slot. The cluster execute data aggregation to enhance the common signal after receiving all data from nodes. Due to this process it reduces the uncorrelated noises which cause the disturbances in the signals.

Second Step: Transmission of aggregate data from the HC to the BS is the second step in data transmission. The distance from B.S. This process is shown in the figure.(4)

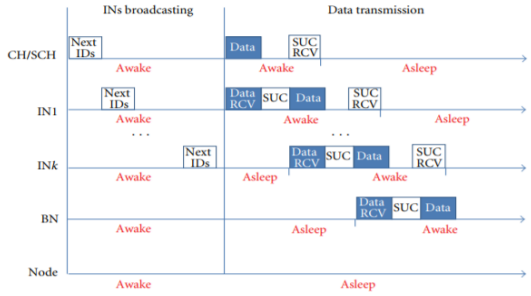

Figure 4: Timeline for each category during data propagation from CHs to BS

In this process, at first CHs (or SCHs) select suitable next hop nodes and hop nodes broadcast NEXT-IDs message as per information of neighbor table. This message includes:

(i) Next hop node's ID

(ii)Hop count from CH to BS along all further hop node.

The nodes after receiving next IDs message CHs or SCHs, mark themselves as INI to select their further hop nodes and then rebroadcast NEXT IDs message. NEXT IDs message again broadcast until branch nodes send the message. In this manner, sensor node in WSNs may be specific between non intermediate nodes and intermediate nodes.

Only CHs/SCHs, INs and BNs are to be awaked and they should take part in the data transmission from CHs to BS. For smooth transmission of data, other nodes convert into sleep until the procedure ends. The sender node waits for SUC information from the recipient after the end of energy data transmission. If the SUC information is received, the sender turns into the sleep until the end of the data transmission. In this process, the data transmission process is to be repeated. If the sender is not receiving the SUC information in a short period of interval then the sender resends the data to another next hop node. Also in last INs broadcasting process, each IN knows the actual hop count of the path on which it is residing. Thus, wating time T_{INi} can be obtained by

$$T_{IN_i} = k\sqrt{H_{path}^2 - H_{IN_i}^2}\ \triangle T$$

where H_{path}=total hop count of the paths

H_{INi}=hop count from IN_i to Bs

T= The approximate data transmission time between two nodes at one jump, which includes data transmission and reception time and SUC time transmission of messages and reception k=coefficient k greater than 1. The delay in transmission of data shall be recorded. During the TIN period, NIs do not assume the nominal value part until the end of T_{INi} . Using this flexible MAC protocol, all nodes are put into rest in their unnecessary time, so the consumption of the energy is decreased enough in this phase.

The path of data transmission from CHs to BS has several discontinuities. In other words, there are many disjoint paths . This is already explained in Fig.(3) as follows:

(i) The solid arrow path is called the primary path from CH to BS

(ii) The dashed arrow paths are alternative paths of the base paths.

Finally the base retrieves the following informations:

(i) Sensed data

(ii) Parameters of the networks i.e. the sum of the nodes N and the whole residual energy Eto

Hence, the B.S. initiates another round.

5.2.4 Node Classification

The sensor nodes are classiffied in following categories:

(i) BN

(ii) CH

(iii) SCH

(iv) Information Node

(v) Other nodes

6. Analysis of Performance

The performance of the proposed mechanism has been evaluated considering the following two factors, i.e.

(i) Power consumption

(ii) Reliability

In the first step, the energy dissipation quantity of each category in a cycle was observed and should be analyzed. After that, the energy saving must be analyzed following the next steps:

(i) Strategies for Branch Node Energy Conservation.

(ii) Flexibility of INs MAC protocol.

The proposed mechanism is to be compared with clustering based works on the basis of the performance of network lifetime. It is really a synthesis factor to evaluate the ability of the WSNs. In this context, different node failure rates are considered and the average ratio of the packet delivery is observed. This reflects the success rate of information transmission to the BS. The situations of the multipath routing algorithm with as well as without SCHs are to be compared. During this step, WSN reliability is to be measured for the success.

6.1 Experiment Setup

A series of experiments took place using the NS-2 simulator. The following are the values of the parameters used in the simulation:

Table 2: Simulation Parameters

Parameters	Value
Topology Size	1100m × 1100m
Number of Nodes	1100
Transmission range	75m
Sensing Range	50m
Initial Energy	5.55
Packet size	4100 bites
Location of BS	(700,180)
Bandwidth	1.2 mb/s
Electric Energy	55 NJ/bit
Free space ε_{fs}	10.5pl/bit/ m^2
multipath fading εmp	0.0015 pj/bit/m^4
Average data aggregation energy	5.5 NJ/bit/signal
Percentage of CHs(%)	4,5,6

In this experiment, the percentage of cluster head number is 4%, 5 % and 6 % respectively. The energy dissipation of different categories of nodes in one round has been evaluated. The reliability has been observed considering two types of strategies. Every result obtained is the average of 150-250 experiments. During this process, the confidence interval is 94 % in this simulation.

6.2 Energy Dissipation

The average energy dissipation is to be obtained for different categories of nodes in one round . A round has been divided into four phases which are already illustrated in fig.(5).

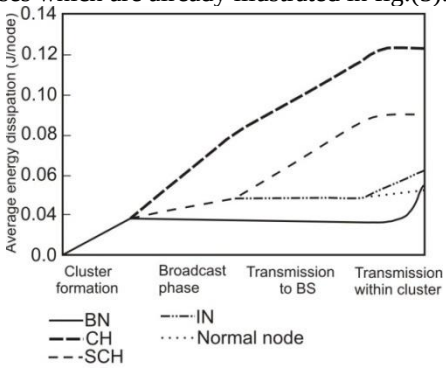

Figure 5: The energy dissipated average of each category in a round time

It is observed that the power dissipation for all kind of nodes is different in each phase. This happens due to the following factors:

(1) Specific network and MAC protocol in each phase of different category

The first phase is the primary broadcasting in a round. All sensor nodes despise. They broadcast and receive information's for collecting whole information of the network as well as neighbors. It is found that energy dissipation is equal for each categories of nodes.

The second phase is cluster formation phase. BNs are not taking part in any cluster formation activities for conserving energy. Due to more work load CHs consume more power than other nodes.

Third phase is the data delivery within the clusters. BNs are inactive and their roles are not changing from the second phase. TDMA MAC protocol is applied in this process. Sensed data has been transmitted by normal nodes in the slot of allocated time. Hence the average energy dissipation is very low of normal nodes. The energy consumptions of CHs and SCHs have been increased due to activities of CHs and SCHs in this phase.

The fourth ie. last phase is the transmission of data from CHs to SCHs .In this phase, a exible MAC protocol is used. Nodes are divided into parts:

(i) Ins

(ii) Normal nodes

The nodes (involved in data transmission) keep awake and remaining nodes do not take parts in transmission if they are not in Ins. During this phase, the following nodes

(i) CHs

(ii) SCHs

(iii) I_{ns}

(iv) B_{ns}

take part in their work time and then go to rest after their work and before the arrival of packets. BNs consumed maximum energy due to high work loads of neighbor nodes to BS for the transmission of data.

The influences of the factor concerned with energy dissipation are as under:

(i) It is observed that CHs consume more energy than other nodes in a round. This deficiency is to be solved by selecting CHs in rotation. This is also applied in the case of SCHs.

(ii) The time slot of each phase is not exactly same in a round. The period of data transmission is almost maximum in a round within cluster. In the experiment, the percentage of cluster head is 5% . The trend for their percentages is also same so there is no need of alternative experiments.

(iii) Bns conserve the energy by taking less participation in same phases. Hence the energy dissipation is reduced similar to normal nodes.

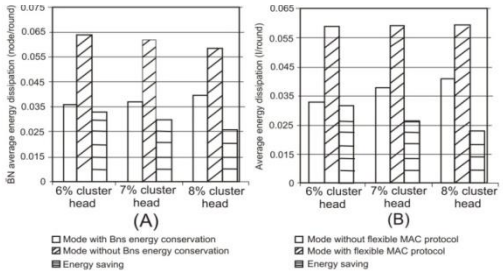

Figure 6: (A) Comparison of average power dissipation of BNs with/without BN energy conservation strategy. (B) Comparison of node average energy dissipation with/without flexible MAC protocol

In fig.(6(a)), it is found that the average energy dissipation of Bns is decreased approximately between 35%-55% if BN sleep strategy is used.

iv. In fig.(6(b)) the average energy consumption of sensor nodes is compared considering following two mechanisms:

i. Having flexible MAC protocol
ii. Without flexible MAC protocol

The role of flexible MAC protocol is to design strategy for power control for respective phase. The steps in phases of cluster formation and data transmission within cluster are given below:

(i) BNs turn off radio and then they are in sleep mode

(ii) In case of data transmission from CHs to BS, Ins as well as Bns take active part in assigned time.

Due to this strategy, the energy conservation is approximately between 28% to 40%. The amount of energy saving due to increase of CHs percentage. This happens because the number of paths from CHs to BS increases in multi hop data transmission and hence the number of joint Ins also increases.

The performance of energy saving in proposed protocol has been compared with the following protocols:

(i) Clustering based protocol
(ii) LEACH
(iii) HEED

The routing protocol from CHs to BSs of data transmission are different in each step of work. In LEACH, CHs communicate to the BS directly after the collection of data and aggregation.

In HEED, the Tiny OS beaconing approach, first spanning breadth root of tree is constructed at the BS. LEACH is not fit for the large scale WSNs because in case of increasing the distance, sensor nodes are unable to communicate with the BS directly. The HEED does not take in account the reliability and fault tolerance of data transmission.

6.3 Dependability of Data Transmission

The reliability of data transmission is one of the most important factors to be considered in WSNs. Any strategy to improve the reliability of data transmission requires more energy consumption, as there are extensive exchanges of message. The energy consumption is reduced by taking extra optimal CH selection algorithm as well as MAC protocol. Three protocols network lifetime are compared when the number of nodes are 550 and 1050. The comparison has been shown in figure (7). The finding of figure (7) is mentioned below:

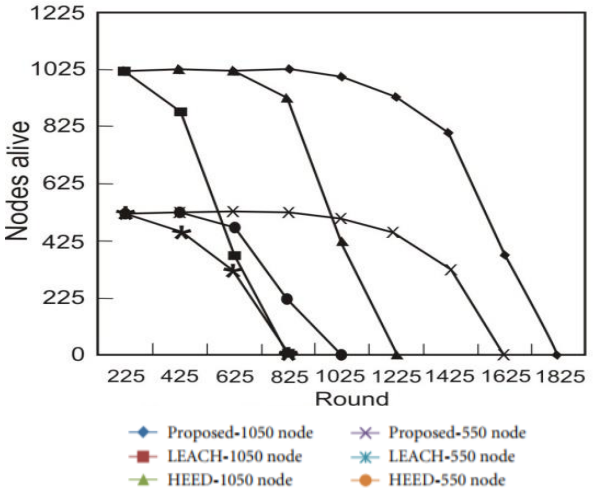

Figure 7: Comparison of network lifetime

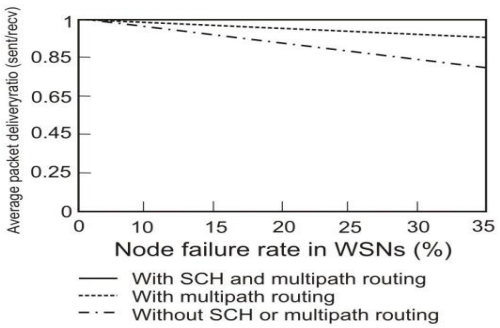

Figure 8: Comparison of average packet delivery ration

(i) By the help of proposed protocol, the lifetime extends about 5% than LEACH and 50% than HEED. This happens because LEACH selects randomly the cluster heads and the selection of cluster heads in HEED is depend on the residual power of nodes. In the proposed technique, the following parameter is considered:

(i) The residual energy
(ii) Density (number of neighbors)
(iii) The distance of BS (the depth to BS)

After the consideration of the above mentioned parameters, the final CHs are distributed in a proper manner across the network. The transformal MAC protocol improves the capability of saving of energy by following steps:

(i) Turning of nodes radio if they are inactive

(ii) The 50% of power wastes in WSNs occurs due to useless listening.

As per observations of Fig.(8), the average packet delivery ratio decreases if the node failure ratio in WSNs increases. The reliability is expressed as

$$\text{reliability} = \frac{\text{The total number of effective information received at the BS}}{\text{Total number of effective information initiated from all the sensing nodes}}$$

Hence the reliability is considered as the successful delivery of the message. In case of data aggregation direction, the number of delivered message is not considered only as the measure parameter. The number of effective information is taken as measure parameter in case of data reliability. Generally, data delivery has following two steps:

(i) The delivery of data within cluster
(ii) The delivery of data to the BS

The SCH strategy is responsible to look after the failure of data delivery within cluster. The multipath routing strategy is designed to increase the fault tolerance in case of data delivery from CH to BS.

There are two types of influences that impact the faults in WSNs:

(i)The node failure
(ii) The link failure

In this paper, the situation of node failure has been considered. SCH mechanism is an interesting part of this study. This is also a creative strategy which is evaluated seriously. The node failure happens instantly. It includes following situations:

(i) The failure of normal nodes
(ii) The failure of SCHs as well as CHs

The failure of CHs and SCHs may occur simultaneously in the same cluster. Thus our fault model is more effective for fault tolerance in WSNs. Several researchers [6,7,12,14] have already studied the effect of multipath routing protocols.

In figure (9), SCH and multipath routing mechanism have been compared The decrease of data delivery ratio as compared to the case of the mechanism without SCH or multipath routing algorithm is with so significant. The decreasing tendency of data delivery is improved by the following approaches:

(i) SCH approach

(ii) Multipath routing algorithm

7. Conclusion

1. Cluster based energy efficient mechanism has been proposed. This mechanism has improved the reliability of WSNs. It is responsible to integrate the importance of clustering HS as well as the tolerant system for the faults in WSNs.

2. Sensor nodes have been classified into five categories which are based on its functionalities. Special network, MAC protocol and the processing of operations in every category is remarkable.

3. Our proposed mechanism is helpful in providing maximal reliability, energy efficiency and scalability due to flexible strategy in the mechanism.

4. There may be some extra energy consumption due to effective strategies for fault tolerance and reliability. The performance of reliability is affected

by the strategies for energy efficient.

5. The flexible MAC protocol(used in proposed mechanism) decreases energy consumption. Due to power control algorithm, node cannot participate at proper time in the network.

6. The average package delivery ratio decreases if the node failure ratio in WSNs increases.

7. A critical issue is the trade of between energy efficient and reliability in WSNs.

8. The proposed mechanism should be evaluated in a real problem or environment as a future work.

References

1. A. A. Abbasi and M. Younis (2007), "A survey on clustering algorithms for wireless sensor networks," *Computer Communications*, vol. 30, no. 14-15, pp. 2826–2841.
2. Y. Challal, A. Ouadjaout, N. Lasla, M. Bagaa, and A. Hadjidj (2011), "Secure and efficient disjoint multipath construction for fault tolerant routing in wireless sensor networks," *Journal of Network and Computer Applications*, vol. 34, no. 4, pp. 1380–1397.
3. A. Boukerche, R.W. N. Pazzi, and R. B. Araujo(2006), "Fault-tolerant wireless sensor network routing protocols for the supervision of context-aware physical environments," *Journal of Parallel and Distributed Computing*, vol. 66, no. 4, pp. 586–599.
4. C. Karlof and D. Wagner(2003), "Secure routing in wireless sensor networks: attacks and countermeasures," *Ad Hoc Networks*, vol. 1, no. 2-3, pp. 293–315.
5. Y. Jing, X.Mai, X. Jinfu, X. Baoguo, and H. Lu(2009) ,"A cluster-based multipath delivery scheme for wireless sensor networks," in *Proceedings of the 2nd IEEE International Conference on Broadband Network and Multimedia Technology (IEEE ICBNMT'09)*, pp. 286–291, Beijing, China, October.
6. G. Gupta and M. Younis(2003), "Fault-tolerant clustering of wireless sensor networks," in *Proceedings of the IEEE Conference on Wireless Communications and Networking*, vol. 3, pp. 1579–1584.
7. F. Ingelrest, D. Simplot-Ryl, I. Stojmenovic(2004), Target transmission radius over LMST for energy-efficient broadcast protocol in ad hoc networks, in: Proceedings of IEEE International Conference on Communications, ICC'04, Paris.
8. J. N. AL-Karaki and A. E. Kamal(2004), **"**Routing Techniques in Wireless Sensor Networks: A Survey", IEEE Trans on Wireless Communications, vol. 11, no. 6, pp.6-28.
9. J. Lian, K. Naik, and G. Agnew(2006), "Data Capacity Improvement of Wireless Sensor Networks Using Non-Uniform Sensor Distribution," Int'l J. Distributed Sensor Networks, vol. 2, no. 2, pp. 121-145.
10. W. Lou and Y. Kwon(2006), "H-SPREAD: a hybridmultipath scheme for secure and reliable data collection in wireless sensor networks," *IEEE Transactions on Vehicular Technology*, vol. 55, no. 4, pp. 1320–1330.
11. Zeydin Pala, Kemal Bicakci, Mustafa Turk(2014) ,"Effects of node mobility on energy balancing in wireless networks", Elsevier, Computers and Electrical Engineering, pp. 1-11.
12. Abdul Waheed Khan, Abdul Hanan Abdullah, Mohammad Abdur Razzaque and Javed Iqbal bangash,(2014), "VGDRA : A virtual Grid based Dynamic Routes adjustment Scheme for Mobile Sink based Wireless Sensor Networks", IEEE Sensors Journal, Vol.0. No. 0, pp. 1-9.
13. V. Mhatre, C. Rosenberg(2004), Design guidelines for wireless sensor networks: communication, clustering and aggregation, Ad Hoc Networks vol.2 ,pp. 45–63.

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