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SLEEP SCHEDULING MECHANISM IN INTER-CLUSTER COMMUNICATION FOR WSN

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Abstract

Wireless Sensor Network is easy to configure and deployment of network is also simple. It is very useful in gathering the information. As sensor device are small in size and it is operated by the battery which once die is not rechargeable, so minimizing energy consumption and node death rate is challenging issues in WSN. Once node die it can't take part in information gathering which is not good for the overall system performance. Making cluster is a way to reduce the energy consumption in WSN by making cluster head which only communicate with base station and rest of the node communicate with cluster head, because distance is major factor for energy consumption in transmission of data. Wireless Sensor Network need more improvement and hence proposed intra and inter-cluster communication with sleep/active rate of node in WSN. Author establish a tradeoff between active node and energy consumption because if more node in sleep state then for achieving the target packet failure probability or error free communication all node take more energy take part in Sub-cluster head communication or more hop-distance communication with more energy. Result in terms of network life time, energy consumption, node decay rate and communication overhead shows that presented work performed well when compare with existing technique.

Keywords:

Inter-cluster, PFP, SCH, WSN

1. INTRODUCTION

In Wireless Sensor Network, a sensor nodes are consist of various types of hardware device which work continuously for detecting the environmental data. Sensor nodes are have their own processing power and it's contain multiple memory units for processing. Three types Sensor nodes tasks can be divided in to three categories first is to sense the local environment data, second is processing those data or performs some computation on sensed data, and at the last transmit those data to base station or neighbor nodes. Application of wireless sensor network in the field of robotics, industrial automation, monitoring of traffic, military camp etc. Sensor nodes powered by small battery which not rechargeable and sometime non removal, its deployment area is some time dangerous like tactical or battle field where for replacement of battery soldier can't go again and again. Improvement of network life time of WSN network is a challenging and interesting research areas for the researchers.

More energy consumption by the sensor nodes are due to always in active mode and keep sensing the environmental data it also cause the network overhead because each node try to transmit their sensed data to the base station which require lots of energy. To overcome from this problem clustering method is widely used in WSN environment [1]. Clustering techniques is very effective and scalable, in this approach nodes are grouped together and form a cluster and load can be balanced among them. In a cluster head is a node which is rich in energy and connection is more with other nodes. Leach is well known clustering approach in which cluster head selected randomly and cluster head itself generate their own cluster. In cluster members of the cluster gather data and send it to the cluster head, and cluster head send those data to the base station [2].

In [4], enhanced LEACH selection method of cluster head which is random is used and cluster head node is selected which has high energy and optimal number of selection of cluster head is done. Manzano et al. [12] proposed a new model for energy saving called LEACH-C, cluster head selection is done by base station and id of various cluster head's is broadcasted to the network. Base station keeps track the record of residual energy of all nodes and based on energy level, base station choose the network. In [5] [6] low energy consumption model is proposed which is based on cooperative transmission using LEACH hierarchy. In this approach cluster head received data from all the cluster member and transmit it to the sink or base station if distance is large between cluster head and base station in that case cooperative nodes are used by the cluster head to transmit data to base station. LEACH based multihop routing protocol is proposed in [7] for Wireless Sensor Network. In [7] cooperative Leach method is given in which for long distance communication cooperative nodes are used but in this scheme they are not considering the distance factor between cluster head and base station. Kim et al. [10] used the cooperative node communication and consider the distance factor between cluster head and base station and improved their result. Roa and Rani [14] proposed an energy aware sleep scheduling protocol, this work used the clustering techniques and sleep mode of node for conservation of energy, but here inter-cluster communication is not considered. Energy efficeinet clustering techniques for intrusion detection in Wireless sensor network is discussed in [15]. Xie and Wang [8] proposed energy-efficient protocol for intra-cluster communication by the use of TDMA algorithm but inter-cluster communication interference is missing. Wang et al. [9] discussed about two types of collision in inter-cluster communication one is primary interference and other is secondary interference. Primary interference occur when node try to transmit and received packet at the same time. When sensor nodes receive two or more packet at the same time secondary interference occurred. Energy conservation in WSN by sleep/active modes of sensor nodes is presented in [11] where nodes sleep or active conditions are scheduled based on demand on the network.

In [16] carried out extensive survey on optimization technique to preserve the lifetime of wireless sensor network. They showed that appling Meta-heuristic evolutionary computaing algorithm can aid in solving energy efficiency and lifetime issue of wireless sensor network. However the meta-heuristic algorithm suffers from local optima problems. As a result, it cannot be used under different network condition (i.e. for both high and low desnity network).

LEACH method is not suitable for the today's highly dense network environment due to unstable structure of selecting LEACH cluster head and path loss in large distance communication [3]. Once cluster is formed there are two types of communication can be happen intra-cluster communication and inter-cluster communication. In intra cluster communication sensor nodes can communicate within the cluster and member of cluster communicate with cluster head while in inter-cluster communication cluster head can communicate with other cluster head directly or through some intermediate nodes. Inter-cluster communication through the intermediate nodes is more energy efficient techniques in WSN because in this way cluster head can save their energy to avoid direct communication through base station if distance is more. Distance is an important factor for energy consumption more the distance more energy required for the communication between cluster head to cluster head or to the base station. For that reason communication through intermediate nodes or multi-hop communication is more useful for the energy conservation. Multihop communication is possible if number of sensor nodes is more than two or at least two.

Reduced overall energy utilization in WSN can be achieved by transmitting through intermediate nodes for communication. Intermediate nodes can be named as co-worker or co-cluster head. Loss of energy in WSN also observed due to the collisions of packet or packet failure at the time of transmission. In some cases nodes are ideal at that time energy is utilized in ideal listening which is wastes of energy. For saving the energy in WSN network one more concept added, i.e. sleep and active nodes strategy in periodic way. In way of rotation nodes can sleep and active in this way they can save energy because at the time of sleep nodes not communicating with any cluster member and cluster head and energy required for the communication is saved.

Here focus is given over the sleep strategy on sensor nodes for preserving energy. Comparison of overall energy consumption is done by the sleep vs non sleep scheme in inter or intra cluster communication in wireless sensor network. Overall all energy consumption, packet drop and efficiency of network achieved is better than exiting LEACH methods.

Rest of the paper organized as follows in section two proposed model of packet failure probability and sleep/active mode of sensor nodes and their affect is discussed. Section three contained the result obtained after simulation of the proposed work, and at the last conclusion is given.

2. RESEARCH METHOD

Here, wireless sensor network architecture is divided in to two parts, intra cluster and inter cluster network architecture which use sub cluster head for multi-hop communication. Let us assume that densely deployed sensor nodes in a network were network density is ρ. One cluster head CH is selected for the each cluster. So if number of cluster is N then N number of cluster head is required. Each cluster has cluster member and cluster head. Cluster member job is sensing the data of surrounding, processing and then transmit it to the CH. Custer head aggregate received data from cluster member do some processing then forwarded it to the next hop. Distance between cluster head and cluster member can be considered as $0 < d \leq D$, If distance between cluster head and sink is large energy consumed to transmit the data by the cluster head to the sink is more. To avoid this large distance communication sub-cluster head concept is used. Sub cluster head SCH is used for communicate multi-hop distance in intra-cluster communication or in inter-cluster communication. For CH to communicate with base station SCH is used and reduced the energy consumption. Here distance between two clusters is supposed to a (cluster head center to other cluster head).

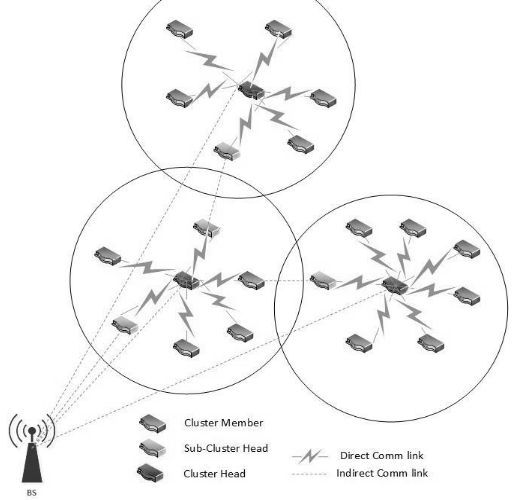

Fig.1. Network Architecture

2.1 ENERGY CONSUMPTION MODEL

In Wireless sensor network energy consumption model can be defined as intra-cluster energy consumption and inter-cluster energy consumption. At the time of broadcasting of message packet in intra or inter cluster communication probability of occurring error or message is not decoded properly. Packet failure probability (PFP) calculation and finding their solution is needed in the WSN. In intra-cluster communication where distance is less square-law path loss is applicable while in case of inter-cluster communication distance between two clusters is large and can be denoted as a (measured from center of two cluster). Length of packet is set as S and bit failure is denoted as PF^{b}_{intra} and PF^{b}_{intra} and packet failure probability can be given as PF^{p}_{intra} and PF^{p}_{inter} and average packet failure for intra and inter cluster can be given as $PF^{p}_{avgintra}$ and $PF^{p}_{avginter}$. Overall packet failure probability of SCH communication in both intra and inter cluster communication, when k is the number of nodes which decode the message packet correctly can be given as,

$$PF^{p}_{all} = \exp\left(\rho\pi D^2\left(1 - PF^{p}_{avgintra}\right)\right) \times \sum_{k=0}^{\infty}\left(\frac{\left(\rho\pi D^2 - \rho\pi D^2 PF^{p}_{avgintra}\right)^k}{k!} \times PF^{p}_{inter}\right) \quad (1)$$

Based on packet failure probability in intra-cluster and inter cluster message decoding over all energy consumption can be given as, consumption of energy per bit in case of intra-cluster broadcasting can be given as Eb_{intra} and for inter-cluster it can be given as Eb_{inter}

$$Ene_{all} = Ene_{intra} + Ene_{inter} \quad (2)$$

$$S\left(\left(1+\gamma\right)\left(Eb_{intra}+\rho\pi D^2\left(1-PF^p_{avgintra}\right)\right)Eb_{inter}\right) \\ +S\left(\left(\rho\pi D^2\left(1-PF^p_{avgintra}\right)+2\right)Ene_{ct}+\left(1+\rho\pi D^2\right)Ene_{cr}\right) \quad (3)$$

Ene_{ct} and Ene_{cr} denote the transmitter and receiver circuit energy, γ is the transmission efficiency.

2.2 ENHANCEMENT PROCESS FOR REDUCING THE ENERGY CONSUMPTION

Optimization of energy consumption based on parameter which is used in Eq.(2), in case of large sensor network in each cluster lots of sensor nodes are present which lead to generate more number of *SCH* which is helpful in inter-cluster communication. But another issues is that if all the nodes active all time in the network and participate in network activity like receiving broadcasted data packet from cluster and decoding it, which increased lots of energy consumption (mostly circuit energy) in the network. Keep all the nodes active always is not feasible for wireless sensor network where energy saving is very important.

Second scenario if considered as if some nodes keep in the sleep modes then it reduced the circuit energy consumption in the network. At the same time to achieve the *PFP* less, *SCH* require more energy to transmit data packet correctly in inter-cluster communication due to less number of active nodes in the network, which also increased the energy consumption in the network. So in that case the sensor network is organized based on sleep/active mode is used. If sensor nodes are in the sleep mode they not take part in the decoding of the message packet. Here, node active rate concept is used for sensor node sleep/active strategy. α is set as active rate of sensor node, so based on this new active node rate, and optimizing inter-cluster energy consumption a new optimize energy can be given below,

$$Ene_{Oall}=S\left(\left(1+\gamma\right)\left(Eb_{intra}+\alpha\rho\pi D^2\left(1-PF^p_{avgintra}\right)\right)Eb_{inter}\right) \\ +S\left(\left(\alpha\rho\pi D^2\left(1-PF^p_{avgintra}\right)+2\right)Ene_{ct}+\left(1+\alpha\rho\pi D^2\right)Ene_{cr}\right) \quad (4)$$

where, $0 < Ene_{inter} \leq Ene_{max}$, node active rate $0 < \alpha \leq 1$

$$PF^p_{all} \leq PF_t$$

PF_t is the target overall packet failure probability, revise PF^p_{all} considering active rate can be given as,

$$PF^p_{all}=\exp\left(\alpha\rho\pi D^2\left(PF^p_{avgintra}-1\right)\right)\times\sum_{k=0}^{\infty}\left(\frac{\left(\begin{array}{c}\alpha\rho\pi D^2 - \\ \alpha\rho\pi D^2 PF^p_{avgintra}\end{array}\right)^k}{k!} \times PF^p_{inter}\left(Ene_{inter},k\right)\right) \quad (5)$$

From the above equation value of active rate α is determined for given Ene_{inter}. Once optimal value of α is generate, random value between $\beta \in (0,1)$ is generated by the sensor node. If value of $\beta > \alpha$, in that case sensor node selected which can goes into sleep mode or turn their radio off. And rest of the sensor nodes equally distributed among the network for achieving overall *PFP*. If node active rate is low in that case less number of node in the network which can decode the message properly, and they required more energy to transmit that message to achieved overall *PFP*. When PF^p_{all} is low in that case for proper decoding and less error sensor network require more SCH and it leads to the high active rate of nodes and more energy consumption.

2.3 MINIMIZATION OF ENERGY CONSUMPTION

To achieve an optimal value of α and value of Ene_{inter} with respect to minimum Ene_{all}, and performaed search operation repeatedly for α under some value of Ene_{inter}. The upper bound of bit failure probability in inter-cluster communication is thus determined.

$$PF^b_{intra} \leq \binom{2k-1}{k}\left(\frac{N_0 a^2}{4GEne_{inter}}\right)^k \leq \left(\frac{N_0 a^2}{GEne_{inter}}\right)^k \quad (6)$$

where, N_0 Gaussian noise factor and G is the antenna gain. Upper bound of overall *PFP* can be denoted a PF^p_{Uall} . For Ene_{inter} value of α can be given as,

$$\alpha_0=\frac{\ln\left(\frac{4PF^p_{Uall}GEne_{inter}}{SN_0a^2}\right)}{\left(\frac{N_0 a}{GEne_{inter}}-1\right)\rho\pi D^2\left(1-PF^p_{avgintra}\right)} \quad (7)$$

$$PF^p_{Uall} \leq PF_t \quad (8)$$

In above equation put the optimal value of Ene^o_{inter} and get the optimal value of node active rate. When value of Ene_{inter} is low (SNR value is low), active node in the network is more which take part in *SCH* communication operation in the network, which leads to high circuit energy consumption which again leads to high energy consumption. There for optimal value of Ene_{inter} is set to be moderate (SNR value 15dB).

Number of sensor node or network density affect the value of α, if network size is small or value of ρ is small in that case node active rate is high or equal to 1 for achieving the overall *PFP* because maximum node take part in inter cluster communication SCH. If sensor network is large optimal value of α become smaller and overall value of PF^p_{all} also smaller.

Sensor node sleep mode strategy is beneficial to reduce the overall energy consumption, in highly dense area the sleep strategy make redundant node radio turn off and reduced the energy utilization. If D is smaller active rate of node is high because cluster size is small and more node take part to perform communication. If D become larger, cluster is big and more number of sensor nodes are their so value of α_o turn to smaller.

3. RESULTS AND ANALYSIS

Practical implementation done in the system which configuration is, windows 10 enterprises which is 64-bit operating system with 4GB of RAM. We have used sensoria simulator, it is very helpful and powerful simulator tool which allow user to simulate small and large scale Wireless Sensor Network with graphical user interface. It also gives user to design and generate different types of simulation scenario and user can display obtained result graphically [13]. Sensoria simulator is based on C# programming and used dot net framework 4.0 visual studio 2010. We have conducted simulation study on following parameter for network lifetime and packet transmission delay and compare it with existing one and we have varied node size by 450,650,1000. The Table.1 Network Parametrepresent the Network simulation parameters.

Table.1. Network Parameter

Network Parameter	Values
Size of network	35×35
Number of Sensor nodes	450,650,1000
Base station location	1m×1m
Length of Data packet	2000 bits
Initial energy of sensor nodes	0.1J
Radio energy dissipation	50nj/bit
Data packet delay	0.1ms
Idle energy consumption	50nj/bit
Amplification energy	100pj/bit/m2
Transmission speed	100bits/s
Bandwidth	5000bits/s
Active Rate	$0 < \alpha \leq 1$

In Fig.2 Network life time is given for 45,650 and 1000 sensor nodes for proposed and existing method. Lifetime analysis for 450 nodes is 332 second for existing and 420 second for the proposed method, lifetime measured for 650 nodes is 205 second for existing and 472 second for proposed system, lifetime analysis for 1000 nodes is 144 second for the existing method and 640 second for the proposed method.

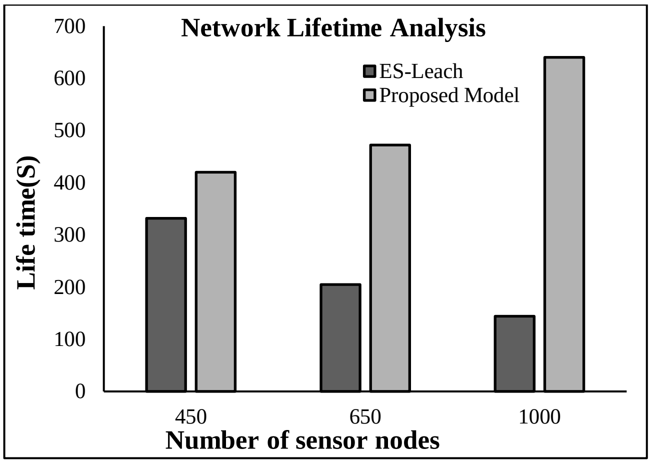

Fig.2. Network Lifetime

Active node rate or percentage depends upon value of α and number of sensor nodes in the network, and based on sleep/active concept more number of nodes alive or percentage of alive nodes are more as compared to existing system. Active node percentage 67.2% and 83.7% for existing and proposed work in case of 450 nodes. For 650 nodes active rate percentage is 66.53 for existing system and 83.33% for proposed system. Active percentage measured for 1000 node is 65.7% for existing system and 82.8% for proposed system.

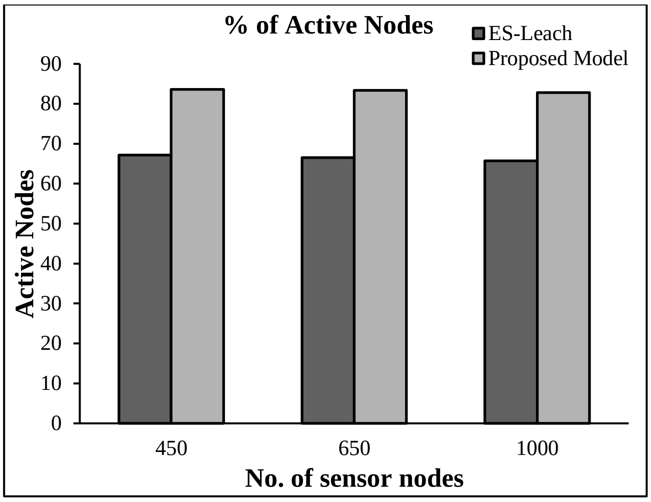

Fig.3. Percentage of Active Node

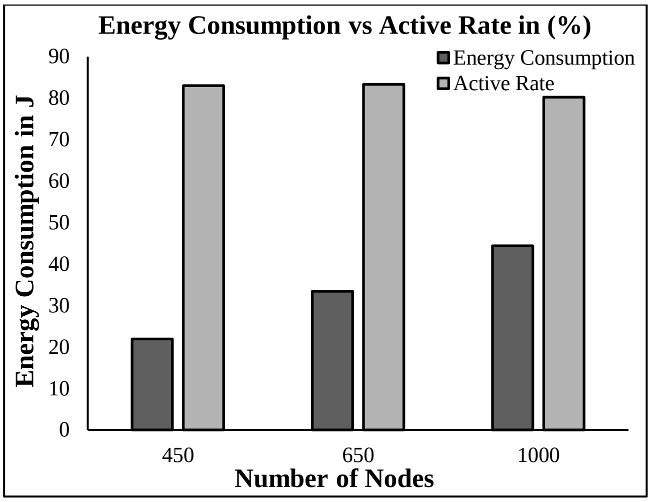

Fig.4. Energy vs Active Node

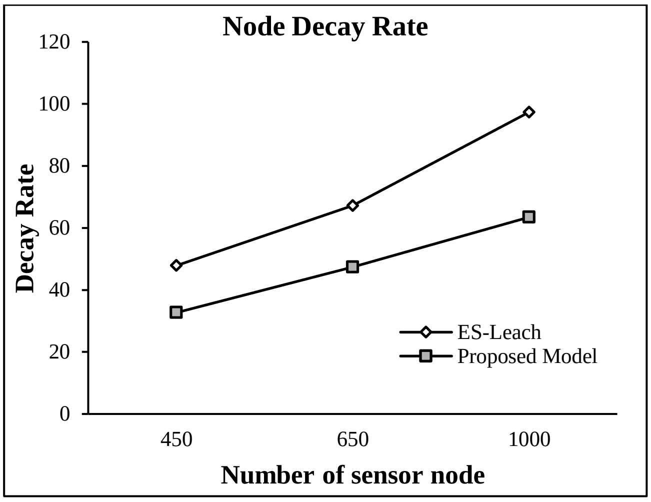

Fig.5. Nodes Decay Rate

Here in Fig.4 energy consumption vs. active rate of nodes is given which shows that as number of nodes is active rate of nodes behave as a constant more number of nodes alive in the network. Node decay rate in the network is given in above Fig.5 for proposed and existing system. Existing system node decay line is above the proposed system node decay line and proposed system line decay rate is not increasing rapidly. From sleep/active concept node die rate decreased for the proposed system and network life is longer than existing system.

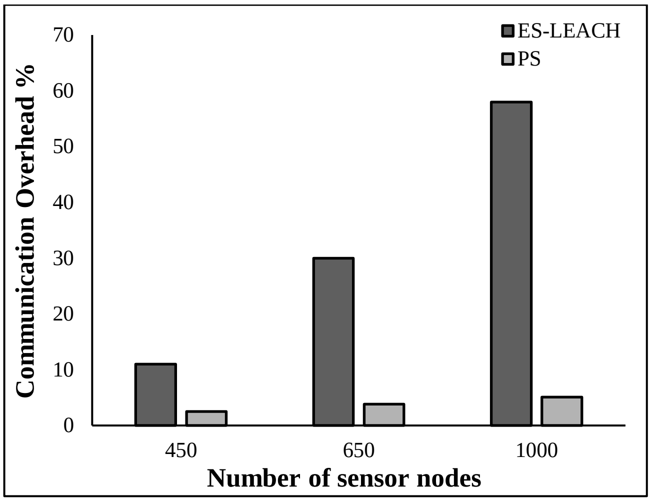

Fig.6. Communication Overhead

In above Fig.6 network communication head is given for the proposed and existing system. Communication overhead in the network is increases when all the nodes are decoding the message packet and take part in broadcast message receiving and again to transmit it. Our proposed work which is based on achieving packet failure probability and define active rate of node, in that case some nodes are in sleep mode which does not take part in network communication, and reduced the network overhead. Here for 450 nodes communication over head for existing system is measured as 11% and for proposed work measured percentage is 2.5%, for 650 nodes existing system communication overhead is 30% while for proposed system measured percentage is 3.8%,for 1000 nodes communication overhead measured for existing system is 58% while measure percentage for proposed system is 5.1%. So from above result we can assured that proposed sleep/active work in Wireless Sensor Network work excellent and reduced the communication overhead greatly.

4. CONCLUSION

Wireless sensor network is energy constraint, because sensor nodes are small in size and powered by battery. Once sensor nodes die, replacement of nodes are hurdle and it impact was not good on the overall system performance. This paper consideres two thing one is packet failure which reduced the system performance due to loss of message or transmission delay and other is energy consumption. Further, the packet failure probability and energy consumption is co-related. For reduced the energy consumption active rate of sensor nodes are generalized. Active rate of sensor nodes also impact the energy consumption and packet failure probability, for that a tradeoff establish and generate an optimal value of active rate of sensor nodes. If nodes are not used it turn their radio off and goes in sleep mode to save their energy. obtained result is terms of network life time, communication overhead, node decay rate, percentage of node active for proposed and existing system compared and obtained result shows that proposed work perform better than existing.

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