# NODE NON-UNIFORMITY FOR ENERGY EFFECTUAL COORDINATION IN WSN

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**Abstract:** The energy of the sensor node in the Wireless Sensor Network mainly causes the difference in the network lifetime. The throughput and network delay be influenced that how long system withstands i.e. consumption of energy. Network sustainability can be increased by introducing non-uniform nodes concerning energy as well as synchronize the local clock of individual nodes with the network's global clock. In this paper, we suggest a new algorithm called as Node Non-uniformity for Energy Effectual Synchronization Algorithm (NEESA). It works on the basis of spanning tree which based on the formation of cluster. In the first phase of the proposed algorithm, all the nodes are assembled into the cluster and create the hierarchy. All the nodes belong to the particular cluster as well as cluster head itself synchronized with global timing of the network. Additionally, clock skews possibly will cause inaccuracies which further are responsible for network delay and energy consumption. To minimalize the consumption of energy and network delay, NEESA uses MAC protocol which is TDMA based for time slot synchronization. The results display that step by step synchronization which is used in NEESA is energy effectual and has a reduced amount of delay as related to the advanced solutions.

**Keywords:** Network Delay, Synchronization, Energy, Nodes

## 1. INTRODUCTION

Time and clock synchronization are a significant service area for the cooperative and synchronized processes in Wireless Sensor Networks (WSNs). Time synchronization in the sensor network is generally exaggerated by small-cost clocks, node failures, and error sources for the period of communiqué, regular topological fluctuations as well as source restraint environment of the nodes. For example, network protocols like time division multiple access (TDMA) rigorously stresses synchronization between sensor nodes. Clocks which are not synchronized in the network with global timing generally take additional time to send the packet to the base station (BS) and therefore consume extra amount of energy. The sensor nodes which are used in the creation of the network are fright of energy and cannot withstand for a longer duration of time. Similarly, certain portion of node energy is used in the synchronization of events of the nodes. To enhance the network lifetime and resolve the problematic, certain fraction of the nodes with fluctuating energy is further added to the system.

The consumption of energy in synchronization algorithm is diminished by synchronizing the universal clock of the BS and the local clock of the sensor node [1, 2]. The events of the sensor nodes are planned based on the time frame and all the time slots are coordinated with the global or universal clock of the network. The unfeasible network situations and fright resources of WSNs make it crucial to improve time and clock coordinated algorithm that can withstand the network for long duration of time with reduced amount of energy consumption. The spanning hierarchy mechanism functions level by level decreasing the multi-hop communication confining the necessity of huge system bandwidth.

The inappropriate planning and synchronization of the data packets created from the lower level of the network to the higher level cause extra energy consumption. Moreover, retransmission delay is caused because of deviation in the clock skews and inappropriate slot distribution to transmit the gathered packets. The effectual technique to decrease the retransmission delay is planning MAC protocol to accomplish time slots of sensor nodes and cluster head (CH) through global timing scale. The data transmission from node to the BS can be in one step or multi step which totally depends on the profundity of the spanning hierarchy fashioned in inter and intra cluster communication. The data packet planning events of the sensor nodes are totally reliant on the accessibility of the channel, nevertheless, equivalent to the synchronization time [2].

The adjacent node will coordinate their schedules from time to time to avoid long duration clock drift. Timing-Sync Protocol for Sensor Networks (TPSN) [3], reflects the traditional methodology of two-mode message interchange among sender-receiver synchronization with a rise in sync inaccuracies and energy consumption. The traditional protocol is not energy effectual and it’s tough to implement for WSN. Due to the restrictions of energy source and processing capability, the present time synchronization mechanisms such as NTP, RBS and GPS may perhaps no longer assist WSNs fine and essential to be reformed or remodeled. This paper attentions on the totaling of controlled node heterogeneity to diminish the energy consumption with decreased delay. The sensor nodes used are non-uniform concerning energy which supports to rise network lifetime. The grouped planning forms the spanning hierarchy with non-ideal clocks. The regularity of each clock is presumed to fix. The step by step synchronization used in SPT advances the network performance compared to the organized algorithm.

## 2. RELATED WORK

This segment delivers the awareness how one can advance the QoS of the network by use of coordinating the clocks of the sensor nodes and BS.

In [2] Synchronized Data Aggregation algorithm studies the spanning hierarchy mechanism to advance the energy consumption as related with TPSN. It displays the reduced sync errors and energy consumption. [4] Describes a time synchronization protocol which is based on spanning hierarchy. A spanning hierarchy formed by sensor nodes is separated into several sub-trees [5]. The sub-tree synchronization method benefits to minimalize the synchronization errors by changing the clock time inside the level. In [6, 7] Clustered Time Synchronization algorithm and energy model is offered, that keeps the energy alongside accurateness despite the fact synchronizing the WSNs.

In [8] authors use the synchronization among two receivers by the intermediary sensor nodes within the listening range of the sender and receiver. The intermediary sensor nodes send the message for recording the time therefore saves energy in clock updates. The main drawback of this algorithm is that the energy is misused in coordinating the reference sender. In [9] authors Recommends the disseminated clustering data accumulation algorithm with reflection of mobile and non-uniform nodes into the clusters. The movement of sensor nodes regularly vagaries the arrangements and consequently ingests more energy.

In [10] Author considers the network with non-uniform nodes concerning energy with a movable sink. It displays enhancement in throughput and lifetime of network. Because of movement of sink control outflows are enlarged and ingests certain portion of node energy. In [11] authors Consider hybrid synchronization outline for WSN used to examine the sensations with smallest sync errors. Authors used the fractional counterpoise time synchronization of TPSN and clock regulation for reduced energy ingesting of K nodes. In [12] authors Suggests the hybrid outline to guarantee the sync accurateness with smallest energy. It considers incomplete outline to compute the time counterpoise of limited member nodes.

In [13] time synchronization of sensor nodes and network is done at the time of cluster creation. It decreases energy ingesting and comparative time drifts used in data gathering from the tree. In [14] authors Suggest the cycle-based sync planning in the delay-sensitive requests to accomplish small packet delay and high throughput in the communiqué of data packets from intra to inter-cluster communication. It reschedules the communication instruction by augmenting the cycle span. It has a constraint of overhead with enlarged network size and synchronization error.

In [15] Authors Suggests TDMA established slot division for transmitting the accumulated data packets from CH to BS with reduced energy consumption despite the fact the movement of sensor node. The TDMA planning demands the appropriate synchronization for reduced data packet collisions.

In [16] Authors minimized clock skew by coordinating the local clock of sensor nodes regarding universal clock of the network. The time and clock synchronization is the main concern in sensor network for enhancing network constraints. The clock drifts and disturbing global clock of the network with the logical clock of the sensor node outcomes in sync errors for the duration of synchronization. Congruently, slot division for collision-free data communication plays a significant role. This paper suggests the method of adding the non-uniform nodes with energy in the network as a result it can withstand for a long time and diminishes energy loss and error. The spanning hierarchy mechanism is used to transmission the data packets to BS step by step with collision-free slot sharing.

## 3. PROPOSED NETWORK MODEL

This paper put forward the cluster- based Time Synchronization for sensor network. It uses the spanning hierarchy mechanism for coordinating the slots along with clocks of the non-uniform nodes with the universal clock of the network. Clusters in the system are basically used to form the spanning hierarchy with ‘W’ set of CH linked with ‘H’ wireless links Y (W, H) as shown in Figure1.

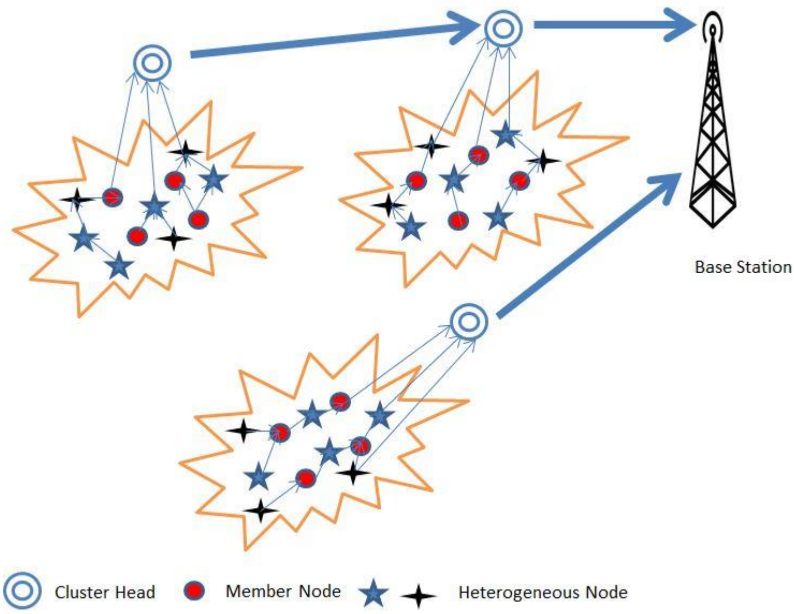


*Fig. 1. Network Model*

The network Y (W, H) is further separated into several sub-trees of clusters Y1, Y2, Y3,…, Yn. The BS is positioned at the origin of the hierarchy. The system has sub-tree of clusters with one CH and many sensor nodes inside the cluster. As well, a spanning hierarchy of all sensor nodes in the cluster is formed and thus splits into sub-levels. Every single sub-tree is a set of sensor nodes together with CH and numerous member nodes. The occurrence of every single clock is almost stable and keeps the time stamp that is coordinated with the universal clock of the system for the duration of synchronization. The main objective of planned node non-uniformity-responsive method is to diminish network delay and energy consumption. The formation of proposed algorithm progress as:

1. First Form the cluster hierarchy and implement step by step accumulation.
2. Coordinate the events of the sensor node to diminish energy consumption.
3. Plan the events of the sensor nodes according to permitted slots.
4. Diminish the inaccuracies because of clock skew therefore the network delay and energy consumption.

### 3.1. Spanning Hierarchy Creation

The key idea of coordinating the local clock of all sensor nodes inside the cluster with CH and then with BS is to decrease the energy consumption and sync errors. In the preliminary stage, all the unsystematically distributed sensor nodes are gathered into a number of clusters which is based on the clustering algorithm [7, 8] at time period‘t’. The re-selection of CH is not considered to diminish energy consumption in spreading the message. The CH is supposed to have level 0 and transmit the message; nodes receiving broadcast messages at single step are linked. The Kruskal algorithm is basically used to form the smallest spanning hierarchy of sensor nodes with the edge creating loop are rejected as revealed in Figure 2

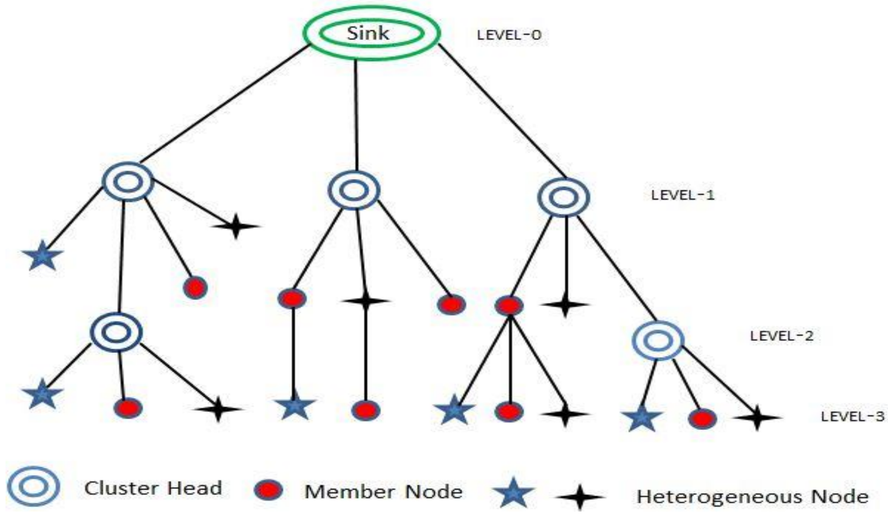


*Fig. 2. Proposed spanning hierarchy mechanism*

In second level, the spanning hierarchy of CH is formed with altered level and BS at origin with level 0. The CH straight connected to BS is at level 1 and left over CH and sensor nodes will preserve the advanced order conferring to the depth of spanning hierarchy. All the CHs which are at level1will synchronized with level 0.Similarly CHs at level 2 will be synchronized with level1 level2 and so on. The progression of synchronization carries on the similar way inside the cluster till entire sensor nodes in the network have been coordinated with BS. The sink node keeps global idea of time to coordinate the clocks of all sensor nodes in the creation of spanning hierarchy and communiqué of data packets. The error because of clock skew among global and local clock will happen for the duration of synchronization process. The level by level synchronization of child and parent node decreases clock drifts and overheads essential to keep the same time measure between all sensor nodes at one time.

### 3.2. Energy and Delay Analysis

The key idea of adding the non-uniform sensor nodes in the system is to withstand network for a long time with lowest energy consumption as well as network delay. NEESA basically uses energy model which is describe in [8], with outline of precise node non-uniformly. The complete initial energy of cluster is given by equation (1)

$$E_{Initial} = n(\alpha E_{Normal\ Nodes} + \beta E_{Advanced\ Nodes} + \gamma E_{Super\ Nodes}) \qquad (1)$$

where: $\alpha$ is the percentage of total number of normal nodes which having energy $E_{Normal\ Nodes}$ which is equal to 20 J.; $\beta$ is the percentage of total number of advanced nodes which having energy $E_{Advanced\ Nodes}$ which is equal to 30J.; $\gamma$ is the percentage of total number of super nodes which having energy $E_{Super\ Nodes}$ which is equal to 40J with identical number of sensor nodes in the network $\alpha$= $\beta$= $\gamma$=1/3; $n$= Total number of sensor nodes in cluster.

In WSN, the energy consumption is influenced by time required for communiqué of accumulated data packets, depth of spanning hierarchy and clock skews which cause errors.

Nodes to CH, CH to BS and the total number of packets transmitted by sensor nodes in the lower level to CH; the energy consumption is given by equation (2)

$$e(di) = k(e_t\, di\mu + e_0)t_{slots} \quad (2)$$

where: $\mu$ is the path loss exponent which be influenced by distance between node to CH and BS; K is the total number of packets; $e_t$ is the transmitter energy; $e_0$ is the initial energy.

The energy consumption based on the radio situations as transmitter ($E_{tx}$), receiver ($E_{rcv}$), listen ($E_{lst}$) and sleep ($E_{sleep}$) and clock skew '$e_s$' is considered based on the [15] is given by equation (3)

$$Energy\ Consumption = (E_{tx} + E_{rcv} + \mathrm{n} \times E_{lst})L \times t_{slot} \times e_s \quad (3)$$

where synchronization period 'T' is collected of successive time slots L. The total time is sensibly distributed into slots as $t_{slot}$ and these time slots are co-ordinated between nodes to avoid collision of data packets and clock skews. Also, time required to plan 'k' packets at CH is computed based on the total number of forwarding's as given by equation (4)

$$T_{ch} = \left(\frac{N}{K} - 1\right) t_{slot} \quad (4)$$

The total time required to send the gathered data packets to BS is given by equation (5)

$$T_{sink} = k.\, t_{slot} \quad (5)$$

Therefore, total time required for data packets to reach to BS is given by equation (6)

$$T = \left[\left(\frac{N}{K} - 1\right) + k\right] t_{slot} \quad (6)$$

All the events of every single sensor nodes are planned and coordinated in the time slot 1≤ $t_{slot}$ ≤ T

### 4. SIMULATION AND ANALYSIS

The simulation parameters and its value for randomly positioned non-uniform nodes are listed Table I. The cluster based spanning hierarchy functions level by level. The performance of proposed NEESA Algorithm is compared with different existing algorithm like TPSN, SDA, BESDA and MHS.

*Table 1: Simulation Parameters*

| Simulation Parameters | Value |
|---|---|
| Number of Nodes | 50,100,150,200 |
| Number of Sources | 49,99,149,199 |
| Number of Base Station | 1 |
| Initial Energy | 100 |
| Idle Power | 14.4mw |
| Receive Power | 14.4mw |
| Transmit Power | 40mw |
| Energy of Non-uniform node | 20J,30J,40J |

Figure 3 displays the graph of synchronization errors with spanning hierarchy mechanisms with TPSN. It is clearly seen from graph that performance is better in spanning hierarchy mechanism compared to the TPSN. The main reason for superior performance is step-by-step synchronization done by the suggested mechanism. CH subsequent to the BS will accept clock from the BS and nodes which is at lower level will accept it from corresponding CH. In TPSN mechanism, the global timing is applied through the network at single time, and every single node has to coordinate with global time, it presents clock drifts at different-different levels which further decreases performance.

Figure 4 displays the graph of average energy consumption of the entire existing algorithm as well as the proposed algorithm. It reflects that proposed algorithm NEESA has less energy consumption compared to the TPSN by almost 31.11%, BESDA by almost 17.23% and MHS by almost 36.11% but more than SDA. Average energy consumption in case of TPSN is larger than that of NEESA only because of TPSN efforts to use global timing through the network at every single time but NEESA apply the spanning hierarchy which mechanisms on a level by level. The gathered hierarchy planning does not require transmitting message for long distance therefore saves energy.

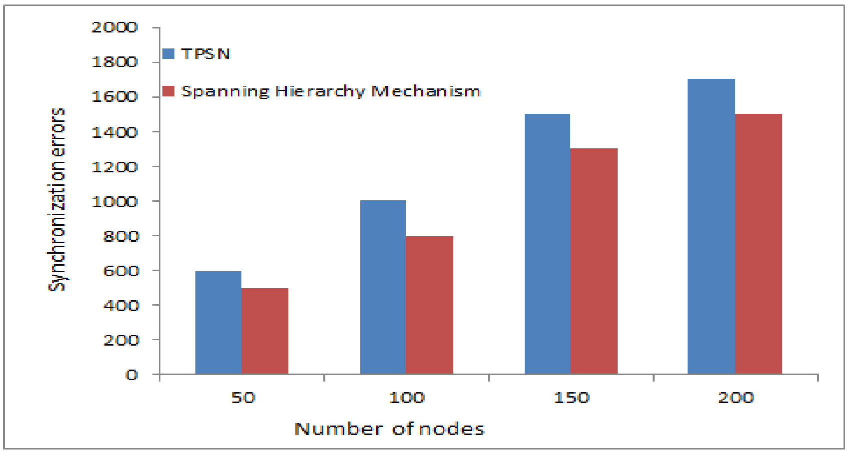


*Fig. 3. Synchronization errors*

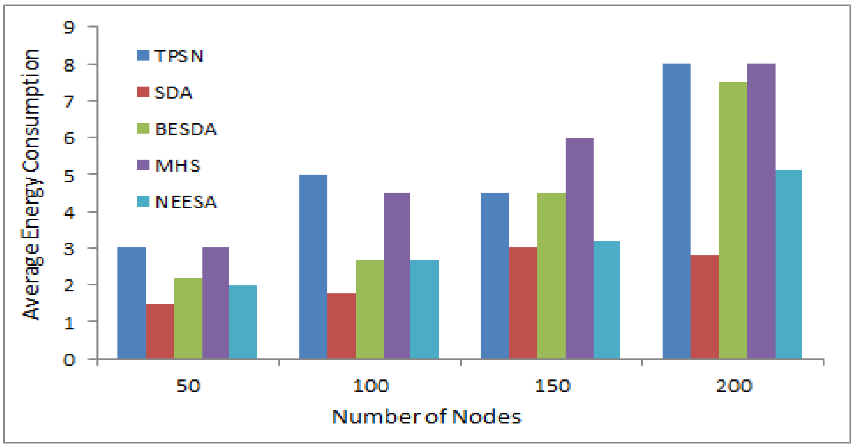


*Fig. 4. Average Energy Consumption*

Figure 5 displays a relationship of average throughput calculated at the BS. The average throughput of SDA is almost greater than 1.91%, MHS is almost greater than 3.11% and BESDA is almost 5.11% compared to the proposed NEESA algorithm.

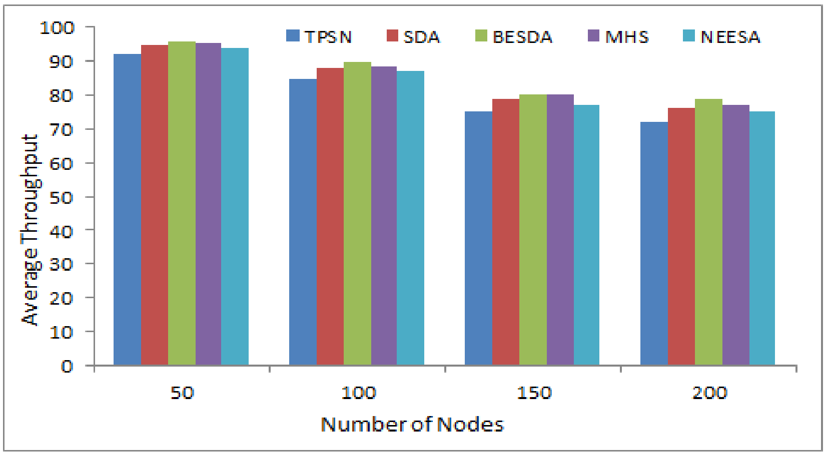


*Fig. 5. Average Throughput*

This is because of mobility of sensor nodes in the system rises probabilities of one stage neighbours to transfer the gathered data packet. By adding controlled non-uniformity, network remains effective although some sensor nodes die quickly. It displays enhancement in throughput of NEESA as related to the TPSN.

Figure 6 displays the delay in the network because of communication of data packets from sensor nodes to CH and further from CH to the BS. While introducing of controlled non-uniformity of nodes, an average delay in local and global clock is almost decreased by 6.75 %, 12.88% and 18.32% as related to SDA, BESDA and TPSN as network withstands for a longer duration of time. The higher drifts in time announced in TPSN takings a higher time to make a choice on plan as compared to NEESA. Furthermore, retransmission delay is happening because of clock skews happened because of mismatching in clocks. The overheads in the system are enlarged, that leads to enlarged delay and less throughput in TPSN.

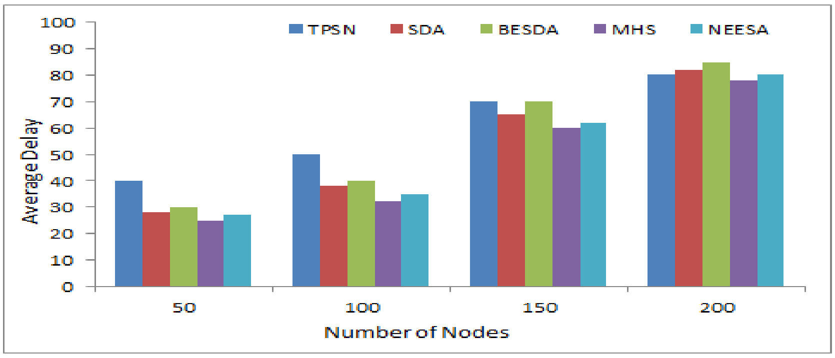


*Fig. 6. Average Delay*

## 5. CONCLUSION

The proposed NEESA algorithm with spanning hierarchy mechanism reflects development in amount of energy consumption as well as in delay compared to TPSN, MHS and BESDA. Extra addition of non-uniform sensor nodes in network along with synchronization of local and global clock supports to survive the network for a longer duration of time. The clock synchronization decreases drifting in clock and therefore errors that consequence in rise of throughput and decreases the delay. While introducing the controlled sensor node non-uniformity, performance of synchronized algorithm is almost enhanced by 4.2%. Moreover, pairwise synchronization diminishes the likelihood of retransmission of data packets and diminishes the delay. Form simulation results, paper reflect that MHS and BESDA are bandwidth effective however NEESA is energy effectual Algorithm. This work can be further stretched by assuming sink mobility in the system.

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