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Cluster Based Communication to Improve Network Lifetime of WSNs

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ABSTRACT:- *Wireless Sensor Networks (WSNs) possess two unique characteristics when compared to other traditional wireless communication systems: (1) limited power supply of sensor node (2) Redundant data that are related among other nodes in the network. The above two are associated with energy consumption. In this thesis, three layer frameworksare suggested for data collection. This framework includes 3 major specific layers called sensor, cluster head and mobile collector. Mobile collector layer is also called as SenCar layer. These three layers have their own importance in collecting the data. Hence this framework introduces a method called LBC-DDU. The major motive is-achieving increased lifetime of network, also to achieve high scalability and even very low latency for data gathering. Sensor layer, at this layer an algorithm called distributed load balanced clustering is used, where they organize themselves into clusters. After the sensors have self-organized themselves into clusters at sensor layer, at cluster head layer, transmission range for inter-cluster communication is chosen carefully so that there is guaranteed connectivity among the clusters. Lastly at SenCar layer, it is outfitted with multiple(say 2) 'antennas' that permits several cluster-head to forward the collected data from its cluster members to SenCar simultaneously using MIMO (multiple input Multiple output) technique. SenCar selects its polling point such that it is within transmission area (range) of multiple cluster-heads, hence collects the data from multiple cluster heads.*

Key Words*: *Cluster head, Wireless sensor networks (WSNs), Wireless Networks (WNs), Multi-user multi-input and multi-output (MU-MIMO), polling points, dual data uploading; load balanced clustering, data collection.

I.INTRODUCTION

WSN compromises of randomly deployed sensor nodes which monitors various environmental phenomena's, considering 'temperature', 'sound','vibration', 'pressure' etc. at various locations. WSN compromises of n number of mobile nodes which gets randomly deployed and they might have a fixed location to look after the environment.WSNs are the development considering past years and indulge in scattering sensornodes inthe network. Usually sensor within network observes all environment changes & informs other sensors within the network over system architecture. Node deployment takes in hostile environment or even over geographical areas.

Each sensor nodes in a network has a functional unit such as sensing, processing, communication and storage unit. In the network since sensor nodes are randomly deployed the position of sensors are not predetermined. The needs for the implementation for low-power consumption, low-cost utilization, and multifunctional sensors have made WSN an important data gathering mechanism. These multifunctional sensors in the network underwent a rapid growth as a new information gathering mechanism taking into account various different examples of applications. In many such applications, sensors in the network are randomlypositioned &dispersed entirely over thedetecting (sensing) area and are unattended once deployment, hence leading to battery replacement.

Four basic components to consider in WSN: (i) an interconnecting wireless network (ii) group of randomly distributed sensor nodes. (iii) Sink node (iv) a group of computing devices at base station which helps in analysing &interpreting the data obtained from other sensor nodes in a network.

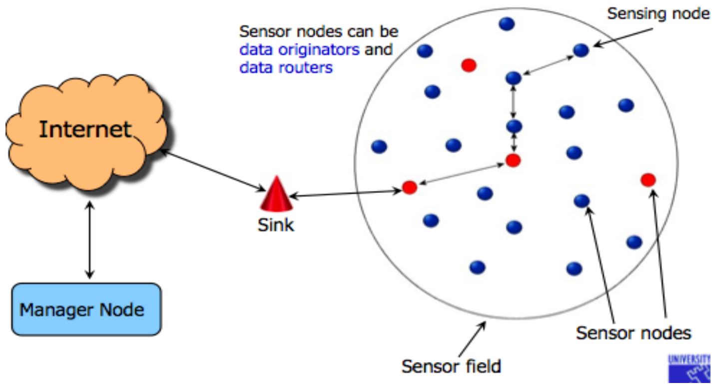

Figure 1.1: WSN components

As shown in figure 1.1, sensor nodes are outfitted with 'sensing unit', a wireless communication device (or radio transceiver), a micro controller &source of energy usually a battery. In network while relaying data from one sensor node to another, the sensor which is near to the sink node typically exhaust their energy much faster than other because of further relaying data traffic. Due to the depletion of energy by the sensors it may not guarantee the connectivity & coverage of network. Limiting to these, it is very tough to build (or design) an energy-efficient data collection scheme which aims in consuming uniform energy throughout the sensing area to accomplish extended lifetime of network. Some applications considers certain time specification for data gathering, hence effective, significant data gathering mechanism must be selected which aims at various network parameters such as high scalabi1ity, 1ong network 1ifetime and 1ow data 1atency.
Number of approaches exists for efficient data gathering and based on certain approaches they are categorized into three sections. Relay routing falls under first category wherein the data is relayed form one sensor node to another till it reaches the base station. Second category deals with organizing sensors into clusters& each cluster-head within the cluster takes the accountability of transmitting the collected data to base station. Clustering is useful for data gathering because it reduces the collision and balances the work load among sensor nodes. The last section describes about mobile collector which collects the data from various cluster-heads instead of relaying data form one node to another and also reduces the burden of data routing from sensors.
Although these approaches provide effective solutions even then certain inefficiencies has been noticed. Mainly in relay routing, forwarding the data gathered may not reach sink node due to failure of sensor node in the mid as some precarious nodes on forwarding route might exhaust energy more vigorously than other nodes. Whereas considering clustering scheme, cluster-head will typically utilizes more energy compared to other sensor nodes due to inert-cluster data transmitting. Based on these observations LBC-DDU is proposed. The major aim focuses on using clustering for scalability, also introducing mobi1ity for energy saving& uniform1yingesting energy and use MU-MIMO method which helps simultaneous data forwarding to reduce latency in the network. Since the mobile collector is used to forward the data to sink node, SenCar typically a mobile collector is outfitted with multiple (two) antennas such that it allows simultaneous uploading of data from two cluster-heads making use of MIMO concept. SenCar gathers data from cluster-head by stopping at each cluster. It decides its staying location in cluster such that it consumes less time for data collection from multiple cluster-heads. MIMO technique is used to reduce data transmission latency by allowing dual data uploading to SenCar.

II. LITERATURE SURVEY

The survey of the related work is done in similar way with the improvements in the area of routing schemes in WSN. The related work carried out is discussed in the literature survey which focuses mainly on improving the network lifetime by consuming minimum amount of energy and also achieving high scalability and low latency for data collection. Achieving these is possible using a MU-MIMO technique.

O.Gnanwali et al [1] proposed a paper on "Collection tree protocol" which describes the method proposed to examine the data path and it is divided in two ways. The first way is the data path approval and second is versatile beaconing.

According to the author there are two principles for wireless routing protocols. These principles include data path validation and quickly identifying data traffic and fixing the routing inconsistencies. There are certain goals to inspire the necessity for data path validation and 'adaptive beaconing' which are discussed below.
Reliability: When a route exists in the network a protocol must supply end-to-end packet transmission.
Robustness: It must yield enough capability to function without tuning else even configuring in network conditions, workloads & environmental conditions.
Efficiency: To transmit a packet from one end to other end in the network it should take minimum number of transmissions across the network.

B.Gedik et al [2] proposed a paper that provides one of the most efficient ways to collect the data in wireless sensor network by periodically extracting the raw sensor reading. However this includes examining the cost of power consumption. As per this literature survey, it consists of clustering, sampling and prediction. In this paper ASAP is developed and the main idea behind using it is that the vigorously altering subsets of nodes are used as samplers where sensor readings of the sampler node is directly collected. Whereas probabilistic models are predicted for reading for non-sampler nodes. ASAP is used to improve the network lifetime by keeping the data collection at high rate.

R.Shan et al [3] proposed a paper which examines architecture to gather the sensor data in sparse sensor networks. To provide low transport channel for sensor data mobiles entities called mules are utilized. In this paper, it concentrates on analytical model for knowing the performances parameters of the system.

The paper proposed by M.Zhao et.al [4] describes the traversal of a mobile collector in the network. It should traverse in such a way that it should be within the transmission range and packet transmission should take single hop distance. This approach leads to tremendous increase in data collection latency due to the consideration of squat moving speed of mobile collector in the network. It is observed that the latency occurred due to data collection can be condensed by carrying out local data aggregation via multihop transmissions and then forwarding the data gathered to mobile co11ector.

M.Zhao,M.Ma et.al [5] proposed a paper, which addresses the issue of efficient data gathering by assuming mobility andspace divisionmultiple accesstechnique. In this paper SenCars are meant as mobile collectors that collect data from nodes& forwards the gathered data to sink. Activity performed by SenCar yields to accomplish uniform energy consumption. And SDMA technique is utilized for data collection through outfitting SenCar by multiple (two) antennas where multiple sensors can upload the data to SenCar simultaneously. This paper mainly focuses on reducing the time taken for data collection among various areas and proposed few algorithms like region-division & tour planning algorithm wherein data collection time is balanced among various areas.

M.Ma et.al [6] proposed a paper where a new data collection scheme is established. A mobile collector, SenCar acts like mobile robot collecting data from multiple sensor nodes within network and transmits data collected to base station. Compared to SenCar, sensor nodes within the network are erect (or static) and can be made available in very simpler and inexpensive manner. The paper also talks about SenCar's moving path which greatly has the impact on network lifetime which adversely affects it. The author proposed an algorithm for planning the trajectory path of SenCar to collect data & balance the workload in the network. Network lifetime can be prolonged by implementing load balancing algorithm that discovers the turning points to gather data and clusters the network recursively.

III. IMPLEMENTATION MODULES

Implementation phase is a process of knowing a technical specification or an algorithm as a program & it is important phase as it provides the concluding solution at theend. This phase focuses on converting the design to feasible solution with the use of programming languages. In our project two programming languages are used. Also this phase gives detailed information about the coding language and the development platform used.

1 Topology module

Topology module can also be referred as network module. It describes about the functionality ofthe scripts used for building network topology.

The steps involved in this module are as follows:

- **Wireless Network topology setup:** This considers setting up of node configuration, topology creation and environmental settings.
- **OLSR Parameters setup:** This includes the parameters that are being used such as node functions, its range and channels assigned are defined.
- **Bandwidth and threshold setup:** always there will be certain bandwidth and threshold associated to each and every node in the network.
- **Finding the neighbour nodes:** Euclidian distance concept is used to know the neighbours of a particular node.
- **Stating source node, destination node and data:** The node from where data needs to be sent i.e. 'source' and the node which must receive data i.e. 'destination'. Data is nothing but the quantity of information sent in specific time period.
- **Stating simulation start and end time:** In NS2, whole transmission gets over in short period of time and it can be seen from NAM window at any instant of time period. Hence considering simulation it is mandatory to specify the start and end time.

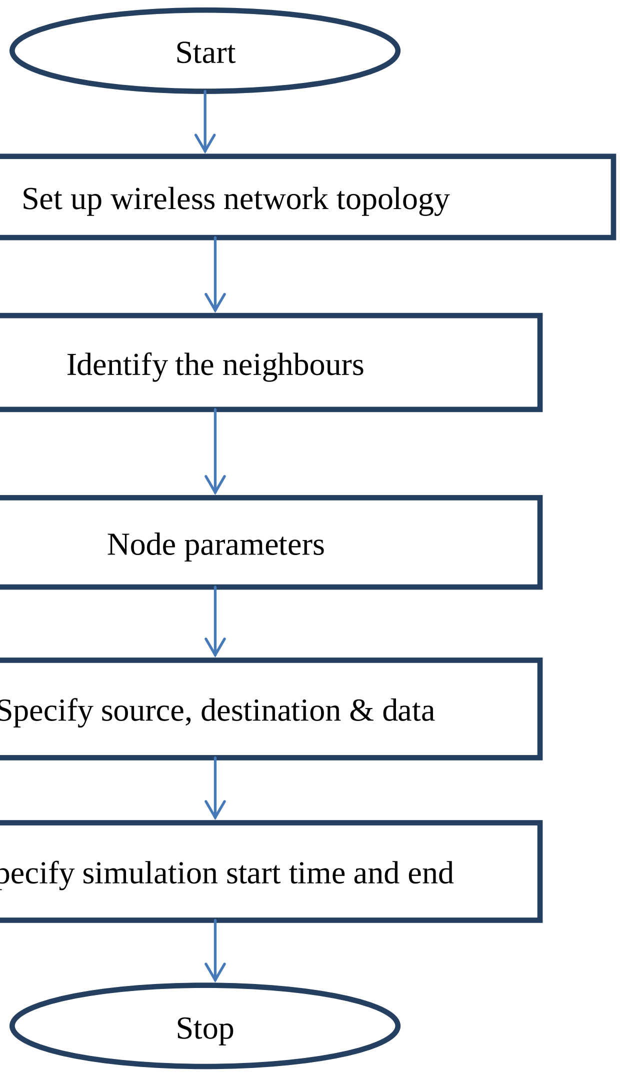

Figure 3.1: Flowchart of Network Topology

2 Energy module

Energy module is referred to as a node attribute when implemented. It specifies the level of energy a node has in the network. The node owns the initial energy value which is referred as the energy level the node has at the start of the simulation. This energy level is called initial energy. The node reaches certain energy level after transmitting and receiving the data, hence that energy level is referred as txPower and rxPower.

The energy model just maintains the total energy and not the radio states. The old energy model did maintain some of the radio states but they were utilized only by the adaptive fidelity module. This approach may cause inconsistency with wireless-phy. Now allthe access to energy modelshould gothrough wireless-phy.

In energy module- assigning the nodes initial energy, calculating the consumed energy and residual energy of individual nodes is carried out.
Residual energy is calculated by
RE = IE(initial energy)– CE(consumed energy)

3 Cluster Formation Module

To construct the topology a cluster-based architecture is utilised. Nodes in the network collaborate to form clusters and each has its cluster-head (CH) with some of its cluster members (CM) within the transmission range of CH.
In this model if a node notifies itself as CH then it broadcasts CH hello packet (CHP) to other nodes to identify its neighbours. The nodes that lie in the transmission range of CH, then it accepts the CHP packet to participate as cluster member in this cluster. Cluster members within the cluster are at a one hop distance from each other.CH and CM cooperate and keep in touch with each other by sending CHP and CMP in certain time period Tu.

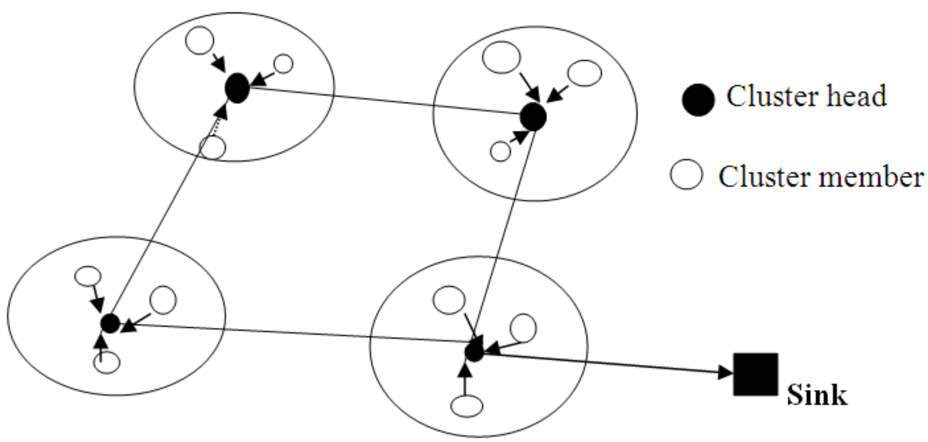

Figure 3.2: Clustering in WSN

Cluster-formation algorithm

This algorithm is used to partition the network nodes as per the hierarchical structure with the aim of decreasing the number of entries in the routing table.
Cluster formation algorithm partitions the entire area into multiples zones. Each cluster has a set of nodes as its cluster members. This algorithm is responsible for deploying the nodes in the network and divided into x and y regions. X region is bounded with certain limits with some xmin and xmax and y region with ymin and ymax.

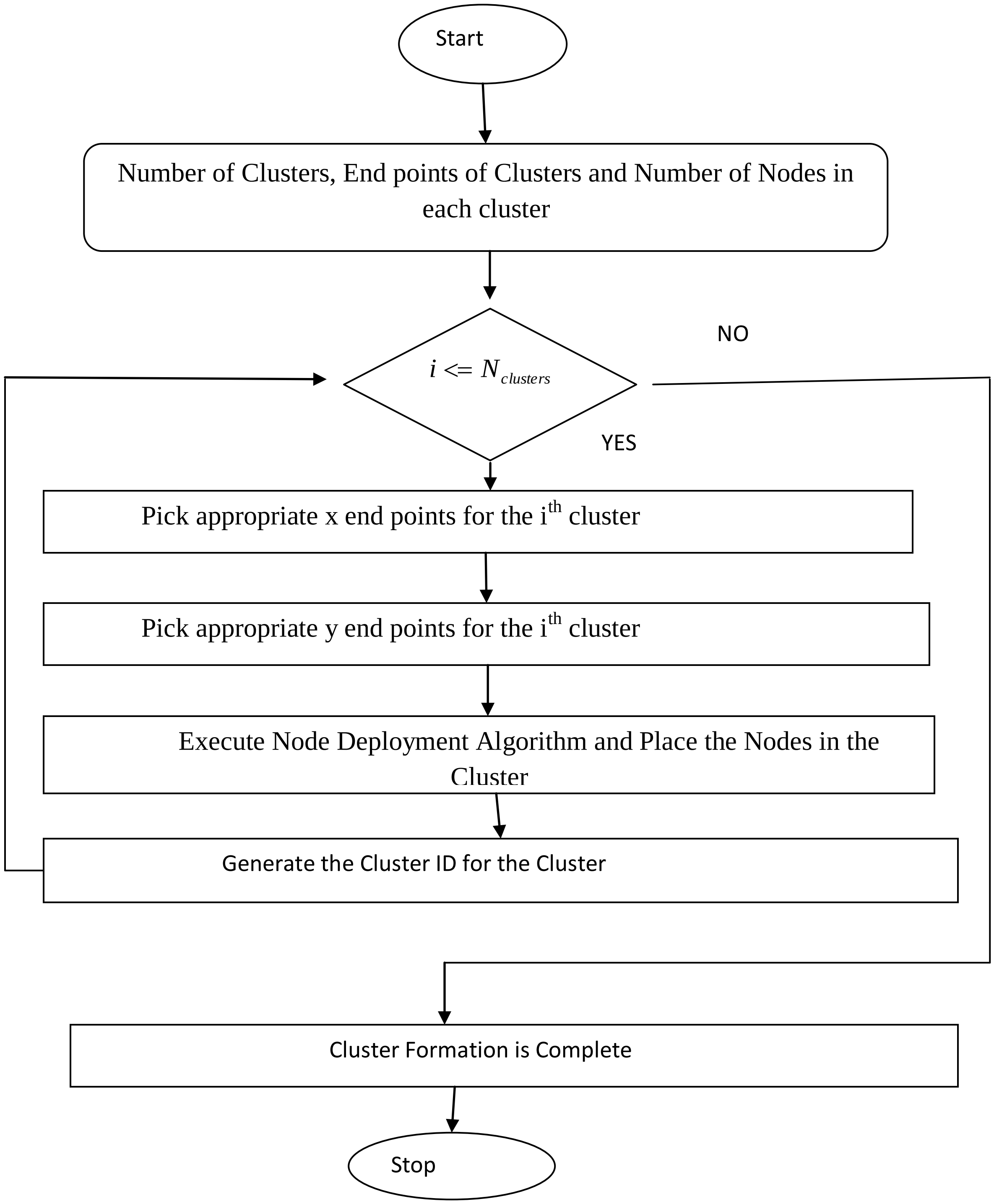

Figure 3.3: Cluster formation algorithm

The steps followed by cluster formation algorithm are as follows:

- Number of clusters,vertical and horizontal/end points for eachof the cluster in the network-acts as input.
- Until the clusters are formed for each of cluster formation steps 3,4 and 5 are repeated.
- Select suitable X and Y end points for cluster.
- Cluster ID for the cluster is generated.
- Execute Node deployment algorithm and" place the nodes within the cluster."

4 Error Module

Error model, where the packets are flagged to be error according to multiple probability distribution. The enhancement is carried out in error module by introducing noise in the channel.

The error module containing implementation and configuration, introduces packet loss into simulation. An error can be placed among any two NsObjects. In this module, noise in the form of error is being added.

If the packet is termed as error, then either the packet will get dropped or it is marked with an error flag. SINR is used for checking the interference level.

Code used for implementation of project

```
Phy/Wire1essPhy set CPThrsh_ 10.0
Phy/Wire1essPhy set RXThrsh_ 3.652e-10s
Phy/Wire1essPhy set bandwidth_ 2e6
Phy/Wire1essPhy set +Pt_ 0.88183815
Phy/Wire1essPhy set frq_ 914e+6
Phys/Wire1essPhy set CSThrsh_ 6.30957e-12          ;# -82 dBm
Phys/Wire1essPhy set noise_f1oor_ 7.96159e-14       ;# -101 dBm
Phys/Wire1essPhy set PrMonitrThrsh_ 2.653e-14   ;# -105.7 dBm (noise_floor_ / 3)
Phys/Wire1essPhy set HeadrDuratn_   0.000020       ;# 20 us
Phys/Wire1essPhy set BasicModu1ationScheme_ 0       ;# BPSK
Phys/Wire1essPhy set L_ 1.0                         ;# default
Phys/Wire1essPhy set Preamb1eCapturSwitch_ 1
Phys/Wire1essPhy set DatCaptreSwitch_ 0
Phys/Wire1essPhy set SINR_Preamb1eCaptre_ 3.1623;   ;# 5 dB
Phys/Wire1essPhy set SINR_DtaCaptre_ 10.0;         ;# 10 dB
Phys/Wire1essPhy set trac_dist_ 1e6                ;# trace until distance of 1 Mio. km ("infinty")
Phys/Wire1essPhy set PHY_DBG_ 0
```

5 Performance Analysis Module

In Performance analysis module, output result is processed to know the various performance metrics required to analyze and compute the network parameters. This module includes the following:

- "AWK scripts to compute various performance metrics."
- "To analyse the network performance the graphs are plotted for the performance metric."

Trace file keeps the record of all the computations (simulation) happening in the network. Knowing (or understanding) the trace file format is necessary for modeling the performance metric computation.

In this module, various performance measures have been considered as listed below in the table 3.1. The major focus is made on two of the parameters for improving the network lifetime of WSN. The two parameters include Throughput and Energy. The throughput and energy values are achieved as desired. Thus increasing the throughput and minimizing the energy consumed by the nodes, network lifetime of WSN is improved.

PARAMETERS	MIMO	ERROR (NOISE)	REMARKS
Throughput (kbps)	226	231	Increased
Energy (J)	19.8	19.2	Consumed less
End-to-End Delay (msec)	92.7	256	Increased
Overhead	14.16	15	Increased
Packet Delivery Ratio (%)	96	93	Reduced

Table 3.1: Results of Performance Parameters

The above table 3.1 shows the experimental values for various performance parameters. Among the listed parameters, two parameters are considered- throughput and energy. When compared with MIMO, on introducing the noise factor the throughput increases and the energy consumption will be reduced. This shows the efficient data gathering hence improving the network lifetime.

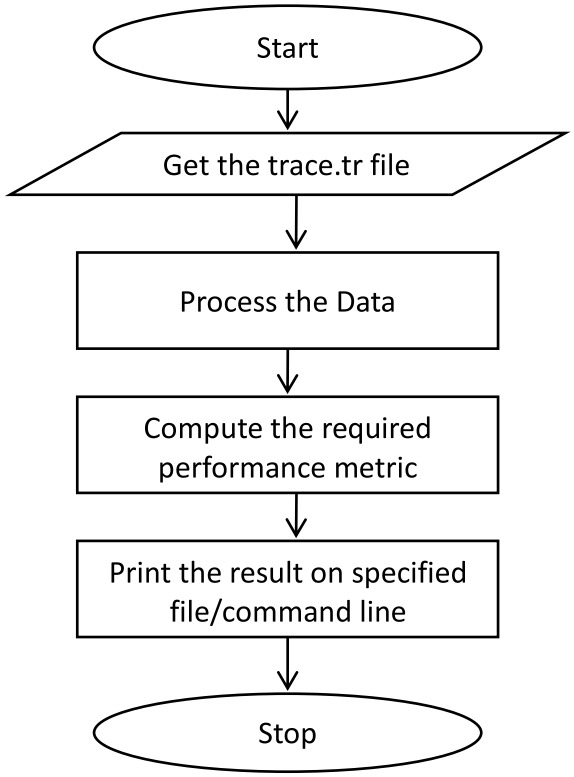

Figure: 3.4: Flow chart for performance analysis module

IV SNAPSHOTS

4.1 Node Creation

The below figure 4.1 presents the simulation of 51 nodes which are randomly deployed every time, when it is simulated.

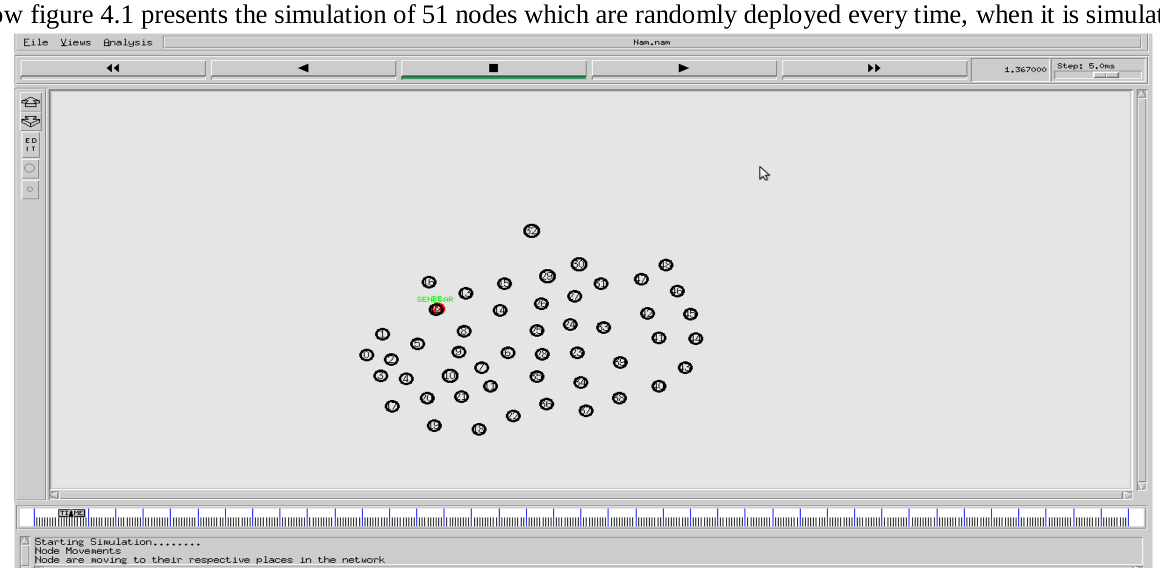

Figure 4.1: Creation of Nodes

4.2 Formation of Cluster

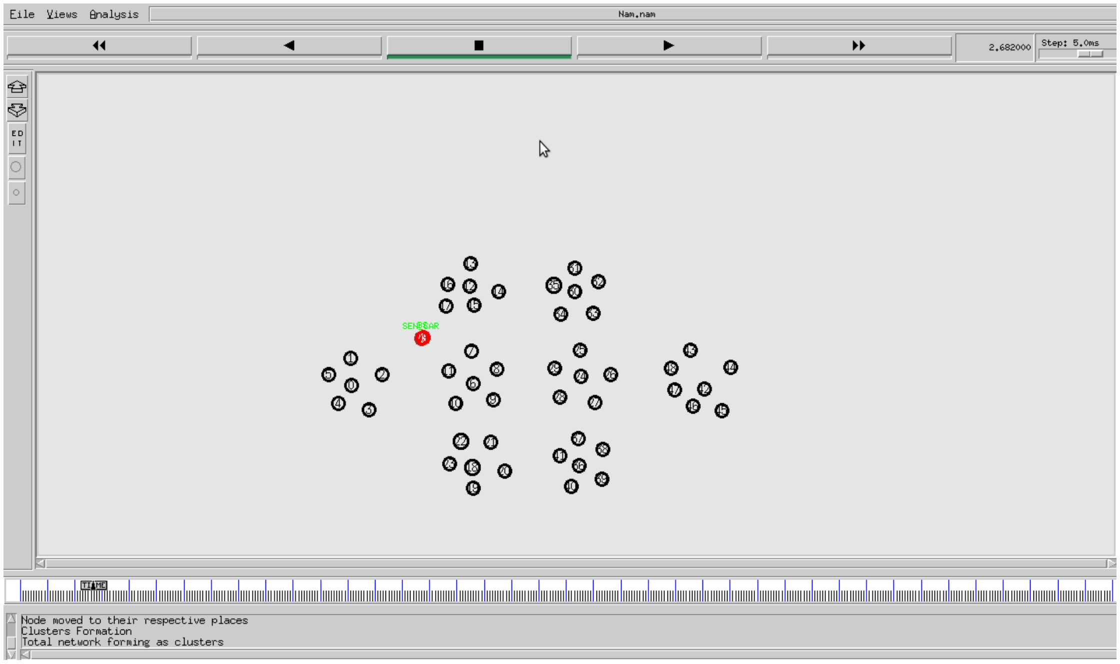

Figure 4.2: Cluster Formation

The above figure 4.2 exhibits the nodes mobility, the nodes form into clusters. Within the cluster, the nodes are at one hop distance. Nodes mobility ensures that there is a change in position of nodes with concern to specific time slot.

4.3 Communication Channels

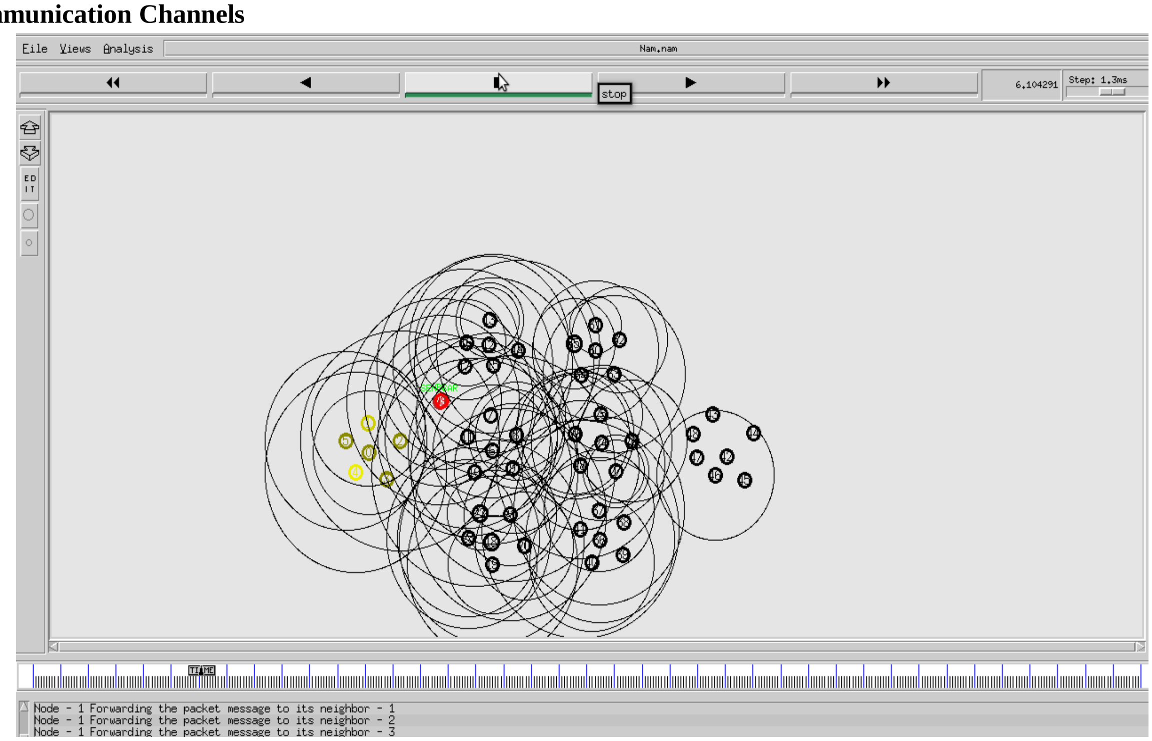

Figure 4.3: Communication channels

The above figure 4.3 depicts about the communication channels that each nodes broadcasts. Each node in the network broadcasts its transmission range i.e. by sending beacon messages. The neighboring nodes are the one which are within its communication range.

4.4 Cluster-head Formation

The figure 4.4 shows the formation of cluster-head within each cluster. The cluster member with highest residual energy is elected as the cluster-head. Cluster-head handles the transferring of data to sink via SenCar.

Each cluster contains multiple cluster-heads. In below figure, nodes with purple color are the two cluster-heads within each cluster. Multiple cluster-heads manages work load within each cluster.

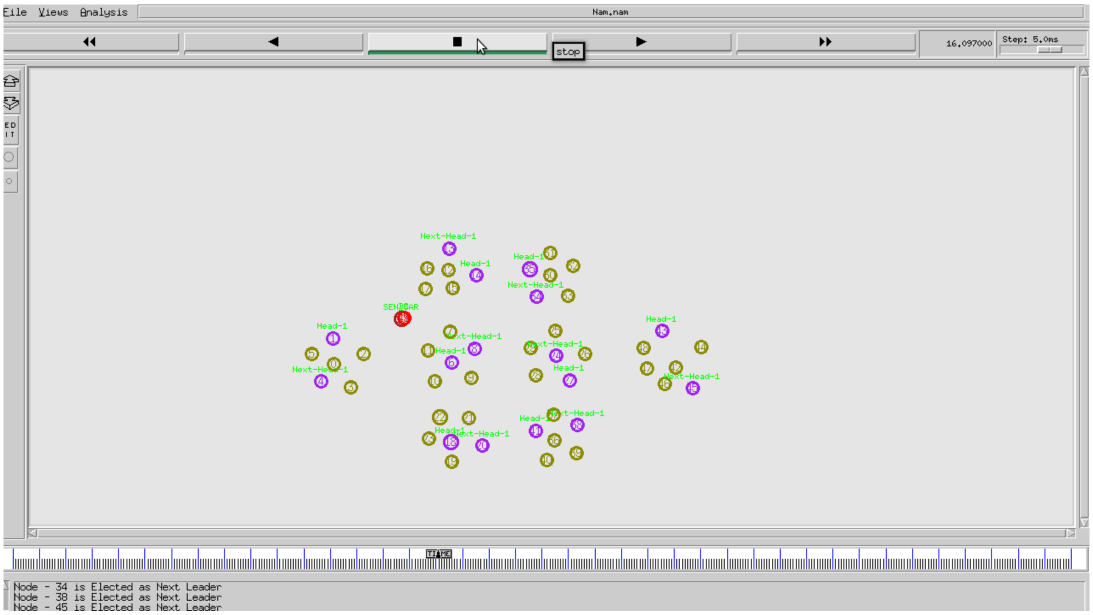

Figure 4.4: Cluster-head Formation

4.5 SenCar Movement

The below figure 4.5 depicts the movement of SenCar which a mobile collector in network. SenCar moves throughout in the network selecting one stop location where it stops forcollecting the data from cluster-heads simultaneously from multiple clusters. The SenCar movement is shown in the below figure.

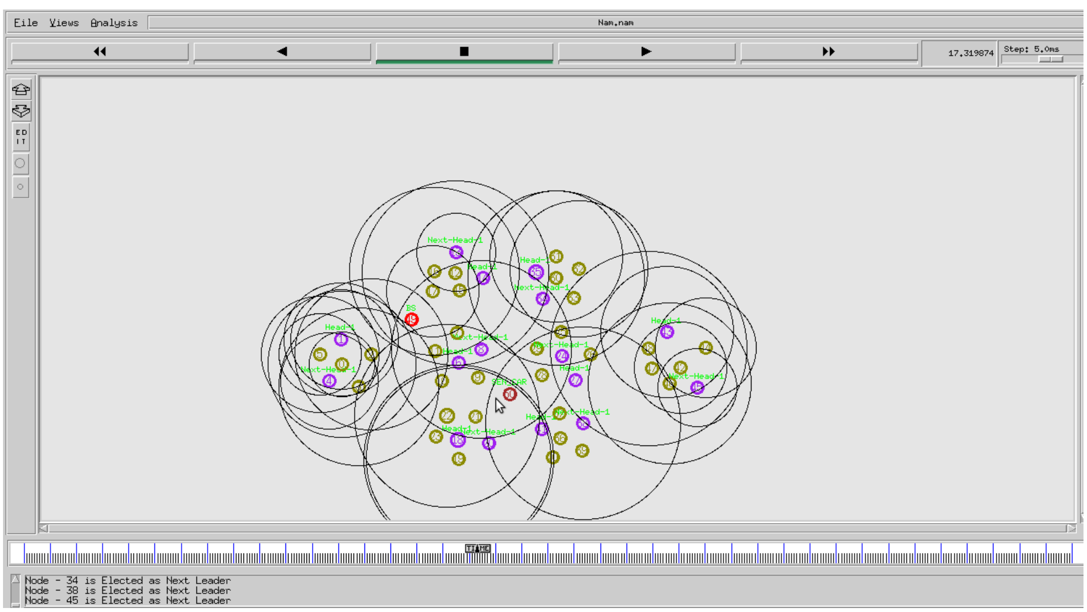

Figure 4.5: SenCar Movement

V Conclusion

To overcome the problems of existing system, three-layer framework has been proposed as a solution. This three-layer framework introduces a distributed algorithm known as LBC-DDU. The results show that after introducing the noise in the transmitting channels in the work and rectifying it we achieve high throughput of 231 kbps compared to mimo which achieved 226 kbps. Also results show that energy consumption is less which is of 19.3 J hence increasing the lifetime when compared to mimo which consumed 19.8 J.

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