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# *Early Warning System deploying wireless sensor network for flood management*

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***Abstract: In Indian scenario flooding from rivers or the sea is a natural hazard that has a major impact on people and environment. The definition of flood management involves a suit of management plan which fall into three categories of prevention, protection and preparedness and also address's the cause, the effect of flooding and a long term solution. The work encapsulates on the deploying of wireless sensor network (WSN) in flood management and creates an early warning system (EWS) for the Government (Flood management administration) to express early about occurring flood in a specified area. To develop an early warning system a river in West Bengal has been considered in the present work. Several clusters of wireless sensor having measuring capacity of different parameter causing flood are formed. These clusters will receive flood causing parameters and convert them into normalized data which create an analogy to the probability of occurrence of flood. This normalized data is ultimately transmitted to central monitoring station (CMS). CMS will generate early warning alarm to the neighborhood stations to minimize damage, loss of lives and properties. In this work leach method is used to form clusterhead and entire simulation of network was done by Qualnet Simulator.***

***Keyword- WSN; Qualnet; ANN; leach; EWS***

## I. INTRODUCTION:

The topic comes for an intense action which is taken against flood. In India every year lots of lives and damages is occurred every year due to flood. So we first crate a wireless sensor network and we create an early waning system in this network. The solution is done by three consecutive ways. First we select a flood prone area in river side and then keep some sensors along the river bed. We group them into several clusters and select their clusterhead by a standardize method. Second after selecting the clusterhead a network is created using well-known software called Qualnet. In Qualnet a source node is necessary to deploy the whole network and from this source node packet is delivered to the destination. The clusterhead node is selected here as a source node. The third part is creation of an alarming system. This is done by neural network. Here we select a large number of flood parameters and then by this parameter we select four output levels as a condition of flood-no flood, alarming, low flood and high flood condition. The entire topic will be discussed in following section elaborately.

## II. DESIGN OF WIRELESS SENSOR NETWORK:

We choose a flood effected area at Damodar river basin and then we create a network using wireless sensor network. The network is deployed by software called Qualnet which is discussed in the next chapter. Here we are discussing about design and method of deployment. A large number of sensor nodes are taken. The area is selected shown in the figure. They are allocated through the whole area along river bed. Sensors are grouped in separate clusters. In each cluster a node communicates with all other nodes in the same cluster which is called clusterhead and all clusterheads are communicate with each other and finally with a control central and tell about the possibility of flood in this area early.

We choose a flood –prone area on the Damodar river basin from Google map. Then selects some wireless sensors and place them into river bed. These sensors are used for gathering the information about flood parameters, such as weather report or rainfall etc. They are grouped into several clusters. Each cluster consists of six nodes. Each node senses a flood parameter. A short design idea is given here. Suppose node A, B, C, D, E, F are selected for one cluster. Node A senses water velocity, node B senses water level, node C senses moisture, node D senses wind velocity, node E senses rainfall and node F senses atmospheric pressure. All nodes select a cluster head among them according to their optimal distance.

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| Parameter | Value |
|---|---|
| Max message size | 36 bytes |
| Duty cycle | 100% |
| Sensor height from ground | 3m |
| Distance between sensors | 300m |
| RF output power | 50mW-5W |
| Internal modulation | 2 level FSK via internal modem |
| Maximum deviation | +/-7.5 kHz |
| Adj. channel power | >65dB at 12.5 kHz |
| Rise time | <9ms |
| Radio baud rate | 150-9600 bps over air |
| RF Bandwidth | 12.5 kHz |
| Radio data ratio | 36 bytes |

**Table1: WSN radio specification**

The distance from A to B is 300 meters, B to C is 250 meters, C to D is 400 meters, D to F and C to F is 350 meters, D to E is 500 meters, A to E is 300 meters, A to F and E to F is 330 meters. All the nodes are connected wirelessly. The data senses by the node are sent to clusterhead of each cluster. Then they are transferred to the control base station via BTS. For this reason several numbers of BTS is placed near sensors. These antennas work as a repeater to the control base station. The nodes are communicated with the near BTS via wireless access mode; but BTSs are connected each other and to the control station via wire network. In figure, we have shown one cluster by a red circle

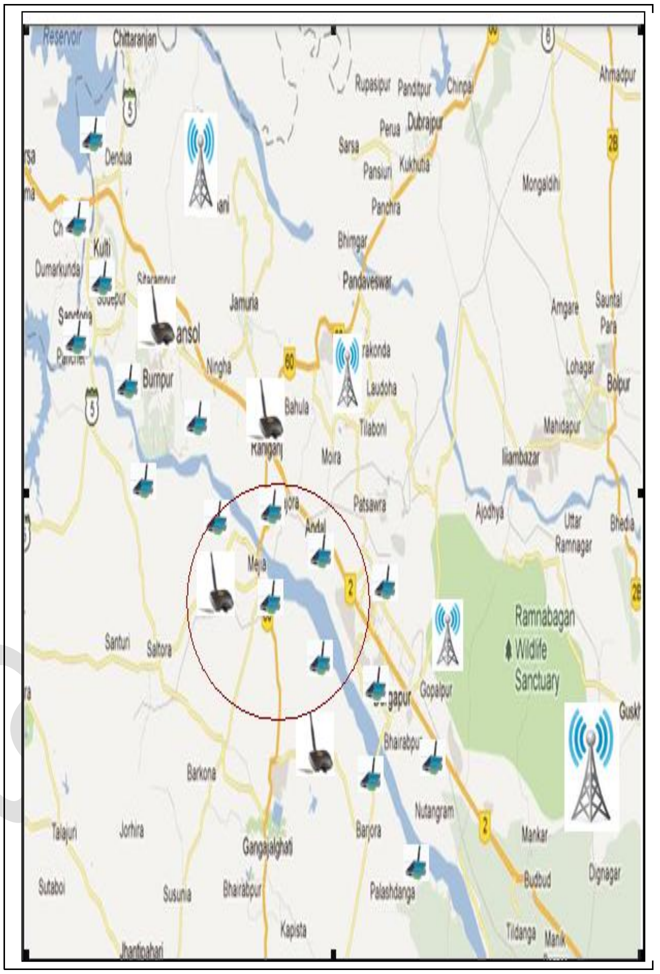


**Figure1: Deployed area**

III. LEACH PROTOCOL:

LEACH (Low Energy Adaptive Clustering Hierarchy) is designed for sensor networks where an end-user wants to remotely monitor the environment. In such a situation, the data from the individual nodes must be sent to a central base station, often located far from the sensor network, through which the end-user can access the data. There are several desirable properties for protocols on these networks:

- Use 100's - 1000's of nodes
- Maximize system lifetime
- Maximize network coverage
- Use uniform, battery-operated nodes

Conventional network protocols, such as direct transmission, minimum transmission energy, multi-hop routing, and clustering all have drawbacks that doesn't

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allow them to achieve all the desirable properties. LEACH includes distributed cluster formation, local processing to reduce global communication and randomized rotation of the cluster-heads. Together, these features allow LEACH to achieve the desired properties. Initial simulations show that LEACH is an energy-efficient protocol that extends system lifetime.

LEACH is a cluster-based WSN protocol. It adapts the clustering concept to distribute the energy among the sensor nodes in the network. It improves the energy-efficiency of WSN beyond the normal clustering architecture. It uses a TDMA/CDMA MAC to reduce inter-cluster and intra-cluster collisions. As a result, we can extend the life time of our network, and this is the very important issue that is considered in the WSN field.

## IV. OPERATION OF LEACH

The operation of LEACH is divided into two phases:

- Setup Phase (Where cluster-heads are chosen)
- Cluster-head Advertisement

### 4.1. Algorithm for Setup Phase

Execute the following for each node

- Cluster-head Advertisement
  1. Let x be the random no between 0 and 1, n is the given node, P is the cluster-head probability, r is the current round, G is the set of nodes that were not cluster-heads the previous rounds.
  2. If x < T (n), then that node becomes a cluster-head. The threshold T(n) is determined as:

  $$T(n) = \begin{cases} \frac{P}{1-P*(r \bmod \frac{1}{P})} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

  Here G is the set of nodes that are involved in the CH election. LEACH clustering is shown in Figure (1). In the steady state phase, the actual data is transferred to the BS. To minimize overhead the duration of the steady state phase should be longer than the duration of the setup phase. The CH node, after receiving all the data from its member nodes, performs aggregation before sending it to the BS. After a certain time period, the setup phase is restarted and new CHs is selected. Each cluster communicates using different CDMA codes to reduce interference from nodes belonging to other clusters.
  3. Nodes that are cluster-heads in round 0 can't be again next 1/P rounds; after 1/P - 1, the threshold value will be T(n)=1
  4. In 1/P rounds, all nodes are eligible again to become cluster-heads
  5. After the election of cluster head, each node will broadcasts an advertisement message to the rest of the nodes by using a CSMA MAC protocol.

The algorithm is designed so that each node becomes a cluster-head at least once.

After the completion of this phase, each non-cluster-head node decides the cluster by using the received signal strength of the advertisement.

- Cluster Set-Up
  1. Each node informs the cluster-head node about its choice
  2. Each node uses CSMA- MAC protocol to transmit the information
  3. Cluster heads must keep receivers ON

- Transmission schedule creation
  1. Creates a TDMA schedule as per the number of nodes in the cluster.
  2. Each node send their data during their allocated transmission time to the cluster head

### 4.2. Algorithm for Steady State Phase

1. Begin sensing and transmitting data to the cluster-heads.
2. Then, the cluster-head node, receive all the data, aggregates it before sending it to the base-station.

After a certain time, which is determined a priori, the network goes back into the setup phase.

## V. DISCUSSIONS ON LEACH

One of the major drawbacks of LEACH is that the actual number of cluster heads formed per round is varying with respect to the desired number of cluster heads, specified as an input parameter to LEACH. Huafeng Liu,Liang Li and Shiyao Jin in their work on "Cluster Number Variability

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Problem in LEACH" had discussed about this problem, and proposed an improved clustering scheme (I-LEACH) as an improvement over LEACH. In the above work, they discussed the I-LEACH protocol in the following steps:

- Base station (BS) receives the aggregated data from the cluster heads. Therefore, it can be calculated that the number of nodes become the cluster head in the present round.
- Then the BS sends a broadcast message that contains the probability for the nodes to become the cluster head in the next round.

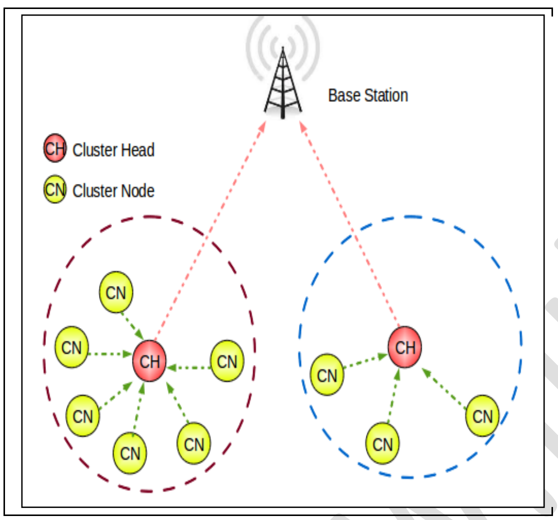


**Figure2: Leach Protocol**

**Table2: functional specification**

| | **ZigBee 802.15.4** |
|---|---|
| Transmission Range (meter) | 1-100 |
| Battery life (days) | 100-1000 |
| Network Size (no. of nodes) | > 64000 |
| Throughput (Kb/s) | 20-250 |

VI. RESULTS:

After a number of simulations, the following results were gathered. Based upon these results, a detailed analysis is presented. Figure 3 shows the initial field distribution of the network, where LEACH protocol is implemented. A 100m*100m field is taken and nodes are randomly placed in it. The base station is placed at the center of the field (50, 50). Placing the base station at the center is convenient so that no node finds it out of its transmission range. Here, the advanced nodes are shown by a plus symbol (+) and the normal nodes by a circle (○). In Figure-3, all the nodes are alive in the network.

After a few rounds, a few of the nodes drains out all their energy. Such dead nodes are shown by the dot symbol (●). Such scenario is shown in Figure-2. The reason why some of the nodes drained out their energy before the others is because these nodes would have become the cluster-heads in the initial rounds of the data transmission. Since the clusterheads have to aggregate the data and send it to the base station, which might be located far from the base-station, the cluster-heads use up their energy faster as compared to the non-cluster head nodes.

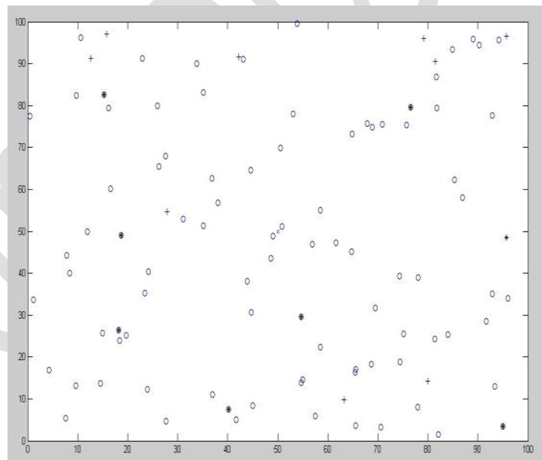

**Figure3: Clusterhead selection**

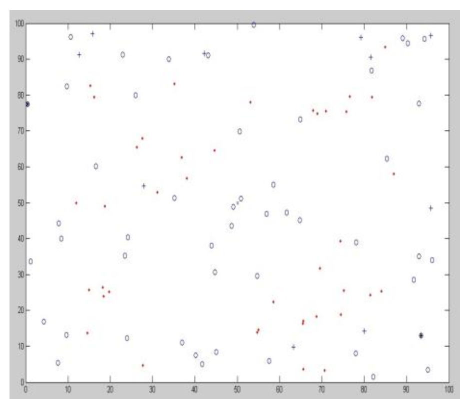

**Figure4: Position of dead nodes**

VII. DEPLOYMENT OF NETWORK:

In the preceding section we discussed the sensor nodes are deployed by the process of data aggregation along the river basin. The sensor used here is made of zigbee technology.

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*A. ZigBee Overview:*

ZigBee (IEEE 802.15.4-2006 standard) is a category in the IEEE 802 family, along with some of the well-known protocols such as Wi-Fi, Bluetooth which uses the 2.4 GHz for industrial, and scientific and medical (ISM) radio band. ZigBee also utilizes 868 MHz and 915 MHz in different parts of the world according to local standards. Unlike Wi-Fi and Bluetooth, ZigBee was developed for low-rate WPAN (LR-WPAN) which feature long battery life by having low date rates.

The ZigBee protocol was designed to provide static, dynamic, or mesh network topologies supporting up to 65,000 nodes across large areas for industrial use. In order to handle faults caused by various environmental effects, the ZigBee protocol provides a self-healing ability for the network to detect and recover from network or communication link faults without human intervention. This is done through certain features of the ZigBee protocol such as clear channel assessment, retries and acknowledgments, and collision avoidance.

*B. Network Topologies*

ZigBee networks can contain a mixture of three potential components. These components are a ZigBee coordinator, a ZigBee router, and a ZigBee end device. Different types of nodes will have different roles within the network layer, but all various types can have the same applications.

- **ZigBee coordinator** – For every ZigBee network, there can be only one coordinator. This node is responsible for initializing the network, selecting the appropriate channel, and permitting other devices to connect to its network. In a star topology, the coordinator is at the center of the star, and all traffic from any end device must travel to this node. It is still possible for end devices to talk to another end device, but the message must be routed through the coordinator. In a tree topology, the coordinator is at the top of the tree, and in a mesh network, it is the root node of the mesh. A ZigBee coordinator can also take part in providing security services.
- **ZigBee Router–** A router is able to pass on messages in a network, and is also able to have child nodes connect to it, whether it be another router, or an end device. Router functions are only used in a tree or mesh topology, because in a star topology, all traffic is routed through the center node, which is the coordinator. Routers can take place of end devices, but the routing functions would be useless in such cases. If the network supports beaconing, then a router can sleep when inactive, periodically waking up to notify the network of its presence.
- **ZigBee End Device** – The power saving features of a ZigBee network can be mainly credited to the end devices. Because these nodes are not used for routing traffic, they can be sleeping for the majority of the time, expanding battery life of such devices. These nodes carry just enough function to talk to parent nodes, which can be either a router or a coordinator. An end device does not have the ability to have other nodes connect to its network through the end device, as it must be connected to the network through either a router, or directly to the coordinator.

In the following sections, we go into detail about the three different types of topology possible for a ZigBee network. The legend to all topology figures are shown below, and each type of device is given a color code for easy viewing.

**i) Star Topology**

In this simple topology, a coordinator is surrounded by a group of either end devices or routers. Even though routers are connected to the coordinator, their message relaying functions are not used. This type of topology is attractive because of its simplicity, but at the same time presents some key disadvantages. In the event that the coordinator stops functioning, the entire network is functionless because all traffic must travel through the center of the star. For the same reason, the coordinator could easily be a bottleneck to traffic within the network, especially since a ZigBee network can have more than 60000 nodes.

ii) **Tree Topology**

In a tree network, a coordinator initializes the network, and is the top (root) of the tree. The coordinator can now have either routers or end devices connected to it. For every router connected, more child nodes can connect to the router. Child nodes cannot connect to an end device because it does not have the ability to relay messages. This topology allows for different levels of nodes, with the coordinator being at the highest level. For messages to be passed to other nodes in the same network, the source node must pass the message to its parent, which is the node higher up by one level of the source node, and the message is continually relayed higher up in the tree until it can be passed back down to the destination node. Because the number of potential paths a message can take is only one, this type of topology is not the most reliable topology. If a

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| | |
|---|---|
| CCA mode | Carrier Sense |
| Transmission power | 3.0 dBm |
| Packet Reception model | PHY 802.15.4 Reception model |
| Modulation Scheme | QPSK |

router fails, then all of that router's children are cut off from communicating with the rest of the network.

**iii) Mesh Topology**

A mesh topology is the most flexible topology of the three. Flexibility is present because a message can take multiple paths from source to destination. If a particular router fails, then ZigBee's self healing mechanism will allow the network to search for an alternate path for the message to take. In our project, one of the scenarios is to investigate this feature by removing a router from the network during operation, and seeing the end devices find an alternate path to communicate with the coordinator.

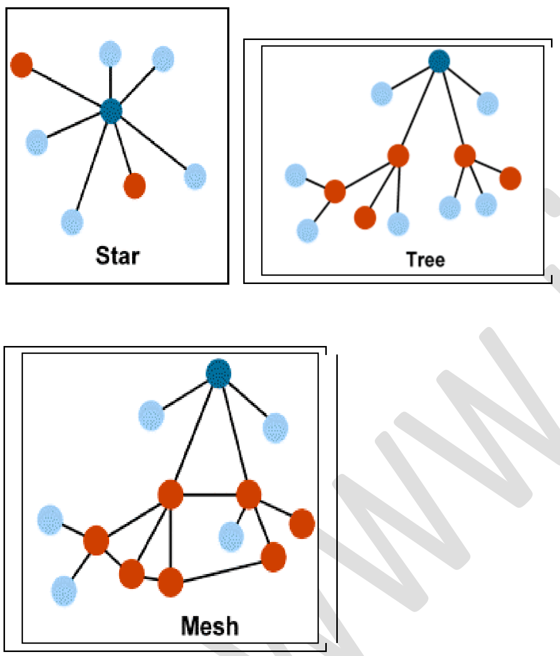
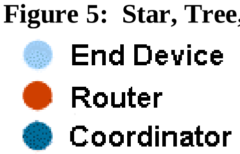



**Figure 5: Star, Tree, Mesh Topology**




VIII. SIMULATION OF NETWORK USING QUALNET:

The performance analysis of designed network has been evaluated in the platform of Qualnet.

*A. Wireless Subnet properties:*

*1) Physical Layer*

- **Radio Type 802.15.4**

**Table3:** Physical layer properties

*2) MAC Layer*

- **MAC protocol: 802.15.4**
- **Device type: FFD**
- **FFD mode: Coordinator**

- **Specify Antenna modulation file**

| | |
|---|---|
| Antenna Gain (dB) | 0 |
| Antenna height (Meter) | 1.5 |
| Antenna Efficiency (dB) | 0.8 |
| Antenna Mismatch loss | 0.3 |
| Antenna cable loss | 0.0 |
| Antenna connection loss | 0.2 |
| Antenna model | Omni-directional |
| Temperature (k) | 290.0 |
| Noise Figure | 10 |
| Energy Model | Mica-Motor |

**Table4:** Antenna specification

*3) Default Device property*

- **Interface: Default type**

*4) Node configuration*

| | |
|---|---|
| Network protocol | IPv4 |
| Enable IP loopback | Yes |
| IP loopback address | 127 |
| IP fragmentation unit | 2048 |

**Table5: interfacing unit**

IX. NETWORK CONFIGURATION:

The node configuration for star network is shown in the figure 4.6. The total area composed of four clusters. Each cluster has six nodes. They are connected wirelessly. The

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following figure shows node configuration for all three networks.

*A. Star Network:*

In case of star network only nodes are connected to wireless subnet. It looks like a star. Such as in fig. node 5, 59, 4, 47, 39, 11 are grouped in one cluster. They are connected to wireless subnet (dotted line). Only one node in each cluster acts as a source node. The packets are transferred from this node to the destination node which is 121 for this case. Her source node is 5 for first cluster. Eventually for 2nd, 3rd and 4th cluster source nodes are 1, 31 and 38 as shown in fig.

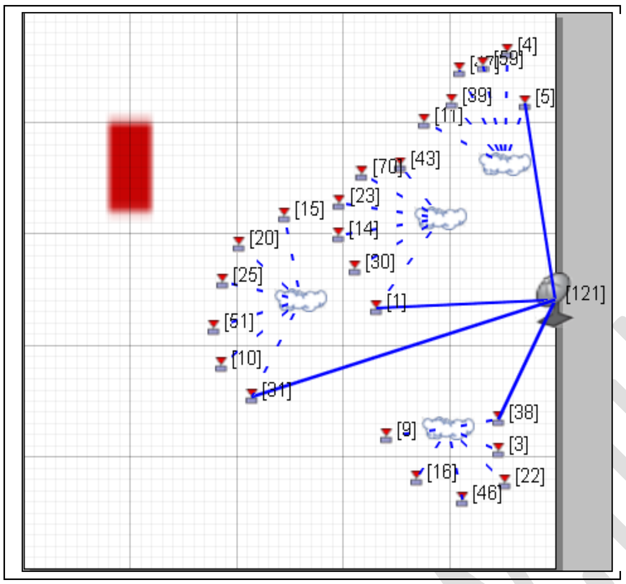
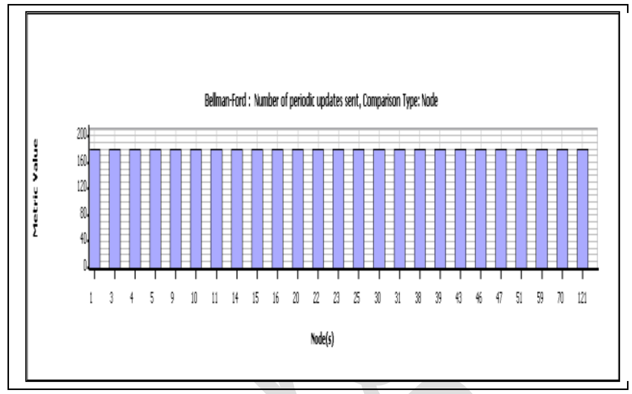



**Figure5: Design of star**

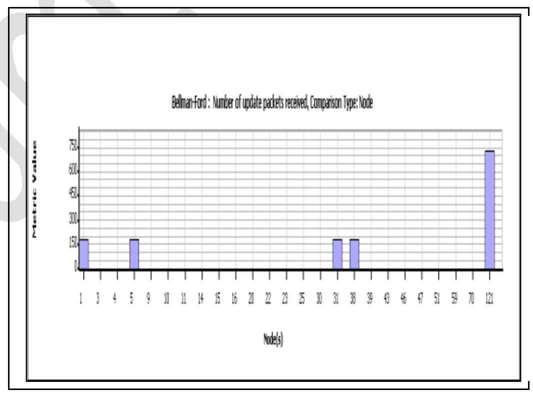
*1) Performance Analysis for star network:*

The following figure shows the packet update transfer from source to destination node for star network. The results are coming using Belmond-Ford algorithm. This is done for all networks.

- **Periodic update packet sent:**




- **Update packet received:**




- **Triggered updates sent:**

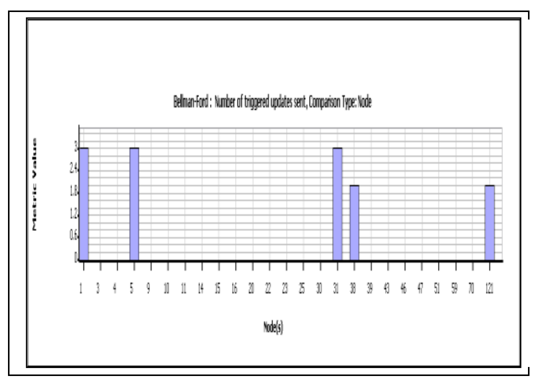



**Figure 6:** Performance analysis for star

*B. Mesh Network:*

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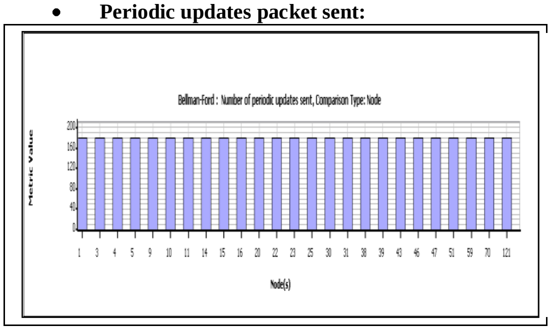
In case of mesh network each node in a cluster is connected to subnet as well as nodes are connected among each other wirelessly. Fig. shows the design methodology.

*2) Performance analysis for mesh network*

- **Periodic updates packet sent:**



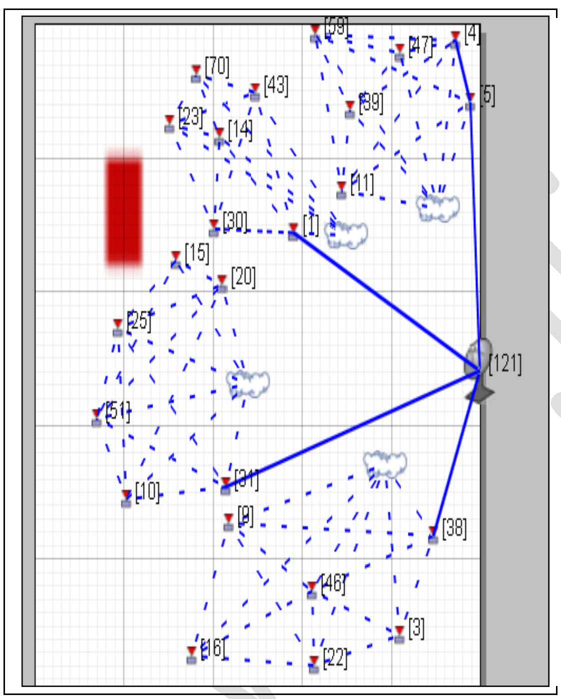
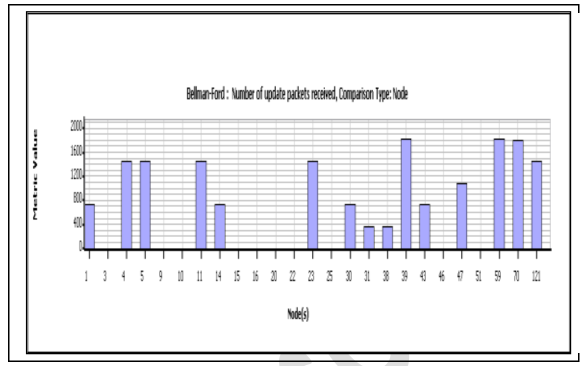




**Figure7: Design of mesh network**

- **Update packets received:**




- **Triggered updates send:**

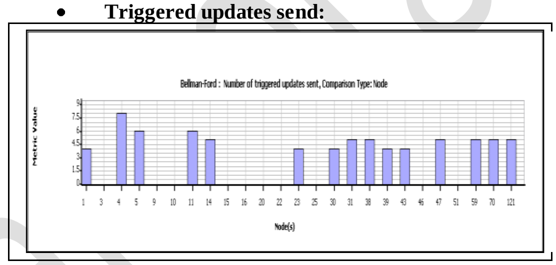



**Figure8: performance analysis for mesh**

*C. Ring Network:*

In case of ring network each node in a cluster connected to its either side's nodes through wireless subnet. They are looks like a ring as shown in fig.

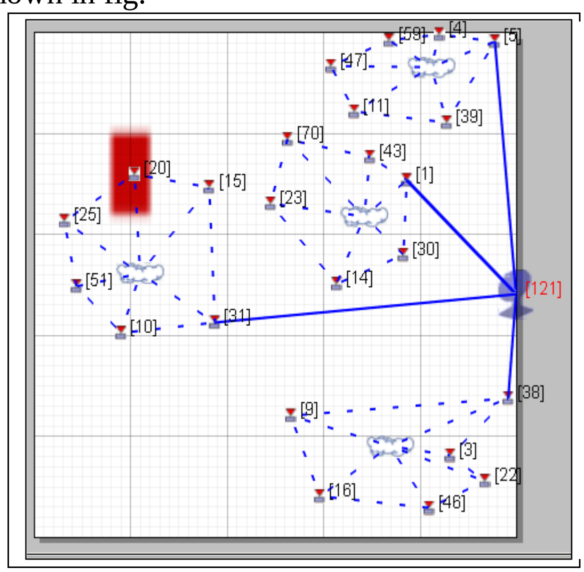



**Figure 9: Design of ring**

*3) Performance analysis for ring network:*

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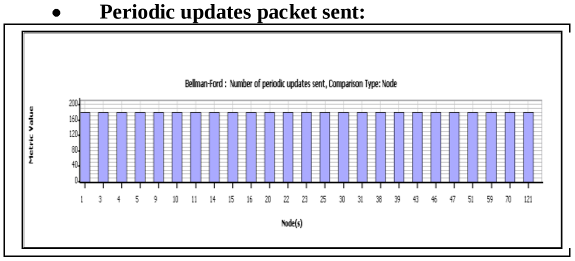
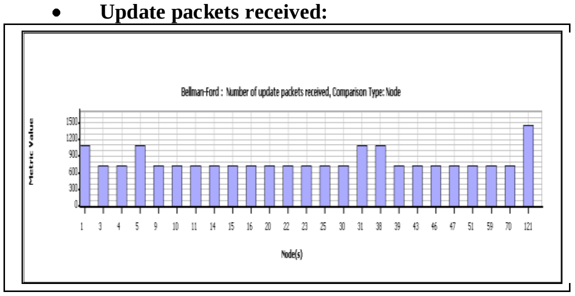
- **Periodic updates packet sent:**




- **Update packets received:**




- **Triggered updates sent:**

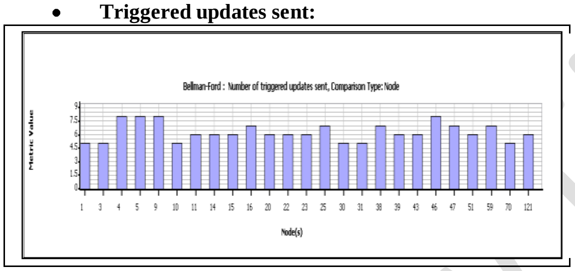



**Figure10: Graphical analysis**

## X. COMPARISON OF PERFORMANCE AMONG THREE NETWORKS:

From simulation result and graphical analysis it is shown that the network is working properly in time. No packet loss is occurred in star mesh or ring network.. After comparing we see that rate of the packets send by each node is same for all three network- star, tree and mesh but rate of packets received is different for each network configuration and the rate of packets send by the clusterhead node for each cluster is also different. The amount of packets send in this case is also less number compare to other two configurations.

## XI. CONCLUSION:

The network is implemented properly. The required data is sent through the network. However the data source in the network is working timely with mesh, star and ring network. There is no packet loss occurred in the network. The validation of network is fully compatible with the project. In future we will work with some other network and send data with source and destination specification and for all other performance with different configuration.

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