long delay for discovering a route to a destination prior to the actual communication.

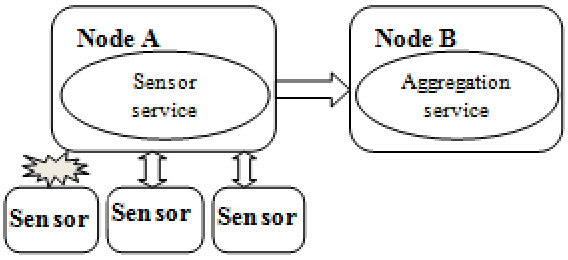


**Figure 1:** Failure cause by loosely connected sensor

## 2. Related Work

C. Kavitha, et al., [1] an Energy efficient fault-tolerant multipath routing technique which utilizes multiple paths between source and the sink has been proposed. This protocol is intended to provide a reliable transmission environment with low energy consumption by efficiently utilizing the energy availability and the available bandwidth of the nodes to identify multiple routes to the destination. To achieve reliability and fault tolerance, this protocol selects reliable paths based on the average reliability the rank (ARR) of the paths. Average reliability rank of a path is based on each node's reliability rank (RR), which represents the probability that a node correctly delivers data to the destination. In case the existing route encounters some unexpected link or route failure, the algorithm selects the path with the next highest ARR, from the list of selected paths. Simulation results show that the proposed protocol minimizes the energy and latency and maximizes the delivery ratio.

Seokcheon Lee, et al., [2] stated a new metric, energy cost, devised to consider a balance of sensors remaining energies, as well as energy efficiency. This metric gives rise to the design of the distributed energy balanced routing (DEBR) algorithm devised to balance the data traffic of sensor networks in a decentralized manner and consequently prolong the lifetime of the networks. DEBR is scalable in the number of sensors and also robust to the variations in the dynamics of event generation. They demonstrated the effectiveness of the proposed algorithm by comparing three existing routing algorithms: direct communication approach, minimum transmission energy, and self-organized routing and find that energy balance should be considered to extend lifetime of sensor network and increase robustness of sensor network for diverse event generation patterns.

Julien Beaudaux, et al., [3] have worked on an original layer-independent scheme. The key aspect is to create fake data sources that have acted as storage nodes during the failure of links leading to the sink station. They use control messages during gradual recovery phase, thus maintaining a negligible overhead in terms of message complexity and energy consumption, and also resulting in much improved data delivery ratio. They aim at detailing their contribution for message loss avoidance along prone-to failure paths that monitoring reports would follow from sensors to sink stations.

Raza H. Abedi, et al., [4] proposed a new approach that uses Bayesian Network model to compute the failure probability of relay nodes. Sensor nodes learn about the failure probability of relay nodes through regular updates. Moreover, an algorithm is proposed to find two disjoint paths for each sensor nodes in the network. Simulation results are presented to analyze the fault tolerance in different network configurations.

Meikang Qiu, et al., [5] proposed a novel energy-aware fault tolerance mechanism for WSN, called Informer Homed Routing (IHR).In Informer Homed Routing (IHR), the non cluster head nodes limit and select the target of their data transmission. Therefore, it consumes less energy. Their experiments show that proposed protocol can dramatically reduce energy consumption, compared to two existing protocols, LEACH and DHR.

## 3. Proposed Methodology

To achieve the fault tolerant energy efficient wireless sensor network, a randomly deployed wireless sensor network requires a cluster formation protocol to partition the network into clusters. Moreover, most of the WSN applications need data aggregation to reduce communication overhead.
Here, we analyze maximal clique based cluster-first technique where each node obtains a list of its neighbour's connectivity as well as their degree of connection at first which forms non-overlapping clusters of size *n*; where *n* is the maximum cluster size. By exchanging information of 1-hop neighbours, all sensor nodes in the network are grouped into a number of disjoint cliques, in which all the nodes can directly communicate with each other. Among all the nodes in a cluster, the node with maximum energy becomes cluster head. Then, the node with highest degree of connection initiates clique formation process and makes the cluster. Among all the members of the cluster, the node with maximum energy is selected as cluster head (CH).

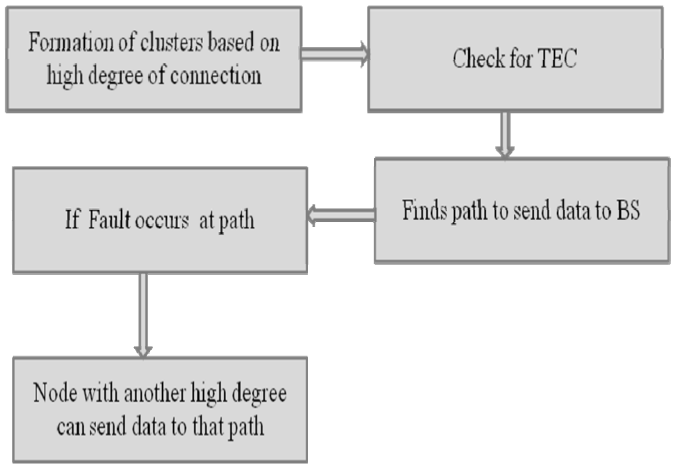


**Figure 2:** Detection of faults and energy efficiency

Generally, sensors consume energy when they sense, receive and transmit data. However, the amount of energy consumption for sensing is unaffected by the routing algorithm and only a small difference exists between the power consumption for idle and receiving modes.

The clusters that are formed need to check for Total Energy Cost (TEC) in order to find out the energy cost of clusters. Nodes with low total energy cost finds path to send data to base station. If faults occur at that path then node with another high degree can send data to that path.

The definition of the composite measure, energy cost (ECi) for a transmission from node i to j is:
ECij =Required energy from node i to j/Available energy at node i.

The basic idea of the proposed routing algorithm is to use a path having the minimum EC. When a sensor i sends data to the base station, it can transmit data to the base station directly or route the data to one of its neighbours (Ni). In other words, the sensor determines which sensor is the best candidate for direct communication with the base station among its neighbours and itself. For evaluating these alternatives, sensor i considers the total required energies to the base station via neighbouring nodes. The total energy cost (TECik) of a neighbouring node k at senor i is simply the sum of the energy costs from node i to k and from node k to the base station:

TECik = ECik + ECk, BS

This measure is the composite quantity that indicates the goodness of a path including a neighbouring node. Based on this metric, sensor i can select the best candidate, node K, for direct communication with the base station:

If the best candidate node is the node i itself, it sends data to the base station and completes the routing process for the data. Otherwise, it forwards the data to the best candidate among its neighbouring nodes and that node then repeats the same routing process. This process continues until a node selects itself as the best candidate and sends directly to the base station. This localized decision making process results in a monotonic decrease of energy cost over time because the best candidate can have an indirect path that is better than direct transmission.

## 4. Implementation Work

### 1. Network Model

Consider a set of sensors dispersed in the field. We assume the following properties about the sensor network:

i. Every node is assigned a unique ID.
ii. Links are bidirectional, i.e. two nodes *u1* and *u2* are connected if both of them can communicate to each other.
iii. A message sent by a node is received correctly within a finite time by all of its one-hop neighbours.
iv. Network topology does not change during cluster formation process.
v. The network consists of multiple mobile/stationary nodes, which implies that energy consumption is not uniform for all nodes.

### 2. Cluster formation process

The first five phases describe the cluster formation process while the rest two specifies CH rotation, addition and deletion of node respectively.

a) Constructing Connectivity Matrix Phase: Each node receives the connectivity list from its all one-hop neighbours and computes the degree of connectivity from that list. This can be provided by a physical layer for mutual location and identification of radio nodes.
b) Cluster Formation Phase: This phase is continued until all nodes join in a cluster. Each node checks its connectivity matrix and finds out whether it holds highest degree of connection or not. If it does not, then it waits until it is added to a cluster by neighbour nodes or it becomes the highest degree node after some iteration. Otherwise, it waits for random time *t*, and starts cluster formation phase.
c) Cluster Head Selection Phase: After finishing cluster formation process, the node which initiated clustering process will select the cluster head. It will check the received signal strength of all other nodes in the cluster and choose the best node as CH. In case of tie, the lowest node ID will be selected as CH.
d) Cluster Announcement Phase: The nodes which have joined in the cluster, will inform neighbours regarding its membership. Hence, the non-clustered nodes will able to update their connectivity matrix list by removing the clustered nodes.
e) Cluster Head Rotation Phase: The cluster heads of all clusters will periodically check the energy level of its neighbour nodes. If it finds a node with more energy level then the current CH will request the node to become CH and will convey the information to all other nodes in the cluster.
f) Node Insertion and Deletion Phase: Node insertion phase is executed by the cluster head if it receives an add request containing neighbour list from a new node. On receiving such request, the CH checks whether this node is connected to all other members in the clique or not. If the CH gets positive confirmation from all its neighbours then the new node is added to the cluster and every node would update their clique information immediately. A node will announce itself as CH if it fails to join in any cluster.

## 5. Simulation Result

### A. Simulation Parameter

A grid of 1000 x1500 is considered number of nodes: 50.The scenario of communication from one node to other node. The speed for communication as 20m/s with a pause time of 10s. Packet count 10000, transmission time is greater than equal to zero and its statistics shown from node zero to node 49 i. e 50 nodes.

The implementation result broadcast the data in cluster formation process and communicates from one node to another node and result gives the energy consumption of each node.

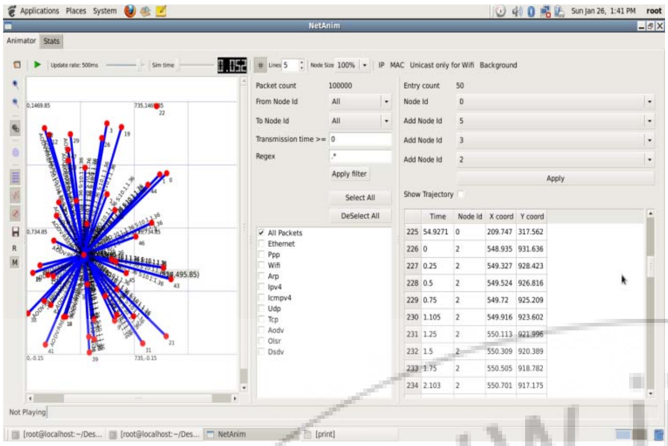

**Figure 3:** Broadcast the data from one node to other node

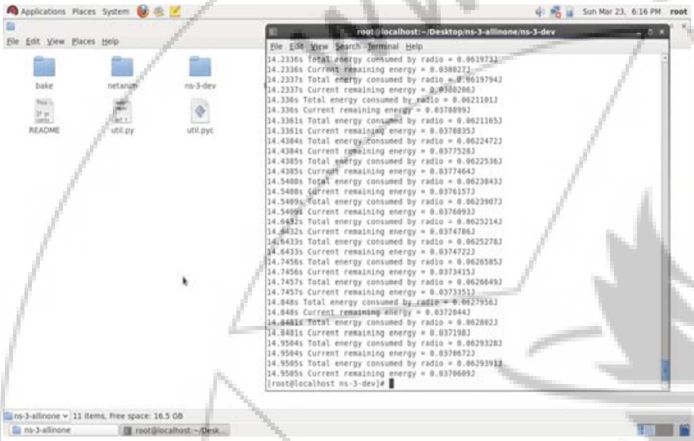

**Figure 4:** Energy consumption of each node

## 6. Conclusion

Cluster formation process is an appropriate choice to achieve Fault tolerance in Wireless sensor networks (WSN).This introduces a clustering scheme which discovers its connected neighbour sets and initiates clustering process on the basis of degree of connectivity. Each node finds out its energy consumption in order to find the energy efficient path to send the data from node to node. The proposed technique has a number of advantages. For example, it requires only the knowledge of one-hop neighbours to form clusters. Furthermore, the clustering scheme is robust for topological change caused by node failure, node mobility, CH change and even for node insertion or removal.

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