Efficient and Protected AOMDV Routing Protocol using Dual Clusters through Replication for Wireless Sensor Networks

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***Abstract* – In Wireless Sensor Networks (WSN), the sensor nodes have a limited transmission range and their processing, storage capabilities and energy resources are limited. Secure routing protocol for wireless sensor networks is achieved through dynamic clustering mechanisms. Distributed Hash Table Replication (DHTR) is used to achieve efficient consistency maintenance during replication. Replication provides better data accessibility and increase the node energy lifetime. The main objective of this paper is to provide the data accessibility and increase in the network life time using dual cluster heads in Wireless sensor network.**

Index terms - DHTR, Dual Cluster Heads, Replication, Routing protocol, Wireless Sensor Networks (WSN).

I. INTRODUCTION

A mobile database is a database that resides on a mobile device such as a smart phones, laptop etc. Such devices are subject to resources such as memory, computing power, and battery power. Within a wireless network, a mobile database has got one or more base stations. These stations are responsible for controlling the communication signals that need to be passed from one node to another. Hence a mobile computing system can be viewed as a dynamic type of distributed system where links between the nodes in the network change dynamically. The ACID (Advanced Caller Identification) properties should be maintained in all data management activities. The WSN comprises the Mobile Adhoc Networks. Mobile Ad hoc Network (MANET) is a collection of wireless mobile nodes. These nodes form a temporary network without any fixed infrastructure where all nodes can freely move around the network. The links in this network are highly error prone and can get easily broken down often due to the mobile nature of nodes. Due to the high dynamic nature of MANETS, the stable routing isn't possible. So, to provide a means of long-standing routing and also to ensure a proper communication, a clustering architecture is used. In this architecture, the nodes are grouped into clusters. Each cluster has a cluster head which is responsible for organizing the nodes and maintaining all its information. The other nodes of the network communicate with the cluster head by packet forwarding. The routing among the nodes is established through a routing protocol. The routing protocol used here is Adhoc On Demand Multipath Distance Vector (AOMDV) routing protocol. In the figure 1.1, the laptop acts as a source that communicates with the destination that is a mobile phone through various intermediate nodes.

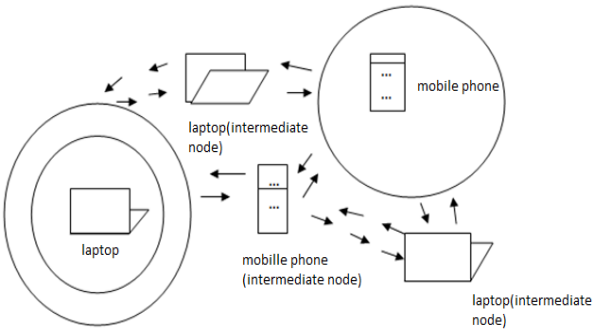

Figure 1 Communication between mobile devices

In order to provide communication within the network, a routing protocol is used to discover routes between nodes of the network. The primary goal of such an ad-hoc network routing protocol is to ensure and provide correct and efficient route establishment between nodes so that messages gets delivered in a timely manner. An Ad hoc routing protocol is a convention or standard that controls nodes that come to agree in which way it wants to route packets between computing devices in a MANET. In ad hoc networks, nodes do not have a prior knowledge of topology of network, so they need to discover it. The basic idea is that a new node announces its presence and listens to broadcast announcements from its neighbours. The node learns about new neighbour nodes and also the ways to reach them, and announces that it can also reach those nodes; reactive protocol is preferable to violate the congestion in network due to heavy traffic.

When a node wishes to transmit traffic to a host to which it has no route, it will generate a route request (RREQ) message that will be flooded in a limited way to other nodes. This causes control traffic overhead to be dynamic and it will result in an initial delay when initiating such communication. A route is considered found when the RREQ message reaches

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either the destination itself, or an intermediate node with a valid route entry for the destination.

Multiple Loop-Free and Link-Disjoint path technique is the one used in AOMDV protocol. In AOMDV only disjoint nodes are considered in all the paths, to achieve path disjointness. For a route discovery, route request packets are propagated throughout the network by establishing multiple paths at destination node and at the intermediate nodes. Advertised hop count method is used for multiple Loop-Free paths at each node. This advertised hop count is required to be maintained at each node in the route table entry. The route entry table at each node also contains a list of next hop along with the corresponding hop counts.

Every node maintains an advertised hop count for the destination. Advertised hop count is the maximum hop count for all the paths. Route advertisements of the destination are sent using this hop count. An alternate path to the destination is accepted by a node if the hop count is less than the advertised hop count for the destination. The routing entries for each destination contain a list of the next-hops along with the corresponding hop counts. All the next hops have the same sequence number. This helps to track a route.

For each destination, a node maintains the advertised hop count, which is defined as the maximum hop count for all the paths, which is used for sending route advertisements of the destination. Each duplicate route advertisement received by a node defines an alternate path to the destination.

Loop freedom is assured for a node by accepting alternate paths to destination if it has a less hop count than the advertised hop count for that destination. Because the maximum hop count is used, the advertised hop count therefore does not change for the same sequence number. When a route advertisement is received for a destination with a greater sequence number, the next-hop list and the advertised hop count are reinitialized. AOMDV can be used to find node-disjoint or link-disjoint routes.

To find node-disjoint routes, each node does not immediately reject duplicate RREQs. Each RREQs arriving via a different neighbor of the source defines a node-disjoint path. This is because nodes cannot be broadcast duplicate RREQs, so any two RREQs arriving at an intermediate node via a different neighbor of the source could not have traversed the same node. In an attempt to get multiple link-disjoint routes, the destination replies to duplicate RREQs, the destination only replies to RREQs arriving via unique neighbors.

The advantage of using AOMDV is that it allows intermediate nodes to reply to RREQs, while still selecting disjoint paths. But, AOMDV has more message overheads during route discovery due to increased flooding and since it is a multipath routing protocol, the destination replies to the multiple RREQs those results are in longer overhead.

II. CLUSTER MECHANISM

A cluster is a group of nodes that communicate with each other. It is the division of the network into different virtual groups, based on certain rules in order to discriminate the nodes allocated to different sub-networks. The goal of clustering is to achieve better scalability in large networks and highly mobile network. Nodes can be dynamically added to or removed from the clusters at any time, simply by starting or stopping a channel with the configuration and name that matches the other cluster members. Each node in the cluster will be assigned a specific role. The role of nodes in a cluster includes;

- Cluster-Head: local coordinator of a cluster
- Cluster-Member: an ordinary node

The advantages of clustering include reduced single points of failure through Server failover functionality. It has the ability to takeover maintenance and upgradation with limited downtime. It includes the ability to easily scale up the cluster to a maximum of seven active servers.

The communication between the clusters in a network plays an important role. As shown in figure 2, the communication between the nodes in a single cluster is known as intra- cluster communication. The communication between the nodes of two different clusters is known as inter-cluster communication.

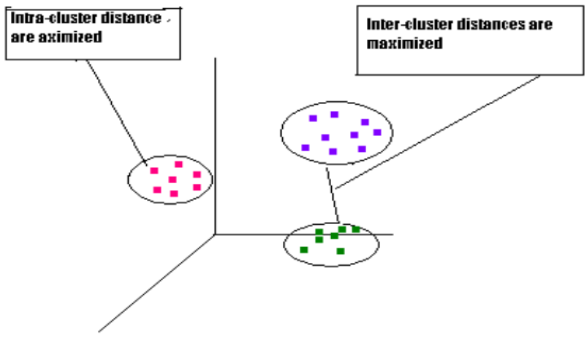

Figure 2 Communications between Clusters

Many clustering algorithms are available like K-means and its variance, Hierarchical Clustering, Density based Clustering etc. Energy efficient data aggregation is one of the key research areas of WSNs. Many clustering techniques have been proposed for topology maintenance and routing in these networks. In addition to this, these techniques are also beneficial in prolonging the network life time. Clustering protocols proposed in existing literature use a Single Cluster Head (CH) for a group of nodes (Cluster). In these protocols, the CH performs a number of activities, such as data gathering, data aggregation and data forwarding. As a result, the CH depletes its energy quickly as compared to its member nodes. Re-clustering is required frequently, which consumes considerable energy.

The clustering mechanism used here is the Dual-Head Clustering Scheme (DHCS). The DHCS is a three step process that includes cluster formation, route formation and data communication. Like other routing algorithms the first step remains the same. Let *n* be the number of rounds for which the first step will execute, which means if *n* is 10 the new heads will be selected after 10 rounds and *n* will decreased continuously and will reach to 1 at certain time. Thus, we can save energy which is consumed in the first step of network initialization.

Initially all nodes have high energy, so the value of *n* is also high which gradually decreases when nodes are operating. A significant amount of energy is utilized in each round with a single cluster head and the same cluster head may not be fixed for a specific number of rounds. The proposed approach is capable of fixing the CH for specific number of rotations. After Aggregator Head (AH) selection, the CH broadcast a message to all member nodes to communicate and send data to the aggregator head. The metrics for aggregation head selection is a node with high power node and closer distance to the cluster head. After the cluster formation, every CH broadcasts a metrics to other cluster heads. This metrics consists of cluster head energy, id, and distance from the sink. On the other hand, every CH calculates the distance to the other CH based on received signal strength and finds shortest distance to the sink for efficient communication of data. After formation of route, the CH selects a node with higher energy and closest to it from the list of its members, as an AH.

After the AH is selected, every member node in the cluster sends the sensed data to the AH. The AH receives data from the nodes, aggregates it and sends it to the CH for further transmission. The CH then forwards data received from AH to the sink and also forward data received from other cluster heads to the sink. In this paper a novel concept of energy efficient clustering and routing scheme for wireless sensor networks, called Dual Head Clustering Scheme has been proposed.

In DHCS, every cluster has two cluster heads; Cluster Head and Aggregator Head. Both heads divide the duty of single head among each other. The jobs of CH are the cluster maintenance, data forwarding, while the duties of AH is to collect data from the field via cluster members and aggregate the collected data for transmission. In cluster formation process, the CH is selected for a specified period of time. Thus DHCS out performs in cluster head life time, network life time, network average energy, and network latency.

In large-scale mobile ad-hoc networks with frequent replica update operations, the energy saved by DHTR are significant towards maximizing the lifetime of the network and application systems. Our system can also cope with the dynamic nature of mobile ad-hoc networks and handle failures of individual mobile nodes. Simulation experiments show that DHTR uses less energy and takes less time for update propagation.

To improve the reliability and availability of Distributed Hash Table Replication (DHTR), an efficient cluster head rotation mechanism should be explored to shift the role of cluster head before the original head dies due to energy depletion. Dual cluster heads within one cluster can be considered to make the system more stable in high dynamic environments.

In this proposal, the problems of data replication in solving the mobile database issues are considered. Replication of data in a MANET environment focuses on how to improve reliability and availability of data to the mobile clients (node). There are many issues revolving around replication of data in such a scenario like power, server and node mobility, networking partition and frequent disconnection. So that it is planned to propose an approach for replication of data and to overcome the issues related to node mobility or disconnection problem in MANET environment. Here two phases are involved; initial phase consisting of formation of cluster and cluster head (CH) and in the second phase, the distributions of data (replicated data) to the respective cluster head.

In the initial phase, nodes are clustered based on two factors; received signal strength of nodes and distance from past movements. The node which is most stable is elected as the cluster head. These cluster head act ultimately as "basket nodes" (those cluster heads which posses the replicated data) and share with the member nodes (according to the queries). The server initially collects queries from the nodes, before the cluster formation.

In the second phase, the distribution of data to the "basket node" from the main server is done. This distribution (replication data's) depends on the queries from the nodes. According to the queries, the replicated data's are sent to the nearest cluster heads from which uninterrupted data services can be maintained. Replication of data into a single cluster head increases the overhead of the cluster head as well as the power consumptions.

III. SYSTEM ARCHITECTURE

The concept of dual cluster has been proposed to prolong the lifetime of the network. It can give more security for communication between cluster head and the replica manager. The Replica manager is the brain of cluster heads in a group of cluster structure. The Dual cluster environment is implemented to increase the lifetime of the network using cluster technique. The distance based routing algorithm can be used for dual cluster implementation and AOMDV routing protocol can be used for data transaction.

The server will send acknowledgment for every request and response that has been received as shown in figure 3. The received requests are divided between the two cluster subheads and the response is sent to the nodes at the same time. The single cluster replaced with dual cluster implementation consumes less energy, provides data security, improves the lifetime of the nodes and also it is scalable for large number of nodes.

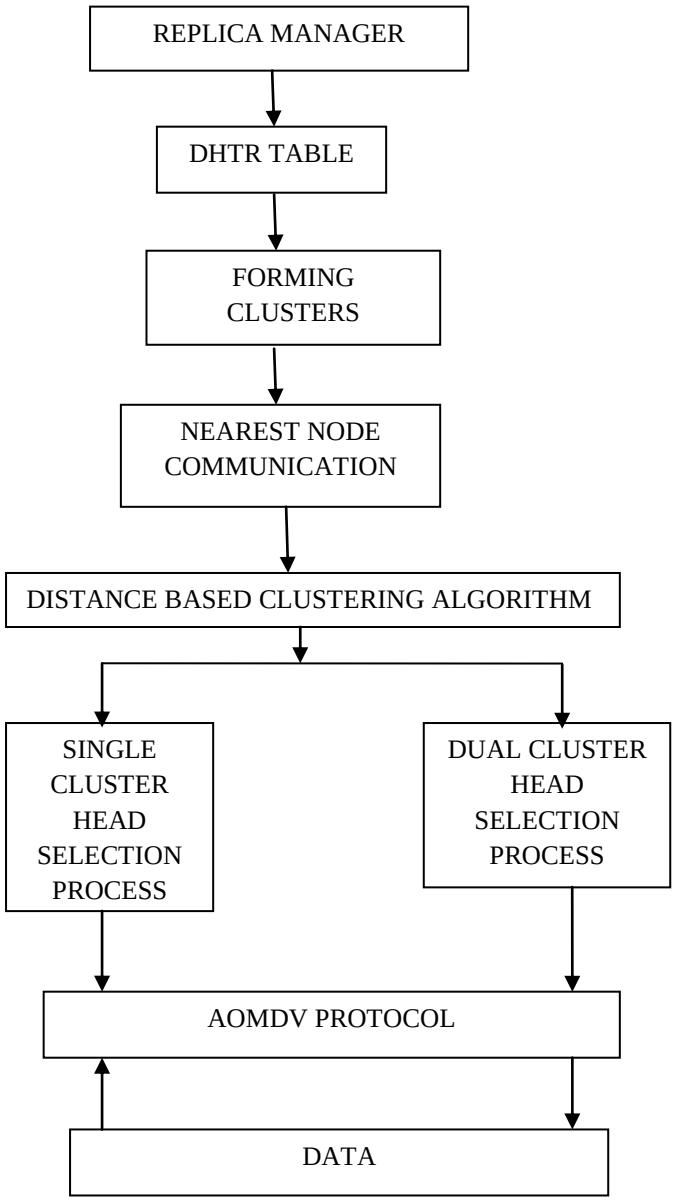

Figure 3 System Architecture for proposed system

The Data Flow Diagram (DFD) is a graphical representation of the flow of data through an information system. It enables us to represent the processes in our information system from the viewpoint of data. The DFD lets us visualize how the system operates, what the system accomplishes and how it will be implemented, when it is refined with further specification. The DFD in figure 4 shows that, source sends a data packet to the destination in a network. The transmission of a packet is achieved through the AOMDV routing protocol. The dual cluster head in a cluster is formed by using SNR values and it attains consistency by using Replica Manager. Finally the packet reaches the destination.

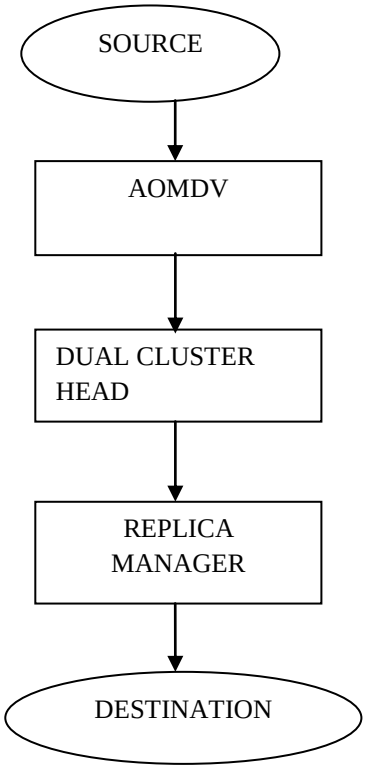

Figure 4 Data flow diagram for proposed system

IV. SIMULATION RESULTS

The algorithm that is used in this project is described as follows which is done using Network Simulator:

- Creation of nodes for a WSN.
- Set dynamic nature to nodes to create a mobile environment.
- Assign node colours for different clusters and unique colour for cluster head (CH) nodes.
- Assign the sink nodes and the simulation instance.
- Defining the cluster formation with cluster head.
- In dual cluster head mechanism, cluster head along with sub cluster head is defined for each cluster.
- Replica keeper is defined to maintain the cluster head information as a common administrator.
- Simulation carried out with single and dual cluster head mechanism.

Performance comparison is made between single and dual cluster head mechanisms based on Packet Delivery Ratio (PDR). PDR is the ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination.

$$PDR = \frac{\sum \text{Number of packets received}}{\sum \text{Number of packets sent}}$$

The graphs plotted for the Single cluster head and Dual cluster head mechanisms with Replication technique with

respect to Packet delivery ratio to determine the performance and reliability of the protocol are shown in figures 5 and 6 respectively.

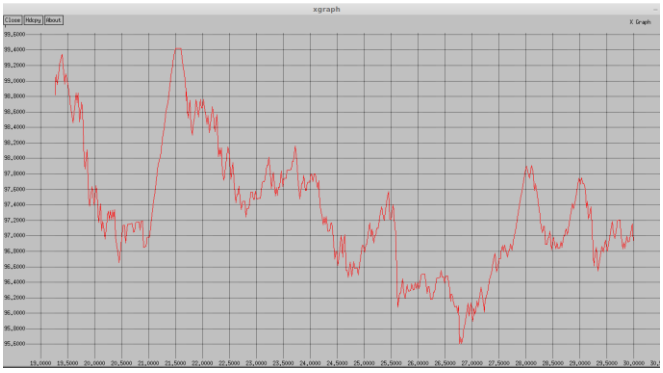

Figure 5 Packet delivery ratio graph for Single Cluster

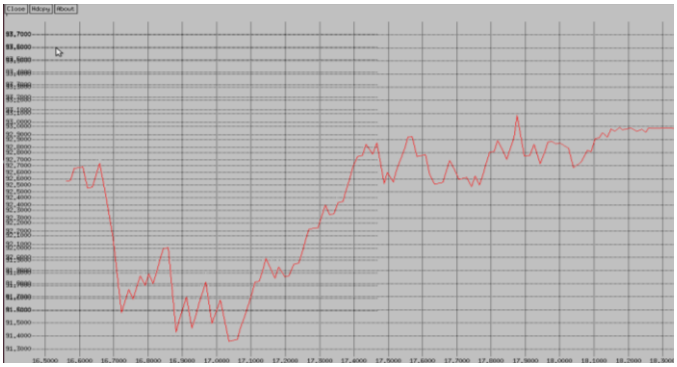

Figure 6 Packet delivery ratio graph for Dual Cluster

The figure 7 shows a comparison graph that is made with respect to the PDR for both the mechanisms. The greater value of packet delivery ratio means the better performance of the protocol. The x-axis indicates the time in seconds and the y-axis indicates the energy. Thus better performance is achieved through the Dual cluster Head mechanism with Replication technique.

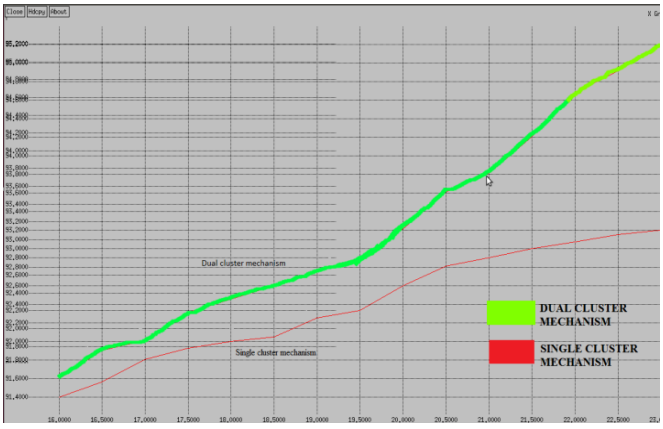

Figure 7 Comparison graph of Single and Dual cluster mechanisms for Packet delivery ratio

V. CONCLUSION

In this energy efficient routing protocol for WSNs through dynamic clustering mechanisms, can partition the nodes into clusters and select the cluster head (CH) among the nodes and non CH nodes join with a specific CH. Distributed Hash Table Replication (DHTR) is used to achieve efficient consistency maintenance during replication. In the large scale ad hoc network, Replication provides a feasible solution for improving data accessibility in a highly dynamic mobile ad hoc environment and increases the node energy lifetime. Dual cluster head with replication technique provides better data accessibility and node energy life time. It increases Packet delivery ratio with respect to Single cluster mechanism. Thus increases the network life time and data accessibility using Dual cluster heads in Wireless sensor network.

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