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CLUSTER BASED ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORKS

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Abstract - Wireless Sensor Network (WSN) is an emerging technology that is predicted to change the human life in future. It can be deployed in such situation where human interaction is not possible like border area tracking enemy movement or fire detection system. Wireless sensor networks have critical applications in scientific, medical, industrial and military domains. Information is collected from many sensor devices and they can be used for further consumer application in the Sensor network. In such a case routing is very prominent one. Routing is the process of selecting paths in a network along which to send network traffic. But, various routing protocols have been proposed, but they are not scalable. In this paper, we propose cluster based routing protocol (CBRP) based on Inter-cluster Routing algorithm and Intra cluster routing algorithm, which provides low cost communication between clusters. Through our new protocols have increased the throughput and number of packets in the network and we decreased the average latency and control overhead. At present the proposed idea is implemented and tested for both intra cluster routing and inter cluster routing. We have also evaluated the performance of CBRP with AODV (Adhoc On-Demand Distance Vector), DSDV (Destination-Sequenced Distance Vector) and DSR (Dynamic Source Routing).

Keywords- WSN, Cluster, Routing, Protocols, Sensor

I. INTRODUCTION

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or environmental conditions such as temperature, sound and pressure to cooperatively pass their data through the network to a main location. The WSN is built of "nodes" from a few to several hundreds or even thousands, where each node is connected to one or more sensors. Sensor network development was initiated by the United States during the Cold War [7]. The main characteristics of a WSN are power consumption constraints for nodes using batteries or energy harvesting, ability to cope with node failures, mobility of nodes, communication failures, heterogeneity of nodes, scalability, ability to withstand harsh environmental conditions and ease of use. WSNs can be deployed in a wide geographical space to monitor physical phenomenon with acceptable accuracy and reliability. The sensors can monitor various entities such as temperature, pressure, humidity, salinity, metallic objects, and mobility; this monitoring capability can be effectively used in commercial, military, and environmental applications. The routing process is moving a packet of data from source to destination. Routing is usually performed by a dedicated device called a router. Routing is a key feature of the network, because, it enables messages to pass from one computer to another and eventually reach the target machine The main goal of Wireless Sensor Networks is to Collect the data at regular intervals and then transform data into an electrical signal. Finally, the signals are sent to the destination node. The major advantages of Wireless Sensor Networks are as follows:

- Mobile users are provided with access to real-time information even when they are away from their home or office.
- Setting up a wireless system is easy and fast and it eliminates the need for pulling out the cables through walls and ceilings.
- Network can be extended to places which cannot be wired.
- Wireless networks offer more flexibility and adapt easily to changes in the configuration of the network.

"A sensor network is a deployment of massive numbers of small, inexpensive, self powered devices that can sense, compute, and communicate with other devices for the purpose of gathering local information to make global decisions about a physical environment" [8].

Routing Protocols for ad-hoc networks can be divided into two categories. They are: Table driven Routing Protocol and On-demand Routing Protocol. In table driven, the routing tables are discovered and maintained even when the network is not used. Whereas, in case of on-demand routing protocol the routes are discovered only when it is needed by the source node [1]. The concept of On-demand routing protocol is employed in this paper.

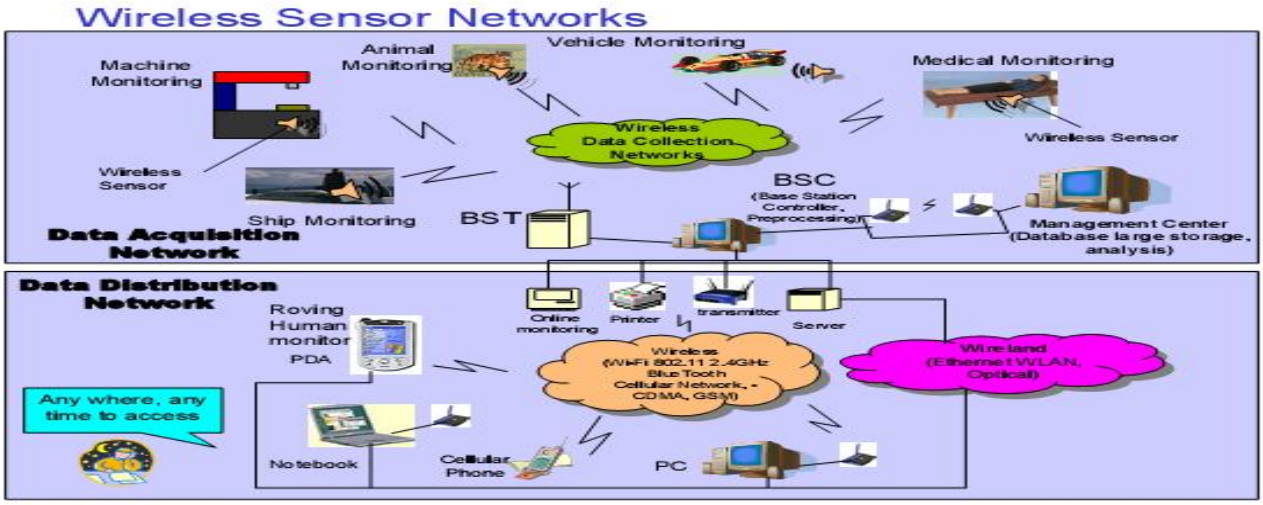

Figure 1. Wireless Sensor Networks

Rest of the paper is organized as follows: Section two deals with the proposed cluster based routing protocol, in section three we discuss performance evaluation, experimental results are dealt in section four and finally, we conclude with future research direction in section five.

II. CLUSTER BASED PROTOCOLS

The proposed effective cluster based routing protocol is illustrated in this section. This protocol works on three modules.

2.1 Cluster formation:

WSNs involve a large number of sensors ranging in the hundreds or even thousands. Clustering is an effective mean for managing such high population of nodes. The first step involved in this phase is the plotting of sensor nodes in a 250*250m square region randomly. The residual energy of all sensor nodes is computed. The probability of a node to become cluster head is chosen. And the node that is having the residual energy greater than the average will be elected as cluster head. Then the nodes that are closest to the cluster head will be formed into groups [2, 5-6].

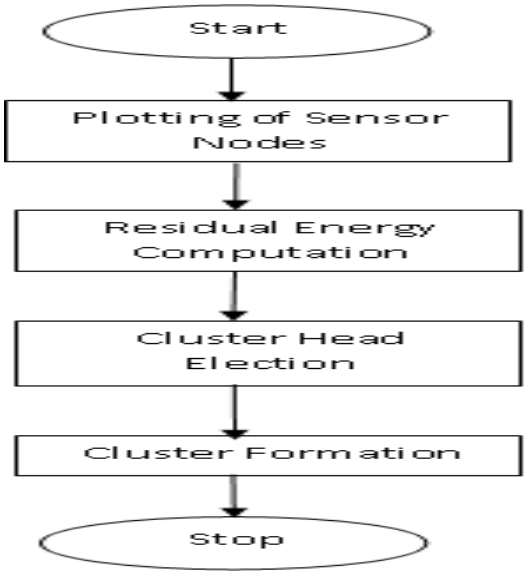

Figure 2. Cluster Formation

2.2 Inter-Cluster Routing

In Inter-cluster routing, when the demand for inter cluster route occurs; the source node sends the inter-cluster route request packet to the border nodes. This method is to acquire the adjacent cluster's intra-cluster routing information [1]. If a node (source node) in a cluster wants to communicate with another node (destination node) in some other cluster, it sends the packet to the border node. The border node in turn will check whether that particular node is in its own cluster. If it is present, it will forward the packet to the destination node through the shortest path. If the node is not present in its cluster, it broadcasts the packet to its border node. This process is repeated till the packet reaches the correct destination.

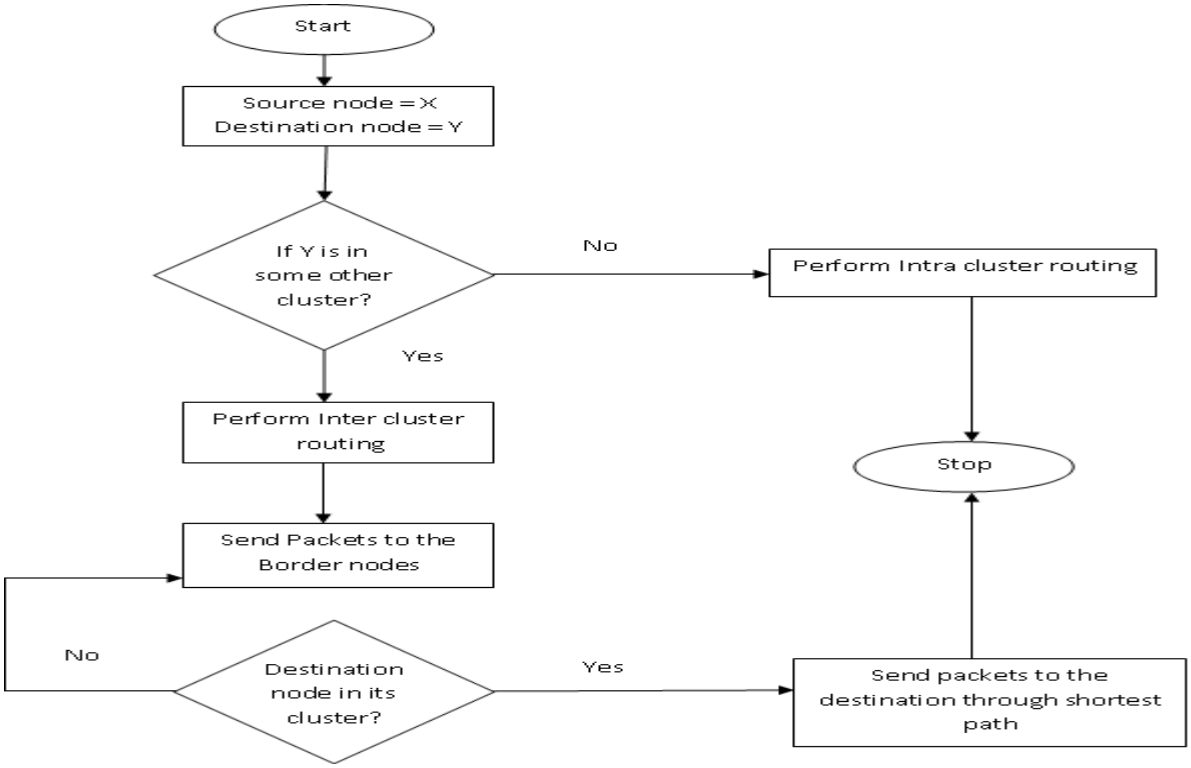

Figure 3. Inter cluster routing

2.3 Intra Cluster Routing:

In intra cluster routing, the source node broadcasts a route query packet to every node until the border nodes in adjacent clusters around the local cluster receive it. Every node maintains other nodes routing information (such as destination, next hop, sequence number and the cluster id of the destination node) within its cluster. It limits the broadcast range within the cluster and the next hop of it to lower control overhead and to reduce interference of the shared media [1]. If a node wants to send packet to other node in its own cluster it can make use of the routing table and it can choose the shortest path to deliver the packet.

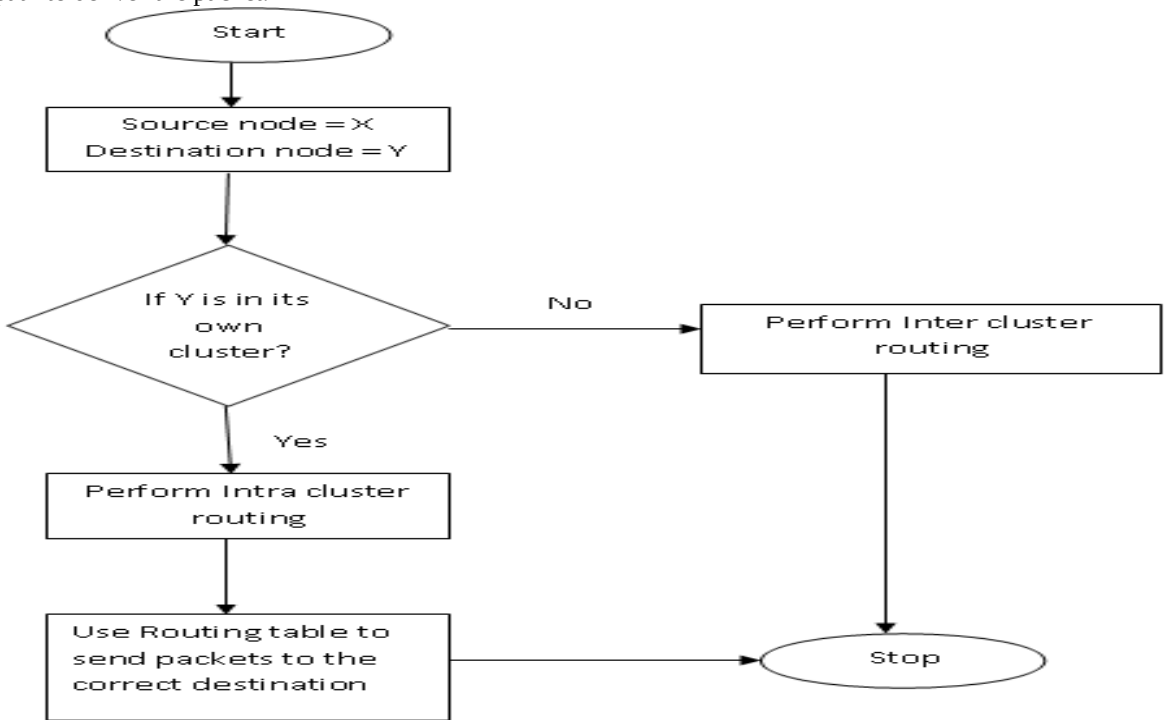

Figure 4. Intra Cluster Routing

III. PERFORMANCE EVALUATION

From then on, we have proposed a set of performances measures. The most common evaluation measures are throughput, average latency, control overhead and packet delivery ratio. Throughput is the total number of data packets sent per unit of time. It is the average rate of successful message delivery over a communication channel. Average latency is the average delay time of a packet between transmitting from the source and receiving at the destination. There are possible delays caused by buffering during route discovery latency and retransmission. Control overhead is the total number of packets generated during discovering routing paths. The generation of control overhead will decrease the protocol performance. Packet delivery ratio is the rate between numbers of data packets received by the destination and the number sent by the source. It describes the percentage of the packets that reach the destination [1].

DSDV is a table driven scheme, each entry in the routing table contains a sequence number, the sequence numbers are generally even if a link is present; else, an odd number is used. AODV is reactive routing protocol, meaning that it establishes a route to a destination only on demand. When a link fails, a routing error is passed back to a transmitting node, and the process repeats. DSR is a reactive protocol; it uses source routing instead of relying on the routing table at each intermediate device.

Performance of cluster based protocol is compared with the existing protocols like AODV, DSDV and DSR. From that, we have found that Cluster based routing protocol's performance is more accurate compared to the existing protocols.

IV. EXPERIMENTAL RESULTS

To assess the performance of CBRP, simulated CBRP performance using simulator and compared its performance with other routing protocols such as AODV, DSDV and DSR. Performance is measured by number of nodes form a cluster and total data messages successfully delivered. Throughout the simulations, we consider several network configurations with several nodes.

TABLE 1. SIMULATION PARAMETER

Parameter	Value
Simulation Area size	250 X 250
Number of Nodes	50
Traffic	CBR (Constant Bit Rate)
CBR Packet Size	512 bytes
Transmission Range	250 m
Node Speed	Fixed 20 m/s
Mobility model	Random way point mobility

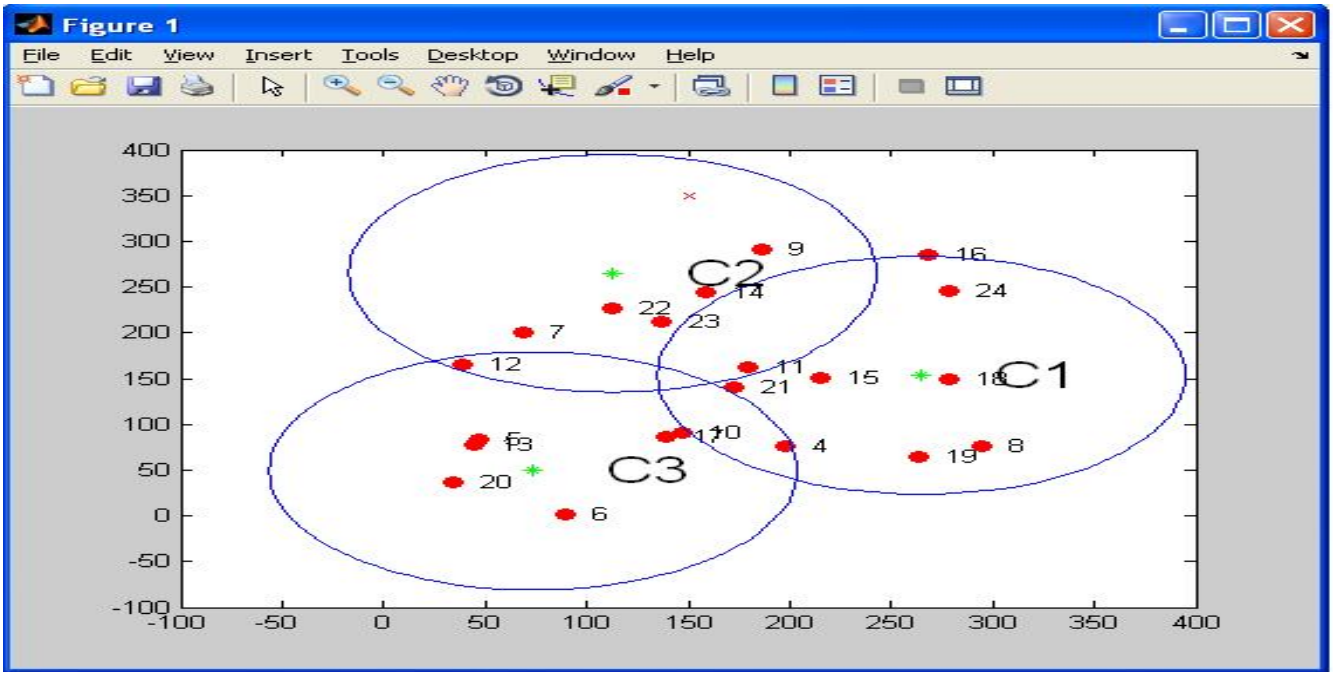

Figure 5. Cluster Formation

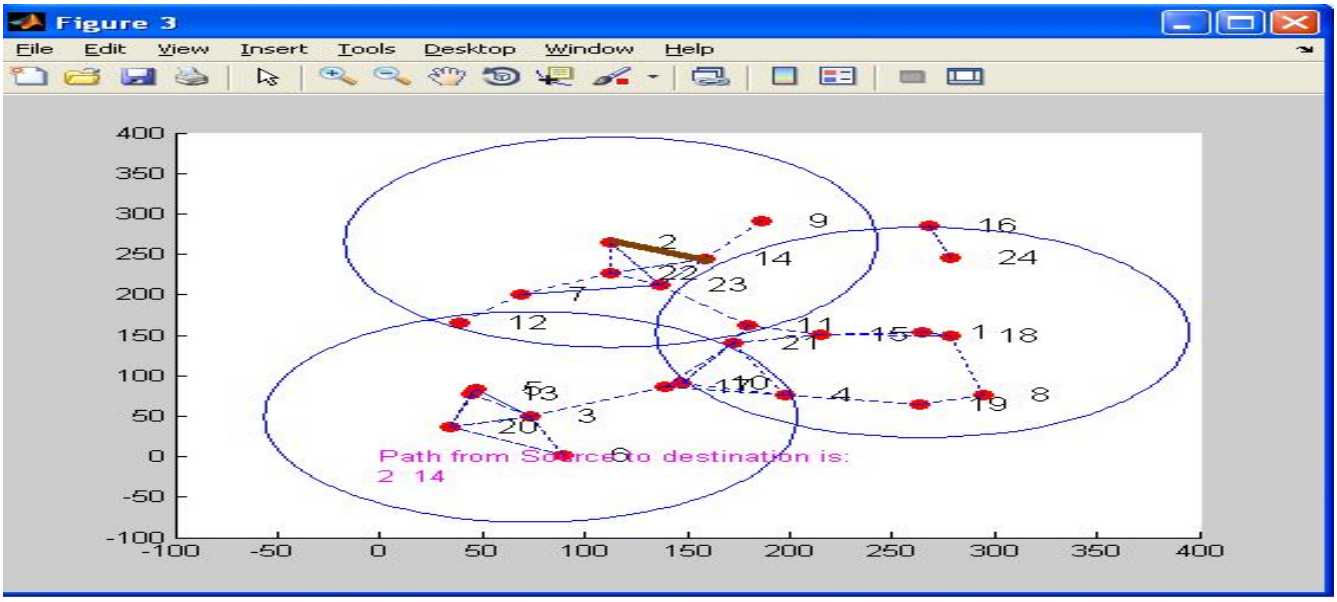

Figure 6. Inter Cluster Routing

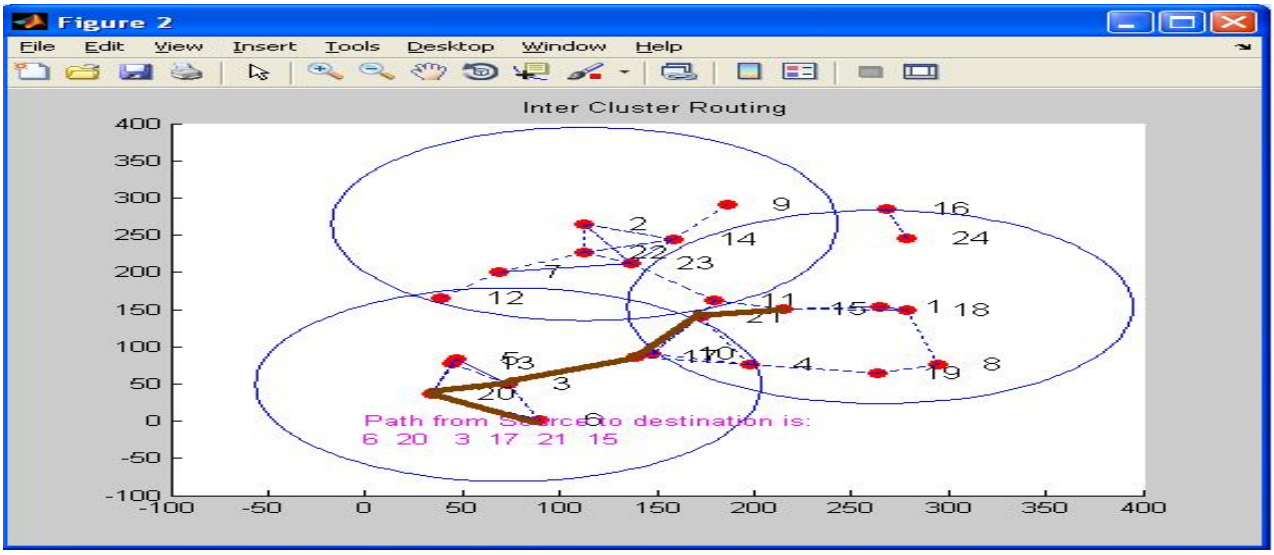

Figure 7. Intra Cluster Routing

TABLE 2. THROUGHPUT

Protocol	**Throughput for number of nodes**			
	50	**100**	**150**	**200**
DSDV	108	908	2418	5096
DSR	107.2	723.7	2069.9	3684.4
AODV	409.1	4313.9	16397.3	37597.9
CBRP	520	4917	18323	40000

TABLE 3. AVERAGE LATENCY

Protocol	**Average Latency for number of nodes**				
	0	**50**	**100**	**150**	**200**
DSDV	28	10	8	9	11
DSR	15	12	14	8	10
AODV	15	14	17	9	10
CBRP	10	11	12	7	8

TABLE 4. CONTROL OVERHEAD

Protocol	Control Overhead for number of nodes				
	0	**50**	**100**	**150**	**200**
DSDV	0.4	0.53	0.42	0.48	0.40
DSR	0.3	0.5	0.65	0.5	0.2
AODV	1.3	0.8	0.4	0.3	0.2
CBRP	0.2	0.4	0.3	0.25	0.1

TABLE 5. PACKET DELIVERY RATIO

Protocol	Packet Delivery Ratio for number of nodes				
	0	**50**	**100**	**150**	**200**
DSDV	0.8	0.7	0.9	0.95	1
DSR	1	1	0.9	0.95	1
AODV	1	0.9	0.8	0.9	1
CBRP	1	1.05	1.05	1.05	1.1

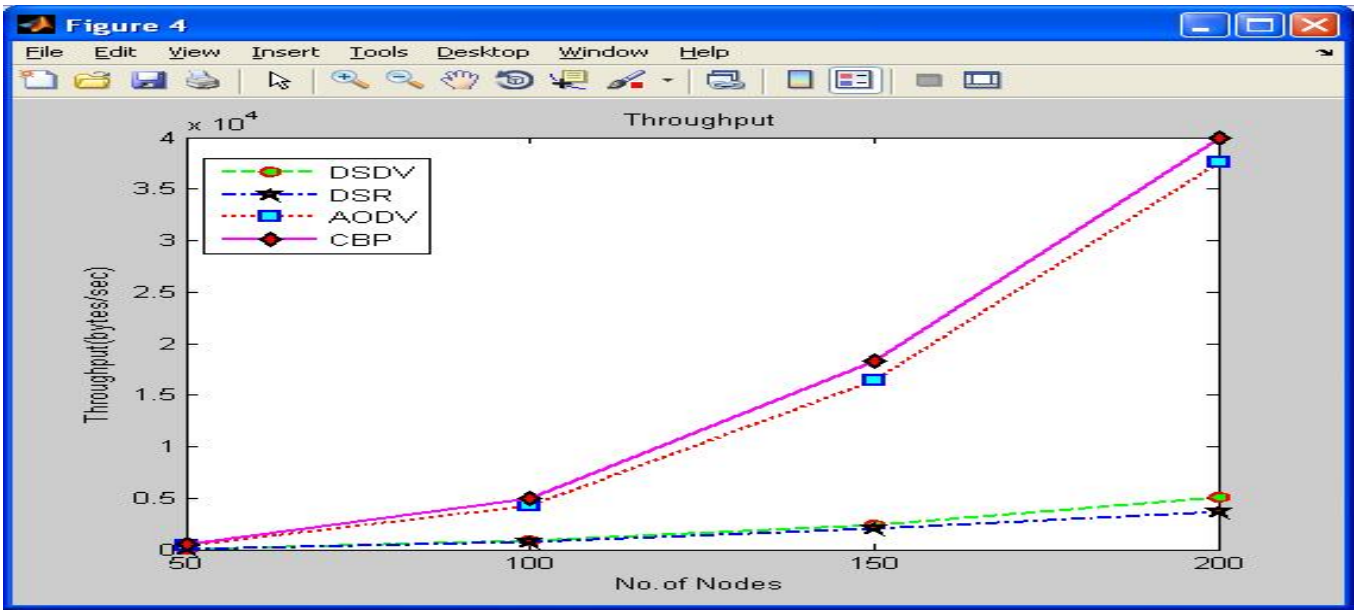

Figure 8. Throughput

$$\text{throughput} = \sum_{i=0}^{n} \text{pktrecvd}/\text{tmetkn}$$

where, pktrecvd is the number of packets received from source node
tmetkn is the total amount of time taken for receive a number of node from source.

Figure 8 shows the Throughput for all the four protocols. For each node, the corresponding throughput values are plotted. Throughput is the average rate of successful message delivery over a communication channel. This data may be delivered over a physical or logical link, or pass through a certain network node. This is the measure of how soon the end user is able to receive data [4]. CBRP (proposed protocol) shows higher throughput. CBRP has much more routing packets than the other. So, its throughput is higher than other protocols at high mobility.

Figure 9 shows the Average Latency for all the four protocols. For each node, the corresponding average latency values are plotted. These measures the delay time of a packet sent by the source and received by the destination. Whereas the DSR and AODV are reactive routing protocols, route is obtained while it is demanded. The route discovering may delay the transmission of data packets by queuing them in the buffer [3]. In CBP, the packets could be delivered from one cluster to next cluster quickly. So, CBRP has the best performance than the other protocols

$$Average\ latency = (pktsndtme - pktrecvdtme)/totpktrecvd$$

Where, pktsndtme is the total amount of time for sent all packets from source node
pktrecvdtme , the total amount of time for received all the nodes from source node
totpktrecvd is the total no. of packets received from source node

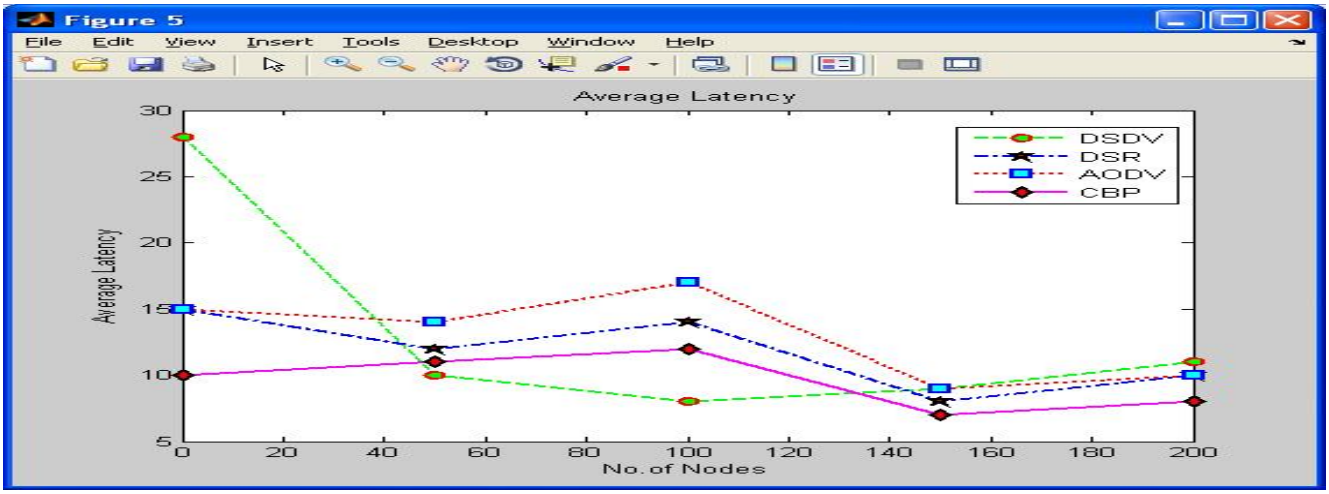

Figure 9. Average Latency

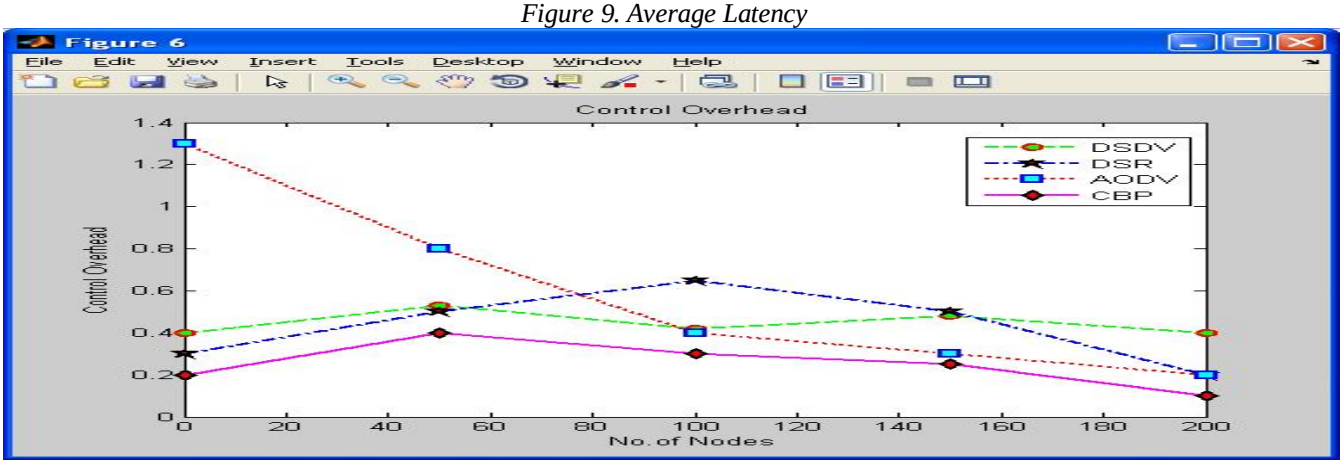

Figure. 10 Control Overhead

$$\text{control overhead} = \sum_{i=0}^{n} \text{numnodes} / \text{numpktgen}$$

Where, numnodes is the number of nodes,
numpktgen is the Number of packets generated.

Figure 10 shows the Control overhead for all the four protocols. For each node, the corresponding overhead values are plotted. The flooding of routing overhead has great influence on the performance of whole network [3]. CBRP limits the flooding of packets within the cluster. So, it indicates that overhead involved is lesser compared to other protocols.

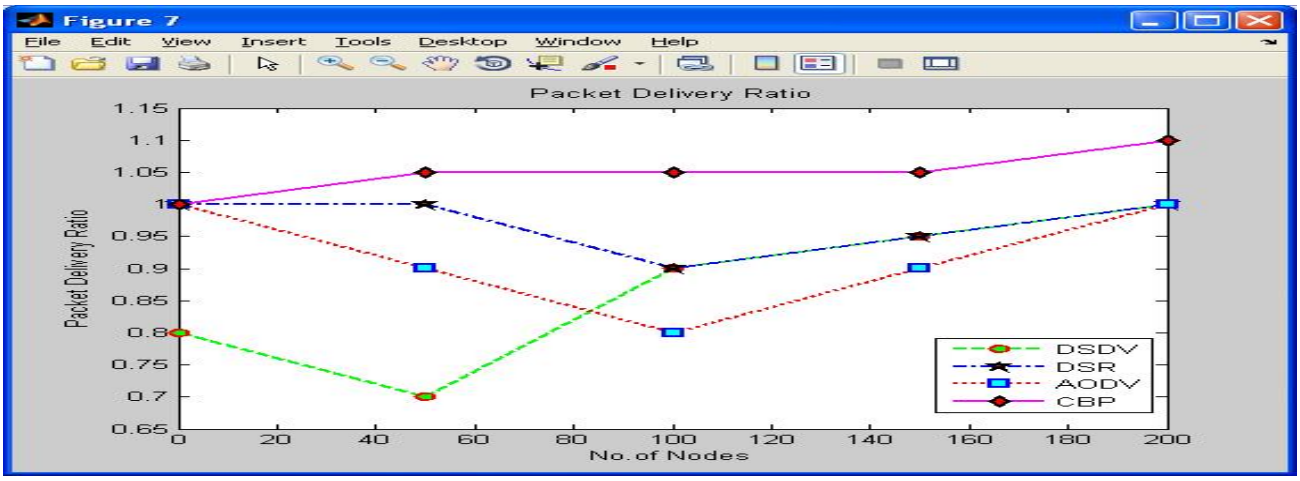

Figure 11. Packet Delivery Ratio

$$pdr = \sum_{i=0}^{n} pktsndsrc/pktrecvddest$$

Where, pktsndsrc is Number of packets sent by source Pktrecvddest is No. of packets received by destination.

Figure 11 shows the Packet delivery ratio for all the four protocols. For each node, the corresponding values are plotted. The ratio between number of packets sent by the source and number of packets received by the destination gives the packet delivery ratio. Other protocols have significant dependence on route stability, thus its packet received rate is lower [3]. Although, the amount of packet received is inversely proportional to propagation delay, CBRP has the best performance than other protocols. So, CBRP delivers more number of packets compared to other three protocols.

V. CONCLUSIONS AND FUTURE ENHANCEMENTS

In this paper, we have proposed a new technique for cluster based routing protocols like inter cluster routing algorithm. We have proved our idea by simulating a network of 50 nodes. While justifying our idea through results of our simulation we have considered the performance metrics like Throughput, Average latency, Control overhead and packet delivery ratio. By using proposed technique we have increases the throughput and packet delivery ratio in a network and we decreases the average latency and control overhead. At present, the proposed idea is implemented and tested for both intra cluster routing and inter cluster routing. Currently this protocol is implemented and tested in a simulation. This work can be tested on real motes and then while considering real environment more mature results can be achieved.

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