Asian Journal of Information Technology 15 (15): 2683-2692, 2016
ISSN: 1682-3915

Cross Layered Energy Conservative Multicast Routing Protocol For MANET

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Abstract: The Mobile Ad hoc Network (MANET) is a wireless network between the collection nodes which is constructed dynamically without using centralized infrastructure. In MANET energy conservation is one of the important challenge issue to improve the efficiency of the multicast routing in the network. We propose a Received signal strength based Cooperative Multicast Routing Protocol (RCMRP) that implements energy conservative technique over which the life time of every node increases for longer periods without frequent charging. It also ensures low communication overhead and reliable network connectivity. The cross layer framework is designed by combining physical, MAC and network layer. The physical layer provides reliable network connectivity by cooperative transmission. At MAC layer, the nodes are classified into clusters and the cluster head is responsible for inter cluster transmission. The Network layer has RCMRP. The received signal strength value is taken from the physical layer and is used as one of the parameter to make decision on whether to select the link or not, prior to the route discovery process. Because of this, number of route discovery process has been reduced which in turn reduces the energy consumption to great extend. The simulation results are compared with other three protocols such geographic routing protocol, Greedy Perimeter Stateless Routing protocol (GPSR), Cooperative Multicast Routing protocol (COMRoute) in terms of packet delivered, throughput, delay and Residual energy of the communicating nodes. The NS-2 simulation results reveals that the proposed work is energy efficient in reference to increased number of packets delivered and more residual energy of the network.

Key words: Co-operative transmission, partner clustering algorithm, RSS based Co-operative Multicast Routing (RCMRP), packets delivered, throughput, delay, residual energy

INTRODUCTION

The main objective of a multicast Routing protocol is to convey the data packet from a source to particular destination of a multicast group should be carried over with enough Quality of service (QOS) (Janssen *et al*., 2002; Tavli and Heinzelman, 2006). The Quality of Service (QOS) is defined as the performance level of a service offered by the network (Murthy and Manoj, 2004). Specially QOS is maintaining high Packet Delivery Ratio (PDR), keeping low packet loss and packet delay and reducing the energy dissipation of the network. During transmission of data, the energy associated with every node should be managed properly. In MANET, each node acts as a store and forward station for routing packets. When two nodes want to communicate, they can do so directly if they are within the radio range of each other or otherwise route their packets through other nodes. As the nodes are highly dynamic, maintaining routes become a greater challenge.

Generally, the routing protocols can be classified into two categories: tree-based and mesh-based. Tree-based approaches (Wu and Tay, 1999; Xie *et al*., 2009; Lee *et al*., 1999) maintain a single loop-free route between the source and each receiver while mesh-based approaches (Sun *et al*., 2006; Oh *et al*., 2008; Biradar *et al*., 2010, 2014) construct multiple routing paths from a source to each destination and the nodes can deliver data copies through separate paths. Tree-based approaches have low control overhead and excellent bandwidth utilization but they suffer from the frequent link breakage caused by node mobility. Compared with tree-based approaches, mesh based approaches are more resistant to the link breakage. However, they should pay for extra high maintenance cost and unnecessary bandwidth wastage. To solve the problems caused by Tree-based and mesh based approaches, it is required to design a new multicast routing protocol that incurs low communication overhead (as tree-based approaches) while guaranteeing reliable network connectivity (as mesh-based approaches).

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Clustering in WSNs is an effective technique for prolonging the network lifetime. In most of the traditional routing in clustered WSNs assumes that there is no obstacle in a field ofinterest. Although, it is not a realistic assumption, it eliminates the effects of obstacles in routing the sensory data. In this energy-efficient homogeneous clustering, the algorithm periodically selects the cluster heads according to a hybrid of their residual energy and a secondary parameter such as the utility of the sensor to its neighbors. In this way, the selected cluster heads have equal number of neighbors and residual energy. We then present a route optimization technique in clustered WSNs among obstacles using Dijkstra's shortest path algorithm. This method effectively reduces the average hop count, packet delay and energy-consumption of WSNs.

Greedy Perimeter Stateless Routing (GPSR), a novel routing protocol for wireless datagram networks that uses the positions of routers and a packet's destination to make packet forwarding decisions. GPSR makes greedy forwarding decisions using only information about a router's immediate neighbors in the network topology. When a packet reaches a region where greedy forwarding is impossible, the algorithm recovers by routing around the perimeter of the region. By keeping state only about the local topology, GPSR scales better in per-router state than shortest-path and ad-hoc routing protocols as the number of network destinations increases. Under mobility's frequent topology changes, GPSR can use local topology information to find correct new routes quickly (Karp and Kung, 2000).

A Cooperative multicast routing protocol, COMRoute which utilizes cross-layer design by integrating the physical-layer for cooperative transmissions, Medium Access Control (MAC)-layer for clustering and network-layer for multicast routing (Bhanumathi and Dhanasekaran, 2012; Li and Kai, 2009). This is an on demand source based multicast routing protocol which operates on network layer to construct robust and reliable multicast route with more reliability. However, more energy will be consumed for overhearing. In this case, a mechanism to reduce the energy consumption from unnecessary overhearing is needed. So to overcome this, an energy efficient algorithm for reducing the amount of overhearing based on RSS value (Royer and Perkins, 1999; Johnson and Maltz, 1996) has been designed. The RSS value determines whether to select the link or not prior to the route discovery process.

Physical layer with co-operative transmission: The cooperative transmission mainly deals with the physical layer issues. Cooperative transmission typically refers to a system which allows users to share and coordinate their resources in order to enhance the data transmission quality. This is a generalization of the relay communication where multiple sources also serve as relays for each other. Cooperative communications are firstly developed against channel fading effect at physical layer in wireless ad hoc networks. Cooperative communications, exploiting the wireless broadcast nature and utilizing signal combination scheme. When the sender sends its packets, the helpers overhearing the transmissions will relay the overheard signals to the destination simultaneously.

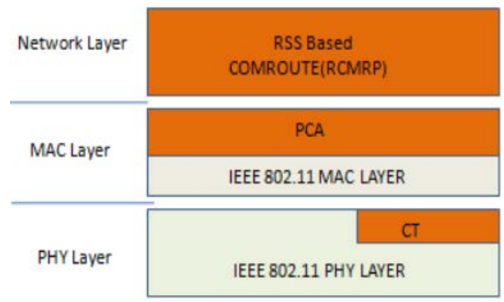

Fig. 1: Protocol architecture

The receiver getting these signals then uses signal combination scheme to decode these superposition signals. Utilizing cooperative communications, nodes enjoy the following benefits:

- Signal intensification: Through signal combining technique, the received signal can be intensified by receiving multiple copies of it
- Energy conservation: Because the signal can be intensified by receiving multiple copies, each node using a smaller transmitting power can still deliver data to its destination. It has been shown in (Cui *et al*., 2004; Zhou *et al*., 2008) how cooperative transmission saves transmission power
- Spatial diversity gains
- Reliability: Spatial diversity offers extra reliability when the channel condition is poor

Figure 1 shows the three-layer protocol architecture of RCMRP In physical layer, we design a Co-operative transmission scheme, CT on top of the IEEE 802.11 physical layer. In MAC layer, a partner clustering algorithm, PCA, is introduced to partition the network into a cluster. Finally, in network layer, RCMRP is designed to support on-demand cooperative multicast routing.

In this RCMRP architecture, nodes are separated into several clusters, each of which is constituted of one Cluster Head (CH) and many Cluster Members (CMs). The

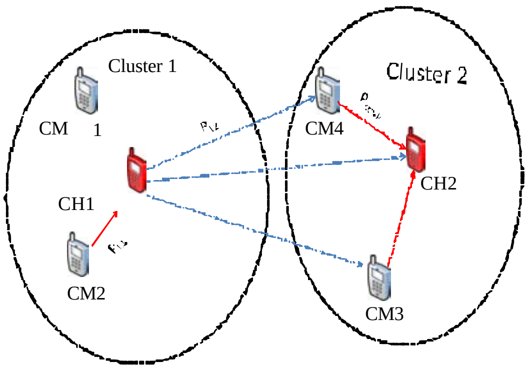

Fig. 2: Multi node code decode and forward co-operative transmission

CH within a cluster, acts like gateway which is responsible for inter cluster transmissions through multi-node decode-and-forward cooperative transmission between clusters. The CMs may or may not hear each other and only need to directly communicate with the CH. Moreover, we assume that each node, depending on its current role in the network can control their transmitting power between three power levels, PL1 PL2 and Pcoop. PL1 is used to conduct intra-cluster transmission or called Layer-one (L1) transmission between CMs and their CHs, PL2 is used by CHs to communicate with each other in inter-cluster transmission or called Layer-Two (L2) transmission while Pcoop is for cooperative transmission between CMs and their Chs. CM2 of Cluster 1 has messages to send to Cluster 2, it transmits the messages to CH1 (the CH of Cluster 1) using PL1 for the L1 transmission and the CH1 broadcasts the messages using PL2 for the L2 transmission. After that, the CMs in Cluster 2 receiving the messages cooperatively relay them to CH2 (the CH of Cluster 2) using Pcoop.

Figure 2 illustrates our considered transmission scheme. When CM2 of cluster 1 has message to send to cluster 2, it transmits the messages to CH1 using PL1 for L1 transmission and the CH1 broadcast the messages using PL2 for L2 transmission. After that, the CMs in Cluster2 receiving the messages cooperatively and relay them to CH2 using P_{coop} Because, we assume that CHs can combine signals through physical layer cooperative transmission, the more CMs participating in the transmission, the less transmission power needed. Therefore, Pcoop can be expressed as:

$$P_{coop} = \frac{\alpha * P_{L1}}{N_{cm}}$$

Where:

P_{coop} = The transmitting power of cooperative transmission

N_{cm} = The number of CMs and

α = A system parameter used to adjust a proper power level for the system

MAC layer with partner cluster algorithm: Specifically, Our partner clustering algorithm uses distance, relative speed and degree difference as metrics to select proper CHs periodically in a distributed manner and nodes of each cluster will select only one CH to join, forming logically non-overlapped 1-hop clusters. First, the nodes estimate their suitability for being a CH. After the suitability has been finalized, a suitability dissemination mechanism is then exercised. Finally, the nodes with higher suitability becomes CH the remaining are CM. The details of these steps are elaborated on as follows:

Step 1: Start

Step 2: Every node n in the network ,computes its suitability Sn for being a CH according to the following Eq. 2:

$$S_n = \frac{1}{D_n + V_n + Q_n} \tag{2}$$

Where:

S_n = The suitability of the node

D_n = The average distance

V_n = The average relative speed

Q_n = The degree Difference between n^{th} node and its neighbors

Step 3: Encapsulate the suitability score into BECON message and Broadcast it to 1 hop neighbor and rebroadcast to the next hop.

Step 4: A node having largest S_n with in 2 hop coverage area becomes CH.

Step 5: Elected CH add the CH information to ECON message and broadcast it.

Step 6: The CH's neighbours receive the message and becomes CM.

Step 7: The CM broadcast its information through BECON.

Step 8: The neighbor CH receive it and maintain cluster member list.

A node with a smaller average distance is likely to have nearer neighbors than other nodes. Consequently,

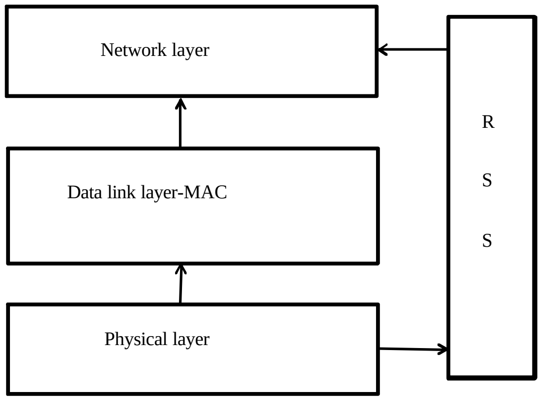

Fig. 3: Cross layer design

the cluster constructed by this node is stabler and this node is more suitable to be a CH. The D_n can be formulated as:

$$D_n = \frac{\sum_{i=1}^{K_n} \sqrt{\left[(X_n - X_{ni})^2 + (Y_n - Y_{ni})^2 \right]}}{K_n}$$

Where:

- K_n = No. of 1-hop neighbors of node
- $n (X_n, Y_n)$ = The position of node n and
- (X_{ni}, Y_{ni}) = The coordinate of the ith neighbor of node n

Similarly, the smaller the average relative speed Vn owned by a node n, the stabler the formed cluster. Vn is given as:

$$V_n = \frac{\sum_{i=1}^{K_n} \sqrt{\left[(V_{nx} - V_{nix})^2 + (V_{ny} - V_{niy})^2 \right]}}{K_n}$$

Where:

- (V_{nx}, V_{ny}) = The velocity of node n and
- (V_{nix}, V_{niy}) = The velocity of the ith neighbor of node n The needed information for n V_n, V_n computation are piggybacked in the MAC Layer BECONs

Cross layer design: A cross layer design is designed by covering the bottom three layers such as physical, MAC and network layer. Figure 3 shows the diagrammatic representation of the design The physical layer transfers the received signal strength value to the top layers. Mobility is defined as the average change in distance over time between all nodes (in m/sec).

Mobility can be found from the RSS of the corresponding links. When mobility of the nodes in a network is high, link errors frequently occur and this results in high stale route information in the route cache. This ensures the stability of the selected route for certain period of time. From this, it is clear that RSS determines the link quality. If RSS value is more, link quality will be good, otherwise link will likely to be broken soon. The RSS value is captured for determining the cache expiry of all the individual links, so as to conserve the energy, at the same time life time of the battery will be improved. Hence, it improves the overall lifetime of the network. The RSS value of these links such as link (i, j) are calculated based on the formula given in Eq. 3:

$$RSS = P_t(\frac{\lambda}{4\pi d})^n G_t G_r \quad (3)$$

Where:

- λ = Wavelength
- P_t = Transmit power
- $G_t\, G_r$ = Represents the unity gain of the transmitting and receiving antennas
- d = The distance between the transmitter and the receiver
- n = The damping factor and it denotes the power decay ranges from 2-4

Equation 3 is modified based on the assumption that the interference is negligible and it is given in Eq. 4:

$$RSS = \frac{P_t}{d^2} \quad (4)$$

The threshold (RSSthres) value for finding the overhearing and rebroadcast probability (POR) is calculated based on Eq. 5 as follows:

$$RSS_{therss} = \frac{P_t}{2} \quad (5)$$

Normally as the distance increases, the received signal strength starts decreasing. This increases the chances of link breakage between two nodes. Hence, the cluster with RSS value greater than RSS_{therss} is selected as forwarding cluster during the route establishment phase. Mobility model is chosen as Random Way Point (RWP) model. In this model, a mobile node moves on a finite continuous plane from its current position to a new location by randomly choosing its destination coordinates, its speed of movement and the amount of time that it will pause when it reaches the destination. On reaching the destination, the node pauses for some time distributed according to some random variable and the

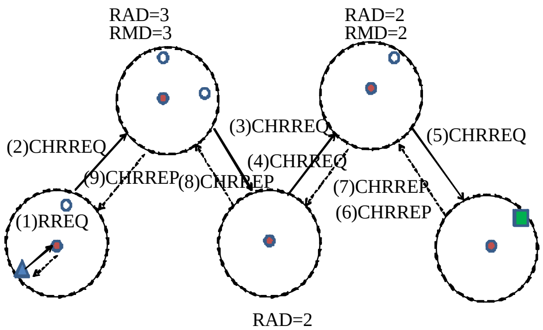

Fig. 4: Control packet exchanging procedure

process repeats itself. Once, the pause time expires, the node chooses a new destination, speed and pause time. The Mobility Parameter (MP) of the link is found out using the following formula given in Eq. 6:

$$M = RSS / Pt \tag{6}$$

Based on the mobility Parameter value, Overhearing and Rebroadcast Probability (POR) is calculated based on the Eq. 7:

$$POR = \frac{RSS_{thres}}{RSS} \tag{7}$$

In the proposed architecture, POR value is kept lower compared to MP for maintaining the conditional overhearing level of unicast packets as moderate. RREP here is a unicast packet. It is desired that the nodes which are present in the RREP packet should have a higher RSS value, then only it can withstand for some time. It improves the lifetime of the route. MP value is kept higher than the POR. This ensures a higher value of RSS.

Network layer with routing process: This section describes how the route process takes place using Received signal strength based Co-operative Multicast Routing (RCMRP). This routing involves three phases: Route Request (RREQ) phase, Route Reply (RREP) phase and data transmission phase. To implement the routing process effectively the following control packets are Essential and its usefulness are explained.

Control packets: In RCMRP, the source uses four kinds of control packets when it has data to send. The Route Request (RREQ) and Route Reply (RREP) are for intra cluster communication and Cluster Head Route Request (CHRREQ) and Cluster Head Route Reply (CHRREP) are for inter cluster communication. Figure 4 explains how the packets are exchanged to implement data transmission. When the source is Cluster Member (CM), it uses RREQ (1) packet to request its Cluster Head (CH) to start inter cluster route discovery and CH starts route discovery process by broadcasting the CHRREQ (2) packet. The neighboring cluster's CM decodes the packet and sends it to their CH. Now the CH combines the signals from latest hop and its CMs. The Co operative transmission thus extends until it reach the destination CH then the destination CH reply to the source by CHREP packet by activating the selected routing path. The source cluster's CH informs the CM to start data transmission through RREP packet.

RREQ phase: The RREQ phase invokes Route discovery procedure through two kinds of transmissions as mentioned below:

Intra-cluster RREQ transmission: If the multicast source is a CM, it asks its CH to start the inter-cluster route discovery by transmitting an RREQ packet. Otherwise, the procedure simply goes to inter cluster CHRREQ transmission (step 2). The RREQ packet transmitted inside the cluster contains the following information:

- Packet type shows the type of the packet
- Sequence number is uniquely assigned to a packet by the multicast hosts to identify the duplicate one
- Time To Live (TTL) is the maximum number of hops that the packet can reach
- Multicast group address shows the address of the multicast group
- Source address shows the address of the source
- Last hop address shows the address of the sender in the last hop transmission

Inter-cluster CHRREQ broadcasting: When the source CH receives the RREQ packet from the source CM or the CH itself is the source, it broadcasts CHRREQ packet with some new information which needs to be added with RREQ to create CHRREQ is mentioned as:

- Hop count shows the number of clusters visited by the packet
- RSS value shows received signal strength of node

Route Average Diversity (RAD) records the average diversity of the visited clusters. Here the diversity of an intra-cluster communication is defined as the number of members (including CH) participating in this intra-cluster cooperative transmission. At the beginning of each routing cycle, the CHRREQ packet is generated by the source cluster with the RAD field initialized to 0. During the traversal of the CHRREQ packet over different clusters, this field will be recalculated and updated by the Corresponding CHs as follows:

$$RAD = \frac{RAD_{last} * (N_{hop} - 1) + DIV_{current}}{N_{hop}} \quad (8)$$

Where:

RAD_{last} = The RAD recorded in the received CHRREQ packet
N_{hop} = The hop count until the current cluster
$DIV_{current}$ = The current diversity

Route Minimum Diversity (RMD): Similar to records the minimum diversity among the visited clusters. When CHs receives the CHRREQ packets, they will also update this information. Initially, this value is set to infinity. Note that andare used during the RREP Phase. It helps the destination CH to select a route with more cooperative partners (high and).

Figure 4 shows the example of updating RAD and RMD. The cluster Head CH of source cluster broadcast CHRREQ packet with RAD = 0 and RMD = α. The Cluster1 receive the CHRREQ packet through the cluster member cooperative transmission. Hence, it know the cluster members which take participation in the cooperative transmission, based on this it calculate RAD and RMD.

As per our example two members of cluster1 including CH has participated in cooperative transmission. So the RAD value of cluster1 is 3 as per the Eq. 8. The value is computed based on comparing the diversity of the current cluster with the value recorded in the received CHRREQ packet.The RMD value recorded in the incoming packet is α.

If the current diversity is smaller than the RMD value recorded, then it is replaced by the current diversity. The cluster 1 has current diversity of 3 which is lesser than α recorded, hence this value is updated. These two fields are updated hop by hop until it reach the destination.

Forwarding cluster address: It indicates the next hop to forward the CHRREP packet.

Cooperative transmission between partner clusters: When the multicast source has data to send, it invokes RREQ phase to discover the route. Next the Cluster head sends CHRREQ for inter cluster communication. The Neighboring Cluster's Members (CMs) receive the CHRREQ packet co-operatively and send it to their CH. These signals are combined by the corresponding CH utilizing the physical layer co-operative transmission. In RREP phase the inter cluster routes are setup by selecting the forwarding clusters. The CHs in the forwarding clusters are responsible for data transmission along the constructed route.

Routing information updating: When CH of the neighboring cluster receives CHRREQ packet, it checks whether it is duplicated one. If, it is duplicated one it just update the routing table otherwise it checks the Multicast Routing Table (MRT) to know, it could be a destination. If, it is not a destination CH updates MRT with updated values of RAD and RMD. The node updates the multicast routing table using the process of Backward learning. The source of the packet is stored in the destination field and the last hop in the next field. The activation field is initialized to zero and then activated by CHRREP packet if it is selected as forwarding cluster.

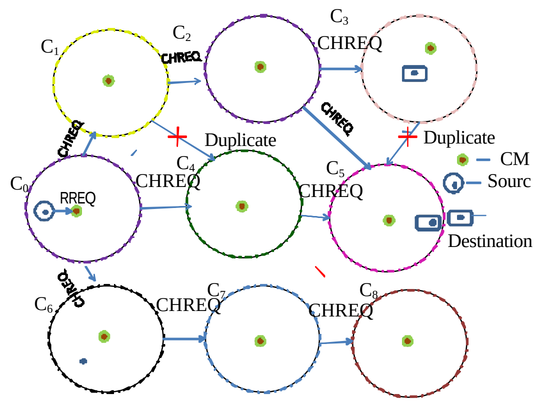

Fig. 5: CHRREQ phase from source to destination

Table 1: Multicast routing table

Activate	Destination	Next	RAD	RMD	CHRREP forwarder	Seq. No.	t-stamp
0	11	3	3	1	30	23	6741

The structure of MRT is shown in Table 1, thus the node of RCMRP make use of this multicast routing table for Data forwarding. When CHRREQ reach the destination CH it replies CHRREP to establish multicast route. The CHRREP has another one new field Forwarder Address field which informs the next hop to forward the CHRREP packet.

Figure 5 Shows how the CHRREQ packet broadcast through intermediate clusters and reach the destination CH. Here the multicast source is cluster member of the cluster C_0 the destination cluster members are in cluster C_3 and C_5. The RREQ phase operations are described as follows:

- The multicast source CM of C_0 transmit an RREQ packet to its cluster Head CH to invoke inter cluster route discovery process
- The CH of multicast source broadcast CHRREQ packet to establish inter cluster transmission
- The C_1, C_4 and C_6 receives the CHRREQ packets cooperatively
- Their CH check the cluster member list to ensure whether their clusters are destination

- Since they are not destination, they update the routing information and rebroadcast it
- The steps 3-5 are repeated until the packet reach destination

Phase transition: Steps 2-4 are performed repeatedly until the TTL of the CHRREQ packets is reached. Once a destination cluster is reached, the corresponding routing process moves into the RREP phase.

RREP phase: When a destination CH receives a CHRREQ packet, it waits a small amount of time to collect a few more CHRREQ packets and then transfers to the RREP phase. In this phase, the destination CH replies a CHRREP packet which assigns the forwarding clusters and establishes the routing paths. This forwarding cluster selection procedure performs as follows:

Minimum hop count and RSS information retrieving: The destination CH retrieves the minimum hop count information and RSS of each node from all the received CHRREQ packets and eliminates the routes whose hop counts are larger than the minimum hop count and Also whose RSS value is lesser than RSS_{therss} value.

Diversity factor computation: Diversity factor listed below is a parameter used by the destination CH to select a forwarding cluster among various clusters which indicates the suitability of being a forwarding cluster:

$$DF = RMD \times RAD = \frac{RMD \times \sum_{i-1}^{N_{hop}} DIV}{N_{hop}} \qquad (9)$$

During the RREP phase, a routing path with not only a high but also a high is selected that is reflected by the current Eq. 9. So that the cluster with more cluster member is selected as forwarding cluster.

Forwarding cluster assignment: The cluster with the largest diversity factor and larger Received Signal Strength (RSS) and minimum hop count is chosen as the forwarding cluster and its address is filled in the forwarding cluster address field of a newly created CHRREP packet. The destination CH then broadcasts the CHRREP packet.

Inter cluster chrrep co operative transmission: The neighboring clusters cooperatively receive the CHRREP packet. The cluster indicated in the forwarding cluster address field becomes the forwarding cluster and its CH sets the Activate field in its Multicast Routing Table (MRT) to 1 and thus it updates the corresponding routing information.

Route establishment: The forwarding cluster's CH repeats steps 1-4 but this time it replaces the role of the destination CH to assign forwarding cluster. This procedure repeatedly performs until the CHRREP packet reaches the source cluster. The Corresponding routing path is thus constructed.

To explain the RREP phase more clearly, we take the previous RREQ phase's destination C3 as an example. Figure 6 shows the detailed operations: (1) there are three candidate routes that can be selected by C3's CH: route 1 (C0-C1-C2-C3), route 2 (C0-C4-C5-C3) and route 3 (C0-C6-C7-C5-C3). Among these routes, route 1 and 2 uses three hops to reach the destination C3 and the other routes uses four hops. Thus, C3 eliminates route 3 whose hop count is larger than the minimum hop count .C3 computes the diversity factors for the remaining routes. The route 1 has the largest diversity factor as the forwarding cluster.

Therefore, the destination C3 prepares a CHRREP packet and forwards the packet to C2. The CH of C2 cooperatively receives the CHRREP packet from C3 and updates the routing information in MRT. Now, C2 takes the role of C3 and re-selects the next-round forwarding cluster. Figure 6 shows the CHRREP phase from destination to source. Similarly the routing has been found for destination C_5. Since the cluster C_5 is nearer to C_0, it send the CHRREP packet through the C final multicast routing with destination C3 and C_5 is as shown in Fig. 6. After establishing the route transition occurs for data transmission phase.

Data transmission phase: Once the source CH receives the CHRREP packet from all the destinations or a CHRREP timeout event occurs, It sends an RREP packet to notify the source CM to start the data transmission. Following the activated route in MRT, the data packets are cooperatively transmitted to the destinations. When the

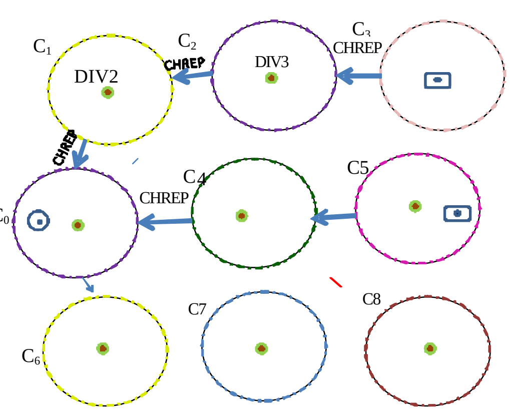

Fig. 6: CHRREP phase from destination to source

packets reach a destination CH, the CH communicates with the destination CM and transmits the data to it. Note that, we conduct the RREQ and RREP phases at the start of each routing cycle and thus the routing paths are updated periodically.

In this protocol, the shortest path will be constructed from destination cluster to source cluster based on which one of the shortest path has high diversity factor and high RSS value. Like this every cluster has one of its predecessor as it's forwarding cluster. This is informed through the multicast routing table as shown in Table 1. Besides, we do not need any extra control messages to refresh the routes. This method effectively reduces the control overhead and redundant packet transmissions.

RESULTS AND DISCUSSION

Figure 7 shows the performance achieved by RCMRP compared with other three protocols in four parameters packet delivered, packet loss, throughput, delay, residual energy. The performance results are collected through an Event driven simulator which models the environment in terms of network model, mobility model, traffic model.

Network model: For the evaluation of the proposed methodology, network simulator NS-allinone-2.28 on windows platform is chosen as the simulation tool. The ad-hoc network topology with 50 nodes in an area of 850×1000 m^2 was considered. The data traffic is Constant Bit Rate (CBR) traffic which is chosen as 120 Mbps. The packet rate injected in the network is 6 packets sec^{-1}. The packet size is 256 byte for every second. Two Ray random access model is considered for the simulation with simulation time of 50 sec. Nodes transmit signals that propagate without error to other nodes within a radius of 250 m. The various simulation parameters used are listed in Table 2.

Mobility model: All network nodes apply the random Way point model. In this model, nodes are uniformly distributed to an area initially and each node moves to a randomly chosen destination with a velocity ranged from 0 to Vmax. Once reaching the destination, a node stays with a random period ranged from 0 to T_{rest} max and then selects a new destination for next travel.

Traffic model: The source nodes uses constant Bit Rate Traffic (CBR) generating 6 data packets per second. Each packet have payload and Header. The Multicast scenario consists of one source and two or more receivers.

Packets received and packet losses: In Fig. 8, we observed that the packets received for RCMRP is higher than the packets received for Normal COM Route. This is because the Route found by this method is more stable, since it avoids the weaker link to participate in routing process. Simulation results showed that RCMRP efficiently solves the frequent link breakage problem and thus increases the packet received more than that of COMRoute. Total packet received in the RCMRP is 3871 after the simulation time whereas the total packet received in Normal COM Route is only 3462. The packets received is more than all the other Protocols like Geographic and GPRS Routing.

Table 2: Simulation parameters

Notation	Values (RCMRP)
No of nodes	50
Simulation time	50 sec
Routing time	29 sec
Simulation area	850×1000
Transmitting node power	99.88
Height of antenna	1.5
Dist_CST	550 m
Packet received	3619
Packet loss	8
Packet generated/sec	6
Mobility model	Random way point
Traffic rate	128 bytes
Traffic model	CBR

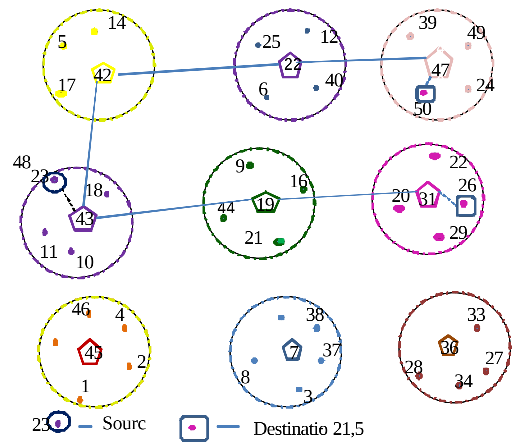

Fig. 7: Data transmission using RCMRP

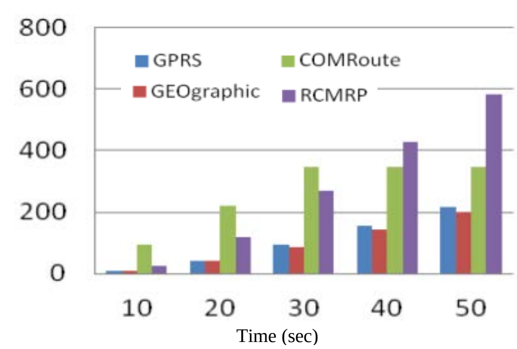

Fig. 8: Packets received

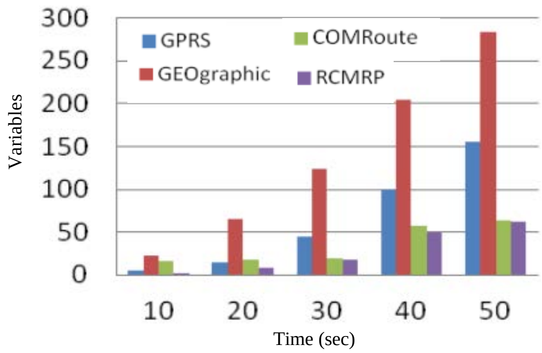

Fig. 9: The packet loss

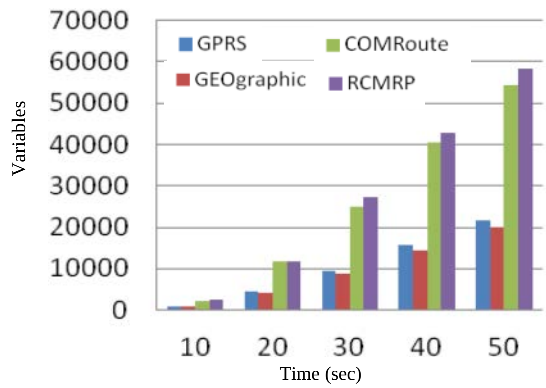

Fig. 10: Throughput

The packet loss occurred in RCMRP is more lesser than GPRS and Geographic protocols and it is also lesser than COMRoute with lesser amonnt.After the simulation time of 50 sec the COM Route has 64 packets loss where as in RCMRP the packet loss was 62 only. During the starting stage of simulation that is afterr 20 sec the COM Route got 18 packets loss and the RCMRP has onlt 8 packets lossed (Fig. 9).

Throughput: It is defined as the total number of packets delivered over the total simulation time. The throughput comparison shows that the four algorithms performance margins for different simulation timings. We know that throughput increases when connectivity is better. The RCMRP has better connectivity than all other protocols is evident from the following comparison (Fig. 10).

End to end delay: Figure 11 the average time it takes a data packet to reach the destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue. This metric is calculated by subtracting time at which first packet was transmitted by source from time at which first data packet arrived to destination. Mathematically, it can be defined as:

$$\text{Avg. EED} = S/N$$

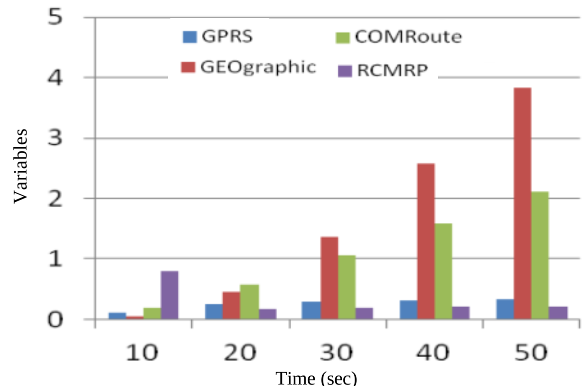

Fig. 11: Delay

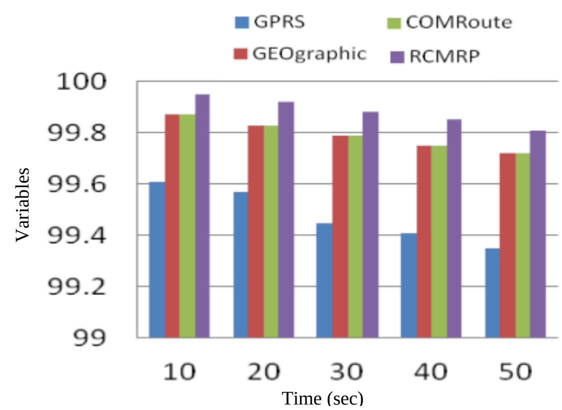

Fig. 12: Residual energy

Where:

S = The sum of the time spent to deliver packets for each destination and

N = The number of packets received by the all destination nodes. The observed performance reveals that the RCMRP has less delay than all others

Energy level of the network: Since our protocol highly reduces the overheads in Route discovery process, the nodes need not dissipate more energy for sending more control messages and also for retransmitting the data. This subsequently increases the energy level of the nodes. This is more evident from Fig. 12 that the energy level of the Network is more for RCMRP than all other protocols after all the packets are received. After 35 ms the energy level of the network in RSS based protocol is 99.85 Joules. But, in normal CMRP it is only below 98 Joules.

CONCLUSION

In this study, we proposed a RSS based cooperative multicast routing protocol, RCMRP which utilizes cross-layer design by physical-layer cooperative transmission, MAC-layer clustering and network-layer multicast routing. RCMRP took the diversity and RSS value into account for route establishment and thus achieved robust network with more throughput and residual energy. It also reduces control overhead and energy consumption than previous CMRP without RSS value. The entire performance in terms of packet received, packet loss, Throughput, delay, residual energy all are better than the other protocols GPRS, Geographic Routing, COM Route multicast protocols.

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