# COOPERATION AND OMNI-STEERABLE: A COOPERATIVE OMNI-STEERABLE ROUTING PROTOCOL (COSRP) FOR WIRELESS ADHOC NETWORK

Nagesh R
Department of Electronics and Communication,
Bangalore Institute of Technology, Bengaluru, Karnataka, India
nagesh.r@gmail.com

Dr. M N Sreerangaraju
Department of Electronics and Communication,
Bangalore Institute of Technology, Bengaluru, Karnataka, India
mnsrr@rediffmail.com

Navyashree H C
Department of Electronics and Communication,
Govt SKSJ Technological Institute, Bengaluru, Karnataka, India
navyashree130199@gmail.com

**Abstract - Due to the rapid development in Wireless Ad-hoc Networks, spatial reuse plays a significant role in refining network capacity. Cooperative communication is a scheme that enables proficient utilization of communication resources and entailed Quality of service (QoS) by exploiting transmit diversity property of MIMO technique. Two leading technologies that can influence the future of wireless networks are Co-operative communication and Directional antenna systems. Directional antenna leads to substantial increase in coverage range, spatial reuse, and overall network capacity. However, combining cooperative communication and directional antenna is a challenging process which involves issues in proper relay selection [2]. We propose a decentralized cross layer protocol, namely, Cooperative Omni-steerable Routing Protocol (COSRP) for wireless Adhoc network. In COSRP the relay selection is based on highest residual battery of a node. Further each node intelligently switches from omnidirectional beam to omni-steerable directional [OSD] beam in cooperative mode. In this paper we enhance the CORB protocol by leveraging physical and network layer co-ordination that was not accomplished in the CORB protocol [13]. During Direct transmission of data, every node uses omnidirectional beam, When the Packet Reception Ratio [PRR] reaches below threshold, cooperative communication is enabled which in turn activates OSD beam in Source, Relay and Destination. The proposed protocol brings coordination between Network layer and Physical layer to effectively utilize the benefits of Cooperative communication and Directional antenna. By analyzing various simulation studies, the results prove that proposed COSR protocol boost the throughput and packet reception. Since, relay selection and monitoring of antennas is done in Network layer overall network performance improved.**

***Keywords*:** Co-operative Communication; Omni-Steerable directional beam; Residual battery; Wireless communication; Directionality; Throughput; Quality of Service (QoS); Beam formation.

## 1. INTRODUCTION

Directional antenna is gaining scopes in space missions, satellite television installations and dish used in satellite internet. Omnidirectional antennas find their applications in radio broadcasting, mobile devices which make use of radio such as walkie-talkies, cell phones and wireless computer networks. In Omni-Steerable Directional antenna coverage range is monitored using six beams each covering an area of 60$^o$. Omni-Steerable directional antennas find advantageous over omnidirectional antennas as it provides dimensional reuse, larger transmission and reception range. The directional antennas best suites when available signals are weak and it also works with frequency bands common for 4G LTE. Cooperative communication also known as virtual MIMO, is a scheme which allows communicating nodes in a network to hear and help the transmission of data to destination by utilizing the broadcast complexion of Wireless communications. Spatial reuse technique involves enabling two communications to occur at same time on the same link. Introducing directional antenna improves outage property of cooperative communication networks [9]. CoopMAC protocol takes the advantage of cooperative communication and utilize the functionality of directional antenna to provide better throughput and delay [1]. Combining cooperation and directional antennas degrade the performance, they are rather foes than friends [2]. By using active relay selection algorithm, cooperation and directionality behaves as friends [3].

In this paper, we focus on locating neighbor's position and give prominence to select best relay to transfer data using Omni-Steerable directional antenna. In proposed COSR protocol the reserved bits in RREQ and RREP control packets are utilized to include the information such as Residual Battery life (one byte) and C bit (one bit). The C-bit is used for enabling the cooperative mode. Locality information (Loc-three bit) is maintained to activate one of the six beams based on the azimuthal angle information. Each node maintains COSR table which keep track of information regarding neighboring nodes. The Residual battery information is used to select the best relay for data forwarding, azimuthal and elevation angle which is obtained through RREQ or RREP is used to discover the position of nodes. Correspondingly three bits of locality information is set which in turn activates the beam. when packet reception ratio (PRR) falls below threshold value C bit is set indicating coop mode is enabled. In omni-steerable directional antenna, when RREQ is transmitted by a node, all the six beams will be activated resulting in omnidirectional transmission (360$^o$).

The paper is organized as follows. In section II, we introduce the related researches made about combining Cooperative Communication and Directional antennas. In section III, we propose the Routing protocol that accustoms omni-steerable directional antennas. Section IV deals with the methodology and operation of proposed COSR protocol. Section V gives the information of simulation parameter and scenario. Section VI evaluation the performance proposed protocol by considering different QoS parameter. Finally, section VII, the Conclusions and Future work are discussed.

## 2. RELATED WORK

In wireless network, optimization of resource usage and power consumption plays a major role. different works have been published in the field of cooperative communication and Directional antennas to study and improve network behavior in combination of these two technologies.

Z. Tao etal [1], claimed pioneer effort to address the collaboration of cooperative communication and Directionality, by scheming a new protocol known as Co-op directional MAC. Operations in both Data plane and Control plane deals with directional antennas. With the help of Cooperation table [Coop Table] and location table[L-Table], the paper provides simulation results which presents the integrity of its use of cooperation with directional antenna nodes for a mobile network. Proposed Co-op directional MAC protocol outperforms other three protocols namely: legacy IEEE 802.11 DCF, Directional MAC and Omnidirectional Coop-MAC with reference to throughput and delay. To investigate system performance in an Adhoc network with appropriate routing protocol is kept as the future work.

Feilu liu etal [2], designed three MAC protocols D-NoopMAC, O-CoopMAC, and D-CoopMAC to study the effect of directionality with cooperative communication. The information related to neighboring stations and their positional information is recorded by maintaining Coop Table and LocTable respectively. Simulation results prove that cooperative communication and directional antennas are foes rather than friends. Relays prevent parallel transmissions by silencing its neighbors and also as the transmission become more directional, probability to find a suitable relay for cooperative forwarding decreases, these two reasons make cooperation and directionality to behave as foes. By implementing active relay selection algorithm can combine these two techniques.

Yi-Yu Hsieh etal [3], proposed an Active Helper Selecting Mechanism for D-CoopMAC protocol. This paper provides a mechanism for source to select the appropriate relay by the use of D-CoTable. With the help of Active helper selecting mechanism helpers will complete its table by selecting its own helpers rather than by passive overhearing and this improves network performance. The author concludes that by fully exploiting cooptable of directional antenna nodes and prevention from interfering with other transmission, two techniques can be friends. Cross layer design and including node mobility is left as future work.

Thanasis Korakis etal [4], proposes MAC protocol that employ directional antennas in the network. This paper speaks about problems associated with directional antenna and tries to provide solution for it. Hidden station problem, Deafness and finding neighbor's location are addressed. By sending circular RTS by transmitter and circular CTS by receiver, hidden station problem can be solved. Location of neighbors are maintained in the form of table called Location table which involves source, Neighbor, Source beam from which it heard packet, Neighbor's beam which received the sent packet information. Effort is made to increase the transmission range with the use of Directional antennas and results proved that there is improvement in performance of Directional transmission compared to performance of omnidirectional transmission.

## 3. PROPOSED ROUTING PROTOCOL

Co-operative routing with Omni-Steerable directional beam is presented in this section which depends on the Cooperative residual battery protocol [CORB] that was designed for efficient resource utilization [13]. In this paper we enhance the CORB protocol by leveraging physical and network coordination in order to utilize the complete benefits of cooperative network.

The key modification and improvement of our COSR protocol with the conventional CORB are

- Selection of transmission beam during Data plane based on highest residual battery node and its position.
- RREQ and RREP packet are modified by incorporating a new field known as Residual battery life of the node which is operating on the packet, location information of neighboring node to activate the beam and maintaining the cooperative enabling bit.
- Activating the beam that directs the data towards the selected relay node.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |J|R|G|ResidualBattery|C| LOC |Rs|   Hop Count|  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Broadcast-ID                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    IP Address of Destination                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Destination Sequence Number                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      IP Address of Source                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Source Sequence Number                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Fig. 1. Modified RREQ Packet.

Out of thirteen preserved bits from conventional RREQ packet one byte is used to handle the residual battery message of node, one bit is used to enable or disable the cooperative mode and location information (LOC) three bits is used for representing and activating beams. Fig 1. represents the RREQ packet format of COSR protocol. The binary pattern for activating beam and its ranges is shown in Table 1. and the beam formation is shown in Fig 2. The '111' and '000' pattern is considered as a redundant pattern.

Table 1. Binary pattern of beam activation

| Binary Pattern | Beam | Coverage |
|---|---|---|
| 001 | Beam 1 | $0^0$-$60^0$ |
| 010 | Beam 2 | $60^0$-$120^0$ |
| 011 | Beam 3 | $120^0$-$180^0$ |
| 100 | Beam 4 | $180^0$-$240^0$ |
| 101 | Beam 5 | $240^0$-$300^0$ |
| 110 | Beam 6 | $300^0$-$360^0$ |

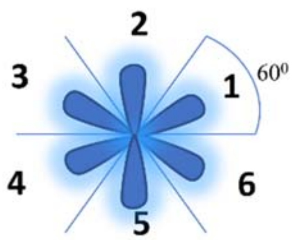



Fig. 2. Beam pattern of node.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |R|A|Residualbattery|C| LOC |psc|   Hop Count   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Destination IP address                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Destination Sequence Number                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    IP address of Source                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Lifetime                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Fig. 3. Modified RREP packet.

In the twelve preserved bits of Conventional RREP, one byte is used to include residual battery details of nodes and three bits for beam activation. The C-bit is used for enabling Cooperative-mode. Fig 3. represents the conventional COSRP RREP control packet.

Table 2. Binary pattern of beam activation

| |
|---|
| Destination node's IP Address |
| **Beam Number** |
| **Residual Battery Life** |
| Lifetime |
| Interface |
| Hop Count |
| Next-Hop |
| Last Hop-Count |
| Routing Flag |
| Precursor list |
| Destination node's Sequence number |

New fields, such as Residual battery life is incorporated in COSR table to keep track of the details of the residual energy of nodes that are participating in the route formation process and Beam number is used as location information of neighboring nodes. The source selects the node which has the highest residual energy and beam that points towards the selected node is enabled for data transmission.

### 3.1. *Control Plane*

The MAC protocol 802.11 DCF is used to build the proposed COSR protocol. According to DCF a random back off time is used before data transmission in order to sense the channel is idle. In the CORB protocol source node gathers the residual battery life information of the intermediate node based on which, the relay is selected for forwarding the data to the destination. The major enhancement in COSR protocol compared to CORB is that the station which are equipped with omni-steerable directional antenna congregates the Position information of intermediate nodes along with the residual battery life. The information is gathered using control packets (RREQ and RREP).

When the source node wants a data transmission, it broadcasts the RREQ packet in all the direction using the omnidirectional antenna. RREQ contains the residual battery life and locality information of the node in addition to the conventional AODV RREQ packet information. Locality information of each node is obtained using azimuthal and elevation angle which are calculated based on the arrival of RREQ or RREP packets. In Omni-Steerable antenna each node's transmission range is divided into six patterns of beam where each beam covers 60 degree of area. The angle information is used to activate one of the beams along which RREQ or RREP is arriving. Each node also maintains the COSR table that keep track of all the information of the potential relay nodes. If a potential relay node exists with greater residual battery life then source node makes use of the locality information of selected relay to transmit the data effectively and efficiently.

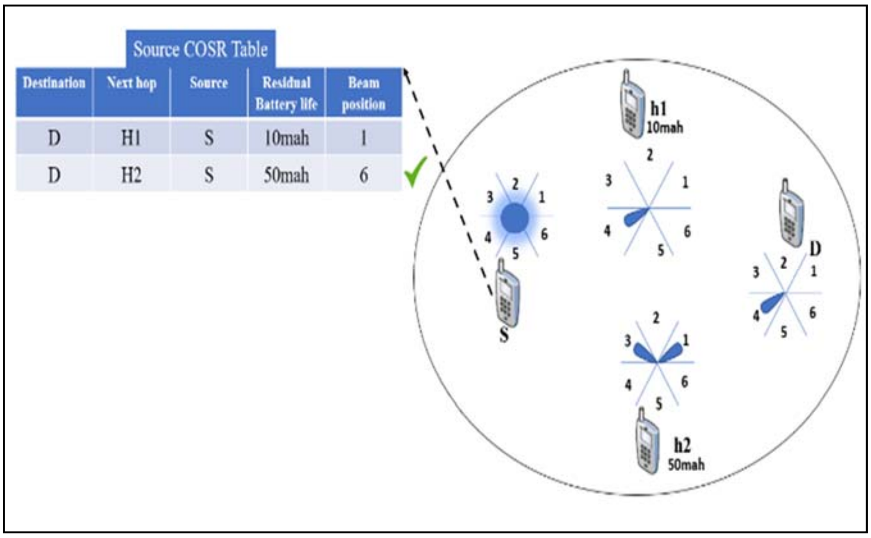



Fig. 4. Illustration of table establishment.

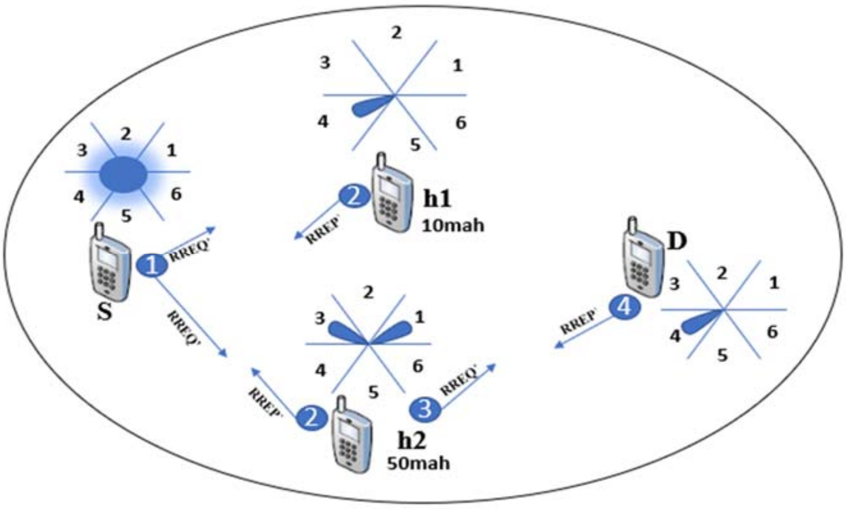



Fig. 5. Control plane working.

Once the RREQ is received by neighboring nodes, they decode the information obtained from RREQ and update the COSR table. On successful updating of COSR table the neighboring node creates individual RREP packet that contain its own residual battery life and position information. Based on the direction in which RREQ was received the neighboring nodes unicast the RREP packet. Unicasting different RREP to the source helps in addressing different intermediate potential relay nodes h1, h2…………hn using different beams. Once the beams of each nodes are activated in control plane, the same beams are used for data transmission in data plane. Since the modification is brought in AODV the data is forwarded based on least hop count and residual battery life information. On comparison of COSR protocol with AODV protocol, throughput and Network lifetime of COSR progressively increased. The complete action of COSR protocol is shown in Fig 4. and the control plane operation is shown in Fig 5.

### 3.2. *Data Plane*

The data transfer is comparatively straight forward where in source node should transmit data to the highest residual battery relay node through the selected beam. This, after a small interval of time forwards the data to the next hop or to the intended destination node based on the selection of beam pattern. Fig 6. shows the working of data plane. As a confirmation of successful transmission of data, the destination node unicasts an Acknowledgement (ACK) to the Source node. If there is no Acknowledgment within the timeout period then retransmission of data takes place until the threshold limit for retransmission is reached.

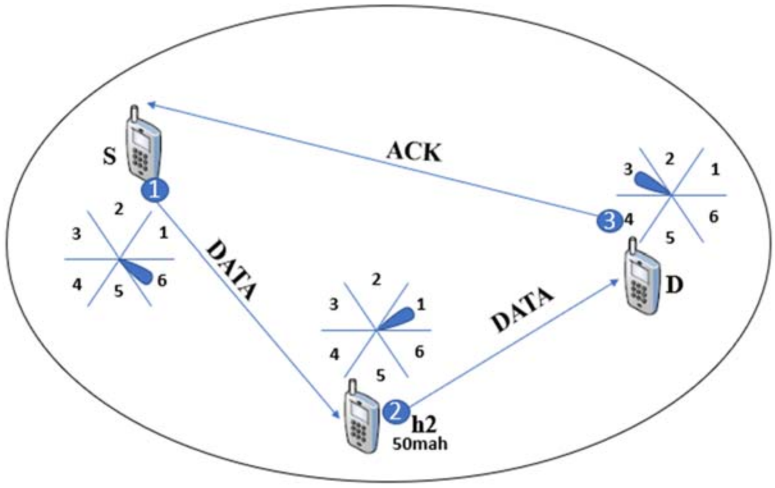



Fig. 6. Data plane working.

### 3.3. *Relay selection algorithm*

(1) Gathering the residual battery life and locality information of all neighboring nodes.

(2) Computing all the residual battery information to select highest residual battery node.

(3) Fourth item in the first level

- (i) Activate corresponding beam which leads to the selected node
- (ii) Transfer the data to the node which is selected.

(4) ELSE

- (i) Again, gather the information of residual battery life to search for the node having highest residual battery.

(5) End

## 4. METHODOLOGY

### 4.1. *Working of Helper Node*

Selecting Relay node from a cluster of neighbor nodes is the most important and challenging task in cooperative communication. In COSR protocol, node with greatest battery life is chosen as the relay. When source broadcasts RREQ packets along with its Residual battery energy, the intermediate nodes calculate the angle of reception of the RREQ packet and activate the corresponding angle of beam such that when data arrives, the same beam efficiently receives the data. Further the intermediate nodes send the RREP by adding their own residual energy details and set the beam number from where it accepted the RREQ packet. RREQ packet is sent from source node with omnidirectional antenna and the helper node update the information of beam with the help of angle from where it accepted source's RREQ also updates the beam in the table and sends RREP packet using Omni-steerable antenna from the beam information in the COSR table. Hence the COSR table is updated with residual battery information and information of beam number. The relay node checks the destination address, if the destination address is same as the current relay address then data is sent to upper layer, else if the address is different the data is forwarded until it reaches to the destination.

### 4.2. *Working of Source Node*

Source node broadcasts modified RREQ control packets to all direction using omnidirectional antenna. Intermediate nodes receive the RREQ packets and send back modified RREP packets. The RREP contains the residual energy of intermediate node and the beam number through which RREQ is obtained. Later on, successful reception of RREP, source selects the Quantitative Relay based on highest battery energy and sends the data based on the beam number that was updated in the COSR table. When PRR ratio is less than the threshold, Cooperative mode is enabled and nodes are equipped with Omni-Steerable antenna for data reception.

### 4.3. *Working of Destination Node*

The destination node continues to be in idle mode till it receives a RREQ from any other node. When RREQ is received the node gathers all the required information and checks the final destination IP address to check whether it is same as the IP address of current node that is handling the control packet. If the destination IP address same as current node's IP then, current node's IP address is placed in the destination address field of RREP packet. The transmission of RREP is from the beam through which it received the RREQ and the same beam number will be set in RREP. Further data is forwarded from source node, to ensure reliable transmission of data an acknowledgement will be sent to the source. If there is no ACK with in the traversal time then the packet will be retransmitted to the destination.

### 4.4. *Mode of data transmission (DC / CC)*

Whenever the Direct Communication (DC) of data not possible or when the Packet Reception Ratio (PRR) is below threshold δ limit, cooperative Communication (CC) mode is enabled. Equation (1) is used to find the PRR value.

$$PRR = \frac{PR}{PT} \qquad (1)$$

Where, PR is Number of received packets

PT is Number of sent packets

Algorithm to enabling Co-operative mode

(1) Initialize: Formulate the PRR value

(2) IF - PRR < δ

(i) Switch to Cooperative Communication

(ii) Select Omni-steerable antenna on each node

(3) ELSE

(i) Enable Direct Communication.

(4) End

### 4.5. *Friis Transmission Formula*

$$P_{rxd} = \frac{G_{txd} G_{rxd} \lambda^2}{(4\Pi d)^2} * P_{txd} \qquad (2)$$

Where $P_{rxd}$ = Power at receiving antenna

$P_{txd}$ = Power at transmitting antenna

$G_{txd}$ = Gain of transmitting antenna

$G_{rxd}$ = Gain of receiving antenna

λ = c/f operating wavelength

$d$ = distance between antennas

### 4.6. *Formula to calculate the Quality of Service parameters*

1. Throughput = ($T_B$ * 8) / ($S_t$ - $F_t$) (3)

where $T_B$ = Data received in Bytes

$S_t$ = Total time for Simulation.

$F_t$ = Time at which first packet arrived

2. Average delay = ($T_D$) / ($N_P$) (4)

where $T_D$ = total transmission delay for packets received

$N_P$ = Total packets.

## 5. SIMULATION SCENARIOS

The proposed COSR protocol performance is evaluated using with Qualnet 7.1 Network simulator, Fig 7 indicates the network scenario. Table 3. gives information about the parameter that are used in the simulation.

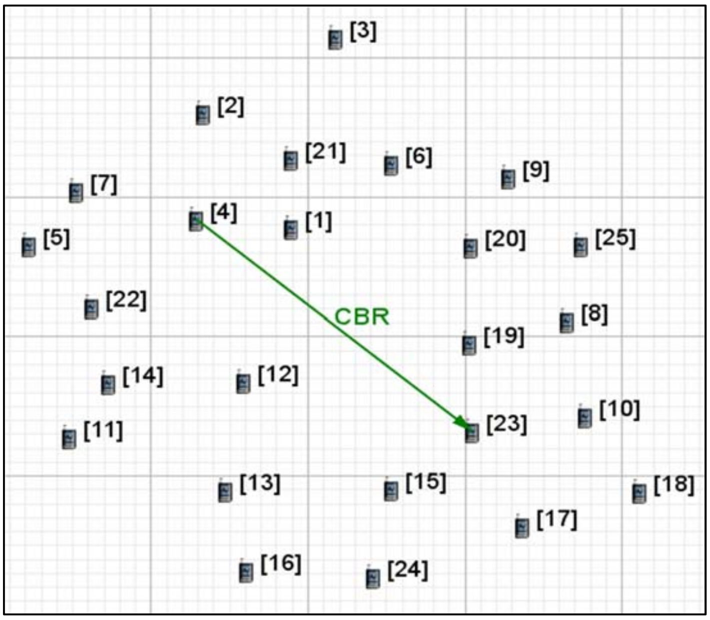



Fig. 7. Scenario of Cooperative network.

Table 3. Simulation Parameter

| Parameter | Values |
|---|---|
| Total nodes | Varies from 25-100 |
| Simulation period in seconds | 300 |
| Terrain area (meter sq.) | 600 x 600 |
| Wireless MAC | 802.11 DCF |
| Traffic generator | Constant Bit Rate (CBR) |
| Packet sent | 1000 |
| Individual packet size (Bytes) | 2048 |
| Threshold limit of PRR | 0.6 |
| Packet Reception model | PHY802.11b |
| Condition for mobility | Random-waypoint |
| Frequency (GHz) | 2.4 |

Wireless network is established by positioning nodes randomly in a 600m x 600m terrain. In order to evaluate the working of cooperative communication the source node and destination node are placed far from each other due to which direct communication (DC) is completely truncated. Many intermediate potential relay nodes help in forwarding the data packets to the destination. The beam pattern of Omni-steerable directional antenna is shown in Fig 8.

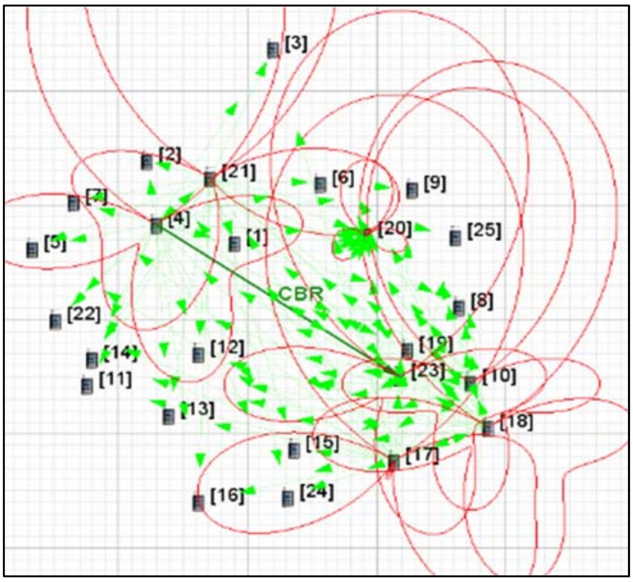
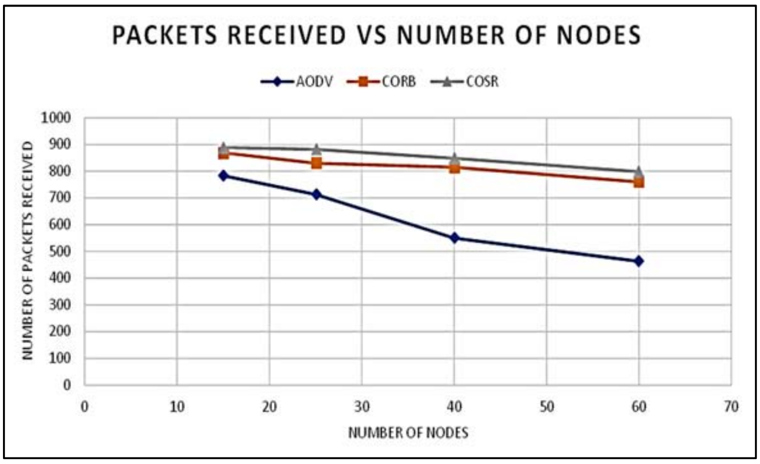



Fig. 8. Beam pattern of Omni-Steerable antenna in Co-operative network.

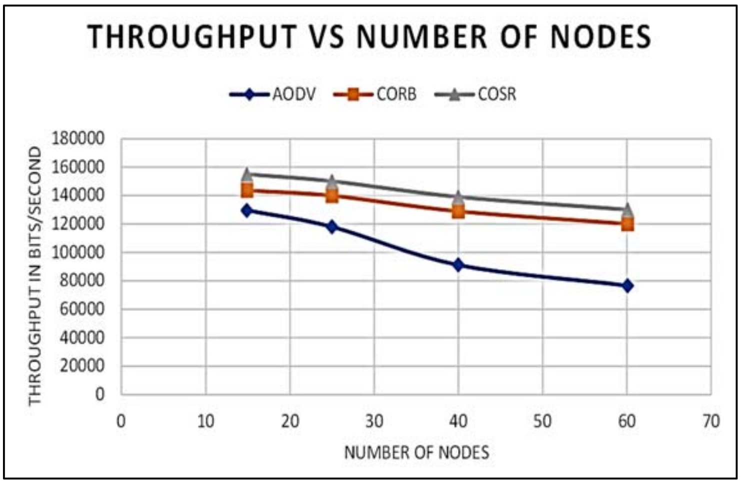
## 6. RESULTS AND DISCUSSION

Simulation results of COSR, AODV and CORB protocol is evaluated. These three protocols are reactive in nature; thus, on demand route formation takes place. Conventional AODV protocol establishes the path based least hop count alone, CORB protocol forms the route based on residual battery life of nodes and least hop count to the destination, whereas COSR protocol establish the path by considering the beam pattern and highest residual battery life of the nodes. Table 3. indicates the simulation specification, simulation setup is carried out by placing nodes in 2D plane with terrain size of 600 x 600msq. Total number of nodes are varied in the range of 25, 50, 75, 100 which indicates different node densities also helps in ease of analyzing the results. The source node transmits 1000 packets with a rate of 10 packet/second. Random-waypoint is introduced in the node to establish mobility in the network. Simulation analysis is made on parameters such as throughput, average end to end delay and packets received. Fig 9. shows the performance results of AODV, CORB and COSR protocol. The simulation results prove that proposed COSR protocol outperforms compared to other two protocols in terms of packet reception and throughput.



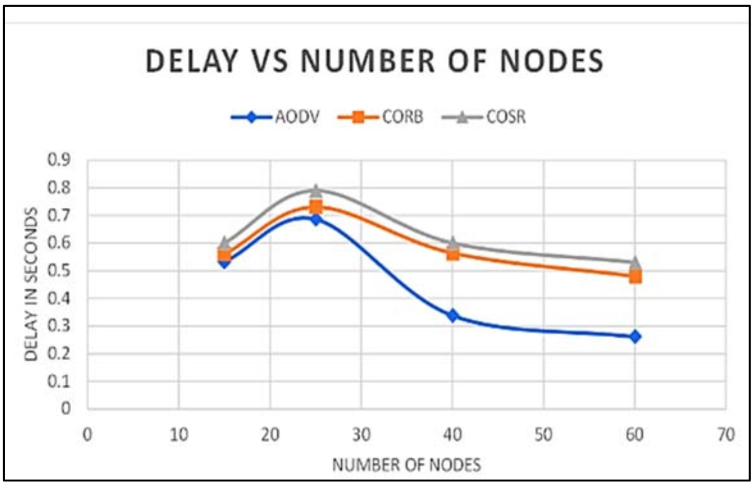

(a) Total packets received vs Total nodes in AODV, CORB and COSR

Results in Fig 9(a). indicates packet loss is low and highest residual battery nodes are best utilized in COSR protocol and our proposed protocol delivers more packets by choosing the highest residual battery node as relaying node and intelligently activates the beam that direct towards the selected relay. As a result, the protocol exploits the advantages of CORB protocol and Omni-Steerable directional antenna.




(b) Delay vs Total nodes in AODV, CORB and COSR

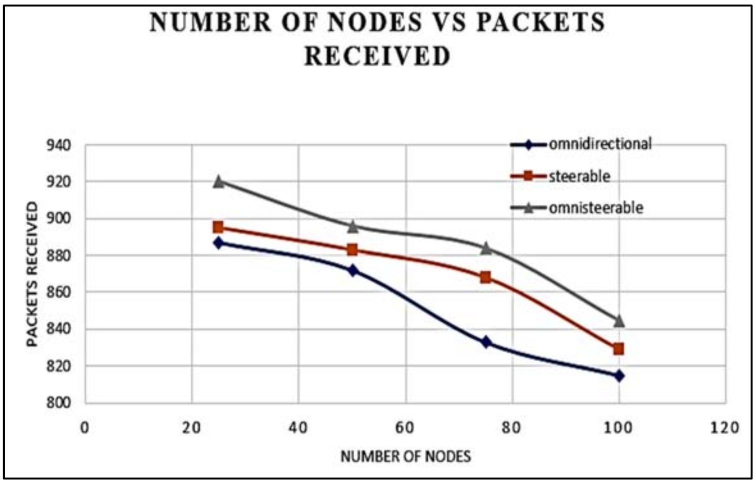
Fig 9(b). indicates when COSR protocol is used the data is transmitted intelligently as data transmission modes are switched interchangeably between co-operative communication and direct communication based on packet reception ratio (PRR<0.6), resulting in more throughput. COSR protocol delivers 10% more data compared to other two protocols. High rate of successful reception of data and nodes availability for longer period in the network improves the network lifetime.



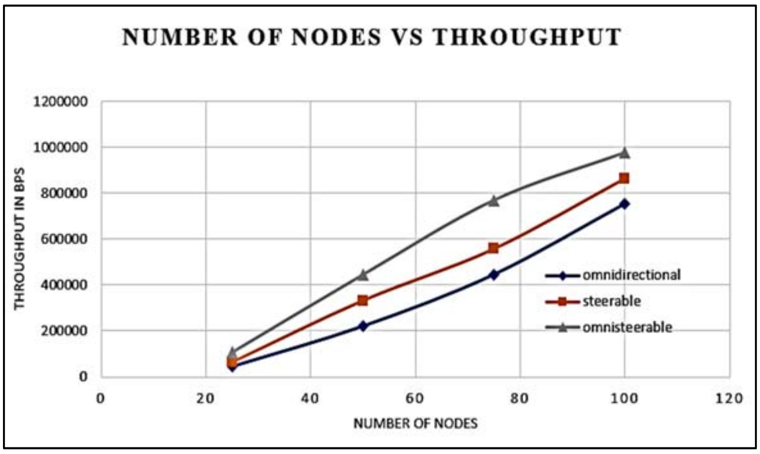

(c) Delay vs Total nodes in AODV, CORB and COSR

Fig. 9. Performance comparison of AODV vs CORB vs COSR

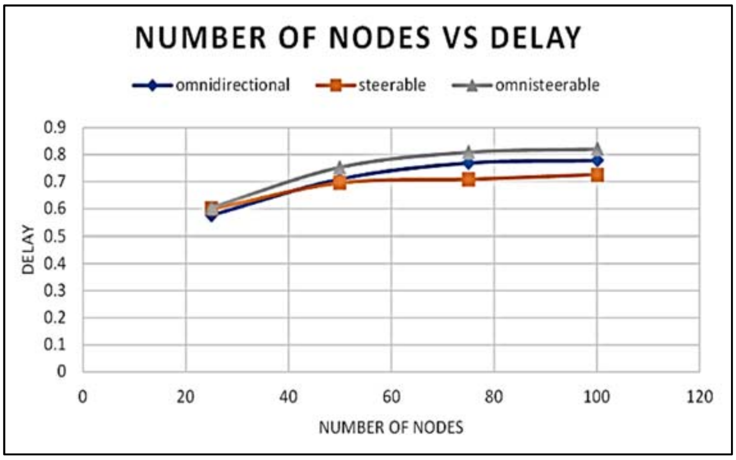
Fig 9(c). shows the variation in delay. End-to-End delay is slightly more in our COSR protocol compared to CORB protocol and Conventional AODV protocol as the route formation depends on both least hop count and on highest residual battery. Depending on packet reception ratio antenna model switches from Omnidirectional to omni-steerable directional antenna which results in few ns of delay. Hence there is considerable increase of delay in COSR protocol where as in CORB protocol the route formation involves considering both least hop count and highest residual battery path and there is no switching between antennas hence it offers less delay compared to COSR protocol but CORB has more delay compared to legacy AODV protocol. AODV protocol leads to less delay compared to other two protocols as the complexity is less and only least hop-count is considered for route formation.




(a) Variation in packets received for different antenna model




(b) Variation in Throughput for different antenna model




(c) Variation in Throughput for different antenna model

Fig. 10. Quality of services vs Varying nodes.

Based on the simulation parameter presented in Table.3. source initiates 1000 packets to send to destination. The simulation involves considering varying number of nodes such as 25, 50, 75 and 100. Fig 10. indicates the diversity in QoS parameter and also the behavior of Omnidirectional antenna, Steerable antenna and proposed Omni-Steerable antenna with different number of nodes. Fig 10(a). shows number of packets received for different number of nodes. Omni steerable antenna manages to receive more number of data compared to omnidirectional antenna and steerable antenna as the node with omni steerable antenna is aware of other nodes from which beam it has to receive the packets with the help of beam number field in COSR table, hence the packet drop is less. Due to increase in node density traffic in the network is more which in turn leads to collisions hence as the node density increases packet received decreases. Fig 10(b). shows the effect on throughput by using omnidirectional, Steerable and Omni Steerable antenna. Throughput of Omni-Steerable is more as it is enabled when the transmission of data enters cooperative mode based on packet reception ratio. Fig 10(c). shows the inequality in delay with three antenna models. Delay using Omni steerable is almost same as other two when node density is less but as the node density increases delay has also increased in small amount as each node needs to switch their antennas to Omni steerable antennas depending on PRR ratio. Omni-steerable antenna outperforms omnidirectional and steerable antenna.

## 7. CONCLUSION

The paper proposes a COSR protocol to leverage the physical cooperation capability, the protocol also brings coordination between Network layer and Physical layer to effectively utilize the benefits of Cooperative communication and Directional antenna. COSR protocol efficiently selects the relay based on highest residual battery and the only the beam that leads to the highest residual battery node is activated. This results in less energy utilization and improvement in transmission range. The COSR protocol is verified through simulation and the results prove that throughput and total packets received to the intended destination is improved considerably. Cross layer designing of Network layer, MAC layer and Physical layer to take best advantage in establishing cooperative communication is sustained as future work.

## References

[1] Zhifeng Tao.; etal. (2007): Cooperation and Directionality: A Co-opdirectional MAC for Wireless Ad Hoc Networks, pp. 1-8.
[2] Feilu Liu.; etal. (2008): Cooperation and Directionality: Friends or Foes, pp. 4424-4430.
[3] Yi-Yu Hsieh.; etal. (2013): An Active Helper Searching Mechanism for Directional Cooperative Media Access Control (MAC) Protocols, pp. 1-7.
[4] Thanasis korakis.; etal. (2003): A MAC protocol for full exploitation of Directional Antennas in Ad-hoc Wireless Networks, pp. 98-107.
[5] Haipeng Li.; (2018): Routing Protocol in VANETs Equipped with Directional Antennas: Topology-Based Neighbour Discovery and Routing Analysis, pp. 13.
[6] Kenta Yamada.; etal. (2010): A Study on Routing Protocol Suitable for Directional Links, pp. 328-331.
[7] Garima Popli.; etal. (2018): Optimization techniques for energy consumption in wireless sensor networks-A Review, pp. 961-967.
[8] Qian Li.; (2012): Cooperative communications for wireless networks techniques and applications in LTE-advanced systems, pp. 22-29.
[9] Zhe Li.; etal. (2016): Research on directional AF cooperative communication system based on outage probability, pp. 497-505.
[10] Alonso-Zárate, J.; etal. (2010): Multi-radio Cooperative ARQ in Wireless Cellular Networks: A MAC Layer Perspective, 52, pp. 375-385.
[11] Yanming Zhang.; etal. (2017): Design of directionality of the antenna using two-dimensional metal photonic crystal, pp. 1-4.
[12] Salma Fauzia.; etal. (2014): Routing in FSO MANETs — QoS and directionality, pp. 1-5.
[13] Nagesh R.; etal. (2020): Cooperative Residual Battery (CORB) Resource Optimization in AODV Routing Protocol, pp. 5560-5567.
[14] Nitin Jain.; etal. (2017): Comparative study of different types of relay selection scheme for cooperative wireless communication, pp. 1-4.
[15] Xi Luan.; etal. (2015): Cooperative transmission based on multi-relay Device-to-Device communications in cellular networks, pp. 1-4.
[16] C. Annadurai.; etal. (2016): Energy efficient optimized cooperative mobile ad-hoc network, pp. 0549-0552.
[17] Gui Chao Huang.; etal. (2015): Antenna Array Design and System for Directional Networking, pp. 1141-1144.
[18] Yi Liu.; etal. (2017): A Dual-Polarized Dual-Band Antenna with Omni-Directional Radiation Patterns, pp. 4259-4262.
[19] Yang Liu.; etal. (2010): An Ad hoc cooperative routing algorithm based on symmetric link selection, pp. 1156-1159.
[20] Hu Liu.; etal. (2016): An ultra-wideband horizontally polarized omnidirectional connected Vivaldi array antenna, pp. 798-799.
[21] Xi-Wang Dai.; etal. (2013): Multiband and Dual-Polarized Omnidirectional Antenna for 2G/3G/LTE Application, pp. 1492-1495.
[22] Liang Hua Ye.; etal. (2018): Wideband Horizontally Polarized Omnidirectional Antenna with Small Size, pp. 1-2.