Customized Medium Access Control (C-MAC) Protocol for Cooperative Wireless Network

Poorvi Behre
GGITS, Jabalpur
Madhya Pradesh, India
Madhya Pradesh, Jabalpur, India

Pankaj Sahu
Assistant Professor
GGITS, Jabalpur
Madhya Pradesh, Jabalpur, India

ABSTRACT
Cooperation is always required in every filed of communication nowadays because neither a single layer, nor a single protocol is able to perform well in a network. In this work, cooperation has been performed using Medium Access Layer (MAC) using the concept of Rely Node. Although it has been claimed previously that cooperative scheme always promises a higher throughput and lower delay performances still here, a medium access control scheme known as C-MAC (Customize-Medium Access Control) has been proposed, where the neighbours, i.e. the relay node is selected not only assuming higher data rate, but also based on its reliability factor, power constraints, throughput, packet forwarding ratio, delay, which leads to motivate for better decision to deciding whom to co-operate with. The overall system has become reliable with an increased lifetime of the network.

Keywords
Relay, MAC, Ad-hoc Network, Reliability, Efficiency, packet delivery ratio (PDR), end-to-end delay, routing overhead

1. INTRODUCTION
1.1 Channel Access Mechanisms
When the source is ready to transmit the data it senses the channel until an idle DIFS duration is detected. After that it goes into random back-off, so as to avoid collision. The back-off lies within the interval [0, CW], where CW is the contention window. Once the back-off counter reduces to zero the station may use the basic access or the RTS/CTS mechanism for the data transmission.

In the case of basic access (Fig 1.1) the source starts by sending the data packet . If the data packet is received correctly, the destination responds by sending an acknowledgement (ACK) packet after SIFS interval. The CW is reset to initial value upon successful transmission. If the ACK is not received at the source, a collision is assumed to have occurred. The value of CW is doubled upon each failure until it reaches the maximum value. The CW is reset if a failure occurs at the maximum retry limit . In the case of failure at the maximum contention window, the packet is dropped.

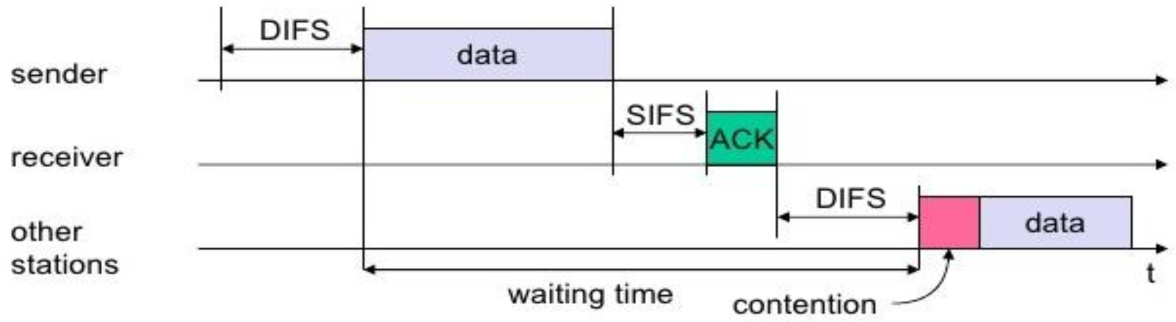


Figure 1. Basic Access Control

In the RTS/ CTS case (Fig 1.2), the source starts the process by sending an RTS control packet. If the control packet is received correctly, the destination sends a CTS control packet after a SIFS interval. Once the CTS frame is received, the source transmits its data packet after a SIFS interval. If the source does not receive the CTS, a collision is assumed to have occurred. DCF also makes use of virtual carrier sensing (VCS). VCS is implemented by means of the network allocation vector (NAV) .

The NAV is maintained by all nodes that are not currently involved in any transmission or reception of packets. When the value of the NAV is non-zero, it implies that the node needs to block its own transmission to yield another ongoing transmission. It tracks the remaining time of any ongoing data transmission. When a node receives RTS, CTS or DATA packet which is not destined for it, it sets its NAV according to the information received in the Duration/ ID field of that particular packet. The Duration field contains the

reservation duration of this whole packet exchange sequence. The RTS/CTS with the NAV settings is able to resolve the hidden terminal problem to some extent.

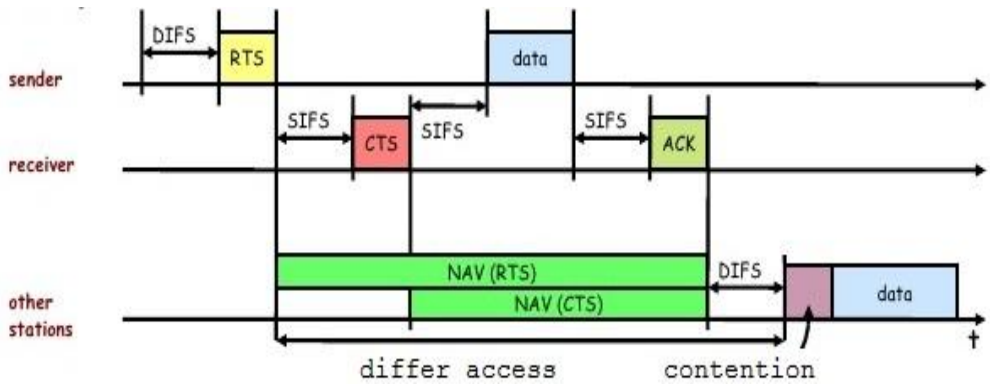


Figure 2 RTS/CTS Access

1.2 Interframe Space

Interframe Space: Inter Frame Space (IFS) is defined as the time interval that exists between consecutive s. IEEE 802.11 defines four main inter spaces.

- **SIFS (Short inter space):** SIFS is the shortest of the inter spaces. SIFS shall be used when mediums are held by the station, and it wants to keep it for the duration of the exchange sequence to be performed. When this smallest gap is kept between transmissions, then other stations do not attempt to use the medium. So, this helps in giving priority to completion of the exchange sequence which are in progress.
- **PIFS (PCF inter space):** This interspace is used at the beginning of the contention-free period only by those stations that use PCF in order to have priority access to the medium.
- **DIFS (DCF inter space):** This duration is used by the nodes to sense the medium idle just before starting a new transmission. If the channel is sensed free in DIFS duration, then the node can transmit after a random back-off period
- **EIFS (Extended inter space):** EIFS is the largest duration and is meant to avoid the collision with an ongoing transmission. When a node wanting to transmit can sense some activity on the channel and is unable to decode due to collision/ error or distance, it defers its transmission for EIFS duration.

2. RESEARCH ISSUES

- **Power efficiency**: Nodes in an ad-hoc network are mobile and have a limited battery life. Due to power constraints, the MAC protocols designed should take into account that the energy of the node is utilized efficiently .And if the security of the network is also included then there may be a trade-off between energy and security.
- **Distributed Operations**: As the ad-hoc network is self-configurable and distributed in nature, all its operations such as file access, are also distributed .Hence, the MAC protocols need to cater to these needs of ad-hoc with minimum overhead.
- **Topology changes**: The ad-hoc network is decentralized type of network which does not rely on preexisting infrastructure. Here the stations keep on changing their positions. So, the MAC protocols should take into account the mobility aspects.

3. CUSTOMIZED MEDIUM ACCESS CONTROL PROTOCOL (C-MAC)

- C-MAC is an extension to the existing Helper Feedback Medium Access Control [26] Protocol (HF-MAC protocol).
- Here, two relays are used to transmit data between the source and the destination. One relay acts as a relay node and the other relay acts as a backup.
- Relay node jumps in to transmit the data if ACK is not received within 2SIFS duration due to interference or collision in the network.

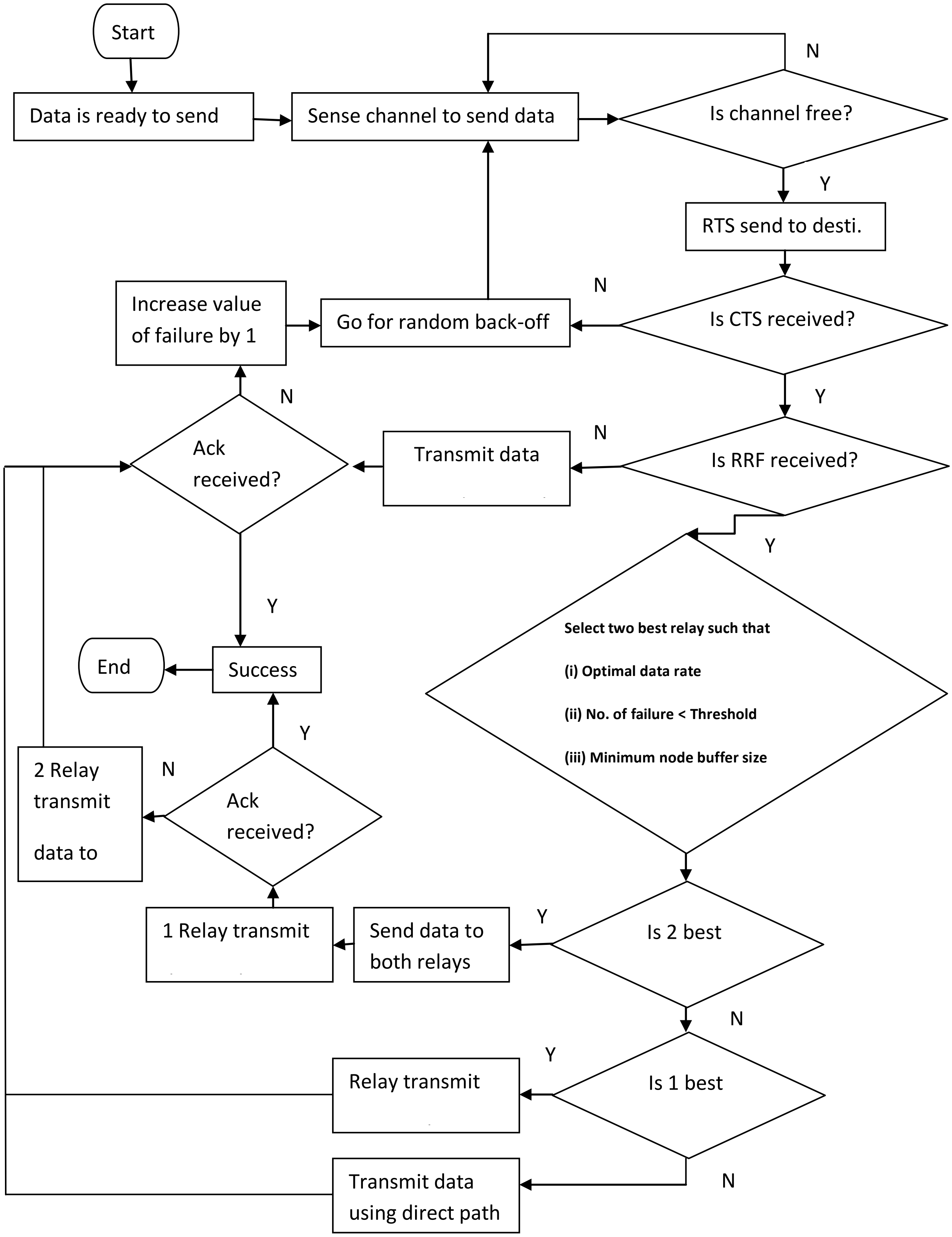


Fig 3. Customized Medium Access Control (C-MAC)

4. SIMULATION PARAMETERS

S.N	Standard Parameter	Standard Value
1	Topology Type	Random: also called as infrastructure less topology. In which two or more devices link together, without the need for an AP
2	Total number of nodes	(10,20,30,40,50,60,70,80,90,100): In data communication, a physical network node may either be a data circuit-terminating equipment (DCE) such as a modem, hub, bridge or switch; or a data terminal equipment (DTE) such as a digital telephone handset, a printer or a host computer, for example a router, a workstation or a server.
3	Topology Area	200mX200m
4	Transmission range	150m
5	Mobility	Random waypoint model: Random Waypoint (RWP) model is a commonly used synthetic model for mobility, e.g., in Ad Hoc networks. It is a basic model which illustrate the movement pattern of independent nodes by simple terms.
6	Traffic Model	Poisson, CBR (simplified traditional traffic generation model for circuit-switched data as well as packet data, is the Poisson process, where the number of incoming packets or calls per time unit follows the Poisson distribution.)

5. PERFORMANCE MATRIX USED FOR RESULT ANALYSIS

5.1 Throughput

It is the amount of data Frame/Packets Received Successfully per unit time. [14]

THROUGHPUT = TOTAL RECEIVED PACKETS / (STOP TIME-START TIME)

5.2 Packet Delivery Ratio

Packet delivery ratio is defined as the ratio of data packets received by the destinations to those generated by the sources. [14]

PDR= DATA PACKETS RECEIVED BY THE DESTINATIONS / DATA PACKETS GENERATED BY THE SOURCES

5.3 End To End Delay

End-to-End delay refers to the time taken for a packet to be transmitted across a network from source to destination. [14]

$$\text{End-to-End Delay} = D_{trans} + D_{prop} + D_{proc}$$

D_{trans} = transmission delay

D_{prop} = propagation delay

D_{proc} = processing delay

5.4 ROUTING OVERHEAD

It is defined as total no. of control packets used to transmit data packet. [14]

6. RESULTS & ANALYSIS

6.1 Throughput

Average improvement in Throughput for 100 nodes is 14.52%.

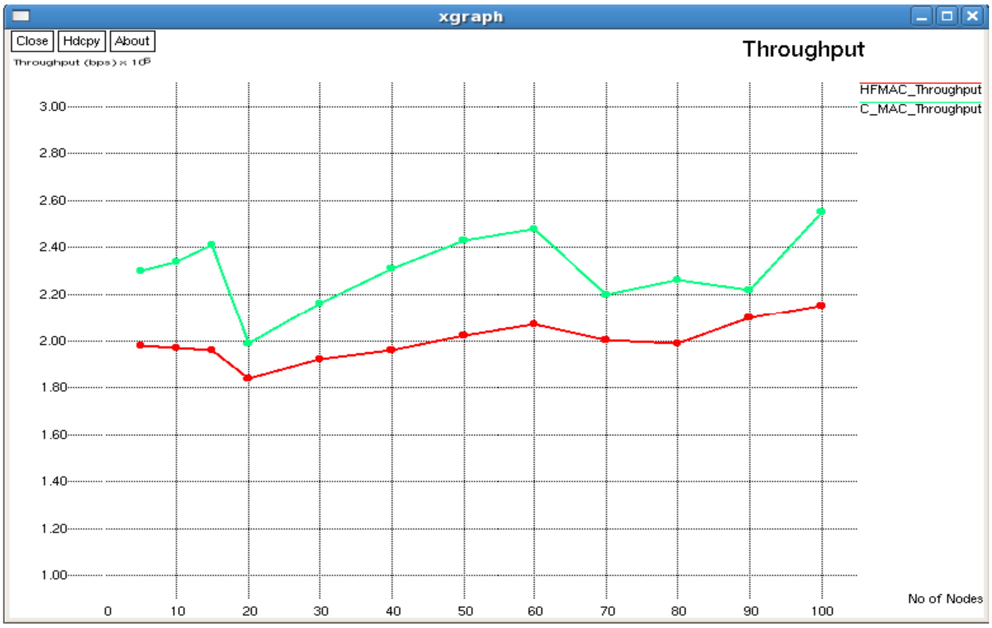


Fig. 4. Throughput at 100 Nodes

6.2 Packet Delivery Ratio

Average improvement in Packet Delivery Ratio is 4.32%.

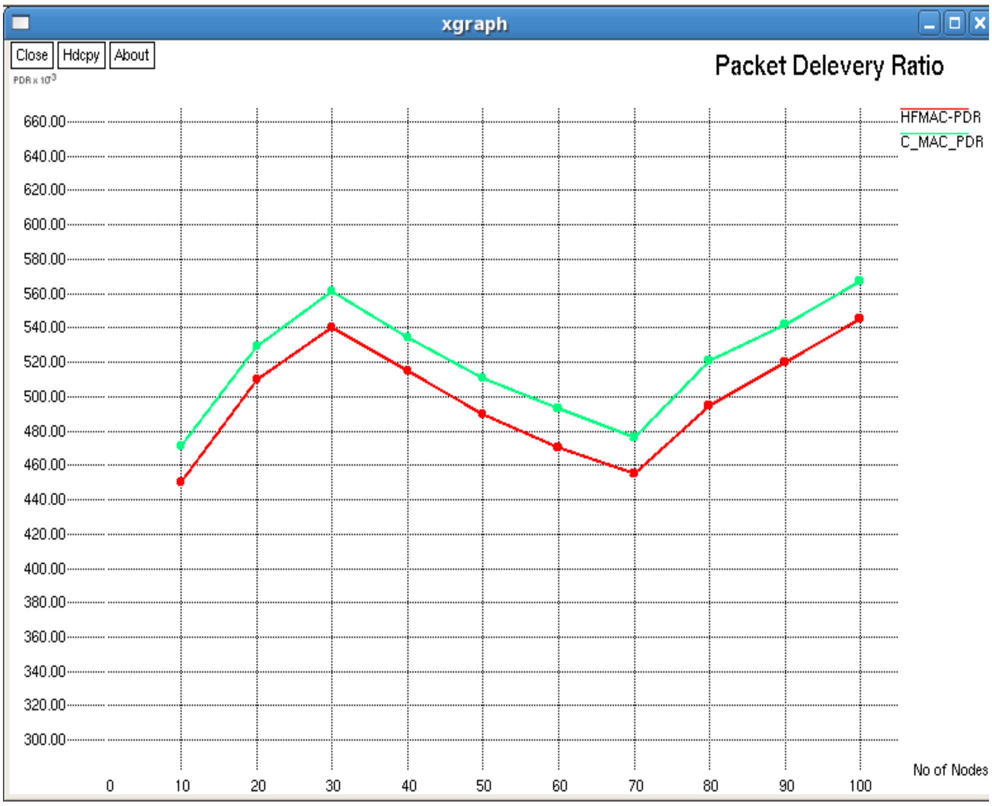


Fig. 5 Packet Delivery Ratio at 100 Nodes

6.3 Avg. End to End Delay

Average reduction in End to End Delay is 8.11%.

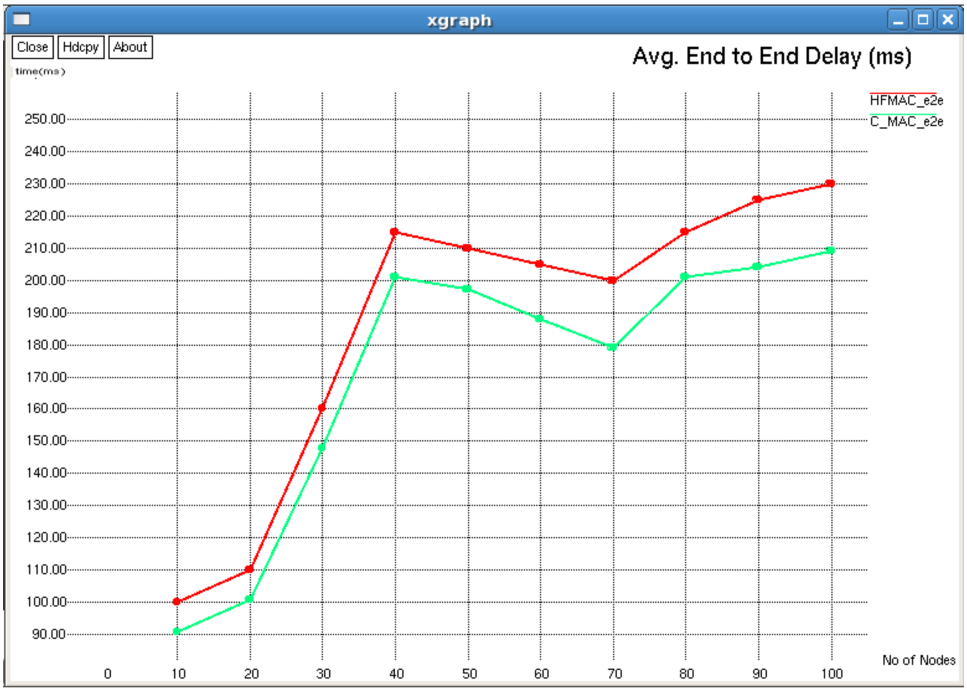


Fig. 6 Avg. End to End Delay at 100 Nodes

6.4 Routing Overhead

Average improvement in routing overhead is 10.37% when compared to 2rcmac protocol.

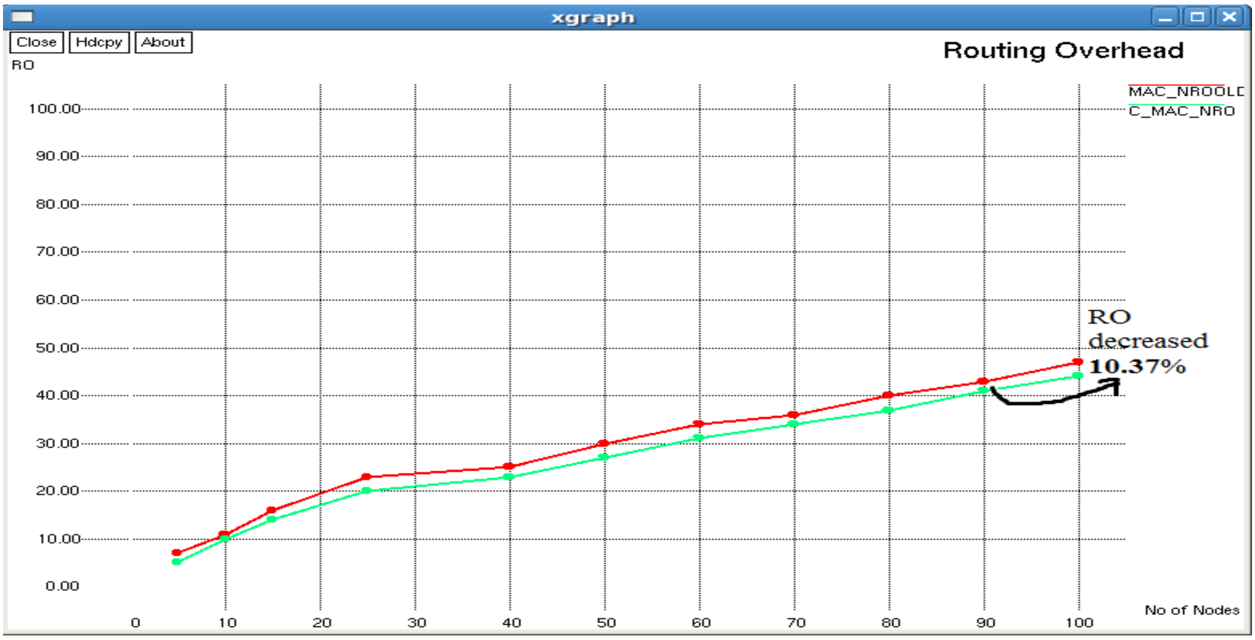
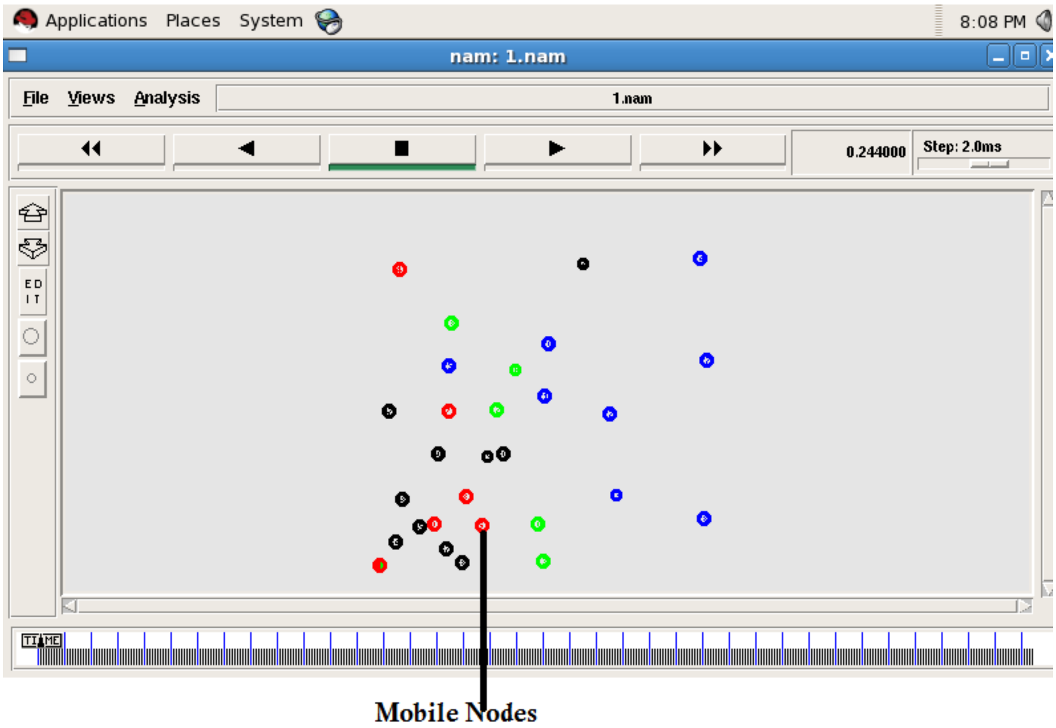


Fig. 7: Routing Overhead at 100 Nodes

7. SCREENSHOTS OF ANIMATION

7.1 Mobile Nodes



.

Figure 8 Mobile Nodes

7.2 Packet Forwarding By Nodes

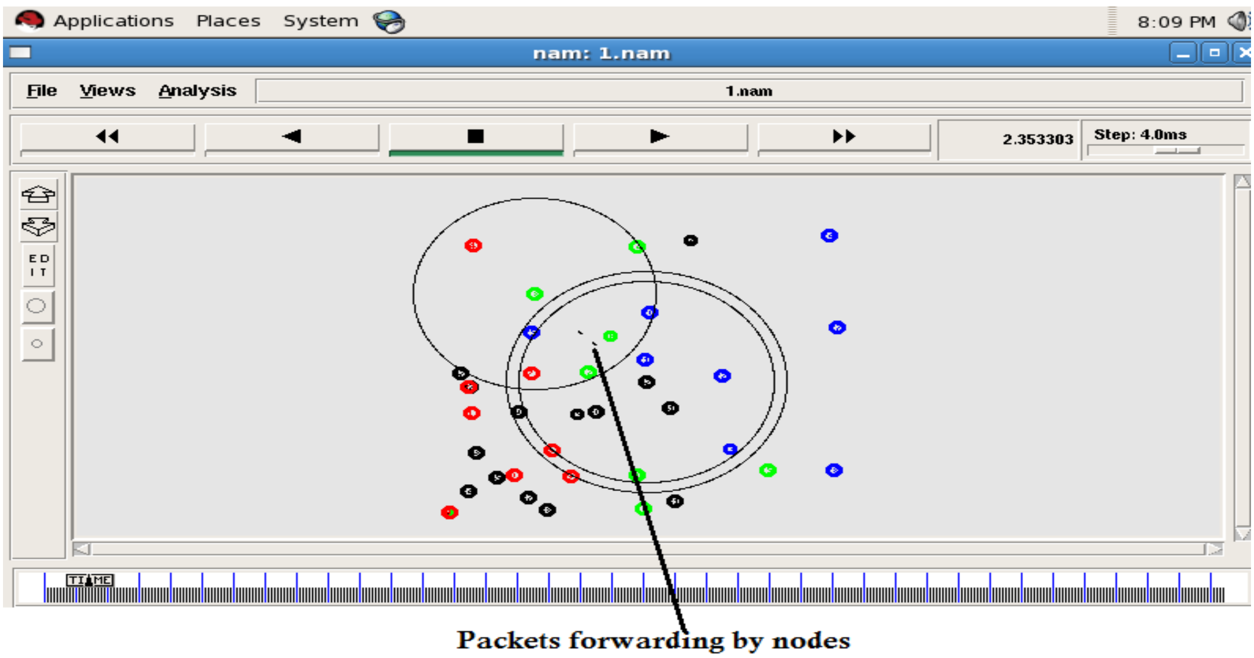


Fig. 9 Packet Forwarding By Nodes

7.3 Coverage Area by Nodes

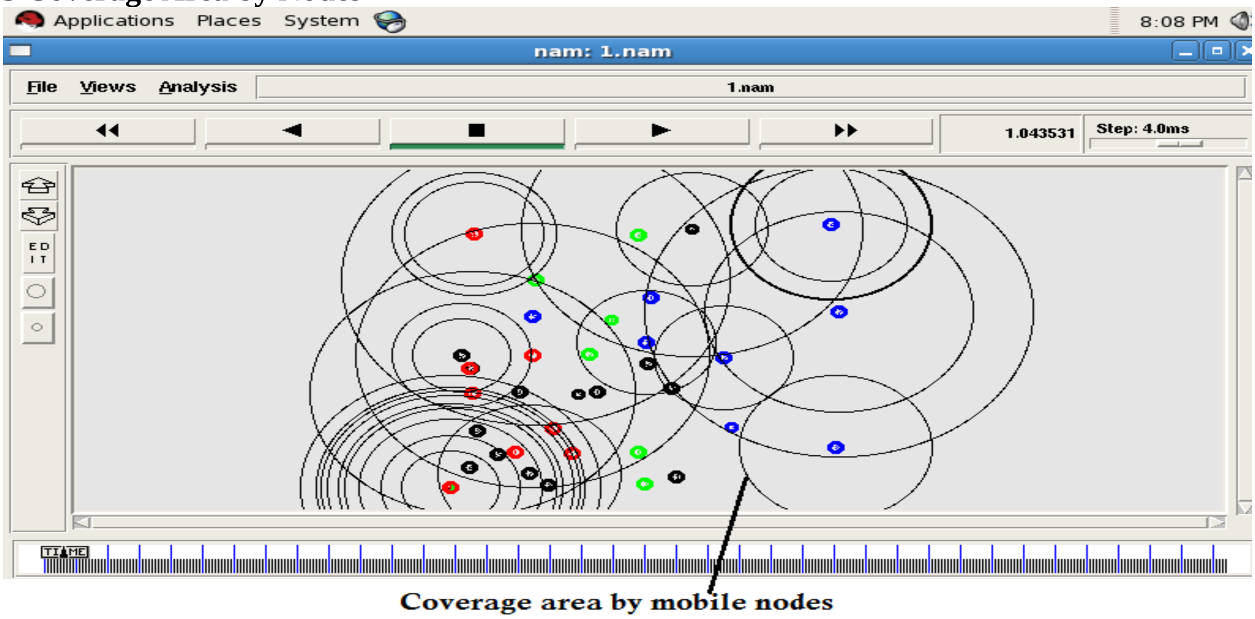


Fig. 10 Coverage Area by Mobile Nodes

8. CONCLUSION, FUTURE WORK & APPLICATIONS

Table 3 Comparison Average improvement in parameters using C-MAC (for 100 nodes)

Throughput	14.52% compared to (HF-MAC)
Packet delivery ratio (pdr)	4.32% **compared to (HF-MAC)**
End to end Delay reduced	8.11% **compared to (HF-MAC)**
Routing overhead reduced	10.37% **compared to** (2RC-MAC)

8.1 Conclusion

- In the proposed protocol C-MAC, the physical layer multirate capability has been efficiently utilized, by the use of two Relay nodes, which transmit data at various rates.
- The protocol proves to be efficient &robust, in case the direct transmission from source to destination fails.
- C-MAC protocol makes the overall system reliable and also increase the lifetime of the network.
- The algorithm is compared with the existing original 802.11 MAC protocol, CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance). Simulation results show that C-MAC performs better than existing MAC in terms of Throughput, Packet Delivery Ratio (PDR) , Avg. End-to-End delay and Routing Overhead at small size network.

8.2 Future Work

- Routing Overhead can be improved more.
- The protocol can be extended by studying various types of attacks by malicious as well as selfish nodes that can take place in C-MAC.
- C-MAC is made for the ad-hoc network. It can be implemented over vehicular network.

8.3 Applications Of C-Mac

- It can be used to minimize collisions in **College Campus** Network.
- In **Airport** to maintain equal sharing of bandwidth & time for each & every user..
- In any Company to provide reliable and efficient information processing.

9. REFERENCES

[1] Xiaoyan Wang, Student Member, IEEE, Jie Li, Senior Member, IEEE, and Feilong Tang, "Network Coding Aware Cooperative MAC Protocol for Wireless Ad Hoc Networks" IEEE transactions on parallel and distributed systems, vol. 25, no. 1, JANUARY 2014

[2] Tingting Chen, Liehuang Zhu, "Stimulating Co-operation in Vehicular Ad-hoc Network: A Coalitional Game Theoretic Approach". IEEE Transactions on Vehicular Technology Vol 60, No. 2 February 2011

[3] Wenbin Zhang , Xiaozong Yang, Shaochuan Wu , "A new improved MAC scheme: RM-MAC". 6th International ICST Conference on Communications and Networking in China (CHINACOM), Aug 2011

[4] Murad Khalid, Yufeng Wang, In ho Ra and Ravi Shankar, "Two relay based co-operative MAC protocol for wireless ad-hoc network". IEEE Transactions on vehicular technology Vol 60, No. 7 September 2011

[5] Tingting Chen, Fan Wu, and Sheng Zhong, "FITS: A finite-time reputation system for cooperation in wireless ad-hoc networks". IEEE Transactions on computers. , vol. 60, no. 7, July 2011.

[6] Mohamed Elsalih Mahmoud and Xuemin (Sherman) Shen,Fellow, IEEE , "PIS:A PracticalIncentiveSystem for Multihop Wireless Networks, "IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL.59, NO.8, OCTOBER, 2010. pp. 4012-4025.

[7] Zilong Jin, Weidong Su, Jinsung Cho Member, IEEE, and Een-Kee "An Analytic Model for the Optimal Number of Relay Stations, IWCMC ", 10, June 28-July 2, 2010, Caen, France.

[8] Long Cheng, Jiannong Cao, Canfeng Chen, Hongyang Chen, Jian Ma, Joanna Izabela Siebert, "Cooperative Contention-Based Forwarding for Wireless Sensor Networks". IWCMC '10, July 2010, Caen, France .

[9] Xin He and Frank Y. Li, "Throughput and Energy Efficiency Comparison of One-hop, Two-hop, Virtual Relay and Cooperative Retransmission Schemes", IEEE European Wireless Conference 2010.

[10] Chang Yeong Oh, Tae-Jin Lee "MAC Protocol Using Cooperative Active Relays in Multi-rate Wireless LANs", IFIP International Conference on Wireless and Optical Communications Networks, 2009

[11] P. Liu, Z Tao and S. Narayan, "CoopMAC A co-operative MAC for wireless LANs". IEEE J. Sel. Areas Communication vol. 25 Feb 2007.

[12] H. Zhu and G. Cao, "rDCF: A Relay-enabled Medium Access Control Protocol for Wireless Ad Hoc Networks," in Proceedings of IEEE INFOCOM, 2005

[13] B. Sadeghi, V. Kanodia, A. Sabharwal and E. Knightly, "Opportunistic media access for multirate Ad Hoc networks," ACM Mobicom 2002, July 2001.

[14] Introduction to Data Communication and Networks, Behrouz A. Forouzan, 4rth Edition, TMH

[15] Qing Cao, T. Abdelzaher, Tian He, and R. Kravets, "Cluster-based forwarding for reliable end-to-end delivery in wireless sensor networks". In Proc. IEEE INFOCOM, 2007.

[16] Duck-Yong Yang, Tae-Jin Lee, Kyunghun Jang, Jin-Bong Chang and Sunghyun Choi, "Performance enhancement of multirate IEEE 802.11 WLANs with geographically scattered stations", IEEE Transactions on Mobile Computing , July 2006.

[17] S. Zou, B. Li, H. Wu, Q. Zhang, W. Zhu, and S. Cheng, "A relay-aided media access (RAMA) protocol in multirate wireless networks" IEEE Transactions on vehicular technology, vol. 55, pp. 1657 - 1667, Sept. 2006.

[18] H. Zhu and G. Cao, "rDCF: A relay-enabled medium access control protocol for wireless ad-hoc networks," in Proceedings of IEEE INFOCOM, 2005.

[19] J. S. Pathmasuntharam, A. Das, and K. Gupta, "Efficient multi-rate relaying (EMR) MAC protocol for ad hoc networks," in Proc. of IEEE ICC'05, Seoul, Korea, July 2005.

[20] A. Nosratinia, T.E. Hunter, and A. Hedayat, "Cooperative communication in wireless networks," IEEE Communications Magazine, vol. 42, no. 10, pp. 74–80, April 2004.

[21] H. Zhu and G. Cao, "On improving the performance of IEEE 802.11 with relay-enabled PCF," Mobile Networking Appl. (MONET), Vol. 9, No. 4, pp. 423–434, Aug. 2004.

[22] A. Sendonaris, E. Erkip and B. Aazhang, "User Cooperation Diversity , Part I : System , IEEE Transactions on Communications , vol. 51, no. 11, Nov. 2003.

[23] J. N. Laneman and G. W. Wornell, "Energy- efficient antenna sharing and relaying for wireless networks," in Proc. IEEE wireless communications and networking, Sept. 2000.

[24] Sergio Marti, T. J. Giuli, Kevin Lai and Mary Baker, "Mitigating routing misbehavior in mobile ad-hoc network". Proc. Int. Conf. mobile computing and networking, Boston. MA, pp 255 – 265 Aug 2000.

[25] T. M. Cover and A. A. E. Gamal, "Capacity theorems for the relay channel," IEEE Transactions on Information Theory Vol. 25, No. 5. Sept 1979.

[26] Nidhi Newalkar, Piyush Kumar Shukla, Sanjay Silakari, "Helper Feedback based Medium Access Control Protocol: A Reliable Co-operative MAC Scheme for MANET," *I. J. Computer Network and Information Security, MECS, Hong Kong,* 2015, 2, pp. 50-58.