Journal of Computer Applications (JCA)
ISSN: 0974-1925, Volume IV, Issue 4, 2011

Enhancing Coding Aware Routing and Handling Link Failure in WSN

C.Ram Kumar [a,*], M.Jennie Bharathi [b,1]

***Abstract* - The objective of this project is to handle link failure during distributed coding aware routing in wireless networks. Network coding is the technique in which the nodes of the network instead of simply relaying the packets they receive, the nodes will take several packets and combine them together for transmission. Network coding is becoming an emerging communication paradigm that can provide the performance improvement in throughput and energy efficiency. Network coding was originally proposed for wired networks. Recently, there is a growing interest to apply network coding onto wireless networks since the broadcast nature of wireless channel makes network coding particularly advantageous in terms of bandwidth efficiency and enables opportunistic encoding and decoding.This will greatly improve the performance of wireless networks. DCAR, the Distributed Coding-Aware Routing mechanism enhances the coding opportunity in the network and route the packets to the destination. However, in the case of link failure, the performance of the network would drop and there will be considerable loss of packets. To overcome this limitation, the routing protocol AODV with Direct Forward Routing Protocol is proposed. It enables routing the packets to another path effectively and reaches the destination. There is significant improvement in throughput. A result shows that the throughput has been improved by 32% and the packet drop reduced by 4.28% that of the existing system.**
***Index Terms* - DCAR, network coding, AODV protocol**

I. INTRODUCTION

Network coding is becoming an emerging communication paradigm that can provide the performance improvement in throughput and energy efficiency. Network coding was originally proposed for wired networks, and the throughput gain was illustrated by the well-known example of "butterfly" network [8].Recently, there is a growing interest to apply network coding onto wireless networks since the broadcast nature of wireless channel makes network coding particularly advantageous in terms of bandwidth efficiency and enables opportunistic encoding and decoding. In this project, the coding and routing mechanism is carried by DCAR, Distributed Coding Aware Routing mechanism. The first forwarding architecture before DCAR was COPE.COPE inserts coding shim between the IP and Mac layers, which identifies coding opportunities and benefits from them by forwarding multiple packets in a single transmission. But however COPE has fundamental limitation that it is limited within a two-hope region only.

Manuscript received, 30-Nov-2011.
C.Ram Kumar[a,*],
Sri KrishnaCollege of Engg & Tech.,
Coimbatore, India -641008
E-mail: ramkumar_957@yahoo.com
M.Jennie Bharathi[b,1],
Sri KrishnaCollege of Engg & Tech.,
Coimbatore, India -641008
E-mail: jenivenkatesh@hmail.com

DCAR as the name implies overcomes the limitation as this mechanism follows in the distributed network also.

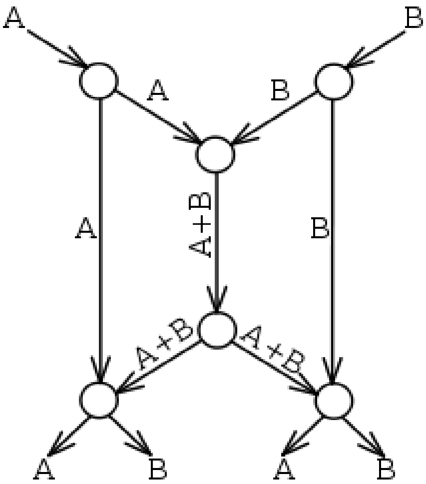

Figure 1.1 Butterfly Network

As the link failures are the most common case of the failures in the networks, the proposed system handles this case. The proposed system handles the link failure that occurs in the network when performing the coding and routing mechanism.

II. EXISTING SYSTEM

COPE, the first practical network coding system for multihop wireless networks. Fig.3.1 shows the basic scenarios of how COPE works. In Fig. 3.1 a, there are five wireless nodes. Suppose node 1 wants to send a packet P1 to node 2 and this packet needs to be relayed by node C; and node 3 wants to send another packet P2 to node 4 wherein node C also needs to relay this packet. The dashed arrows 1→ 4 and 3→ 2 indicate that 4, 2 are within the transmission ranges of 1, 3, respectively. Under this scenario, nodes 4 and 2 can perform "opportunistic overhearing": when 1 (3) transmits P1 (P2) to node C, node 4 (2) can overhear the transmission. When node C forwards the packets, it only needs to broadcast one packet ($P_1 \oplus P_2$) to both 4 and 2. Since 4 and 2 have already overheard the necessary packets, they can carry out the decoding by performing $P_2 \oplus (P_1 \oplus P_2)$ or $P_1 \oplus (P_1 \oplus P_2)$ respectively, thereby obtaining the intended packet. In this case, it is easy to see that there is a reduction in bandwidth consumption because node C can use network coding to reduce one transmission.
It is interesting to point out that network coding can also be used when there is no opportunistic overhearing, and this scenario is illustrated in Fig.3.1 b. In this case, the source node 1 (2) needs to send a packet P1 (P2) to its destination node 2 (1). Since each source is also a destination node, it has the necessary packets for decoding upon receiving the encoded packet ($P_1 \oplus P_2$). Again, instead of four transmissions when network coding is not used, one only needs three transmissions and thereby reducing the bandwidth consumption.

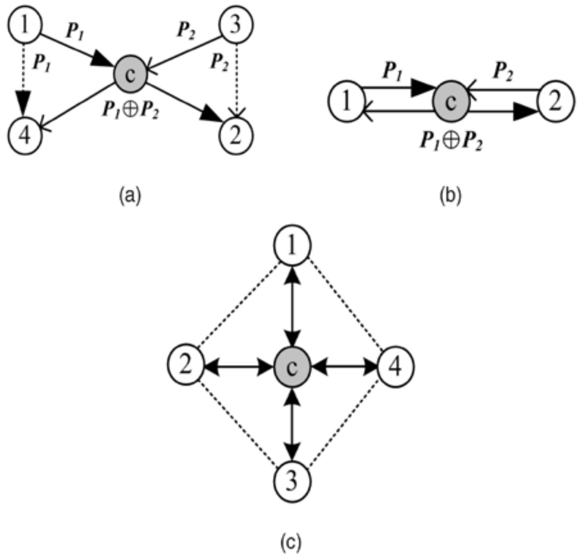

Figure 3.1 Basic coding scenarios in COPE a) Coding scenario with opportunistic overhearing. b) Coding Scenario without opportunistic overhearing c) Hybrid scenario

Fig.3.1c shows a hybrid form of coding which combines the former two cases, namely, some packets for decoding is obtained via opportunistic overhearing, while other packets are obtained by the fact that the node is the source of that packet. Under this scenario, instead of requiring eight-packet transmissions, networking coding can reduce it to five transmissions: four for transmitting a packet to node C and one for node C to encode four packets and transmit the encoded packet. In essence, COPE takes advantage of the "broadcast nature" of the wireless channel to perform "opportunistic overhearing" and "encoded broadcast" so that the number of necessary transmissions can be reduced. However, COPE has two fundamental limitations which is illustrated as follows:

1. The coding opportunity is crucially dependent on the established routes
2. The coding structure in COPE is limited within a two-hop region only

This COPE is further enhanced by another architecture called DCAR (Distributed Code Aware Routing).

DRAWBACKS OF THE EXISTING SYSTEM

1. The existing system does not provide any resiliency and guarantee network coding opportunity in the face of link/node failure.
2. The coding +routing discovery is not supported in the case of link failure. This results in the drop in the network performance.

III. PROPOSED SYSTEM

Mobile ad-hoc Network is one of the most focused research areas in the field of wireless networks as well as mobile communication for the last decade. Ad-hoc network consists of nodes communicating one another with portable radios. In ad-hoc mobile networks, routes are mainly multi-hop because of the limited broadcasting propagation range and frequently, and unpredictably, topology changes, as each network node moves randomly. Therefore, the routing protocol is an essence task as it transfer packets form source node to destination. In other words, it can be described as the process of path finding to reach the desired destination. Finding a new path in ad-hoc network has become a hot research issue. In MANET communication, every node in the network acts as a router as it forwards packet from one node to another.

Many routing protocols have been developed for mobile ad-hoc wireless network.When a host or node wants to send a message to destination-node and does not have a valid route to that destination-node, it initiates a route discovery process in order to find out the destination node. Then, it broadcasts a route request (RREQ) packet to its neighbours, which forwards the request to its neighbours until it reaches the desired destination-node or reaches intermediate node which has information about the route to the destination-node [1]. During the route discovery processing, each intermediate node recodes its own sequence number (called broadcast ID). This broadcast ID is incremented for every RREQ that the node initiates, and also records the nodes IP address (source and destination IP addresses). Intermediate nodes can reply the RREQ, in case they have a route to the desired destination-node, only if the destination sequence number is greater than or equal to that contained in the RREQ [9].

In addition, in forwarding process of the RREQ, the intermediate node records the address of the neighbour from which the first copy of RREQ broadcasted is received, to avoid receiving several copies of same RREQ and to avoid looping problem as well. In case of one of the intermediate nodes receives copies of same RREQ, these packets are discarded. Upon receiving the RREQ by the destination-node or intermediate node with recent route to destination, it responds by unicasting a route replay (RREP) packet back to the neighbours that received the first RREQ from [2].

ROUTING PROTOCOL FOR LINK FAILURE MAINTENANACE

In the presence of Link Failure, when an intermediate node discovers a link failure, the source node instead of re-initiating a route discovery process again, mechanism is introduced that avoids the route re-discovery by the source upon link failure and, at the same time, solves the link failure before the current route becomes completely disconnected.

For this purpose, the re-routing protocol is implemented which works as follows:

This new mechanism uses the link state prediction method for predicating an active link. In addition, it will use one hop neighbours to collect their signal status. Consider two nodes A and B and if there is any link failure between nodes A and B, then the mechanism is as follows: After the link state predication algorithm informs that the link between A and B will be broken soon, node A takes an action to sort out the matter, instead of sending warning message back to the sender as in AODV traditional mechanism Node A circulates a local route request to neighbours except the node that node A is receiving from to check signal status and whether there is a route to the destination. If current node (in this case, node "A") could not receive a positive response from its neighbours (because no one has a route to the desired destination or maybe they do not have a stronger signal than the current connection), the current node (A) will send a notification to previous node (one hop to upstream) indicating the link will be broken soon.

Thus, when this node (the upstream node) receives such notification from the next hop (downstream), it circulates a Local Route Request into its neighbours except the upstream node and it is repeated until the destination is found. Thus the packet is re-routed to the alternate path to reach the destination.

IV. Module Description

Network Coding concept in Wireless Scenario

Network coding is a technique where, instead of simply relaying the packets of information they receive, the nodes of a network will take several packets and combine them together for transmission. This can be used to attain the maximum possible flow in network. Consider the following simple example which depicts how the network coding is carried out.

In Fig.3.1, there are three nodes, 1, C, 2.The nodes 1 and 2 act as both source and destination nodes. There are two information flows in the network. The first flow is from the source node 1 to the destination node 2 through the intermediate node C. The second flow is from the source node 2 to the destination node 1 through the intermediate node c. These two flows have the common intermediate node, C. The node, C, can now XOR the two packets that are transmitted from the two source nodes1 and 2.After that node C can do the single broadcast (XOR packets-P1 and P2), so that it reaches the two destination nodes 1 and 2.After receiving the coded packets, the two destination nodes will decode the packet to get the corresponding packets. Now the node 1 will get the packet P2 and node 2 will get the packet P1.

DCAR-Distributed Coding Aware Routing

Before going in detail about this module, let go into an important term that should be defined with an example. A Coding Node" is defined as a node which encodes packets,. Consider the following simple example. Fig.3.1b, the node C is called as the coding node. The node C encodes the packets that are transmitted by the sender's node 1 and node 2.It is shown that the packets are being XOR –ed at the node C.

A "coding structure" is a collection of nodes and flows including the necessary transmitters for opportunistic overhearing, the coding node, the intended receivers which decode packets, and the necessary relaying nodes connecting the flows. The structures shown in Fig.5.2 are an example of coding structure. It is considered that the coding structures are the basic building blocks for general networks which use the network coding paradigm.

Next is to determine how to discover the available path(s) for a new flow initiated into the wireless network, and at the same time, detect the potential coding opportunities of the paths.

Handling link failure cases in the network

In mobile ad-hoc wireless network, the link failure is the major challenge. This module describes the case of handling link failure. While performing DCAR mechanism, there may be chances of having link failure or node failure. This paper focuses on the link failure. The enhancement to the AODV protocol is done to handle the link failure.

Performance comparison of routing mechanism measuring throughput and delay

After the implementation is done, the following performance metrics are to be measured.

- Throughput
- Delay
- Packet Delivery Ratio

V. Implementation and Simulation Results

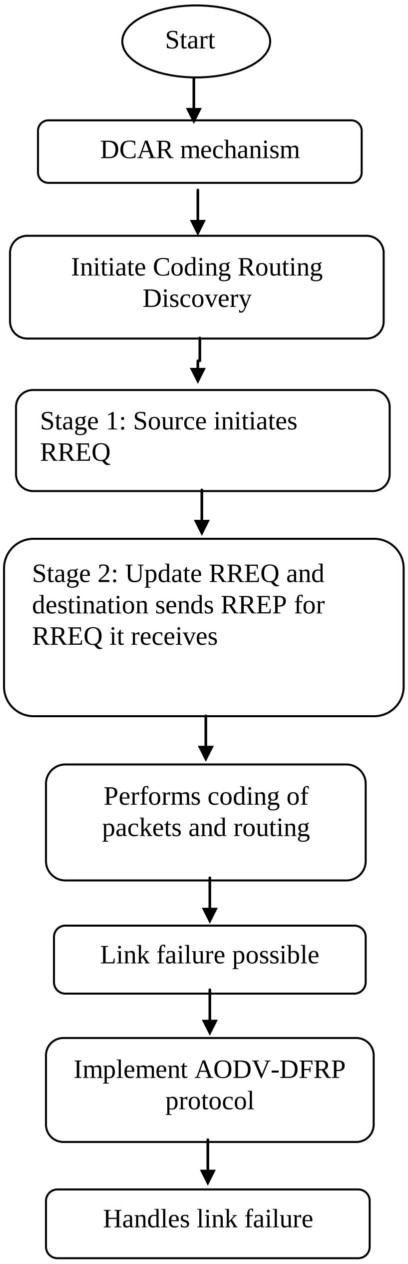

Figure 5.3 Implementation Outline

SIMULATION RESULTS

Implementation is done using Ns-2.Here, there are some important sequence that to be implemented with the simulator. In the existing system, the two flows are to be introduced in the network. The encoding and the broadcasting the packets are carried out in the network .In the proposed system, the link failure is introduced in the network. When the link failure occurs in the network, the node involving the link will find the alternate path that transmits the packets to the destination without the packet loss.

The performance metrics, throughput and the packet delivery ratio are evaluated in the implementation and it is compared with the existing system and it is proven that the proposed system has better performance. In this chapter, how the implementation and simulation results are carried out are explained in detail..

SIMULATION OF THE SYSTEM

Implementation is done using NS2 (Network Simulator version 2).The experimental set up contains 50 nodes. These 50 nodes are arranged randomly in positions. Since this is the wireless environment, the nodes are given the random motion. In the implementation, the packet delay and the throughput in milliseconds are measured.

7.2 DCAR mechanism

In the implementation of DCAR, the network includes 50 nodes that are given random movements. The flows are introduced in the network. That is, the source nodes and the destination nodes are defined by differentiating in different colors. These different flows in the network are made to flow through some common intermediate node. The intermediate node which transmits more than one packet does the encoding process. That is it XORs the different packets that pass through it and do the single broadcast. So that the destination nodes decode the packet and get their corresponding packets.

7.3 Link failure occurrence

With the normal flow of packets in the network, the link failure is introduced in the network. The link failure occurrence in the network is differentiated. The packet delay is measured before and after the link failure occurrence in the network. Also the throughput of the network when the link failure occurs and after the link failure recovery has also been measured.

VI. COMPARISON AND JUSTIFICATION

Topology is built using ns2 simulator. When the link failure occurs in the network, the alternate path is found and the packets are transmitted through the new path.

7.4.1 Comparing Throughput

Throughput of the network is measured in simulation. The number of packets that are transmitted in the network is shown in the following graph. Throughput is measured after the link failure occurrence and after the link failure has been rectified. It is shown that the throughput after the link failure has been overcome is high. There is 32%.

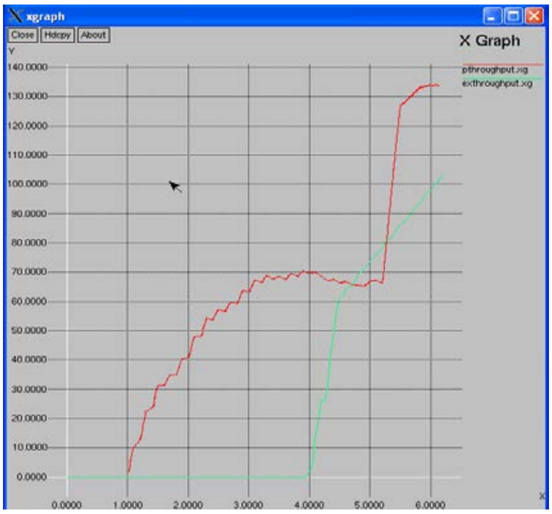

Figure 7.1 Graph representing throughput versus time

Comparing Packet Delivery Ratio

Packet Delivery Ratio is defined as the ratio of the number of packets that are sent by the source node to the number of packets that are received by the destination. Packet delivery ratio is measured for the packets that are transmitted when the link failure occurs in the network and also after the link failure recovery in the network. It has been noted that the packet delivery ratio is high in the case of after the recovery of the link failure in the network. By this, the packet loss reduced by 4.28%.The following graph depicts the comparison of the two cases.

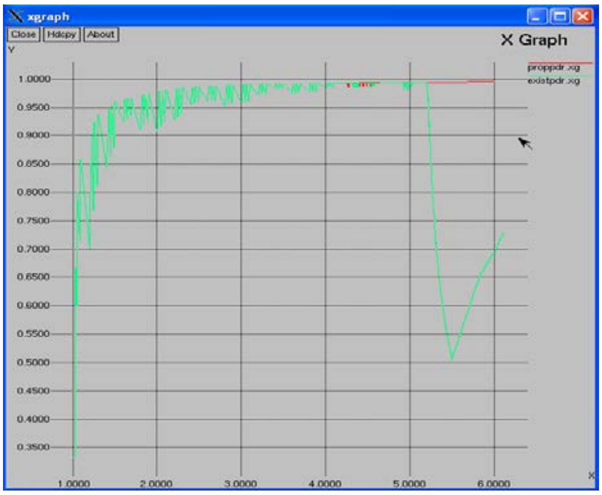

Figure 7.2 Graph representing packet delivery ratio versus time

ADVANTAGES

1.Provide resiliency and guarantee network coding opportunity in the face of link/node failure
2.Improve the network performance significantly

VIII. CONCLUSION

In this project, the first distributed coding-aware routing system, DCAR-Distributed Coding Aware Routing in wireless system is explained. DCAR incorporates potential coding opportunities into route selection using the "Coding + Routing Discovery". DCAR also adopts a more generalized coding scheme by eliminating the "two-hop" limitation in COPE [7].Also the work includes handling link failure that occurs while performing "Coding + Routing Discovery". Extensive evaluation under ns-2 reveals substantial throughput gain when the link failure is handled.

REFERENCES

[1] Christina, F., Dina, K., Athina, M., Muriel, M. and Hariharan, R. (2007) 'Wireless Network Coding: Opportunities & Challenges', Military Communications Conference, MILCOM 2007, IEEE, pp. 1-8.

[2] Douglas, S.J.D.C., Daniel, A., John, B., and Robert, M. (2003) 'A High-throughput Path Metric for Multi-hop Wireless Routing', In ACM MobiCom '03, San Diego, California, pp. 134-146.

[3] Jeherul, I. and Singh, P.K (2010) 'CORMEN: Coding-Aware Opportunistic Routing', Journal Of Computing, Vol. 2, No. 6.

[4] Jilin, L. and John, C.S.L (2008) 'How Many Packets Can We Encode?—An Analysis of Practical Wireless Network Coding', Proc. IEEE INFOCOM, pp. 371-379.

[5] Richard, M.K. (1972) 'Reducibility Among Combinatorial Problems' in "Complexity of Computer Computations", Journal of Computer and System Sciences, pp. 85-104.
[6] Dube, R., Rais, C.D., Kuang-Yeh, W. and Tripathi, S.K. (1997) 'Signal Stability Based Adaptive Routing for Ad Hoc Mobile Networks', Personal Communications, IEEE, Vol. 4, No. 1, pp. 36-45.
[7] Rudolf, A., Nimg, C., Shuo-Yen, R.L. and Raymond, W.Y. (2000) 'Network Information Flow', IEEE Trans. Information Theory, Vol. 46, No. 4, pp. 1204-1216.
[8] Sachin, K., Hariharan, R., Wenjun, H., Dina, K., Muriel, M. and Jon, C. (2006) 'XORs in the Air: Practical Wireless Network Coding', Proc. ACM SIGCOMM'06, Vol. 36, No. 4, pp. 243-254.
[9] Sayid, M.A., Suhaidi, H. and Mohammed, M.K. (2010) 'An Improvement of Link Failure Maintenance in Ad-Hoc Wireless Network', (IJCSIS) International Journal of Computer Science and Information Security, Vol. 8, No. 5.
[10] Shengming, J., Dajiang, Dajiang, H. and Jianqiang, R. (2000) 'A Link Availability Prediction Model for Wireless Ad Hoc Networks', Proceedings of the International Workshop on Wireless Networks and Mobile Computing, Taipei, Taiwan, pages D7-D11.
[11] Szymon, C., Jennings, M., Sachin, K. And Dina, K. (2007) 'Trading Structure for Randomness in Wireless Opportunistic Routing', ACM SIGCOMM Computer Communication.
[12] Xinyu, Z. and Baochun, L. (2009) 'Optimized Multipath Network Coding in Lossy Wireless Networks', IEEE Journal on Selected Areas in Communications archive, Vol. 27, No. 5.

BIOGRAPHY

C.Ram kumar received the BE degree in Electronics and communication engineering from SRM Easwari Engineering college, Anna University in 2010 and pursuing ME degree in communication systems from Sri Krishna College of Engineering and Technology, Anna University of technology, Coimbatore. He had presented national conferences and international conferences in various fields. He is an active member of IETE & IEEE. He has done the project in the area of embedded systems. Now currently doing the project in the field of wireless sensor networks. His area of interest is computer networks, micro-processor, optical communication and wireless communication.

M.Jennie Bharathi received the BE degree in Electronics and communication engineering from St.Peters Engineering college, university of Madras in 2004 and the ME degree in communication system from Thyagaraja college of Engineering, Anna university in Coimbatore in 2008. Now currently she is working in Sri Krishna College of Engineering and Technology as an assistant professor in the ECE department. She has three years teaching experience. She had presented many papers in the national conference and also in the inter-national conference. Her field of interest is wireless communication.