ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, *Vol 9(32), DOI: 10.17485/ijst/2016/v9i32/100205, August 2016* ISSN (Online) : 0974-5645

Improving the Average Number of Network Coded Transmission in AODV Routing Protocol with Network Coding Scheme

Mayank Kumar Goyal[1*], Satya Prakash Ghrera[1] and Jai Prakash Gupta[2]

[1]Department of CSE and IT, Jaypee University of Information Technology, Waknaghat, Himachal Pradesh, India; mayankrkgit@gmail.com, sp.ghrera@juit.ac.in
[2]Computer Science Engineering, Lingya's University, Faridabad, Haryana, India; jaip.gupta@gmail.com

Abstract

Objectives: This paper offers the improvement procedure about Network coding scheme in wireless scenarios and its merits and demerits when integrated with AODV protocol and introduces a modified routing scheme. **Methods/Statistical Analysis:** Using AODV from a known graph G, paths between each pair of nodes are determined and the count of reiteration of each of its nexthops for dissimilar destinations are recorded. For these next hops of a node, the edges connecting them with the node are retained as they were in original graph, while others are deleted. A subgraph of the original graph G' is created to apply Network coding further. **Findings:** On integrating Network coding scheme with the AODV protocol, the algorithm formed is much more energy proficient as compared to the old Network coding scheme since less no. of average transmissions are required per node. The enhancement in the performance of the proposed AODV integrated Network coding scheme over the original Network coding scheme increases with increase in density. Hence a basic alteration of discovering a reduced subgraph from the first original subgraph utilizing AODV routing scheme can enhance the execution of Network Coding to an awesome degree. **Application/Improvements:** The reproduction results shows that proposed modified algorithm improves average number of Network coded transmission in AODV Routing Protocol with Network Coding Scheme.

Keywords: AODV, Ad-hoc Networks, COPE, Network Coding, Opportunistic Listening, Opportunistic Coding, Throughput

1. Introduction

Network Coding (NC) is a freshly emerged standard to proficiently broadcast data in wireless scenarios, where message flows originating from various sources are joined to boost the throughput and upgrade robustness. As opposed to traditional store and forward methodology[1], this actualizes a store and forward procedure, where every node stocks approaching packets in particular buffer and forwards their XORed version.

Initially, An individual network administrator has to make out a sub-graph provided that link capacity can maintain the multicast connections. Secondly, the network code can be built self-governing of that subgraph. Then again, in the different unicast situations, the matter of choosing a sub-graph and the network code formation must be tackled together. The determination of the sub-graph is ordinarily displayed as an breakthrough issue on flows in the network, while the network code formation is algebraic issue. Since we need to tackle both issues mutually, we limit to basic network codes[2].

The benefit of Network coding in case of multicast network can be clarified by easily understood the network presented in Figure 1(a), where source node is 's', and nodes 'r_1' and 'r_2' are the 2 beneficiaries. All the transmission links in the broadcast system has limit one. Source node 's' has 2 bits, 'b_1' and 'b_2' to forward to both beneficiaries. In the beginning, we take the customary multicast scheme without network coding approach as appeared in Figure 1(b). We utilize the straight line to

** Author for correspondence*

address bit 'b_1', the dabbed line to address bit 'b_2' and the intense line to address both the bits 'b_1' and 'b_2'. Bit 'b_1' can arrive 'r_1' along the way 's' to 'a' and then 'a' to 'r_1'. Bit 'b_2' can arrive 'r_2' along the way 's' to 'b' and then 'b' to 'r_2'. Edge form 'c' to 'd' is the familiar edge for bit 'b_1' to arrive 'r_2' and for bit 'b_2' to arrive 'r_1'. Whenever node 'c' gets both bits, it needs to forward them to node 'd' in succession. Assume it advances bit b1 first, at that point 'r_1' and 'r_2' get both bits 'b_1' and 'b_2'. Presently consider utilizing network coding on edge 'c' to 'd'. At the point when node c gets both bits, it initially make a XOR operation to them. At that point it forwards the XORed bit to node 'd'. Whenever beneficiaries'r_1' or 'r_2' get the XORed bit, it can convalesce the first bits 'b_1' and 'b_2' by XORing the XORed bit with the other[3].

An essential result that started the enthusiasm for Network Coding (NC) is that it can provide the throughput gain. When the N beneficiaries plum the network assets, every beneficiary can get the greatest rate it could would like to get, regardless of the fact that it were utilizing all the system assets independent from anyone else. Along these lines, network coding can preferably offer the accessible network assets[4]. Given we get an adequate no. of encoded bundles, irrespective of decipher. The new wind that network coding carry away, is that the linear combination is done shrewdly over the system, not just at the source 's', and hence it is appropriate where nodes just have inadequate data about the complete system state[4].

From the perspective of network security, network coding offers both advantages and disadvantages. As an case we again take the butterfly network of Figure 1(b), if a hacker acquires the coded packet b1⊕ b2, it is unrealistic for him to acquire either b1 or b2. This is a security advantage.

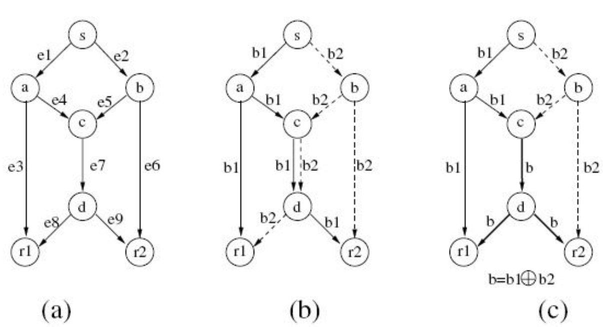

Figure 1. Multicast network (a) Butterfly network (b) Multicast scenario without NC (c) Multicast scenario along with NC.

Another point of interest of network coding in this appreciation is that it encourages the utilization of a sub-graph containing numerous ways to every sink node. At the point when network coding is done crosswise over multiple paths, it offers valuable potential outcomes for data security against foes.

Then again network coding at transitional nodes offers some new dangers in the system. Coded packets that includes some wrong packet result in more mistaken mix packets.

Section 2 describes COPE protocol, CODEB protocol, EBCD scheme, Analog Network Coding (ANC) and reactive Network Coding. Section 3 discusses about proposed modified algorithm and its simulation results. Finally, conclusion and benefits of the proposed modified algorithm are illustrated in Section 4.

2. Previous Work

The issue of broadcast support in MANETs has been broadly examined in[5-8]. In, the issue of high overhead of utilizing basic flooding to sustain broadcast was focused[5]. The issue of least enery consumption broadcasting has been observed to be NP-complete[9] and from that point forward an extensive number of estimation calculations have been proposed. These are either deterministic[5,7] or probabilistic ways to deal broadcast effectively. In probabilistic calculations, packetss are just sent with a specific likelihood[6-8]. In deterministic methodologies, if entire topography data is known, a CDS approach will give ideal outcomes[10]. However, where topology continues evolving much of the time, it's very impractical to get complete topology.

2.1 COPE

To suggest the researchers a vibe for how COPE functions, we begin with a genuinely straightforward case. Take the situation in Figure 2, where Alice and Bob need to swap over a set of packets. In available present methods, Alice sends the data packet to connecting router, which further send that packet to Bob, and Bob forwards the this to the connecting router, which further forward this to Alice. This procedure needs four number of transmissions. Presently following a Network Coding (NC) standard, Both of them transmit their separate packets to connecting router, which apply XOR to the both packets and shows mixed form. It takes three no. of transmissions rather than four. Spared transmissions can be utilized for broadcasting distinct information.

COPE uses three principle strategies:

- **Opportunistic Listening:** Wireless systems provides numerous open doors for mobile nodes to hear packets with omni-directional antenna. Furthermore, every node telecasts received reports to convey its neighbor which data packets this has put away.
- **Opportunistic Coding:** To achieve the gain in throughput, the main question that stands is which packets are to be network coded together. A node may have numerous alternatives, however its objective is to boost the quantity of local packets conveyed, guaranteeing that every proposed next-hop has sufficient data to translate its local packet.

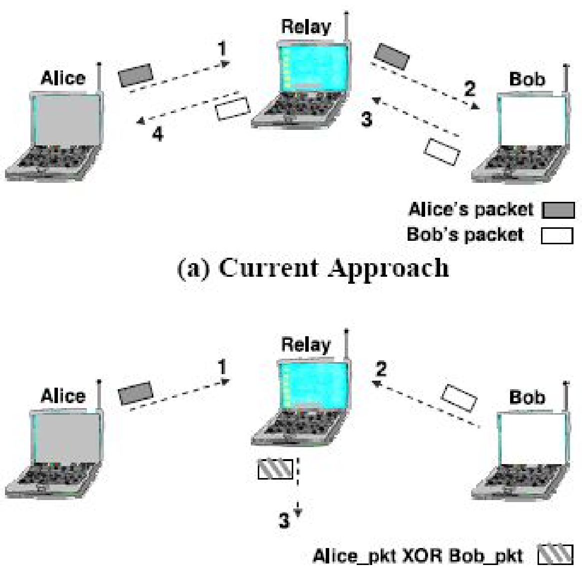

Figure 2. Throughput gain using COPE.

The coding calculation ought to guarantee that all nexthops of an XORed packet can interpret their comparing local packets[11]. This can be accomplished utilizing the below given straightforward principle:

To deliver 'w' packets, to 'm' nexthops, a node can mix the 'w' packets together just assuming each beneficiary has (w–1) packets.

- **Learning Neighbor State:** But how to recognize what packets a node's neighbors have? As clarified before, every node pronounces to its neighbors the packets it keeps. Consequently, a node can't depend exclusively on receiving reception reports[11].

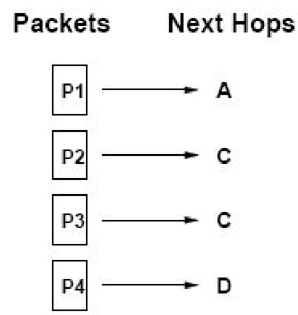

Figure 3. Next-hops of packets in B's queue.

Figure 3, 4, 5 and 6 clearly indicate a simple rule for choosing which packets to code together.

COPE's throughput gain widens as the possibility of network coding raises. At the point when there is higher movement, more packets are accessible at the moderate nodes, and thus there are all the more network coding possibilities.

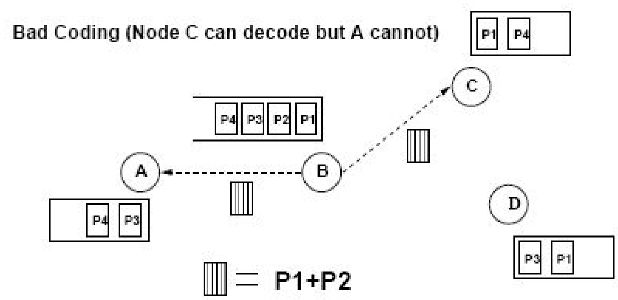

Figure 4. Bad network coding decision.

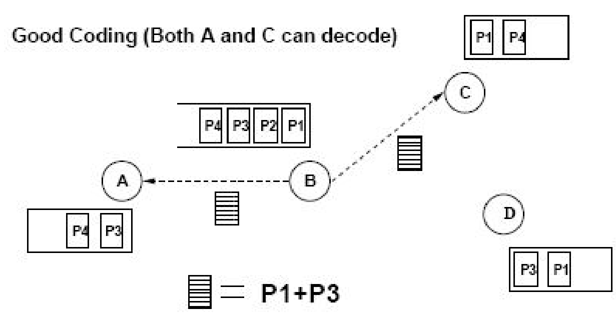

Figure 5. Improved network coding determination.

3. Measurement Metrics

- **Network Throughput:** The deliberate aggregate end-2-end throughput.

- **Throughput Gain:** The proportion of the network system throughputs with the COPE and without the COPE.

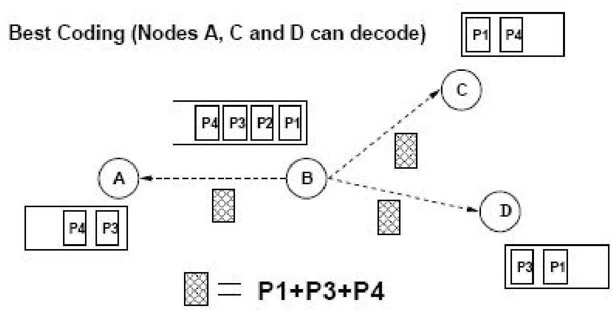

Figure 6. Best network coding determination.

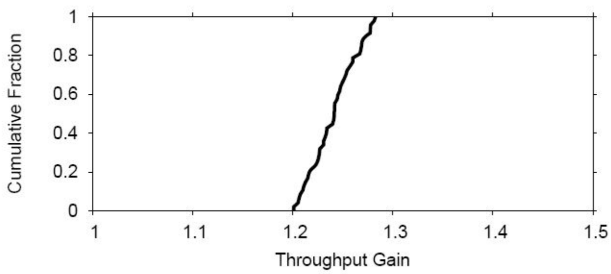

Figure 7. TCP gain in the Alice- Bob topography.

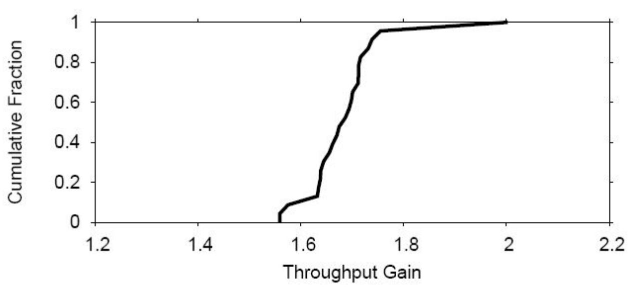

Figure 8. UDP gain in the Alice- Bob topography.

20-node wireless testbed with a bit-rate of 6 Mb/sec has been used to learn the performance of COPE method and the Network Coding (NC).

Our experiments disclose the following conclusions.

For the example considered above i.e. Alice-and-Bob topography the gain, shown in Figure. 7 and Figure. 8, is nearly 1.3 for TCP flows, while it is 1.8 for UDP flows.

3.1 Pseudo- Broadcast

Coded packets should be forwarded to various beneficiaries to achieve throughput gain.

One approach for this is to place nodes into the promiscuous mode to forward the packets. The beneficiaries operates promiscuous mode and receive every packet. Utilizing this way, a coded packet can be conveyed to various recipients all the while[12].

The Figure 9 contrasts the entire under zero coding and coding, and contrasts it against coding over pseudo broadcast.

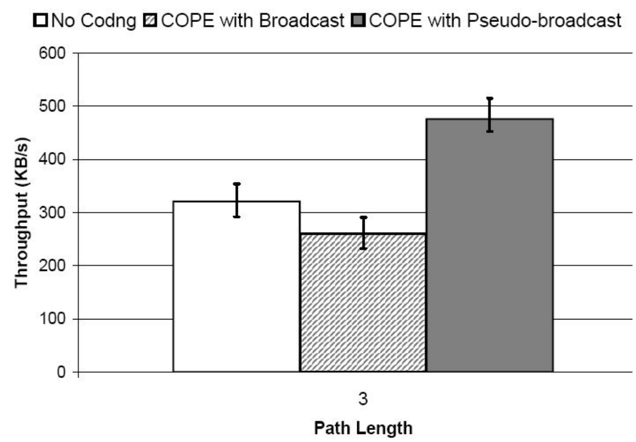

Figure 9. Significance of pseudo-broadcast.

4. CODEB

CODEB has three key characteristics:

- Opportunistic listening: It works in a analogous fashion as COPE. The nodes work in indiscriminate mode and are outfitted with omni-directional antenna. They watch all the correspondences occurring in the remote medium and keep the packets for a restricted period T. The distinction is that nodes don't telecast reception reports as in COPE. When a node 'a' has this knowledge alongside the former hop 'b' of the packet 'p', it could induce that the neighbor of b has gotten p. At the point when 'p' is the coded packet, different inductions are likewise conceivable. In view of this information's, every node makes a neighbor gathering table. If a packet is not ready to discover any coding possibilities, packet can either be transmitted to the interface.
- Forwarder selection and pruning: In contrast to a gossip methodology[13], where all the nodes act as forwarders with a predefined likelihood, just a subset of neighbors are picked as forwarders. Here the PDP calculation from[5] is chosen forwarders. This forwarder selection is made independent of coding.

However regardless of the fact that a node is chosen as a forwarder, it should not send it if verifies that all its neighbors had gotten a specified packet.

- Opportunistic coding: Each node looks at its arrangement of to be sent packets and its Neighbor table got. It then chooses progressively, if it can utilize coding possibilities to drive coded packets instead of transferring non- coded packets. In[14] presents two calculations for coding as was said before: 1. XOR various packets in support to empower most extreme number of nodes to decipher another packet and 2. An ideal coding conspires that makes utilization of Reed-Solomon code.

Table 1 represents the simulation bench parameters for CODEB. Figure 10, 11 and 12 represents the simulation results.

Table 1. Simulation Bench parameters

Parameters	Value
Mac layer Protocol	IEEE 802.11
Bit rate	2 Mb/sec
Nominal range	300 meters
Traffic type	CBR
Packet size	256 bytes
No. of sessions	25
Varied sending rates	2 packets /second (low load) , 4 packets/second (high load)
No. of nodes	100

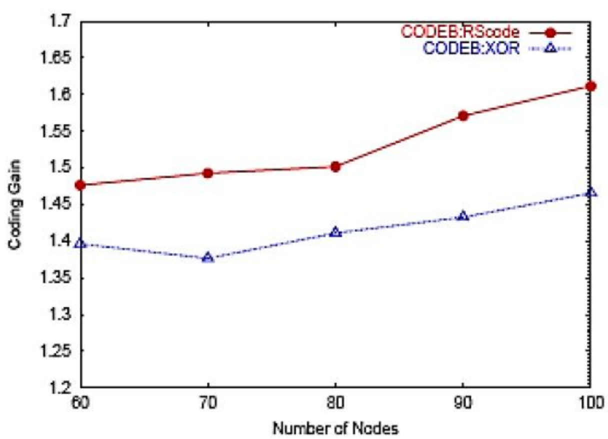

Figure 10. Network coding gain for sending rate 2 packets/ sec.

4.1 Reed-Solomon Code based Optimal Algorithm

This algorithm on getting an encoded packet, by a node 'k', that comprises of 'n' local packets (set S), the node first investigates every single local packet got in the pool of packets. At that point it takes Sk, the subset of bundles in S that it has gotten in advance. After that it develops Λk by the condition Sk = Λk P, and adds the new coefficient vector to grid Λk.

5. EBCD Mechanism

In EBCD, every node chooses its sending status utilizing just neighborhood data and restricted piggy backed show state data. The proposed outline just the mix of the two existing techniques. We exploit the interactional impacts of them to accomplish a far better execution. In spite of the fact that the sending node/edge determination and the further system coding methods are self-regulating, it has been observed that distinctive sending node determination approaches influence the effectiveness of network coding considerably[15].

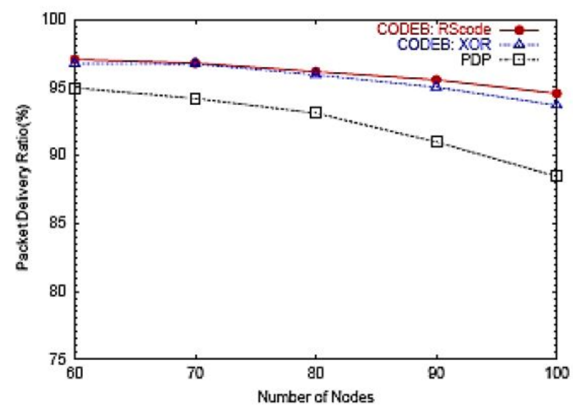

Figure 11. Packet delivery ratio gain for sending rate 2 packets/sec.

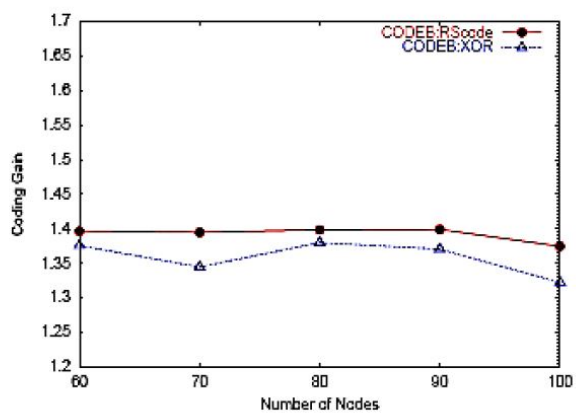

Figure 12. Network coding gain for sending rate 4 packets/ sec.

5.1 EBCD Calculation at Node 'a'

5.1.1 Ahead of Broadcast

- Trade "Hi" messages to upgrade neighborhood topology.
- After getting the very 1st message (before the clock schedule):
- Schedule the clock.
- Redesign the neighborhood priorities based on every message received.
- At the point when clock terminates, force dynamic node cover clauses for every data packet.
- If 'a' is a sending node for a few messages,
  - Adjust edge of a division to every sending edge,
  - conclude coded messages in every division utilizing coding,
  - Select the position with the least aggregate transmissions.
- Forward Network Coded (NCs) messages[8].

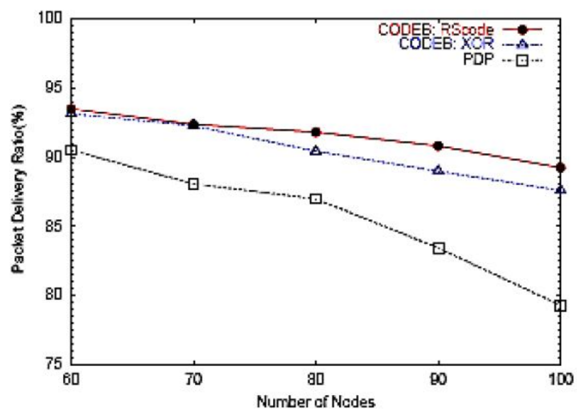

Figure 13. Packet delivery ratio gain for sending rate 4 packets/sec.

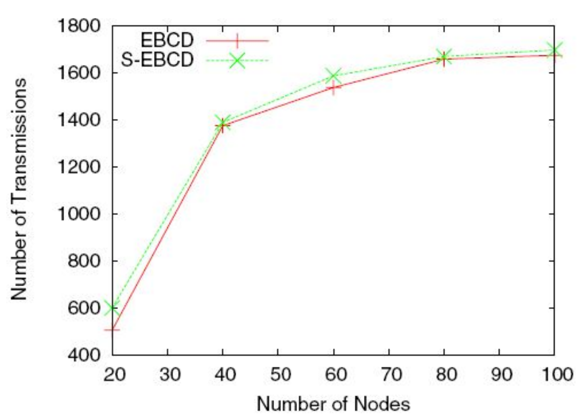

Figure 14. No. of transmission taken as 15.

The source node in the system can just utilize omnidirectional broadcast to convey the messages. In request to assist lessen energy utilization; source node can just switch on segments in which there are neighbors for broadcast.

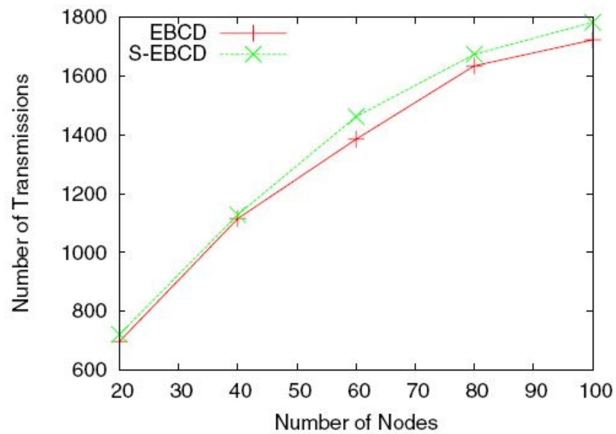

Figure 15. No. of transmission taken as 8.

5.1.2 Static EBCD (S-EBCD)

In the static EBCD, simply topographical knowledge is considered, while in EBCD, broadcast state knowledge of the neighborhood is also piggybacked.

Figure 13, 14 represents the comparative simulation results among the two algorithms EBCD and S-EBCD.

6. Analog Network Coding (ANC)

At the point when two senders' s_1 and s_2 transmit at the same time, the packets have a collision[16]. The signal coming about from an impact is only the entirety of the two impacting signals. Along these lines, if the beneficiary knows the substance of the packet that meddled with the packet it needs, it can wipe out the signal relating to that known packet. The recipient is now left with the signal of the data packet it needs, which it translates utilizing usual techniques. In the wireless system, when two packets impact, nodes frequently know one of the impacting packets by prudence of having sent it before or having caught it. In Network Coding (NC), senders transmit consecutively, furthermore, routers mix the substance of the packets and telecast the mixed variant[11,12]. In Analog Network Coding, senders transmit at the same time. Figure16 and Figure 17. Clearly shows the working of traditional networking and Analog Network Coding respectively. The wireless channels actually mix these signals. Rather than sending xored packets, routers initiate forwarding mixed signals.

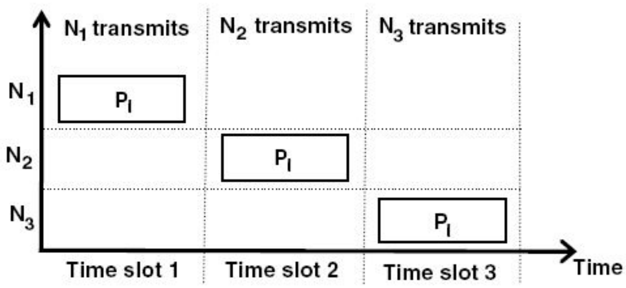

Figure 16. Traditional networking approach.

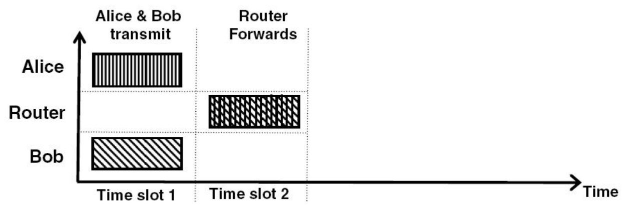

Figure 17. Analog network coding.

7. Reactive Network Coding

In case of reactive network coding, nodes convey new packet mixtures relied on a forwarding factor 'f' which relies on upon their no. of neighbors[17,18]. We detect that there are specific topographies where this methodology does not operate. As a case, think about the situation where a given node 'k' has a huge no. of neighbors and one of them, call 'q', has just 'k' as its neighbor. Because of its high number of neighbors 'k' conveys a little number of packets and, thus, 'q' is unrealistic to have the capacity to interpret all the needed data (as it didn't get enough autonomous packet mixes from 'k').

8. Proposed Algorithm and Results

In our approach, AODV protocol is integrated with Network Coding (NC) approach to make maximum utilization of both the theories. AODV has following main procedures.

8.1 Path Discovery

This process takes off when a source node 'S' wants to exchange some packets with another node for which it has zero routing knowledge[19]. Each node maintains two different counters- a node sequence number and a broadcast id. The source node 'S' begins path discovery by broadcasting a route request (RREQ) packet to its neighbors.

A Route Request has the following fields: <source_address; source_sequence_no.; broadcast_id; destination_address; dest_sequence_no.; hop_count >

When a source node 'S' issues a new Route Request, the broadcast_id is incremented. When a node receives a Route Request, and if it has got a Route Request with the same broadcast id and source address in advance, it drops the duplicate Route Request[19].

8.2 Reverse Path Setup

To establish the reverse path, a node maintains the record of the address of the neighbor from which it has received the initial copy of the Route Request. These reverse path route logs are retained for at least enough time for the Route Request to traverse the network[20].

8.3 Forward Path Setup

At the point when the Route Request comes at a node that has a way to beneficiaries, it figures out if the root is current by looking at the destination sequence number. If sequence number in RREQ is higher than that maintained by the moderate node, the moderate node must not utilize its recorded path.

8.4 Route Table Management

For every entry, active neighbor's address is recorded through which packets for the given destination are received. A neighbor is understood as if it forwards at least one packet for that destination.

In the advised algorithm, using AODV from a known graph G, paths between each pair of nodes are determined. Then for every node, the count of reiteration of each of its next hops for dissimilar destinations is recorded. Next hops are chosen for which the count is maximum. For these next hops of a node, the edges connecting them with the node are retained as they were in the original graph, while others are deleted. Thus, a subgraph of the original graph G' is created. Network coding algorithm is applied over this subgraph.

8.5 Algorithm (G)

- By using AODV algorithm[20], routes are found out for every pair of nodes.
- For every node 'p' in the original graph G do

for Node 'q'=1 to n (No. of nodes) do
for Node 'r'=1 to n do
m.nexthops ← next_hop for source=q, destination=r
Counts ← reiterations for each Nexthop
end for
end for
p.Max = max(p.Counts), nexthop for which count = max is recorded and stored in p.Neighbors
end for

- For Nodes p=1 to n do

for q=1 to n do
if q ∈ i.neighbors then
matrix(p,q)=1
else
matrix(p,q)=0
end if
end for
end for

- Graph G' is drawn keeping only connection between nodes i and j if matrix (p,q)=1.
- Network Coding algorithm is implemented on graph G', a subgraph of G.

8.6 Simulation Assumptions and Results

Maximum allowed degree of a node is taken as 5 for the simulation purpose and algorithm is tested over 50 no. of nodes.

old Network coding scheme
New AODV Integrated Network coding scheme

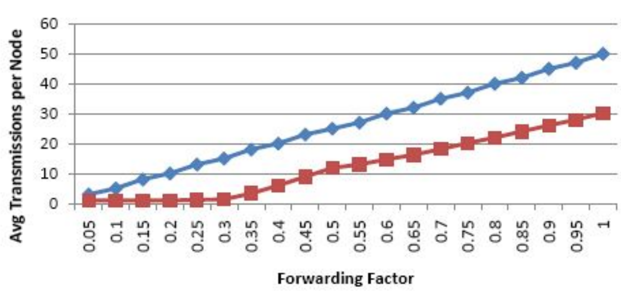

Figure 18. Average no. of transmissions per node vs. forwarding factor.

Figure 18 clearly represents the plot between average no. of transmissions per node vs. forwarding factor in case of both schemes i.e. old network coding scheme and new AODV integrated network coding scheme. Figure 19 clearly represents the plot between packet delivery ratio vs. forwarding factor in case of both schemes i.e. old network coding scheme and new AODV integrated network coding scheme.

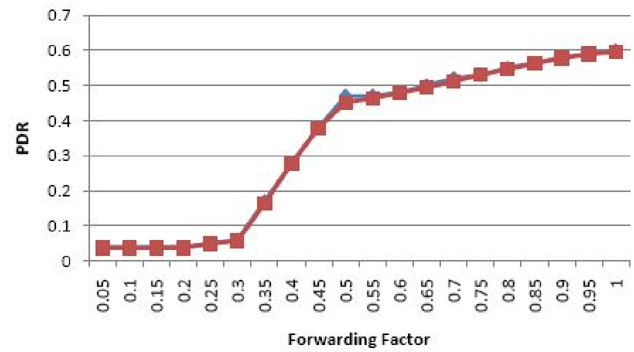

Figure 19. Packet delivery ratio vs. forwarding factor.

9. Conclusion

From the above discussions, facts and figures, it is clear that on integrating Network coding scheme with the AODV protocol, the algorithm formed is much more energy proficient as compared to the old Network coding scheme since less no. of average transmissions are required per node. The enhancement in the performance of the proposed AODV integrated Network coding scheme over the original Network Coding scheme increases with increase in density. Hence a basic alteration of discovering a reduced subgraph from the first original subgraph utilizing AODV routing scheme can enhance the execution of Network Coding to an awesome degree.

10. References

1. Eugster P, et al. Epidemic information dissemination in distributed systems. Computer. 2004; 37(5): 60-7.
2. Traskov D, et al. Network coding for multiple Unicasts: An approach based on linear optimization. IEEE International Symposium on Information Theory; 2014. p. 1757–62.
3. Yang M, et al. Constructing a linear network code for Multicast networks based on Hypergraphs. IEEE Globecom Conference; 2007. p. 1998–2002.

4. Fragoouli C, et al. Network coding. ACM SIGCOOM Computer Communication Review; 2006. 36(1):63–8.
5. Lou W, et al. On reducing broadcast redundancy in ad hoc wireless networks. IEEE Transactioons on Mobile Computing. 2002; 1(2):111–22.
6. Tseng, et al. Wireless Networks. 2002; 8:153–67.
7. Lim H, et al. Flooding in wireless ad hoc networks. Computer Communications. 2001; 24(3-4):353–63.
8. Haas Z, et al. Gossip-based ad hoc routing. IEEE Transactions on Networking. 2006; 14(3):479–91.
9. Cagalj M, et al. Minimum-energy broadcast in all-wireless networks. International Conference on Mobile Computing and Networking; 2002. p. 172–82.
10. Alzoubiet K, et al. New distributed algorithm for connected dominating set in wireless ad hoc networks. International Conference on System Sciences; 2010. p. 3849–55.
11. KattIi S, et al. XORs in the air: Practical wireless network coding. IEEE Transactions on Networking. 2008; 16(3):497-510.
12. Wu Y. Information exchange in wireless networks with network coding and physical-layer broadcast. Conference on Information Sciences and Systems; 2005.
13. Fragouli C, et al. A network coding approach to energy efficient broadcasting: From theory to practice. IEEE International Conference on Computer Communications; 2006. p. 1–11.
14. Li L, et al. Network coding-based broadcast in mobile adhoc networks. IEEE International Conference on Computer Communications; 2007. p. 1739–47.
15. Yang S, et al. Efficient broadcasting using network coding and directional antennas in MANETs. IEEE Transactions on Parallel and Distributed Systems. 2009; 21(2):148–61.
16. Katti S, et al. Embracing wireless interference. ACM SIGCOOM Computer Communication Review. 2007; 37(4):397–408.
17. Fragouli C, et al. Efficient broadcasting using network coding. IEEE Transactions on Networking. 2008; 16(2):450–63.
18. Sagduyu Y, et al. Cross layer design for distributed MAC and network coding in wireless ad hoc networks. International Symposium on Information Theory. 2005; 1863–7.
19. Marina M, et al. On-demand multipath distance vector routing in ad hoc networks. International Conference on Network Protocols; 2001. p. 14–23.
20. Perkins C, et al. Ad hoc on-demand Distance Vector (AODV) routing. 2003.