Enhancing the Functionality of Opportunistic Routing in MANET by using Channel Reuse

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Abstract— Mobile Ad Network is a type of adhoc network that can change location and configure itself on fly. In MANET, routing is a very tedious task so it is an important research area of work due to its unpredictable network topology changes. Opportunistic routing is a new technique which achieves high throughput in the lossy wireless links. The main conception of cooperative communications is to make use of the broadcast nature of the wireless medium. In this paper, we are enhancing the functioning of cooperative opportunistic routing in MANET using spatial channel reusing. In this paper, MORE is used instead of ExOR, since ExOR ties the MAC with routing, adding a strict schedule on routers’ access to the medium. Here, it randomly mixes the packets before forwarding them. Due to this randomness routers hear the same transmission do no forward the same packets. That’s why; MORE has no needs special scheduler to coordinate routers and can run directly on top of 802. Experimental result shows maximum growth in the performance of exiting protocol.

Keywords— Corman, ExOR, MANET, MORE, PSR

I. INTRODUCTION

A Mobile Ad hoc Network is a type of adhoc network that can change location and configure itself on fly. The mobile devices connected by wireless communication network, in which nodes that are not direct transmission range of each other will require to forward data to other nodes. The main challenge of building the MANET, each device has to continuously maintain the information for routing the traffic properly. The network layer has assigned an important task when working on MANET; as a result plenty of routing protocols in such a network with differing objectives and for various specific needs have been proposed [1]. There are two main operations at the network layer, i.e., forwarding of data and routing, are different concepts. Data forwarding means how packets are taken from one link and put on another. Routing explains how to follow path from the source node to the destination.

Routing protocols in Mobile ad hoc network can be categorized in two ways. The basic difference between this is the timing of routing information exchange. On one hand, a protocol may require that nodes in the network should maintain valid routes to all destinations all the time called as proactive routing protocols. And, on other hand, if nodes in the network do not always maintain routing information, when a node receives data from the upper layer for a given destination, it must first find out how to reach the destination, such approach is called reactive routing protocols.

Opportunistic routing has recently emerged as a mechanism for obtaining high throughput even when links are lossy [2][3]. Traditional routing chooses the next hop before transmitting a packet; but, when link quality is poor, the probability the chosen next hop receives the packet is low. In opposite to, opportunistic routing allows any node that overhears the transmission and is closer to the destination to participate in forwarding the packet. Opportunistic routing, however, introduces a difficult challenge. Multiple nodes may hear a packet broadcast and unnecessarily forward the same packet.

Research on co-operative communication at the link layer and above had been little until ExOR [4]. ExOR is the main work in wireless networking and it is an elegant way to utilize the broadcasting nature of wireless links to achieve cooperative communication at the link layer and network layers of static multihop wireless networks. Here, we further broaden the scenarios that the idea behind ExOR can be used, called as Co-operative Opportunistic Routing in Mobile Ad hoc Networks (CORMAN) [5].

As compare to ExOR’s highly structured scheduler, in this paper we address above challenge with randomness and no scheduler. For this purpose have taken use of MORE [3], MAC-independent Opportunistic Routing & Encoding. MORE randomly joins packets before forwarding them. This makes sure that routers that hear the same transmission do not forward the same packet. Indeed, the possibility that such randomly coded packets are the same is proven to be exponentially low. As a result, MORE does not require a special scheduler; it runs directly on top of 802.11.

II. LITERATURE SURVEY

The use of the broadcasting nature of wireless channels at the link layer and above has a relatively recent history when compared to the efforts at the physical layer.
Chlamtac I et al [6], describes about, a mobile ad hoc network (MANET), sometimes called a mobile mesh network, and is a self-configuring network of mobile devices connected by wireless links. The Ad hoc networks are a new wireless networking paradigm for mobile hosts. Unlike traditional mobile wireless networks, ad hoc networks do not rely on any fixed infrastructure. Larsson [7] proposes an innovative handshake technique, called Selection Diversity Forwarding (SDF), to implement downstream forwarder selection in a multihop wireless network, where multiple paths are provided by the routing module. In this case, a sender in the network can dynamically choose from a set of usable downstream neighbors that present high transient link quality. ExOR is solution for that. ExOR is a cross-layer explorative opportunistic data forwarding technique in multi-hop wireless networks by Biswas and Morris. It fuses the MAC and network layers so that the MAC layer can determine the actual next-hop forwarder after transmission depending on the transient channel conditions at all eligible downstream nodes. Leontiadis and Mascolo and Yang et al. [8] suggest using position information for routing in mobile multi-hop wireless networks. Therefore it is supposed that each and every node in a network is mindful of all other node position in the network. MORE improves ExOR to further increase the spatial channel reuse in a single flow via intra flow network coding [9] to reach destination from the source.

III. GOOD EXAMPLE

MORE's design builds on the theory of network coding [9][10][11]. In this section, we are explaining two study examples to explain the intuition underlying our approach and illustrate the synergy between opportunistic routing and network coding.

The Unicast Case: Consider the case in Figure (1) [3]. Traditional routing predetermines the path before transmission. It sends traffic along the path "src→R→dest", which has the highest delivery probability. But, we know wireless is a broadcast medium. When a node transmits, there is always a chance that a node closer than the chosen next hop to the destination overhears the packet. For example, assume the source sends 2 packets, p1 and p2. The next hop, R, receives both, and the destination happens to overhear p1. It would be a waste to have node R forward p1 again to the destination. This observation has been noted in [2] and used to develop ExOR, an opportunistic routing protocol for mesh wireless networks. ExOR, however, requires node coordination, which is more difficult in larger networks.

Consider again the example in the previous paragraph. R should forward only packet p2 because the first packet has already been received by the destination; but, without consulting with the destination, R has no way of knowing which packet to transmit. The problem becomes harder in larger networks, where many nodes hear a transmitted packet. Opportunistic routing allows these nodes to participate in forwarding the heard packets. Without coordination, however, multiple nodes may unnecessarily forward the same packets, creating spurious transmissions.

To deal with this issue, ExOR [4] imposes a special scheduler on top of 802.11. The scheduler goes in rounds and reserves the medium for a single forwarder at any one time. The rest of the nodes listen to learn the packets overheard by each node. Due to this strict schedule, nodes farther away from the destination (which could potentially have transmitted at the same time as nodes close to the destination due to spatial reuse), cannot, since they have to wait for the nodes close to the destination to finish transmitting. Hence the scheduler has the side effect of preventing a flow from exploiting spatial reuse.

![Figure 1—Unicast Example.](image-url)

The source sends 2 packets. The destination overhears p1, while R receives both. R needs to forward just one packet but, without node-coordination, it may forward p1, which is already known to the destination. With network coding, however, R does not need to know which packet the destination misses. R just sends the sum of the 2 packets p1 + p2. This coded packet allows the destination to retrieve the packet it misses independently of its identity. Once the destination receives the whole transfer (p1 and p2), it acknowledges the transfer causing R to stop transmitting.

Network coding offers a good solution to the above problem. In our example, the destination has overheard one of the transmitted packets, p1, but node R is unaware of this fortunate reception. With network coding, node R naturally forwards linear combinations of the received packets. For example, R can send the sum p1 + p2. The destination retrieves the packet p2 it misses by subtracting from the sum and acknowledges the whole transfer. Thus, R need not know which packet the destination has overheard. Indeed, the above works if R sends any random linear combination of the two packets instead of the sum.
The source includes in the forwarder list nodes that are closer to the destination than itself, ordered according to their proximity to the destination.

The proposed solution is the extension of CORMAN [5]. To achieve better performance we use spatial channel reuse in the existing system. The whole system has following modules. Out of which first three modules are in existing system and last three modules are in proposed system work cooperatively with existing system. Figure (3) shows system architecture proposed system.

### A. System Model

The proposed solution is the extension of CORMAN [5]. To achieve better performance we use spatial channel reuse in the existing system. The system has following three modules. Figure 3 shows system architecture proposed system.

### IV. WORKING DETAILS

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### A. System Model

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![Figure 2—Multicast Example.](image)

Instead of retransmitting all four packets, the source can transmit two linear combinations, e.g., $p_1 + p_2 + p_3 + p_4$ and $p_1 + 2p_2 + 3p_3 + 4p_4$. These two coded packets allow all three destinations to retrieve the four original packets, saving the source 2 transmissions.

The Multicast Case: Our second example explains the synergy between network coding and multicast. In Figure (2), the source multicasts 4 packets to three destinations [3]. Wireless receptions at different nodes are known to be highly independent. Assume that each destination receives the packets indicated in the figure—i.e., the first destination receives $p_1$ and $p_2$, the second destination receives $p_2$ and $p_3$, and the last destination receives $p_3$ and $p_4$. Note that each of the four packets is lost by some destination. Without coding, the sender has to retransmit the union of all lost packets, i.e., the sender needs to retransmit all four packets. In contrast, with network coding, it is sufficient to transmit 2 randomly coded packets. For example, the sender may send $p'_1 = p_1 + p_2 + p_3 + p_4$ and $p'_2 = p_1 + 2p_2 + 3p_3 + 4p_4$. Despite the fact that they lost different packets, all three destinations can retrieve the four original packets using these two coded packets. For example, the first destination, which has received $p'_1$, $p'_2$ and $p_1$, $p_2$, retrieves all four original packets by inverting the matrix of coefficients, and multiplying it with the packets it received, as follows:

$$
\begin{bmatrix}
  p_1 \\
  p_2 \\
  p_3 \\
  p_4
\end{bmatrix} =
\begin{bmatrix}
  1 & 1 & 1 & 1 \\
  1 & 2 & 3 & 4 \\
  1 & 0 & 0 & 0 \\
  0 & 1 & 0 & 0
\end{bmatrix}^{-1}
\begin{bmatrix}
  p'_1 \\
  p'_2
\end{bmatrix}
$$

Thus, in this simple example, network coding has reduced the needed retransmissions from 4 packets to 2, improving the overall throughput.
The sender keeps transmitting coded packets from the current batch until the batch is acknowledged by the destination, at which time, the sender proceeds to the next batch.

**Forwarders**

Nodes listen to all transmissions. When a node hears a packet, it checks whether it is in the packet’s forwarder list. If so, the node checks whether the packet contains new information, in which case it is called an innovative packet. Technically speaking, a packet is innovative if it is linearly independent from the packets the node has previously received from this batch. Checking for independence can be done using simple algebra (Gaussian Elimination). The node ignores non-innovative packets, and stores the innovative packets it receives from the current batch.

If the node is in the forwarder list, the arrival of this new packet triggers the node to broadcast a coded packet. To do so the node creates a random linear combination of the coded packets it has heard from the same batch and broadcasts it. Note that a linear combination of coded packets is also a linear combination of the corresponding native packets. In particular, assume that the forwarder has heard coded packets of the form $P' = \sum C_i P_i$, where $P_i$ is a native packet. It linearly combines these coded packets to create more coded packets as follows: $P'' = \sum r_j P_i'$, where $r_j$’s are random numbers. The resulting coded packet $P''$ can be expressed in terms of the native packets as follows: $P'' = \sum (r_j \sum C_j P_i) = \sum (\sum r_j C_j) P_i$; thus, it is a linear combination of the native packets themselves.

**Destination**

For each packet it receives, the destination checks whether the packet is innovative, i.e., it is linearly independent from previously received packets. The destination discards non-innovative packets because they do not contain new information. Once the destination receives $K$ innovative packets, it decodes the whole batch (i.e., it obtains the native packets) using simple matrix inversion:

$\begin{pmatrix} P_1 \\ \vdots \\ P_K \end{pmatrix} = \begin{pmatrix} C_{11} & \cdots & C_{1K} \\ \vdots & \ddots & \vdots \\ C_{K1} & \cdots & C_{KK} \end{pmatrix}^{-1} \begin{pmatrix} P'_1 \\ \vdots \\ P'_K \end{pmatrix}$

Where, $P_i$ is a native packet, and $P'_i$ is a coded packet whose code vector is $C_i = C_{i1}, \ldots, C_{iK}$. As soon as the destination decodes the batch, it sends an acknowledgment to the source to allow it to move to the next batch.

ACKs are sent using best path routing, which is possible because MORE uses standard 802.11 and co-exists with shortest path routing. ACKs are also given priority over data packets at every node.

**B. Mathematical Model**

Let we have $N$ no of packets at source node that we have to send to the destination; 

$N=\{N_1, N_2, N_3, \ldots, N_n\}$

These packets are divided into $K$ batches, where $K$ may vary from one batch to another. Initially, they are uncoded packets. These $K$ uncoded packets are called native packets.

When sender is ready sends the source creates a random linear combination of the $K$ native packets in the current batch and broadcasts the coded packet.

Here, Data packets are always coded and coded packet is given by,

$P'_j = \sum C_j P_i,$

Where the $C_j$’s are random coefficients picked by the node and

The $P_i$’s are native packets from the same batch.

We call them,

$C_j = (C_{j1}, C_{j2}, \ldots, C_{jk})$ the code vector of packet $P'_j$.

Thus, the code vector describes how to generate the coded packet from the native packets.

At Forwarders node, when node hears a packet, it checks whether it is in the packet’s forwarder list. Assume that the forwarder has heard coded packets of the form

$P'' = \sum C_j P_i$, Where $P_i$ is a native packet.

It linearly combines these coded packets to create more coded packets as follows:

$P''' = \sum r_j P''$, Where $P_i$ is a native packet.

Where $r_j$’s are random numbers. The resulting coded packet $P'''$ can be expressed in terms of the native packets as follows: $P''' = \sum (r_j \sum C_j P_i) = \sum (\sum r_j C_j) P_i$; thus, it is a linear combination of the native packets themselves.

At destination, it checks whether the packet is innovative, i.e., it is linearly independent from previously received packets. Once the destination receives $K$ innovative packets, it decodes the whole batch, and then simple matrix inversion original packets are recovered and pass to the destination.
Where, $P_i$ is a native packet, and $p'_i$ is a coded packet whose code vector is $C_i = C_{i1}, \ldots, C_{iK}$ at the last destination decodes the batch and send acknowledgement back to sender to allow it, send next batch.

V. RESULT DISCUSSION

The Following results are found out for basic CORMAN and Improved CORMAN by using channel reuse. Result recorded based on 10 nodes. We have shown below figure 4 as PDR v/s node velocity and figure as packet delay v/s node velocity. After the result we can say that there is rapid improvement in recent protocol.

VI. CONCLUSION AND FUTURE WORKS

So, we have proposed better co-operative opportunist routing in MANET by using spatial channel reuse. As we know, the ExOR is having highly structured scheduler, but implemented technique uses MORE protocol and is sits between network layer and above the 802.11 MAC and has no special scheduler. The improved performance is show with help of diagram in the results. For the future work we suggest working on overcoming the existing problems of CORMAN and present the next extended version of the same.

REFERENCES