Performance Enhancement Using Network Coding in Dynamic Source Routing

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Abstract

Network coding is a new technique that allows the nodes in the network to code the incoming data and transmit. Significant gains such as throughput improvement, robustness, complexity and security can be obtained by using network coding. Dynamic source routing is a reactive protocol for multi hop mobile Ad hoc networks. This paper proposes a better DSR technique using Network coding to reduce the number of transmissions in mobile ad hoc network and increasing throughput efficiency. The simulation results when compared with existing DSR protocol shows potential throughput improvement and communicates more information with fewer packet transmissions.

Keywords: network coding; mobile Ad hoc networks; dynamic source routing; forwarder; reliability; delay.

1. INTRODUCTION

A Mobile Ad hoc network is a collection of wireless nodes with no access points or centralized administration, operates on limited battery energy consumed mostly in transmission and reception. The network’s wireless topology may change rapidly and unpredictability. Limited bandwidth, energy constraints, high cost and security...
are some encountered problems in these types of network. The routing protocols of mobile ad hoc can be classified into three groups, table-driven, source initiated on-demand and hybrid routing protocols. Dynamic source routing protocol is a source initiated reactive protocol.

The network coding technique was introduced by Ahlswede et al. is a recent field in information theory that allows the intermediate nodes to create new packets by combining the packets received over the incoming edges. This technique offers several benefits such as increase in throughput, improvement in reliability and robustness of the network. Using this technique the total number of transmission is reduced and so saves power of some bottleneck nodes and increases the life time of the network. A simple example in a wireless context is a six node topology as shown in figure 1. Node N1 and Node N2 are source nodes. Node N1 transmits to N5 and N6, similarly Node N2 to N5 and N6. Instead of transmitting separately, when network coding approach is used the two packets from the source are combined by means of XOR operations at the intermediate node N3 and forwarded. The receiver can then decode this coded packet to get the required data.

![Network Coding Example](image)

**Figure 1: Simple example of network coding**

Network coding was initially proposed as a distributed mechanism for achieving the multicast theoretic (max-flow, min-cut) capacity in wired networks. Coding are of two types linear network coding and random network coding. Network coding techniques can be applied to wireless network to achieve load balancing, energy saving, network monitoring, security and distributed storage. The example above shows that the network coding technique reduces the number transmissions. It allows for a much larger degree of flexibility in the way packets can be combined. In addition to throughput benefits it is well suited for environments where only partial or uncertain information is available for decision making. Information reception does not depend on receiving specific packet content but rather on receiving a sufficient number of independent packets. This paper is organized as follows: In section 1 the introduction, section 2 we discuss the related work, section 3 description of dynamic source routing, section 4 presents the proposed network coded – dynamic source routing. Section 5 provides the simulation results of the proposed protocol and section 6 concludes this paper.
2. RELATED WORK

Network coding is a hot topic in recent wireless networking research. In the following, we summarize existing research results that are related to our work. Fubao Yang discusses multipath routing problem, which deals with the network coding for researching the mobile ad hoc network multipath routing problem. It presents a Network Coding based AOMDV routing algorithm in MANET. The NC-AOMDV allows packet encoding at a relay node. As a result the packet overhead, average end to end delay is minimum. The NC-AOMDV routing protocol provides an accurate and efficient method of estimating and evaluating the route stability in dynamic MANETs. Baolin Sun proposes a Network – Coding based on demand multipath routing algorithm in MANET (NCMR). It is typically proposed in order to increase the reliability of data transmission or to provide load balancing. Network coding has been proposed as an effective way of improving bandwidth utilization. Optimal network code construction in wireless multicast under different QOS constraints remains as a significant challenge.

Adopting network coding as a means of improving reliable data delivery lowers control overhead in a large scale. The lifetime maximization routing with network coding increases throughput, lowers energy consumption and improves lifetime significantly. Tomonori Kagi has proposed an efficient reliability improvement method in an MANET environment by applying network coding encoded by a relay node. Reliability is improved without sending any redundant encoding packets by the source node. The packet delivery ratio is higher than the existing encoding method packet – level forward error control.

3. DYNAMIC SOURCE ROUTING

The Dynamic source routing protocol is a simple and efficient routing protocol designed specifically for use in multi hop wireless ad hoc networks of mobile nodes. It allows the network to be completely self organizing and self – configuring, without the need for any existing network infrastructure. DSR is a source initiated link state routing protocol. It allows nodes to dynamically discover a source route across multiple network hops to any destination. The use of source routing allows packet routing to be trivially loop free. The protocol is composed of two mechanisms: the route discovery and route maintenance.

Route discovery by which a node S wishing to send a packet to a destination node D obtains a source route to D. Route discovery is used only when S attempts to send a packet to D and does not already know a route to it.

Route maintenance, by which node S, while using a source route to D, is able to detect, if the network topology has changed such that it can no longer use its route to D because a link along the route no longer works. When route maintenance indicates that a source route is broken, S can attempt to use any other route to D it happens to know or it can invoke Route discovery again to find a new route. Route maintenance is used only when S is actually sending packets to D.

Route Discovery and Route maintenance each operate entirely on demand. Unlike other protocols it does not require periodic packets of any kind at any level within the network. In response to a single route discovery a node may learn and cache multiple routes to any destination. This caching of multiple routes also avoids the overhead incurred by performing a new route discovery each time a route in use breaks. DSR allows unidirectional links to be used when necessary, improving overall performance and network connectivity in the system.

4. Proposed Network Coded Dynamic Source Routing

In the proposed method (NC-DSR) Network coding is embedded in DSR routing protocol to improve the performance of network. Usually the routers or relay nodes just forward and duplicate the packets. The
concept of network coding permits relay or intermediate nodes to encode the packets. The type of network coding that is used is linear. The working of DSR will be the same as given in the above section but an intermediate node will act as forwarder node. This forwarder will combine the packets from multiple sources and forward the combination of the packets to other nodes or to the destination node. For combining the packets from different sources together, network coding uses the concept of XOR operation\(^{13, 14}\) between the packets. The forwarder receives packet from several sources encodes and then transmits. The receiver extracts the original data by decoding the received packet. For decoding also same XOR operation is used.

In the proposed method Linear network coding introduced by Ahlswede et al.\(^{15}\) is used. We allow the intermediate node to combine two or three packets and then forward. The basic network coding model is show in figure 2.

Figure: 2 Network Coding model

Node A is the source node and node E and G are the destination nodes. The intermediate nodes D and F acts as the relay node where encoding is done and then forwarded. The network coding concept reduces the number of transmission. Consider that each packet has Y bits. So if the packets combined don’t have same size of bits, then shorter ones are padded with the trailing 0’s. According to the maximum flow minimum cut theorem in graph theory, the maximum transmission rate from source node A to the destination node E and G is less than or equal to 2.

4.1 Coding scheme

Encoding:

The number of original input packets be \( M = (M_1, M_2, \ldots, M_N) \) is generated by one or more sources. Each packet in the network is associated with a sequence of coefficients \( g_i = (g_{1}, \ldots, g_{n}) \) in the finite field \( F_2^{*} \) called encoding vector and the output from the relay node is equal to

\[
X_i = \sum_{i=1}^{n} g_i m_i
\]

Decoding:

The destination node receives the set \((g_1, X_1), \ldots, (g_m, X_m)\) and collects them in a matrix. The original
message can be recovered by performing Gaussian elimination method on the matrix using the same co-efficient.

4.2 Working at the sender side

Given below the working of sender to send the packets to intermediate node i.e. forwarder. Sender is a source node that sends the data to adjacent nodes. In figure 3 it shows how it sends packet and checks whether the network is alive or not. It establish network and send packet if it is alive. The transmitted packet will be received by all the neighbouring nodes.

4.3 Forwarder

The forwarder is the intermediate node or the relay node which performs the coding and forwards the packet to the neighboring nodes. Forwarder will encode the packets together using the concept of network coding and forward the data to the next hop. This node when it receives more than two packets, it will check whether it is of same size and perform XOR operation with the received data and co-efficient chosen from an infinite field.
4.4 At the Receiver side

Receiver receives the encoded packet. It will decode the received packet by performing again XOR operation to get the original data sent by the forwarder or relay node as shown in figure 5.

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**Figure: 4** Forwarder side flow

**Figure: 5** Receiver side flow chart
5. Simulation experiment

In this section we describe our simulation environment and performance metric. Simulation was carried out using OMnet++ simulator. Establish Ad hoc network module and this includes creation of ad hoc network which consists of nine wireless nodes. Nodes communicating within 250m of range and covering the area of 900 x 900m. Each node is assigned an IP address. Node A is taken as source node and Node E an node G is the destination node. Node D acts as the relay node or forwarder. The network is initialized by applying the network properties and nodes. Dynamic source routing is implemented. Mobility is provided along nodes to move along the X-axis and Y-axis. RREQ, RREP, and DSR are controlled by Manet routing module. Each node transmit packets at a minimum rate of 4 packets/s. Mobility speed is assigned as 5mps and it varies from 0 to 10mps. Throughput and delay is measured by varying mobility speed graphs plotted with the readings taken. Network coding concept is implemented (NC-DSR), throughput and delay measured by varying the mobility speed.

Performance metric: We use the following performance metric to evaluate the effect of the proposed network coded dynamic source routing (NC-DSR).

Average throughput: It is defined as the ratio of total packets received to the simulation time.

Average end to end delay: This is the average overall delay for a packet to traverse from a source node to a destination node. This includes the route discovery time, the queuing delay, propagation and transfer time in the wireless channel.

Packet overhead: It is the number of all nodes transmission packets including data and encoded packet.

Performance analysis: We will compare the performance of the proposed network coded dynamic source routing with the existing dynamic source routing protocol.

Figure 6 shows the packet overhead as a function of the node’s mobility for DSR as well as NC-DSR. On an average NC-DSR reduces the routing overhead by 19-26% as compared to DSR.

The figure 7 shows that NC-DSR has lower packet loss, a consequence of lower route discovery latency. Packet loss taken into account the losses at the network layer.
The figure 8 depicts the throughput of NC-DSR and DSR under dynamic network. Mobility speed varies from 0 to 10m/s. We observe that NC-DSR can achieve 20 to 24% improvement over DSR.

The average end to end delay is shown in figure 9. If node mobility is high the packet loss probability increases and a longer route setup time is needed. We find that NC-DSR delay is lower than DSR.
6. CONCLUSION

This paper discusses about a new technique network coding and a modified dynamic source routing called network coding Dynamic source routing (NC-DSR). The key concept of network coding is to increase the throughput, robustness and complexity. More information can be communicated with fewer packet transmission. We performed a simulation study and compared with the traditional DSR protocol. The simulation results show that average throughput is improved and minimizing the delay. In the future it can be attempted to analyze different parameters like load balancing and power consumption using Network coding.

References

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