An Approach on Coding and Congestion Aware Routing Mechanism in MANET

Nilesh R. Rathod, Hardik J. Patel

Abstract— Routing protocols for mobile ad hoc networks (MANETs) have been explored extensively in last few years. Much of this work is targeted at finding a feasible route from a source to a destination without considering current network traffic or application requirements. Routing may let a congestion happen which is detected by congestion control, but dealing with congestion in reactive manner results in longer delay, and unnecessary packet loss and requires significant overhead if a new route is needed. Routing should not be only aware of network coding, but also be aware to, network congestion. This paper present the survey of coding and congestion aware routing protocols for mobile ad-hoc network. This paper argue that network coding aware routing protocol in combination with congestion aware routing protocol allows MANET to operate in a more efficient manner and helps to deal with typical MANET issues such as . Congestion in the network and poor utilization of the network as well as various other issues that have been disregarded in previous MANET researches such as throughput and unreliable channel. By comparison and combination of coding and congestion aware routing mechanism can achieve shorter file downloading delays compared to an existing MANET protocol.

Index Terms—A Mobile Ad hoc networks, congestion aware routing, Congestion metric, network coding

I. INTRODUCTION

The universal need for better control over resources in communication networks is a problem that is studied continuously. Maximum network capacity needs to be defined and then utilized to ensure that as much information as possible is delivered in the most economic manner. One way in which this can be addressed, is by using Network Coding. Research on Network Coding to date led to a wide variety of theoretical results especially in wired networks. MANETs are complex networks of which the topology changes constantly and unpredictably. One documented implementation of Network Coding in MANETs is Random Network Coding [1]. In this paper, we investigate the opportunities that the properties of MANETs provide for practical implementation of deterministic Network Coding.

This paper is structured in the following manner: We first give an introduction to MANETs. We then look at the maximum throughput capacity with the Min cut Max flow theorem. Network Coding is explained together with the advantages possible by combining the inherent properties of MANETs and the advantages of Network Coding. Then identify affecting metric and comparing number of metrics in congestion aware routing protocol. We introduce our new method to implement Network Coding and Congestion aware routing mechanism in MANETs. Finally we present a future work and conclusion.

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II. MOBILE AD-HOC NETWORK

A Mobile Ad-hoc Network (MANET) is a type of wireless network that typically consist of mobile routers and in some cases also laptop computers. These wireless mobile nodes are connected by wireless links to form a varying arbitrary network topology. Because these nodes are free to move randomly and organize themselves arbitrarily, the topology may change rapidly and unpredictably. The management of ad-hoc networks is decentralized. That implies that each node present in the network act as a forwarding node, forwarding messages to other nodes. The selection of forwarding nodes changes dynamically with the topology. A MANET may operate as a standalone network, or be connected to a larger network such as the internet. In other words a MANET is a network that is highly mobile, consisting of nodes with high processing power that receive frequent routing updates.

The advantages and disadvantages of MANETs can be summarized as follows [2]:

Advantages:

i. Adaptability

ii. Flexibility

iii. Efficient communication in environments with little or no infrastructure.

Disadvantages:

i. Vulnerable to attacks

ii. Congestion in the network and poor utilization of the network.

These disadvantages manifest as a result of a combination of factors: The use of an open medium, with a decentralized nature and a topology that changes dynamically, with poor physical security. One of the biggest challenges in working with MANETs is to determine the network capacity. When the capacity is known, using [3, 4], we can make use of Network Coding to utilize this capacity, In our research we focus on developing a new technique to reduce congestion in a MANET while improving the utilization using Network Coding.

III. NETWORK CODING IN MANET

A. What is Network Coding?

Network Coding is a field that was first introduced in 2000 [3] as a method to utilize the maximum capacity of a network and maximize the flow of information in that network. It suggested coding at packet level in wired P2P networks.

The idea sprouts from research done in [4] on satellite communications using a source coding system which consists of multiple sources, encoders, and decoders.

Applications where Network Coding can be especially useful are MANETs, Power Line Communication as well as Wireless Sensor Networks.

B. How does Network Coding work?

We will now explain Deterministic Network Coding: We use the Butterfly network from [5], as depicted in figure 1, to explain the how Network Coding works. The links in the figure all have unit capacity and messages *a*and *b* are binary. Two nodes, *A* and *B* need to transmit their messages to both Nodes *X* and *Y*. Each of the nodes can deliver their own message to the node that is connected to it, but have to route their messages through the network to reach the other node. When making use of traditional routing (Figure 1a), node *C* simply receives and replicate the information it receives from the previous sender node. In this case the two messages *a* and *b* will reach node *C* simultaneously. Node *C* will send out message *a* first, and then message *b*. Thus, at the end of a single arbitrary time unit, only node *Y* will have received both messages, while node *X* still has only message A. This results in a throughput of 1.5.

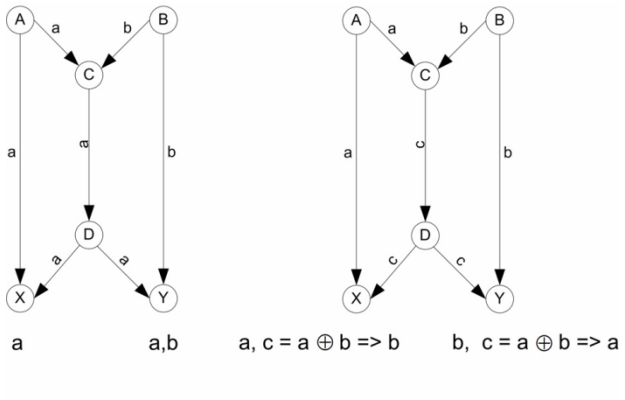

Fig. 1. Butterfly Network a) Without Network Coding
b) With Network Coding

When we make use of Network Coding (Figure 1b), we give node *C* the capability to transmit a linear combination (logical XOR) of the binary messages *a* and *b*. Message *c* has the same length as message *a* and *b*, and is transmitted via node *D* to nodes *X* and *Y*. We then give nodes X and Y the capability to decode message *c* by using the other message it already received and solving the two linearly independent equations. In this special case, it merely means adding the single message that the node has already received to the network coded message. This time, by the end of a single arbitrary time unit, both nodes *X* and *Y* have both messages. Two messages were delivered, making the throughput 2. [3] This method however changes the way node *C* works, because it has to form linear combinations of the messages it receives before forwarding it. It also requires nodes X and Y to have knowledge of the network topology and how the messages reaching it are encoded in order to deduce the two original messages from the messages it received. An attempt to make Network Coding more practical for MANETs is Random Network Coding [1], but we want to see if we can use a known topology of the deterministic approach in a MANET. Because the deterministic approach to network coding requires little overhead, this approach may be useful to improve network utilization in a MANET.

C. Forms of Network Coding

1) Combinatorial network coding
2) Opportunistic network coding for medium access
3) Random linear network coding

The multicast capacity is determined by the min-cut in network and achievable with Random network coding.

D. What benefits do we get from Network Coding

The use of Network Coding in a network may provide the following benefits:

1) Throughput [3], [5], [7]:

The improved throughput in networks was the first major result of Network Coding.

If we refer to the throughput achieved with network coding in the deterministic example, we see that we have achieved the maximum throughput as calculated using the min-cut max-flow theorem.

2) Robustness [5], [7], [8]:

The robustness of the network refers to the ability of the network to remain functioning even though a link has failed completely.

3) Adaptability [7], [9]:

Adaptability is an important benefit when looking at MANETs, as this refers to the ability of the network to cope with nodes constantly joining and leaving the network, resulting in a constantly changing topology.

4) Security [7]:

The security benefit is an inherent benefit, seeing that linear combinations of data are sent over the network, and not the actual data. This benefit while useful, is however not sufficient. If a malicious entity listens long enough and receive sufficient messages to decode the information, the information can still be eavesdropped.

Thus we see that Network Coding can address many of the problems associated with MANETs.

IV. CONGESTION AWARE ROUTING FOR MANET

Wireless ad-hoc network is usually defined as a set of wireless mobile nodes dynamically self organizing a temporary network without any central administration or existing network infrastructure. The node in the wireless ad-hoc network can serve as routers and hosts. So, they can forward packets for other nodes if they are on route from source to destination. Routing is important problem in wireless ad-hoc network. Traditional working protocols cannot work well in wireless ad-hoc network because of the characteristics of the wireless ad-hoc networks. Since, mobile nodes have limited transmission capacity they mostly intercommunicate by multihop relay. Multihop routing is challenged by limited wireless bandwidth, low device power, dynamically changing network topology, high vulnerability to failure. To answer these challenges, many routing algorithms in MANETs were proposed. There are different dimensions to categorize them: proactive routing Vs reactive routing or single path routing Vs multipath routing.

In proactive protocols, route between every two nodes are established in advance even though no transmission is in demand. In reactive protocols, route is discovered when needed transmission and released when transmission no longer takes place. Congestion is one of the most important restrictions of wireless ad-hoc network. It may deteriorate the performance of whole network. In the current design routing is not congestion-adaptive. Routing may let the congestion happen which is detected by congestion control. But dealing with congestion in reactive manner results in longer delay and an unnecessary packet loss and requires significant overhead if the new route is needed. But, now there is another dimension for categorizing for routing protocols: congestion adaptive Vs congestion un-adaptive routing. Our motivation is that congestion is dominant cause for packet loss, long delay, and high overhead in MANETs.

These problems become visible in large scale transmission of traffic intensive data such as multimedia data where congestion is more probable and negative impact of packet loss on the service quality is of more significance. In this paper we studied congestion routing protocols like CRP(Congestion Adaptive Routing Protocol)[3],ECARP (Efficient Congestion Adaptive Routing Protocol)[7],CARP(Congestion Aware Routing Protocol),CADV(Congestion Aware Distance Vector)[8],CARA(Congestion Aware Routing plus rate Adaptation)[8],CARM(Congestion Aware Routing Protocol for Mobile Ad-hoc Network)[8].

3. COMPARISONS

p2 Congestion is a dominant reason for packet drops in ad hoc networks.CRP sends packets on both bypass paths and primary routes simultaneously. So, incoming traffic is distributed on primary and bypass route depending on current congestion status of network. Congestion is subsequently better resolved .In ECARP some parameters of AODV such as TTL_start, TTL_increment are increased. So, it ensures the high availability of alternative routes and reduces the rate of broken rut removal process. CADV is not congestion adaptive. It offers no remedy when the existing route becomes heavily congested. So, CADV improves AODV in delivery ratio only. The real time performance of the CADV is good and the End-to End delay is short. The disadvantage of the CADV is that since, each node maintains all the routes to the nodes in the network and changes the route information periodically, the overhead for maintaining the routing tables is huge. The overhead of the CADV is unacceptable when the network is large or the topology changes frequently. The throughput decreases sharply at the same time. So, CADV may perform well in the small, steady wireless ad -hoc network. By studying the algorithms of CARM, CARA and CADV it is conclude that overhead of the CARM and CADV are higher than CARA, the delay of CADV is shorter than the other two.

V. CODING + CONGESTION AWARE ROUTING APPROACH FOR MANET

As protocols which are implemented in MANET shown above are different in a way their techniques that can be coding or congestion aware, taking different number of affecting metrics in each mechanism. If both (Coding aware and Congestion Routing) protocols compared which are compatible which other in term of metrics, we can definitely achieve such a mechanism which is better in throughput and efficiency of MANET.

The routing protocol is one of the fundamental protocols in MANETs. Standard routing protocols for MANETs have not yet been defined. Currently, there are four leading routing protocols, Ad Hoc On-Demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR), Optimized Link State Routing Protocol(OLSR), and Topology Broadcast Based on Reverse-Path Forwarding(TBRPF), as determined by the IETF MANET group [10]. Before most prior work focused on simulation-based comparisons among different MANET routing protocols. However, due to a lack of proper characterization of different MANET protocols, these simulation experiments are not well designed. For example, the simulation results from different research groups cannot be directly compared . There are no clear conclusions that can be drawn from this prior work. In other words, the relationship between the simulation conditions and MANET routing protocols remains unclear. Therefore, the conclusions based on the simulation experiments cannot be generalized and new methodologies to study MANET routing protocols are clearly needed. Based on this deficiency within the MANET research community, my primary research goal is to provide a new methodology to aid the analysis and evaluation of MANET routing protocols.

Network coding is a multifaceted phenomenon with three significant
contributions:

The rate region enlargement -> the butterfly example

The possibility to cast classically hard problems, i.e. the multicast, as standard optimization problems

The joint optimization of the channel access and the network coded multicast is a particular intriguing area of research

Studying coding and congestion aware routing protocols which are based on various metrics can achieve several potential benefits, than combining both of them in such a way that can be implement on MANET. Then it may be possible to improve throughput and other factors than existing one.

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VI. CONCLUSION

In this paper we proposed a network coding and congestion aware routing mechanism approach in MANET offering detailed analysis of an existing coding and congestion aware routing protocols. We showed that network coding helped exploit unique opportunities offered in the MANET environment, the broadcast nature of wireless medium and node mobility and by exploiting them in full we could have a very simple solution to the issues arising in MANET. We kept the concept in the simplest form in this paper for clearer presentation of the main idea. Immediate future work includes exploring optimization opportunities that the proposed concept allows. It is clear from algorithms available for having adaptive solution for congestion in the network as due to vast pay load on networks, which may be due to flooding of packets or may be due to repeat requests on the basis of error correction techniques. Congestion metrics still remains a great challenge for the future work. It is quite important to obtain an optimal approach that combines related parameters collected from physical layer, MAC layer to measure congestion.

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Finally we can conclude that congestion is the problem associated with the network and has to be countered by having compromised solution rather than elimination.

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