Throughput Maximization in MANET's using AODV Routing Protocol with coding Opportunity Discovery

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Abstract

MANET (Mobile Ad hoc Network) is a collection of nodes interconnected without a fixed infrastructure. For this reason the mobile nodes are resource constraint in terms of energy, storage capacity and processing power. To improve network throughput in MANET routing protocols such as AODV (Ad hoc On-Demand Distance Vector) is proved to be suitable. This is because the AODV protocol is an on-demand routing protocol as it won't establish a route unless it is really required by the network nodes [1]. Research in the area of effective routing has attracted more attention in the industry. XOR coding scheme can improve network throughput. However, the AODV protocol does not support execution of XOR coding scheme. As XOR coding can improve the throughput in wireless sensor network. Especially it improves communication with unicast traffic. In this paper, the XOR coding scheme is used to implement coding opportunity discovery that improves network throughput. The AODV protocol is improved with coding opportunity discovery. The experiments are made using NS2 simulation and the empirical results reveal that the proposed scheme improves network throughput when it is compared with AODV.

Keywords- MANET

1. Introduction

Wireless networks without pre-defined infrastructure contain a set of wireless nodes with multi-hop wireless connectivity. The topology of such network is also not certain. Such networks are formed in real time based on the requirement. In emergency situations such as disaster relief operations, battlefield operations etc. are the areas where the applications of MANET are widely used. As the nodes are wireless in nature and they are part of network without fixed infrastructure, these devices must be self contained in terms of energy, memory and configuration.

They configure on the fly and then reconfigure if required. They can adapt themselves to various network topologies. One important aspect of the mobile devices is that they are resource constraint. They have limited resources such as memory, energy and processing power. This causes the network lifetime to go down as the time goes on. Improvement of network life time of such network is essential. The communication among the nodes should be optimized so as to achieve maximum throughput. In such networks establishing a route only when situation demands is considered very good feature. The AODV protocol used in mobile network has this feature. It is an on-demand routing protocol. However, this protocol has some limitation that is it can't be used to execute coding opportunity schemes such as XOR coding scheme. The XOR coding scheme reduces the communications overhead and ensures quality of communications besides improving the throughput of the network. AODV protocol [1] has to be improved in order to let it support XOR coding scheme. To achieve this AODV's structure has to be changed. The specification of AODV is given by IETF [2]. AODV is an efficient routing protocol for MANETs as it employs on-demand routing and reduces unnecessary overhead. AODV has several flavors. They are known as AODV-BR [4] and AOMDV [3].

Right from the inception of AODV, it has been in the research circles for the last many years. The research has been made on this protocol for improving the efficiency of network. The flavors that came into existence provide improved form of AODV. In this paper, the AODV has been improved and now it is with the feature known as "Coding Opportunity Discovery". This feature is achieved by using XOR codingscheme. Some work has been done in [5] and [6] with respect to network coding. Practical usage of network coding is explored in [6] for unicast traffic.

The nodes in MANET can use the proposed scheme for improving communication efficiency. When any node gets an opportunity, it performs XOR operation on many packets and only a single packet that represents the whole data is transmitted. This improves performance with respect to effective communication. It does mean that it can reduce the communications overhead. Each node in the MANET has sufficient information to perform encoding on decoded packets.

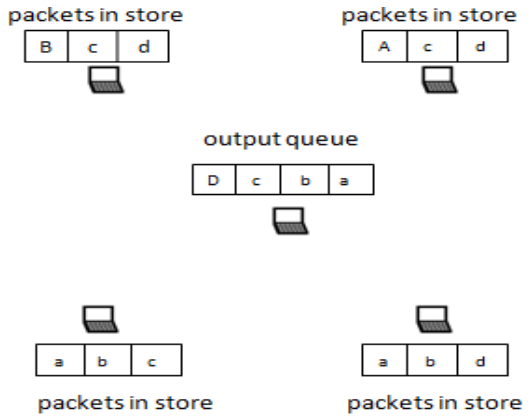

Fig. 1 – Illustrates coding opportunity [1]

As illustrated in fig. 1, there are many mobile nodes in MANET. They are named as A, B, C, D (top two and bottom two named in left to right and top to bottom fashion) and R (middle node). The node R has output queue while the other nodes are showing packets in store. The output queue of R shows four packets. Node R has neighbor nodes and it is fully aware of other nodes packets and their content. When node R gets MAC signals for initiating data transmission, it can send the encoded packet which represents the content of all neighboring nodes. Other nodes can simply get the required information obtained from the packet. Here R does not send the packets in output queue. Instead of that it performs XOR coding scheme that results in a single encoded packet. When compared with traditional store and forward approach, the proposed scheme improves performance of network and particularly throughput of the network is dramatically improved. Redundant packets are the result of wireless channel broadcast. However, there might be many coding opportunities. By using one-hop neighbor and reception information of that it is difficult to discover it. Exchanging packet reception information among the nodes in the network leads to communication overhead. Many research papers such as [6] and [7] dealt with networking coding concept. SRCR is the routing protocol in [6] which is link-state. However, the AODV, every node knows about its one-hop neighbors. Just knowing one hop neighbors is not enough for guessing the coding opportunity requirement. In this paper, this problem is addressed by enhancing the AODV protocol in such a way that it can execute XOR coding scheme as and when required. The summary of the work done in this paper is an analysis is made on the condition in which nodes with AODV protocol can guess the coding opportunity discovery. We proposed AODV protocol with XOR coding scheme execution capabilities that ensures that each node in the network can compute XOR coding and can discover coding opportunity in order to improve the throughput of the network.

2. Related Work

MANETs are networks containing mobile nodes without a fixed infrastructure. This kind of network has nodes with limited resources. The longevity of network lifetime is essential and thus there is a need for research on effective communication approaches that can lead to reduction in consumption of resources available. Coding Opportunity Discovery in routing protocols improves performance of MANETs. This is possible because the nodes in MANET can overhear the packets when they are being flown. Many worked on this area to explore the possibility of coding opportunity discovery. However, the practical work is proposed in [6] a coding scheme was proposed. Its name is COPE which is meant for wireless mesh networks. It is based on XOR coding scheme. It explores on the packet transmission efficiency. The COPE is based on the concept known as network coding. Between IP and MAC layers, COPE can insert coding shim. On the fly this can identify the opportunities for coding and also the possible benefits of it. It demonstrates that routers can benefit from intelligently mixing the data of communication units before they can be forwarded. It exploits the convenient nature of channel. The coding used by COPE is known as inter-session wireless network coding. It supports both UDP and TCP flows and tested in Linux environment. The COPE can't improve energy consumption by the nodes. Moreover it assumes that the nodes in the network are not energy constraint. Another limitation is that the COPE can't support AODV protocol easily. In [8] the focus is on linear network codes. This is because the linear network codes are widely applied. It assumes that the network has only one source node, ***r*** units of randomness and ***m*** units of messages. The results of [8] proved that for security and error detection, random linear network code is good. However, it is not the right choice for multiple source network coding. In [9] a new approach for network coding was introduced. It is a randomized network coding phenomenon. It is meant for compression of information and distributed and robust transmission of data from source to destination. This approach is when compared with traditional approaches is different. For maximum robustness it completely uses the allocated network capacity besides showing total flexibility for allowing different network topologies and supports addition of new sources.

Similar to XOR coding used by COPE, coding aware routing based on XOR coding scheme was proposed in [10] and [11]. With coding awareness [10] investigates the possible performance gains while making routing decisions. It defines the coded transmissions expected for the purpose of successful transmission. Then it focuses on optimization of routing process in order to improve the throughput of network. The problem considered is known

as linear programming problem. The result of coding aware network transmission is the significant gain in terms of throughput especially it is true when there are many long distance network flows. When compared to COPE, it can reduce number of transmissions and improves network performance. In [11] an analysis is made on improvement of throughput when COPE kind of network coding is used. It focuses on a networking coding that works for any topology. Network coding opportunities can be exploited in contract to COPE as it overlooks it. It works with two kinds of routing flows. The first kind is a routing flow where nodes are "close to each other" while the second flow is "away from each other". The former is meant for coding opportunity while the latter is meant for avoiding wireless interference. The work in [11] demonstrates that high throughput is possible by using a route selection strategy that makes use of network coding opportunity. The influencing factors on throughput are traffic pattern, network structure and the possibility of using networking coding.

In [12] Le et al. proposed a routing protocol by name DCAR which is coding aware and distributed in nature. It improves the performance of networks by using coding opportunity. The nodes in such networks can make two types of decisions. The routing decisions are made without coding opportunity and the decisions that use coding opportunity improve throughput of the network. However, it can't be applied to AODV as it requires two processes for coding opportunity discovery and route selection. For this reason the scheme proposed in [12] can't be used for the MANETs where AODV routing protocol is used. In [13] it is explored and found the fact that the network throughput decreases when the nodes use coding opportunity greedily. For this reason, it can be understood that coding opportunity discovery is essential for optimum utilization of network bandwidth, and resources attached in MANETs.

Research is made in [14] proposed by Le et al. on a very interesting aspect that is the number of coding opportunities in terms of upper bound based on the coding structures in MANETs. However, they do not focus on the discovery of coding opportunity practically. The number of coding opportunities required might be having its own impact in the throughput of the network. In [15] Kuo et al. explored the concept of coding opportunity that includes packet arrival reports. However, the work done in [15] is limited to one-hop wireless networks like networks used for cell phone communications. All the approaches discussed so far pave the way for the proposed scheme. The proposed scheme explores the process of discovering the coding opportunity using AODV protocol. To achieve this XOR coding scheme is used for improving throughput of MANETs.

3. Coding Opportunity Discovery

By default AODV works in store and forward style. It does not know the concept of coding opportunity discovery. Just knowing packet reception details is not sufficient for coding opportunity discovery. Intelligent guessing is used in [6] for discovering half of the coding opportunities. In order to guess most of the coding opportunities, two hop predecessor nodes and two hop neighbor nodes information is required. Packet overhearing is the key idea behind the coding opportunity discovery technique. To make this overhearing concept and the analyzing the required information for coding opportunity discovery, two cases are described here.

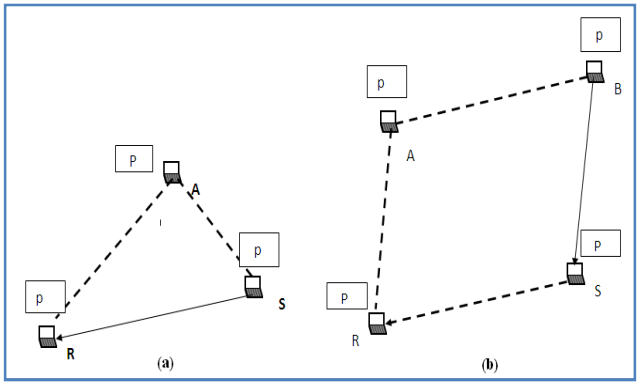

Fig. 2 – Two cases

As seen in fig. 2 (a), the nodes A and S are one hop neighbors. When node R receives a packet it can be overheard by A. By knowing only one hop neighbor the node R can't guess the fact that the packet was overheard by A. However, when R has two-hop neighbor information, it can know that A has overheard packet. As seen in fig. 2(b), nodes S and A are not one hop neighbor nodes.

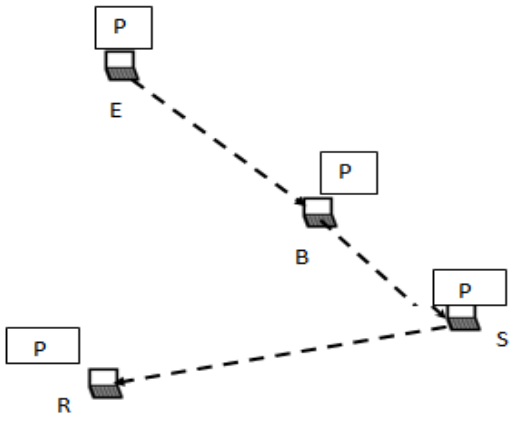

Fig. 3 – Obtaining two-hop predecessor nodes information

As can be seen in fig. 3, the implementation illustrates that while communicating other nodes a node can tell its neighbors about its one hop neighbors and also destination node for each of its one-hop neighbors.

4. Exchanging Information

AODV is an on-demand routing protocol. For this reason periodic routing information exchange does not take place. However connectivity locally is achieved by periodically broadcasting "hello" message. In the proposed AODV with coding opportunity discovery, as exchange of information takes place only among one-hop
neighbors, the hello message is used to piggy back the information pertaining to topology.

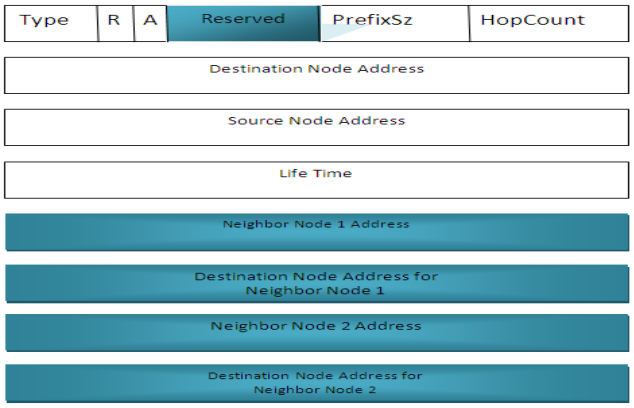

Fig. 4 –Hello message format in AODV with coding opportunity discovery [1]

As seen in fig. 4, it shows actual packet format for AODV with coding opportunity discovery. The fields in color are the ones modified to convert AODV into AODV with coding opportunity discovery. One hop neighbor nodes and also destination node information is found in the reserved field. An interesting fact here is that in the network the proposed AODV with coding opportunity discovery and original AODV can co-exist.

5. Experimental Results

The environment used for the experiments is Linux Ubuntu OS running in a PC with 2GB RAM, and 2.9x GHz processor. The simulation tool used is NS2. The topologies used in the experiments are shown in fig. 5 and 6.

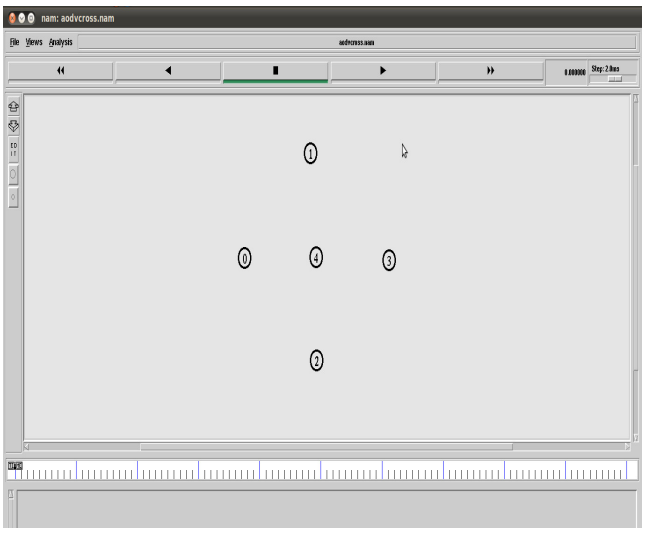

Fig. 5 – Cross Topology

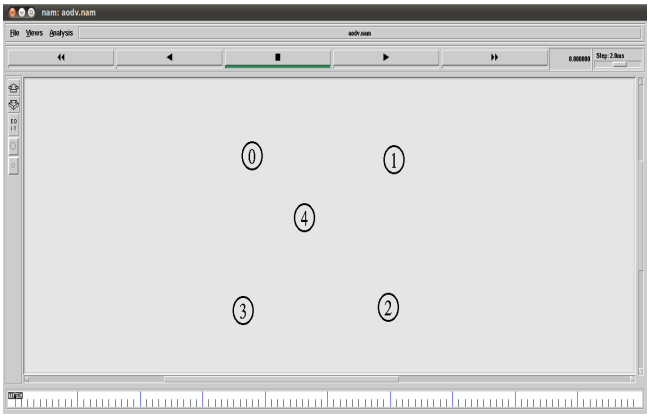

Fig. 6 – X Topology

6. Coding Opportunity Discovery

The proposed system has built AODV with Coding Opportunity Discovery. XOR Coding Scheme is implemented in order to discover coding opportunity and use it to combine multiple packets into a single packet so as to reduce communication overhead and increase the throughput of MANET.

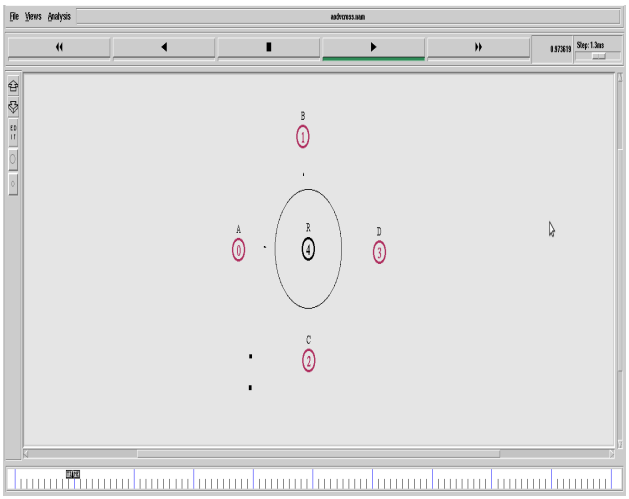

Fig. 7 – Coding Opportunity Discovery

As can be seen in fig. 7, the node R makes use of coding opportunity discovery by executing XOR coding scheme. Thus this node combines packets into a single packet and delivers it to the destination. The XOR coding scheme works in every no so as to help obtain the required packet at the destination. The end result of coding opportunity discovery done at all nodes of the network is that the overall throughput of the network gets increased. Fig. 8 shows throughput achieved for link 1.

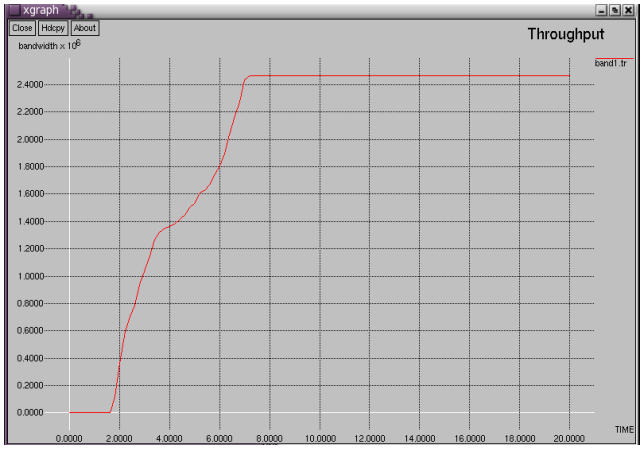

Fig. 8 –Throughput for link 1

As can be seen in fig. 8, it is evident that as the time goes on the nodes in the MANET are involved in communication and they made use of coding opportunity discovery and executed XOR coding scheme thus improving the throughput. This is also reflected in the number of packets delivered or packet delivery ratio. The packet delivery ratio for link 1 is shown in fig. 9.

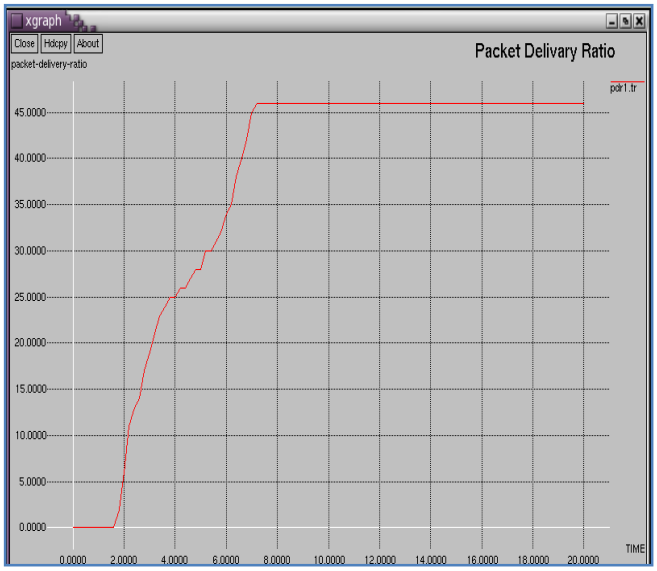

Fig. 9–Packet delivery ratio for link 1

As can be seen in fig. 9, the Y axis shows packet delivery ratio while the X axis shows time. As time increases, the MANET exhibited improved packet delivery ratio as the nodes make use of coding opportunity discovery through XOR coding scheme. Packet delay is also measured and presented in fig. 10.

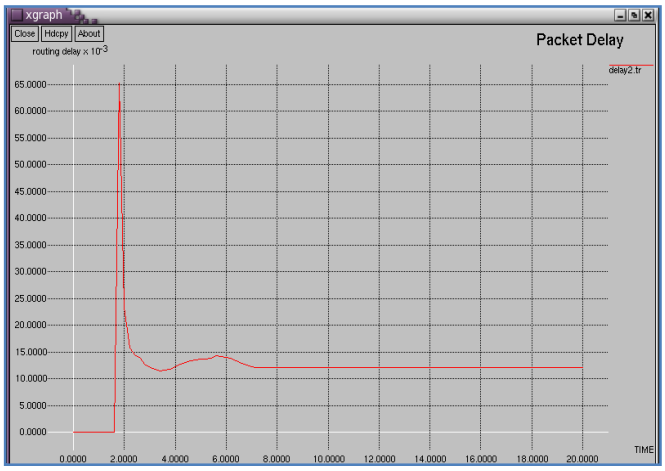

Fig. 10 – Packet Delay for link 1

As can be seen in fig. 10, the X axis shows time while Y axis shows delay. The graph visualizes the packet delay for the given period. Initially the delay is more and later delay is reduced as the coding opportunity discovery is exercised by the nodes in the MANET. The experiments also considered the number of packets received at various links. Fig. 11 shows the total number of packets received at link 1 as time goes on.

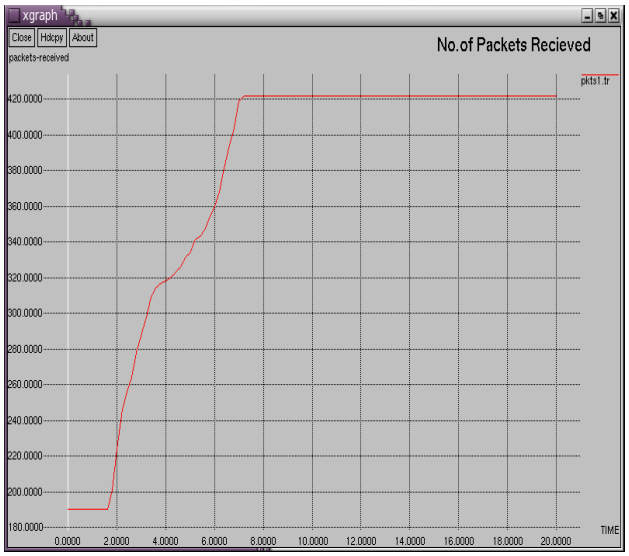

Fig. 11 – Number of packets received at link 1

As seen in fig. 11, X axis shows time and Y axis shows number of packets received. The graph shows the performance of the proposed scheme. As the time goes on the number of packets received increases.

7. Conclusion

This paper presents AODV protocol with coding opportunity discovery. The nodes in the MAENT execute XOR coding scheme for coding opportunity discovery that leads to improving performance of communications. The more coding opportunity discovers the more throughputs in the network. AODV can't support XOR coding scheme by default. Therefore it has been improved to support it. Thus the proposed scheme improves the overall performance of MANET. The concept is demonstrated using NS2 simulations. The results revealed that the proposed scheme is effective and can be used in real time applications.

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