ISSN 2047-3338

Performance Evaluation of Different Topologies for Network Coding in Adhoc Network

Ibrahim Khider, Khalid hamid Bilal and AHoyaida Elwasila

***Abstract*—Network Coding is a new field for research, which has been growing rapidly. Its ability for improving network throughput and robustness enhancement. Hence the allow coding at intermediate nodes between the source and the receivers in one or multiple communication sessions. In the paper a simulation of different topologies and traffic patterns have been conducted in order to provide better understanding of network coding behavior. The results show that network coding has advantages over flooding show in improved Packet Delivery Ratio. We observed that the performance using network coding is strongly dependent upon the topologies. The study concluded that this methodology might be the promising solution to gradually eliminate the variety of drawbacks of the system as a whole.**

***Index Terms*—Wireless Adhoc Network, Network Coding, RLNC and Simulation**

I. Introduction

An ad-hoc network is a collection of wireless mobile nodes dynamically forming a temporary network without the use of any existing network infrastructure or centralized administration. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. One of the challenging problems in wireless pervasive systems is the efficient dissemination and collection of data spread over a distributed network [1]. Classic schemes dealing with this problem are based on the store and forward paradigm .where nodes store new incoming information and forward it, whenever possible, to other nodes. Their main disadvantage is the high overhead required for information dissemination. Algorithms based on network coding allow to more efficiently delivering data through such a network [2]. These schemes implement a store, code, and forward paradigm where information packets are encoded at intermediate nodes and subsequently forwarded.

Ibrahim Khider, Sudan University of Science and Technology, Dept of Electronics, Tel: +249907050333, Email: Ibrahim_khider@hotmail.com

Khalid Hamid, University of Science and Technology, dr.khalidbilal@yahoo.com

Hoyaida Elwasila, Sudan University of Science and Technology, ibrahimchina2008@yahoo.com

Coding improves the dissemination efficiency by reducing the number of transmissions required per successfully delivered information unit [3]. The concept of network coding was first introduced for satellite communication networks in Yeung and Zhang and then fully developed in Ahlswede et al. [4]. In this work, the advantage of network coding over store-and-forward was first demonstrated by the buttery network. Source coding is used to compress information at the sender in order to reduce the channel bandwidth used, on successful reception the receiver can decompress the received data and retrieve the original information. Source coding is referred to as end-to-end as encoding is only performed at the source and decoding is only performed at the sink. Channel coding, on the other side, adds redundancy to make the transmission over any medium more robust against transmission errors. Even channel coding is referred to be end to end as it is applied on a single communication hop between to communication nodes, e.g. mobile device and base station.

Lately the coding family got a new member referred to as network coding by Ahlswede [4]. From a system point-of-view it is not limited to a specific layer, but could be used to standard network nodes such as Kirchhoff's nodes. Figure.1 shows the difference between channel, source, and network coding. We assume that two communication pairs are exchanging information. Both pairs {A,B} and {C,D} are using some source coding according to the service that is being provided. The end nodes are connected with each other via a meshed network. The meshed network is formed by the five relaying nodes in the middle and they are communicating via IEEE802.11a using channel coding B. Let us assume each user node is using IEEE802.11b to connect to the closest relay node of the given meshed network. The link between user node and relaying node is using channel coding A. The outer nodes of the mesh are always connected with two neighbors as well as with the center node, so three in total. The network coding takes place at all five nodes. More precisely the center node will encode packets and the outer nodes are decoding packets. Note that each meshed node is receiving four packets, is sending only one and is performing one coding operation. In a state- of-the-art relaying scenario the center node would send four packets, the same number as it has received beforehand from the outer meshed nodes [5]. Network coding can be classified into three types, XORbased, Reed-Solomon-based and Random Linear Network Coding.

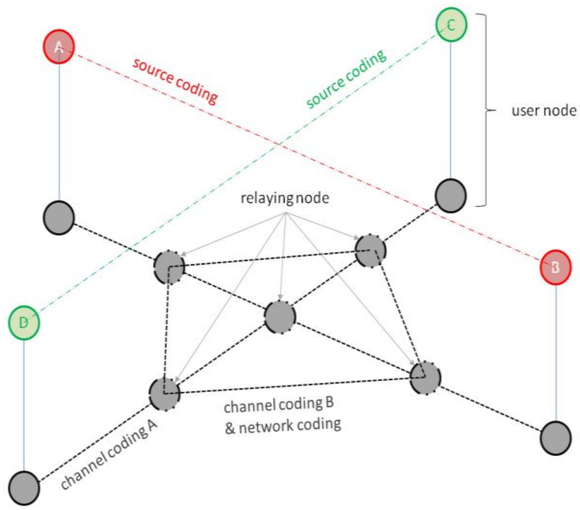

Fig. 1: Channel, Source and Network Coding

II. AN OVERVIEW OF RANDOM NETWORK CODING (RNC)

RNC protocol used in Ad-hoc network base on performing Random Linear Network Coding (RLNC) over a Galois field. When Galois fields are implemented on computer systems the Galois elements are generally of the form 2i and typically i ε {8, 16, 32}. We choose the smallest possible Galois Field, GF (2) to decrease the computational complexity of coding operations. This is done to overcome the challenges posed by the limited computational resources available on ns2. The RNC protocol depends on some libraries. The operation of RNC focuses on the broadcasting environment where every node is a receiver and transmitter. The source generates native packet. The packet consists of multiple symbols of 8 bit each. The encoding operation is performed on each packet. Once the packet is generated, the node checks if there are already some generations available in the memory, if exist Generate a random coefficient from GF(2^8) for that packet and insert the packet in the generation An encoded packet is created with the header containing the generation ID and coding coefficients. A single encoded packet is broadcasted, as this generation contains one new source packet. When an intermediate node receives the first encoded packet of a generation, the packet is cached in the NC buffer and a timer is started. The node then has to establish whether the subsequently received encoded packets belonging to the same generation are innovative. The innovative packets are cashed, while the others are dropped. When decoding matrix has full rank, the node performs decoding to retrieve the native packets belonging to the given generation. The native packets are then encoded again into one packet with a random independent coding vector, so that only one packet is forwarded. If the timer of the NC buffer associated to that generation expires before the matrix rank reaches s, only the set of encoded packets buffered at the node is re-encoded before a new encoded packet is forwarded. Upon receiving encoded packets, the innovative ones are cached for decoding. After building decoding matrix, its rank is checked. If decoding matrix has full rank, the receiver recovers all native packets in a given generation; an early decoding is performed when a sub-matrix of decoding matrix has full rank. In case of Random Linear Network Coding [6], the output flow at the given node is obtained as a linear combination of its input flows. The coefficients selected for this linear combination are completely random in nature, hence the name RLNC. The node combines a number of packets it has received or created into one or several outgoing coded packets. Typically three different operations are performed by RNLC: Encoding, Re-encoding and decoding as shown in Fig. 2.

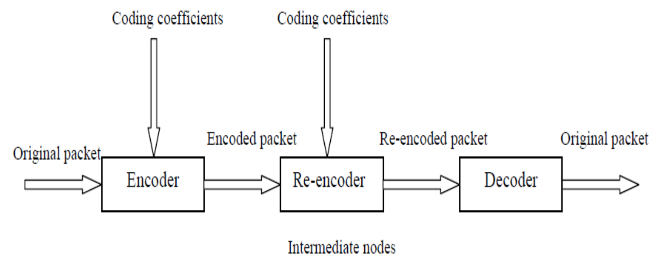

Fig. 2: RLNC Process

III. NETWORK MODEL

All parameters that have been used for simulation are briefly described in this section these are the parameters we used to generate simulation results to evaluate both the forwarding and also the network coding techniques

A. Network Topologies

We start our investigation with circular and grid reference topology and then consider random

- *Circular Network*

Each node has exactly two neighbors as shown in Fig. 3.

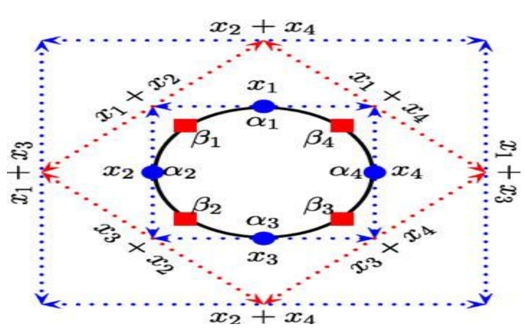

Fig. 3: Circular Network

- Grid Network

Each node has exactly four neighbors as shown in Fig. 4.

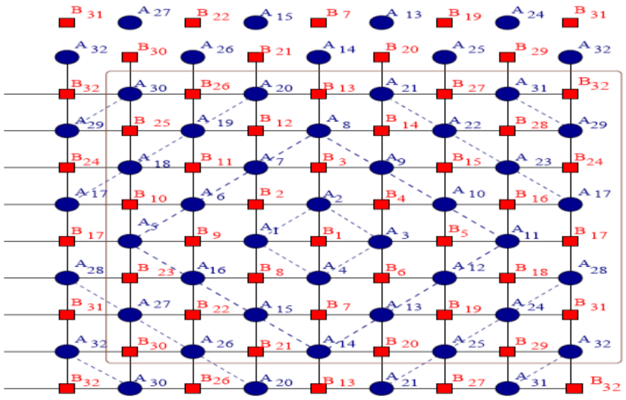

Fig. 4: Grid Network

- Random Network

Each node is randomly positioned within simulation area.

B. MAC Protocols

We consider four different MAC protocols in the simulation IEEE 802.11b, IEEE 802.11b with pseudo broadcast, IEEE 802.11 with pseudo broadcast and RTS/CTS handshaking and Ideal MAC.

C. Network Simulator Version 2 (NS-2)

NS-2 is an open-source simulation tool running on lunix operating systems .It is a discreet event simulator targeted at networking research and provides substantial support for simulation of routing, multicast protocols over wireless networks. It has many advantages that make it a useful tool, such as support for multiple protocols and the capability of graphically detailing network traffic [7].

A. Network Coding

We consider the Random Network Coding Protocol using Probabilistic network coding strategy.

IV. SIMULATION DESCRIPTION

We study the performance of network coding in wireless Ad hoc environment our evaluations are based on the simulation using Network Simulator (Ns-allinone-2.27) environment and RNC protocol and extract the useful data.

Environment consists of 16 wireless nodes forming an ad hoc network over a 1250 X 1250 space, NCR routing protocol for 100 mili seconds of simulated time. The propagation on the physical channel is simulated using the two-ray ground model and a data rate of 1 Mb/s. For finite field operations we select the field $F2^2$, so that each symbol of the field can be stored in a byte. Addition and multiplication operations can be implemented using two lookup tables of size 255 bytes. The coding vectors are transported in the packet header we use randomized network coding.

We compare our network coding algorithms against probabilistic flooding where received packets are re-broadcasted with a certain probability (similar to our forwarding factor). Our performance metrics are packet delivery ratio (PDR), Packet Delivery Delay, D, and Protocol Overhead. The PDR is measured as the number of packets that can be decoded at the destination. Similarly, Packet Delivery Delay is counted as the average time between the transmission of a packet by the original source and successful decoding at a node. We also investigate overhead in terms of number of transmissions required to achieve a certain PDR. Protocol Overhead: is the ratio between the number of transmitted packets at the MAC layer and the number of successfully decoded packets.

This value depends on the adopted MAC protocol and on the efficiency of the network coding strategy. We focus on the impact of different MAC protocols on network coding.

V. RESULTS AND DISCUSSION

In the paper discussion of results that had been collected via ns2 simulations, It had been organized that the performance analysis focus on compression between network coding and flooding depends on varying number of S in Mac 802.11b. We change Number of S (1, 2, 5) for grid and circular topology and collected data are Referring to figure.5, and figure.6,The Network coding outperforms flooding for all values of S in terms of PDR. Increasing the number of packets put into the combination(S) lead to performance degradation. This due to higher complexity and longer time needed for sufficient number of coded packets to be received. The achieved performance is better in grade than in the circular case due to the higher number of neighbors per node. This favours packet mixing and dissemination. Accordingly, it is observed by increasing the number of nodes the performance has improved. Referring to Fig. 7, the protocol overhead is approximately remains unchanged while S increased owing to Mac 802.11b. Both network coding and flooding almost lead to very similar protocol overhead. Referring to Fig. 8, the average delay of network coding stabilizes for increasing S whereas it continued to increase and decrease for flooding. The reason for this is that with flooding, a higher number of redundant packets are received earlier on delaying the reception of innovative packets. For network coding, the combination of packets prevents this from happening and most packets received are innovative even for low S.

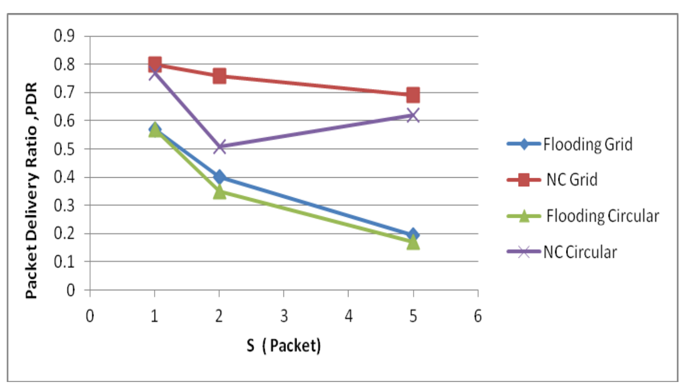

Fig. 5: Packet Delivery Ratio: Comparison of Network Coding and Flooding

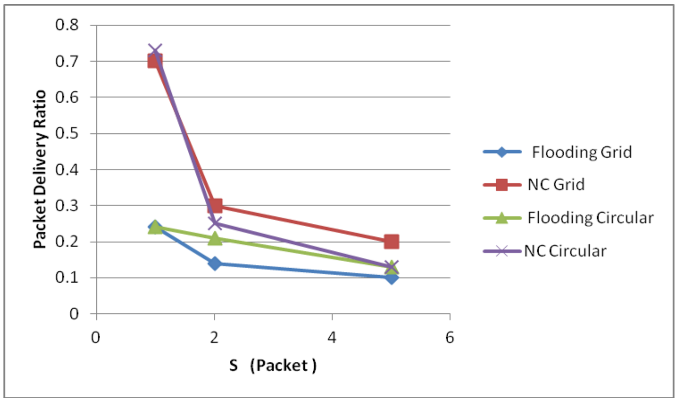

Fig. 6: Packet Delivery Ratio1: Comparison of Network Coding and Flooding

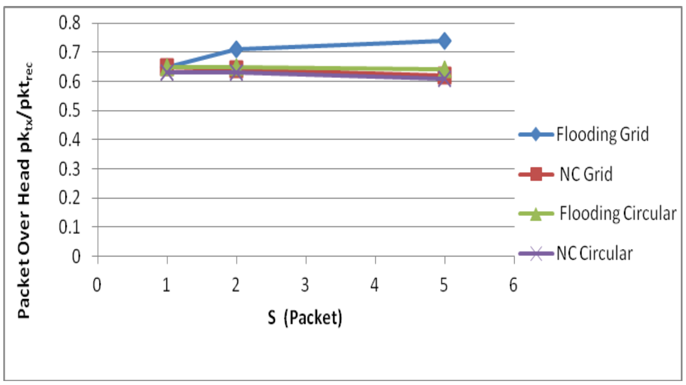

Fig. 7: Protocol Overhead: Comparison of Network Coding and Flooding

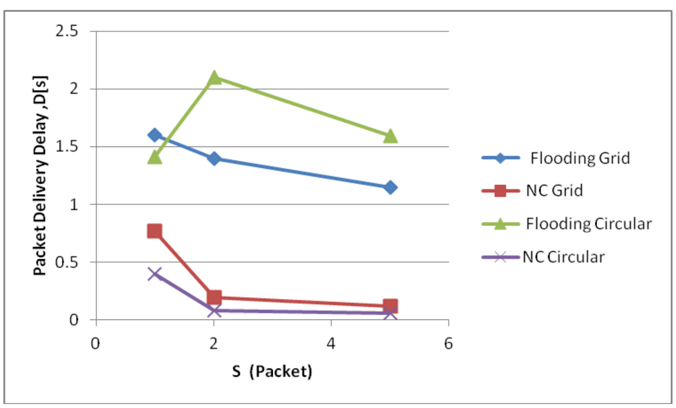

Fig. 8: Packet Delivery Delay: Comparison of Network Coding and Flooding

VI. CONCLUSION

In the paper, we focused on broadcasting schemes based on network coding for wireless ad hoc networks. Network coding by allowing the nodes to perform linear operations on mixing the received packets, has the potential to provide the highest capacity from the network. Maximizing the information diversity leads to better exploit the bandwidth and higher throughput in the paper investigated this possible trade off by network coding. Through simulation analysis, Firstly discussed the impact of IEEE 802.11- like random access on the performance of reactive network coding with fixed number of S under three topologies compared probabilistic flooding and probabilistic network coding Our experiments through the network simulator ns-2 reveal that, Under all the scenarios, network coding proved to be effective than flooding (approximately 49% more than the flooding), This shows the flooding need 3 more times transmission to reach same PDR network coding .

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