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Investigating Steps for Attaining Energy Efficiency Using Arbitrary Network Coding in Wireless Environments

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Abstract: The network coded wireless networks are composed of nodes which broadcasts their location to all the other nodes. The conventional broadcasting allows each and every node to opportunistically forward the received packets. For network coding approach every node eavesdrops the packets that were transmitted from their adjacent nodes, aggregates the received packets and forwards the resulting packets to its adjacent nodes. The ultimate focus is to minimize the transmissions for energy conservation. The research is related to the network coded based neighbor broadcasting with a consideration that all the inter user medium are slow fading and the received energy is compared to the broadcasted energy. A cross layer technique that understands the network coding at the network layer and uses the MAC layer's forwarding and arrangement choices for deciding the ways for network coding of packets. The results of simulation depicts that the network coded systems utilizes less energy as compared to the conventional opportunistic approach.

Key words: Wireless networks, broadcasts, transmission, network coding, MAC

INTRODUCTION

The neighbor based broadcast in wireless sensor networks allows each node within the network to transmit its packets to every other node. These broadcasts can introduce huge traffic and requires energy conservation techniques for which a simple hoard and onward scheme is employed. Here, the technique allows a node to forward the same packet which it receives from the last transmission. The flooding allows each node to retransmit each and every received packets resulting in redundant transmission of data packets over the network. The advanced flooding schemes allow a transmission arrangement based on some sorts of control over the topology (Kishore and Deepa, 2015; Kok *et al*., 2015). These schemes are dependable and effective for a broadcast which unnaturally minimize the complexities over the topology and allocates roles for each node. Moreover, the design and continuance of these structures introduces large overhead and serves useful only in the case where these broadcast service is required frequently and the dynamicity of the node is minimum. The highly dynamic situation requires probability based forwarding (Archita *et al*., 2015). The scheme allows retransmission of freshly received packets with a certain probability where the retransmitted packets serve only for a small part of nodes in the region. The network coding is emerged to best serve for hoard and onward based neighbor broadcast scheme. The main objective of network coding is that it aggregates the former packets and onwards the grouping to the adjacent nodes rather hoarding them and forwarding them as independent packets. This thereby allows only a fewer transmissions and conserves transmission during reception.

Literature review: Kishore and Deepa (2015) addressed the dynamic spraying issue in Mobile Ad Hoc networks. Several studies revealed that the problem can be solved using system coding which reduces the energy consumption by consuming minimum transmission. It is not the cost involved in transmission there are some other which increases the energy consumption. Here, the system coding is employed for reducing the energy consumption by encrypting the information in MANETs. It is interesting that the system coding supports security aspects due to which encryption can be performed in an effective manner. The authors proposed a light weight encryption technique called the P-coding for securing the system. The technique allows the source to randomly permute the nodes very before performing the system

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coding operations. The proposed technique outperforms the conventional encryption schemes and conserves energy utilization in an effective manner.

Kok *et al.* (2015) focused on the minimum throughput of the network due to their multi-hop communication network in wireless ad hoc networks. The network coding technique serves as an alternate for enhancing the throughput over the network by minimizing the volume of workload within the network not by restricting the information transmission. The network coding enhances the communication efficiency by merging multiple packets together and transmitting only the output packets after satisfying the conditions. The authors proposed a network coding routing protocol which holds a novel set of coding conditions and novel routing parameters which considers the coding prospects and workload over the network. The performance analysis reveals that the proposed technique outperforms the conventional techniques.

Archita *et al.* (2015) focused on the energy conservation and security for data in Mobile Ad Hoc networks. These issues can be resolved using network coding which focuses on minimizing the energy utilization by minimum transmission and the proposed system employs data encryption technique. The transmission time along with encryption and decryption reduces considerable energy in the wireless network. The Mobile Ad Hoc network are not reliable, dynamic network and do not have fixed infrastructure which remains a big challenge. The Mobile Ad Hoc networks are composed of dynamic nodes without any fixed infrastructure and serves as a router enabling dynamicity of nodes among the nodes within the network. The greatest challenge within the Mobile Ad Hoc networks is to identify a path between the source and the destination due to dynamic topology of the network. For a group of dynamic users that communicates through bandwidth restricted wireless link employs data encryption standard and advance encryption standard. These algorithms are used for analyzing the time for executing the queries and size of the database. The P-coding schemes are used in Mobile Ad Hoc networks.

Fragouli *et al.* (2008) described the importance of broadcast operation for communicating the information among the network. The utilization of broadcasting in wireless channel does not require all the nodes within the network to be in order in order to enhance the communication between other nodes. The conventional broadcasting schemes can be classified into probabilistic or rebroadcasting schemes. The researchers employed network coding scheme for deterministic broadcasting scheme in order to minimize the number of transmissions within the network. The proposed two algorithms depend on two-hop information and make broad use of opportunistic attention for minimizing the number of transmissions: a simple extensive OR operation for attaining 45% of gains as compared to non-coding conventional techniques and REED Solomon based coding technique for attaining best possible gains based on the local information.

Deepa and Ilyas described Mobile Ad Hoc networks as an infrastructure-less network composed on dynamic nodes. The need for energy conservation remains a big issue in Mobile Ad Hoc network. The present studies reveal that the network coding is employed for minimizing the energy utilization in Mobile Ad Hoc networks by using minimum transmission. The energy utilization not only arises due to cost involved in transmissions also due to encryption or decryption schemes for data. The dynamic nature of Mobile Ad Hoc networks introduces several security threats to the network. Security measures are necessary in Mobile Ad Hoc networks as compared to the wired networks. For successful transmission in Mobile Ad Hoc networks security and authentication with power consumption are required. The author proposes a new lightweight elliptic curve cryptographic based encryption schemes in order to offer privacy over MANETs in an effective manner.

Li *et al.* (2007) described network coding as a novel advancement schemes where the in-between nodes carryout hoard, code and onward operations on arriving packets. The conventional on-warding schemes uses hoard and onward operation which failed to reduce max-flow-min-cut output where the source communicates the information over the blocked paths for accessing the links. The network coding allows several sources to communicate packets over the blocked links for achieving the expected throughputs and maximizes the capacity of the network. The simulations are performed on fixed and dynamic environments for determining the QoS comparison between the protocols for network coding and conventional protocols for ad hoc routing. The results of simulation reveal that the network coding protocol performs well for both PDR and latency in the dynamic networks.

Peng and Lu (2000) addressed that the energy conservation is an important challenge in Mobile Ad Hoc networks. The present studies reveal that the network coding helps in minimizing the energy utilization by minimum transmissions. The cost involved in communication is not only a factor for energy utilization but also due to data encryption and decryption schemes. The authors focused on minimizing the energy consumption by encrypting the data in Mobile Ad Hoc

networks. Network coding allows better security by encryption for which a lightweight encryption technique called P-coding is proposed for attaining privacy for network coded MANETs in an effective manner.

Luo *et al.* (2015) described that the network coded MANET are commonly employed for minimizing the delays, improving the output and enhancing transmissions. The authors proposed a network coding based multipath routing in MANETs. The performance analysis was carried out using NS2 and evaluated for packet overheads, delivery ratio and losses during packet transmission. The results of simulation reveal that the proposed scheme is effective, dependable, multipath and appropriate in MANETs.

MATERIALS AND METHODS

Arbitrary linear coding of networks: The ALCN technique allows each node to aggregate the last received packets and communicates the output packets. The aggregation uses arbitrary co-efficient in an network of 'N_n' nodes, packet 'p_m' generated at node 'm' where $1 = m = N_n$. The symbol level network coding the successive bits 'b' of 'p_m' are treated as symbols over the Galois field 'F_q' with '$q = 2^b$', here a packet of length 'P_l' bits consists of P_l/b symbols.

Consider a node obtains 'p_m' packets (U_x, E_x), where $1 = x = p_m$. $U_x = (U_{k,1}, \ldots\ldots, U_{k,n})$ is the universal vector for encoding and E_x is the load over the coded network. The source packet 'p_m' is related as $E_x = \sum_{m=1}^{n} U_{x,p^m}$ Here, E_x represents the linear aggregation of the source packets created by E_x. A fresh packet (U, E) can be attained by selecting a confined encoding vector $C = (C_1, \ldots\ldots, C_n)$ and calculating $(U, E) = \sum_{m=1}^{n} C_i$. (U_x, E_x). In ALCN, C is selected in an arbitrary fashion and in case the node 'a' does not obtain a packet then (U_a, E_a) is communicated.

By incorporating universal encoding vectors in the network coded packets, the source packet 'p_m'can be decoded by resolving the linear equations $\left\{E_x = \sum_{m=1}^{n} U_{x,k^{m-1}}\right\}$ for the attained packets (U_x, E_x), $1 = x = p_m$. If $p_m = n$ and n of the vectors U_a are linearly autonomous and the decoding matrix formed by these vectors D holds a rank 'r' and the source packets 'p_m' can be obtained.

All the obtained packets are independent with high chances in ALCN for which large field 'F_q' are selected (Sasson and Schiper, 2002). It is to be noted that the huge size of field creates overheads and consumes bigger memory for which the wireless networks utilizes small field size.

Neighbor based broadcast protocols: The working of the protocol is classified into the below stated types.

Synchronization

Centralized: A universal synchronization is needed for synchronizing communication. The synchronization updates every node about the time for communication and accepts constant communication or remains idle.

Scattered: Every node formulates local judgment about the communication, delivery or an idle state.

Selection of coding coefficients

Deterministic: The coding co-efficient are already computed based on a method with less number of transmissions for a given network. The technique is for wireless topology the error during communication must also be considered. In case, if a packet is not accepted by the planned receivers the sender has to re-transmit the same packet until it reaches correctly.

Arbitrary: On comparison to the deterministic approach the nodes arbitrarily selects the coefficients for the use by linear aggregations.

Quality of service

Dependable: A protocol is dependable if it guarantees a neighbor based broadcasting and it does not allow any re-transmission.

Changeable: In case if the broadcast is assured to reach all the nodes the protocol is variable. For example, probability based forwarding is not dependable as the packets are re send with a threshold and thus the probability does not work out.

The aggregation of synchronization, coefficients required for coding and quality of service it is possible to plan several protocols for measuring its performance. The proposed aggregates and focuses on the following aggregations as fixed network coding, arbitrary network coding and possibility based network coding.

For a layman comparison it is considered that the opportunistic protocols with centralized and autonomous coordinators. The deterministic and arbitrary network coding protocols are dependable due to the central coordinator and a rotational transmission. The two protocols uses different network coding which helps to understand the outcomes of several coding in particular the performance over diverse fields.

The possibility based coded networks is based on the probabilistic forwarding wherein, the node

communicates an arbitrarily coded packets with a possibility 'c'. The possibility 'c' is called the forwarding factor that is selected based on the topology of the network and dependable enough to broadcast. For a smaller value of 'c' communication is limited thereby, reducing the collisions and conserves energy but the problem is it does not assure full broadcast.

The shared protocol is easy to maintain in a wireless environment but are not dependable for which suitable solutions are to be designed to improve the neighbor based broadcast without considering the MAC. The MAC differs in two ways as.

Response based retransmission: The technique assures correct response for the transmitted packet by at least a node. Here, a arbitrary node is chosen for forwarding a response after reception and the same is included into the senders packet. Upon communication failure that particular packet is retransmitted.

Packet towing: In case, if the packets are accepted by some other adjacent nodes and if that particular packet is retransmitted then those adjacent nodes which received the packet correctly will not obtain any profit after the retransmission. It is decided to make use of a freshly created arbitrary packet for communicating again.

The classifications indicate the importance of combining network coding and MAC. The improvements minimize the retransmissions and the performance of Neighbor based Network Coding (NNC) improves a bit.

System design

Energy utilization: For designing energy utilization in a wireless environment for transmitting and receiving energy where energy reception includes inactive listening. This modeling is general in wireless scenario for which it is assumed that the power drained during transmission and reception is equal. The total energy utilization per node for all the neighbor broadcast is defined as:

$$N_b = P_e\left(T_{Tr} + T_{RP}\right) \quad (1)$$

Where:

T_{tr} = The total time for transmission

T_{RP} = The total time for reception

Hurdles in broadcast: In order to obtain minimum hurdles during energy utilization for the centralized protocols studies are conducted for node communicating only with the help of two one hop adjacent nodes (Peng and Lu, 2000). For better results the network coded scheme requires n/4 transmissions for completing the transmission in error free medium. The environment is wireless and it does not limits connectivity, i.e., the nodes is capable to accept packets from the far away nodes where, the larger distant nodes minimizes the chances of correct reception.

Hurdles in energy utilization: The number of transmissions and receptions for a node the minimum hurdles on energy utilization per nodes can be calculated easily. Based on Eq. 1, it is possible to estimate the time spent during transmission and reception. These are dependent on the bit rate based on which the packets are communicated and on the size of the packets for nodes 'N'. The energy utilization can be described as:

$$EU = P_e \frac{P(N)}{B_\gamma}\left(T_{TR} + T_{RP}\right) \quad (2)$$

RESULTS AND DISCUSSION

Performance analysis: The simulation of several transmission protocols is performed using a discrete event simulator (Kyasanur *et al*., 2006; Nguyen *et al*., 2007). The load of the broadcast packets and the bit rate of the PHY is chosen minimum and due to the dynamic nature of the environment the channel fading characteristics are also considered. The parameters considered for simulation are average number of broadcast per node and the energy utilization until the neighbor based broadcast is completed. From Fig. 1a and 1b depicts the average number of broadcasts per node in order to complete the communication over different field sizes along with the range of SNR for achieving minimum hurdles. Figure 1a depicts the results of one hop neighbor listening and it is to be noted that all type of approaches require high transmission in lower SNR region where the transmissions are subjected to failures. For high values of SNR all techniques are based on their system models. Figure 1b compares arbitrary coded networks for one and two hop neighborhood listening and with increased neighborhoods it requires only fewer broadcasts for completing the neighbor based broadcasts.

Figure 2a depicts the one hop energy utilization and here, the opportunistic performs better in deterministic coded network rather than the arbitrary coded network. Figure 2b depicts the energy utilization for arbitrary code network for one and two hop listening. On contrary for considering only the broadcast the profit from the improved neighborhood is minimized considerably due to more responses. Figure 3 depicts the results of delivery ratio for various field sizes. For different variations of MAC packet towing and response are utilized by several protocols with choice based network coding.

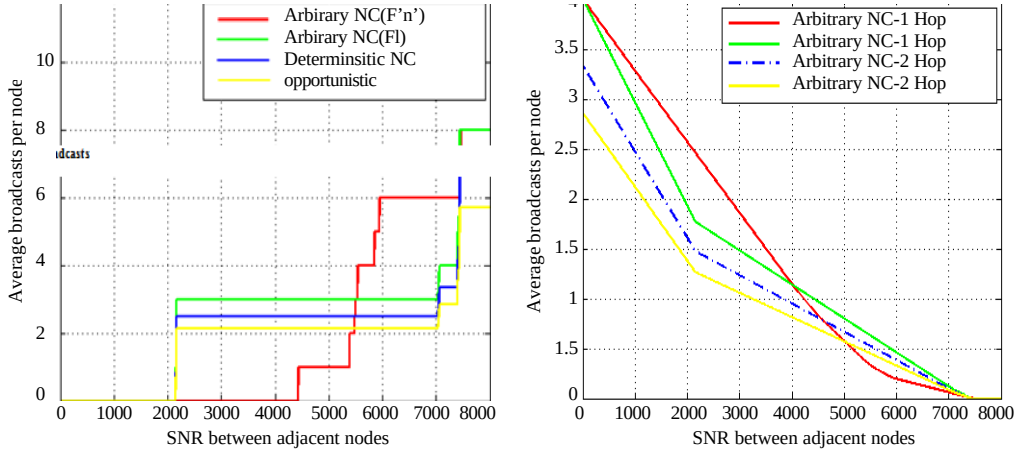

Fig. 1: Average no. of Broadcasts per Node for completing adjacent broadcast for Opportunistic, Deterministic and Arbitrary NC Protocols; 1-Hop Listening; 2-Hop Listening

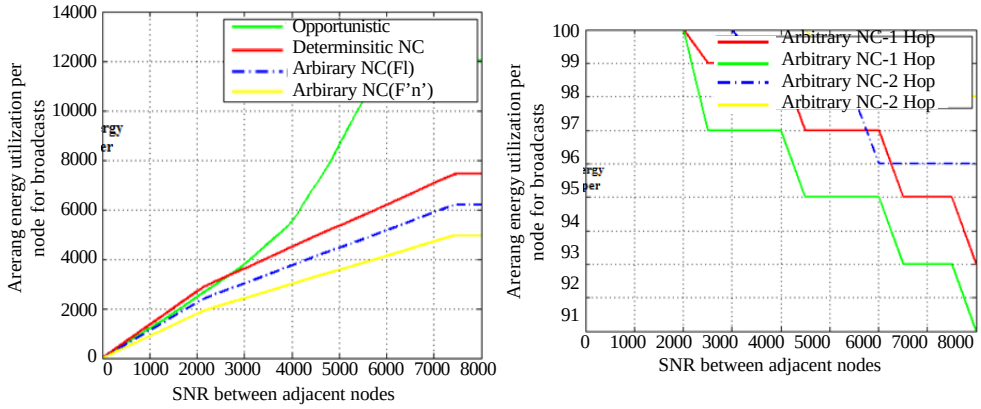

Fig. 2: Energy utilization per node for completing adjacent broadcast for opportunistic, deterministic and arbitrary NC protocols; hop listening; hop listening

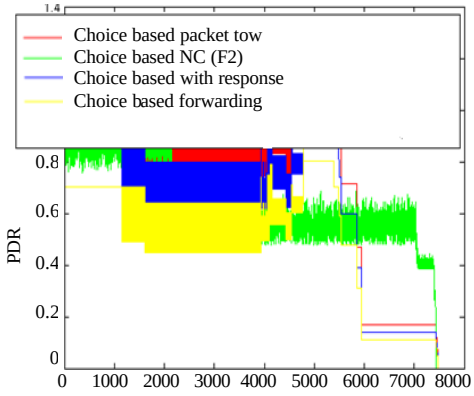

Fig. 3: PDR for choice based NC

From the results it is clear that the conventional choice based forwarding is outperformed by the choice based coded networks and it remains true for the rest of transmission.

CONCLUSION

The study was based on network coding based neighbor broadcast considering the overall broadcast and total energy efficiency along with delivery ratio for packets as parameters. The conventional techniques are used for comparing and energy utilization during communication by a node and the received packets are only considered. Based on the results of theory and simulations by employing rotational topology and less fading medium the results depicts that the deterministic coded networks utilize minimum energy as compared to the opportunistic and arbitrary coded networks i.e.

opportunistic based forwarding is better than arbitrary coded networks. Based on the studies for coded networks over several sized fields the results depicts that the smaller sized packets performs well during two hop listening. The performance in wireless environment for a larger field size requires coded network operations for processing and memory based operations maximizes the energy utilization of the wireless nodes. Furthermore, the variations in protocols at the MAC i.e. response and packet tow permits the performance improvement as result of increased overheads in broadcasted packets.

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