Network coding based cooperative Communications scheme for wireless sensor networks

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***Abstract*- Reliability is an important issue when designing wireless sensor networks (WSNs), since the WSNs need to work for a long time without manual interventions. The main challenges of wireless sensor network are limited resources. Hence it is hot research to design a reliable scheme. There are a few schemes to improve transmission reliability in the WSNs, such as multipath routing and cooperative transmission. In this project, a network coding-based cooperative communications scheme (NCCC) is proposed. Combining the advantages of cooperative communications and network coding .The main goal is to improve the packet loss-resistant capability through network coding and the communications fail-resistant capability through cooperative communications. In the NCCC, coding vectors in network coding procedure are chosen from a finite field randomly, which makes the NCCC easy to be implemented in the resource-limited sensor nodes. By increasing the nodes inside the cluster , thereby reducing the no of cluster and cluster head. Which is reduces the energy consumption, delay and node failure.**

***Keywords* - WSNs, random network coding cooperative communications, NCCC ,reliability.**

I.INTRODUCTION

Wireless Sensor Networks (WSNs) composed of a large number of sensor nodes. The sensor nodes are densely deployed randomly and have cooperative capabilities[1]. The Sensor devices are small and inexpensive, so that they can be produced and deployed in large numbers, and their resources in terms of energy, reliability, latency, computational speed and bandwidth are severely constrained. A sensor network is composed of a large number of sensor nodes. The sensor nodes are densely deployed randomly and have cooperative capabilities. The Sensor devices are small and inexpensive, so that they can be produced and deployed in large numbers, and their resources in terms of energy, reliability, latency, computational speed and bandwidth are severely constrained. The motivation comes from the work on MIMO systems which shows that employing multiple antennas on a wireless node can offer substantial benefits. However, this may be infeasible in small-sized devices due to space limitations .So the Cooperative communications is used to transmit and receive the information from source to sink by using the neighbor nodes.

In this paper we propose a communications scheme, named network coding based cooperative communications(NCCC),target is increasing the reliability of WSNs with low complexity .In NCCC scheme ,the original data in the source cluster and the received packets in the intermediate cluster will be encoded or re-encoded with random network coding before being sent to the next hop. Through coding, the redundancy of the original data will increase, thus the performance of transmission failure tolerance will increase. The cluster transmit the data cooperatively. If any nodes are failure in the transmission, the other node take over the transmission. Combining the both cooperative communications and network coding, this method has less redundancy. Then it has the less energy consumption. NCCC uses the relay in the network that is used to increase the communication between the source and receiver. The simulation results show that NCCC achieve Excellent performance under different conditions[1].

The term cooperative communications typically refers to a system where users share and coordinate their resources to enhance the transmission quality. This idea is particularly attractive in wireless environments due to the diverse channel quality and the limited energy and bandwidth resources. With cooperation, users that experience a deep fade in their link towards the destination can utilize quality channels provided by their partners to achieve the desired quality of service (QoS). This is also known as the spatial diversity gain. In a cooperative communication system, each wireless user is assumed to transmit data as well as act as a cooperative agent for another user. Two features differentiate cooperative transmission schemes from conventional non-cooperative systems: the use of multiple users' resources to transmit the data of a single source.

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The II section introduces the related work with recent years. The Network Coding based Cooperative Communication scheme is proposed in section III ,then the performance analyses of the scheme are carried out in section IV. Experimental results are depicted in section V.VI summarizes the paper.

II RELATED WORK

Cooperative transmission scheme based on distributed space-time block coding and conduct a systematic analysis on the resulting energy consumption[10]. Only sensors that can correctly decode received packets participate in the cooperative transmission, where the number of cooperating nodes depends on both channel and noise realizations; and we use packet-error-rate-based analysis rather than symbol-error-rate-based analysis. This is more realistic since error detection is usually done at the packet level is, e.g., cyclic- redundancy-check codes. Based on the analysis, we further minimize the overall energy consumption by power allocation between the intra clusters and inter cluster transmissions. The source node broadcasts the packet with certain energy to the nodes within the same cluster. All the nodes in the cluster simultaneously decode the received packet[10].

Cooperative wireless networking based on linear network codes consists of multiple users having independent information to be transmitted to a common base station (BS), assuming block fading channels with independent fading for different code words[15]. The users collaborate in relaying messages. Because of potential transmission errors in links, resulting in erasures, the network topology is dynamic. To efficiently exploit the diversity available by cooperation and time-varying fading, we propose the use of diversity network codes (DNCs) over finite fields. These codes are designed such that the BS is able to rebuild the user information from a minimum possible set of coded blocks conveyed through the dynamic network. We show the existence of deterministic DNCs. We also show that the resulting diversity order using the proposed DNCs, which is higher than schemes without network coding or with binary network coding. We also propose simplified versions of the DNCs, which have much lower design complexity and still achieve the diversity. It achieves lower Design complexity. But require high energy consumption.

In this paper, strategies to minimize the total transmit power in a decode-and-forward (DF) multi-user, multi-relay cooperative uplink, such that each user satisfies its quality-of-service(QoS) data rate[14]. Each user in the proposed system transmits its own data towards the base station and also serves as a relay for other users. The base station assigns one or more relays to each user in order to minimize total power in the uplink. The relay selection is based upon the instantaneous user to base station channels, inter-user channels and also the target rates of the users. The simulation results indicate significant power savings over a non-cooperative uplink, under proposed joint relay selection and power minimization algorithm in a DF cooperative uplink when using a space-time coded cooperative diversity Power Minimization under Code Combining. Power Minimization under Diversity Combining. By using this algorithm it can reduce the transmit power but provide less channel gain.

III NETWORK CODING BASED COOPERATIVE COMMUNICATIONS

In this section, the Network Coding Based Cooperative Communications (NCCC) scheme will be proposed. Firstly, the system model of NCCC scheme will be introduced, then the algorithm details will be described.

A. System Model

As depicted in Fig. 1, the transmission of information in the proposed NCCC algorithm is

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cluster-based, and the operation of the system is broken into rounds. It is assumed that the node has data to send to the sink node in each round, and that each cluster is composed of *N* sensor nodes. Firstly, the source node distributes the sensed data to other nodes in the source cluster through broadcasting. Then, each node in the source cluster encodes the data with random network coding and sends the coded packets to the next cluster. Nodes in the intermediate clusters re-encode the received packets and send them to the next cluster. The rest can be

NCCC Algorithm

NCCC algorithm mainly consists of three parts-encoding in the source cluster, re-encoding in the intermediate clusters and decoding in the sink node

Encoding in the Source Cluster

Firstly, the source node broadcasts the original packet, to other nodes in the source cluster. Then each node, which is working, broadcasts a message, which contains the ID of itself, to declare its status at its broadcast slot. Meanwhile, it receives other nodes declarations at other slots and stores the ID of the senders in a transmission queue, named TransQueue, which also contains its own ID. After the broadcasting procedure, the TransQueue contains all the working nodes' IDs. Through this, each node can know which nodes are still working at the current round. At the final stage, each working node splits into blocks and generates a coding vector, over finite field GF(q) randomly. After this, the original packet blocks will be encoded .The coded data and coding vector will be encapsulated and sent to the next hop. Then the length of the transmission queue in the packet transmissions stage, there are N coded packets to be transmitted to the next hop. The N packets will be transmitted by the N nodes in sequence with each node transmitting a packet. After that the working nodes have transmitted coded packets, data slot. Hence, the operation makes the 1st node in TransQueue transmit the packet, the 2nd node transmit the packet and so forth until N packets have been finished transmitting. So, if there are nodes failing at the current round, the other nodes would take over the transmission tasks of the failed nodes with this procedure.

done in the same manner, until the coded packets are de livered to the destination.

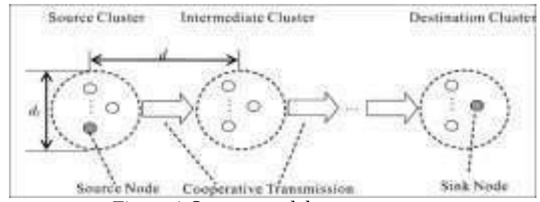
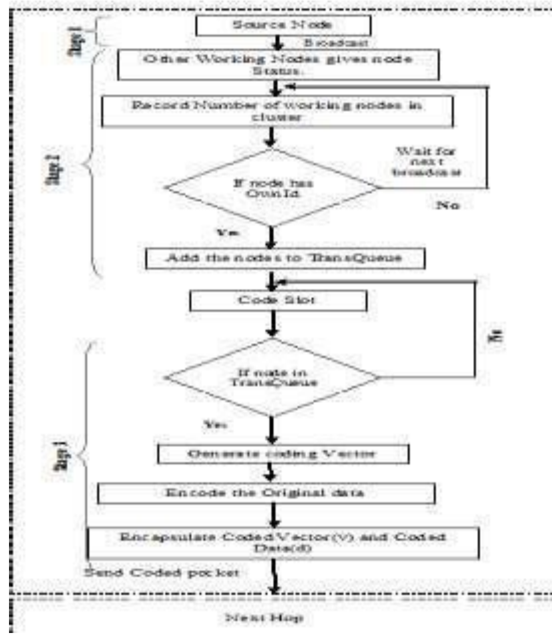
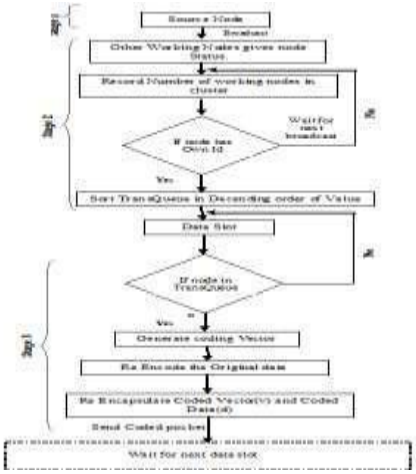


Figure 1:System model

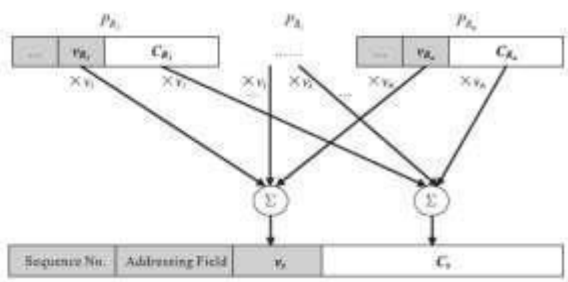


Re-Encoding in the Intermediate Clusters

When the nodes in last hop are transmitting packets, each working node in the intermediate cluster can correctly receive the packets as long as the received signal-to-noise ratio is higher than the threshold SNR0. After receiving the packets sent from last hop, similar to the status broadcasting in the source cluster, each working node broadcasts a message, which contains the ID of itself and the number of received packets, n, at its broadcast slot. Meanwhile, it receives other nodes' broadcasting at other slots and stores the corresponding IDs and n values in TransQueue, which also contains its own ID and the number of the received packets. After that, TransQueue will be sorted in the descending order of values, n.



Finally, each working node re-encodes the received packets and sends the recoded packet to the next hop. The rest intermediate clusters can perform the operation in the same manner, until the coded packets are delivered to the destination cluster.



Decoding in the Sink Node:

As the nodes in the destination cluster receive the coded packets, they forward the received packets to the sink node. After removing the duplicate packets with the aid of the sequence number of each packet,the sink node starts the packets decoding.

IV PERFORMANCE ANALYSES

In order to investigate the performance of the proposed NCCC scheme, analyses will be carried out in terms of delay, Energy consumption, packet Delivery ratio, Throughput. WSNs.

***C. Network Signaling Complexity**:* In each cluster, nodes need to broadcast a message to inform clusters, there will be *n* broadcast Other nodes its working

Packet delivery ratio: the ratio of the number of packets received by the destination to the total number of packets sent by the source.

Delay: the time taken for a packet to be transmittedno(packets)of generated\sent\forwarded |receivedpackets,calculate at every time interval & divided its length.

Routing overhead is the no of routing packets transmitted per data packet delivered at destination from the source node to the destination node**.**

Complexity Analysis

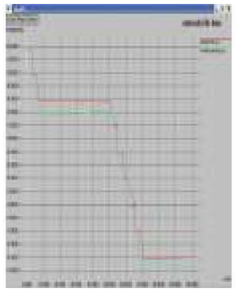
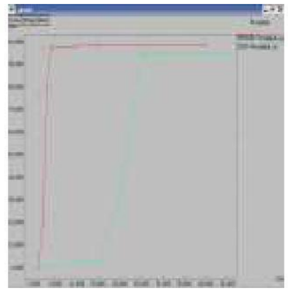
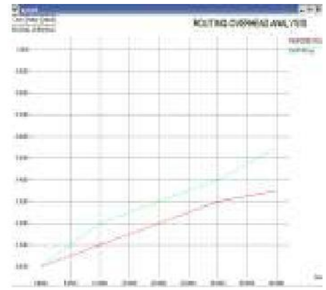
Because the resources in wireless sensor networks are very limited, complicated algorithms can not be easily implemented in WSNs. So, our goal is to design a reliable communications scheme with low complexity. Hence, in this subsection, we investigate the complexity of the proposed NCCC algorithm briefly and demonstrate the feasibility of the algorithm in WSNs. Our complexity investigations include three parts:

A. Encoding Complexity: In the encoding, each nodefirst generates $M(M \leq N)$ coding coefficients randomly over $GF(q)$ to create a linear combination of the M original data blocks. Similarly, in the re-encoding procedures, $m(m \leq N)$ coding coefficients are generated randomly over $GF(q)$ to create a linear combination of the m received packets. Hence, the complexity of the encoding and re-encoding can be regarded as linear, $O(N)$. Since the value of N (the number of nodes in each cluster) is usually small (say $N = 7$ or a bit larger), the complexity of encoding and re-encoding is low.

B. Decoding Complexity: As described in Section III, the sink node decodes the packets with Gaussian, elimination, hence, the complexity of decoding can approximately be cubic i.e. $O(N3)$. Since the sink node is usually a special node, which works as the gateway of a WSN and bridges the communications flows between a WSN and other communications networks, its computing capacity, storage capacity and power supply are abundant. As the value of N is

Statu small, the sink node will be fully qualified for the decoding jobs .As the broadcasting is restricted in the cluster, there will be broadcast messages for $n(n \leq N)$ working nodes in a cluster. Hence, the complexity of the status broadcasting is also linear.

V EXPERIMENTAL RESULTS

a)End-End Delay **b)Network life time** **c)Throughput** **d)Routing overhead**

The Experimental results shows that End-End Delay Network life time , Throughput, Routing overhead. End-End Delay is decreased compare than the Existing method because the no of nodes increased in the each Cluster, then the work will be done in faster manner. Network life time is increased ,because each cluster it has more no of nodes compare than the existing method, so the cluster and cluster head will be reduced.so we can save the energy. Then the Network life time increased.

VI CONCLUSION

By encoding original packets with random network coding in the source cluster, NCCC can increase the packet loss-resistant capability due to the packet redundancy. In addition, NCCC can resist to the nodes failure via cooperative communications. In each cluster, each node would broadcast its working status to the other. By increasing the nodes inside the cluster thereby reducing the no of cluster and cluster head. Hence, each working node would have the information of the number of nodes still in working. In the random network coding, the coding vectors are generated randomly over the finite field, which is easy to be implemented in WSNs. By analyses, the results show that energy consumption , delay and node failure is decreased .So, NCCC achieves an excellent reliability

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