RESEARCH ARTICLE OPEN ACCESS

Energy Efficient Wireless Sensor Network Using Network Coding Based Multipath Routing Protocol For Multicast Network

Gunjal M.S.[1], Prof.S.A.Shaikh[2]
*(Department of Electronics & Telecommunication, PUNE University, Loni-413736)
** (Department of Electronics & Telecommunication, PUNE University, Loni-413736)

ABSTRACT
Network Coding is most promising aspect of WSN. This Network Coding method is combined with multipath routing protocol to form NCMR protocol.(network coding based multipath routing protocol).This protocol is used to obtain energy efficient wireless sensor network.. These protocol leads to decrease the number of constrain routes & the total time of transmission. This protocol is applied on unicast and multicast network separately. And comparison is done with traditional multipath routing protocol for same unicast and multicast network. Simulation result shows energy consumption of NCMR multicast is lower than NCMR unicast and also than TMR unicast as well as multicast. This work is proved by the simulation analysis results. The used multipath model is based on braided multipath routing, and the network coding method is random linear network coding (practical network coding). In braided network multiple paths to the sink nodes are created for each source node, and the packets encoded at source nodes are transmitted through the braided multipath network model. Then, intermediate nodes re-encode these received packets and transfer these new packets to next cluster. Finally, the multiple sink nodes decode the packets received from different paths and recover the original data. Results of the analysis show that multicast NCMR provides more reliability. We compare multicast NCMR routing protocol with NCMR unicast & also with traditional multipath routing protocol for unicast and multicast networks, in terms of the packet loss, energy consumption, successful delivery ratio & end to end delay when a packet is transmitted Some special simulations are carried out specially for NCMR multicast i.e. effect of number of nodes on energy consumption, packet loss & end to end delay.

Keywords - Wireless Sensor Network, Multipath Routing, Network Coding, Energy efficiency, TMR, NCMR

I. INTRODUCTION

A wireless sensor network is a collection of no. of nodes deployed in work place. Every sensor node consist of three subsystems are sensor subsystem, processing subsystem &communication subsystem. Individual sensor have limited sensing region, processing power & energy. Networking a large number of sensors gives rise to robust, reliable & accurate sensor network covering wider region. The WSN may consist of 1000s or 10000s nodes. There are two important features of WSN.First is nodes in WSN's transmit the data through wireless channels, but mostly the link quality of wireless channel is bad due to instability. And second is nodes are used batteries as power supply. But the battery life is limited. Therefore a reliable WSN can be considering with low energy consumption & higher successful delivery ratio.

A lot of work is done & different technologies are developed to improve the energy efficiency & SDR of WSNs.Multipath routing [10-15] is one of the technology used to increase reliability of wireless sensor network. This technique creates no. of path from each source node to sink (destination node).Due to this no. of duplicate data copies are sent through this path. This process increases reliability by increasing redundancy & redundancy results in more energy consumption. Forward error correcting is another technology which also increases reliability. In FEC technique the sender encodes the initial data to new codeword with some redundant bit. Some bits of the data may become garbage in the channel during the transmissions, but at the end receiver can retrieve the authentic data with the redundant bits while the number of inaccurate bits is not more than the correcting capacity of FEC. Means it improves the reliability without retransmission, which is convenient for wireless networks. But, the disadvantage of FEC is that in FEC all the original data bits and redundant data bits in the same packets, and if any one of the nodes in the route stop working, the packets cannot successfully transport, so FEC scheme is not efficient for WSNs. Ideal WSNs should satisfied the following three requirement. First, it should decreases the data redundancy. Secondly, it should avoid retransmission. Third, it is durable to failure of nodes. Network coding may satisfied that three requirements. Network coding combine with multipath routing to obtain energy efficient wireless sensor network. But this system is implemented for multicast network model & some intermediate nodes are considered to be coded.

The flow of this paper is listed as follows. First, we propose a energy efficient WSN using NCMR, that help to reduce the number of required paths and the times of data transmissions. Second, we compare NCMR routing protocol with traditional multipath routing protocol for unicast and multicast network, in terms of the signal delivery ratio, energy consumption ,packet loss & end to end delay. In third, we show that different parameters with respect to number of nodes for NCMR multicast.

The remainder part of this paper is organized as follows. In Section II, network coding. In section III, network model used in simulation is described. In Section IV, we design different algorithms to permit network coding to worked on braided multipath networks so that we can obtain the simulation results. In Section V, We show the results of extensive simulations , the last section summarizes the main conclusion.

II. NETWORK CODING SCHEME

In Network coding [1,9] scheme the intermediate nodes combine packets before forwarding. Due to this practice of network coding total no. of transmission & time of transmission is reduced. Figure.1 shows the random linear network coding means when there are data to be transmitted from the source node, these packets are split into K packets. The source node randomly selects (K+n) × K elements from a Galois field to be a coefficient matrix, and code these K original packets into (K+n) new packets. Multiply each row vector of the coefficient matrix by the K original packets is a new packet which is a linear mixture of these original packets. Intermediate nodes which are coded nodes need to be recoding the received packets, and then these recoded packets send to next cluster. At last when the destination node successfully receives K packets of these (K+n) packets, it decodes and retrieve original data.

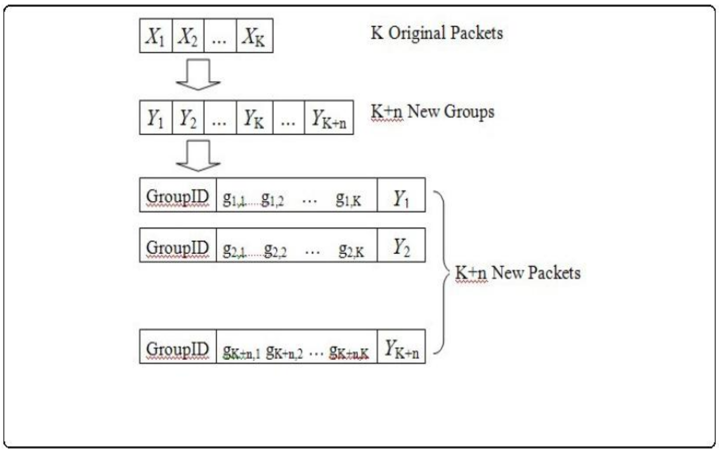

Fig.1. Random linear network coding[15]

III. NETWORK MODEL

There are two models of multipath n/w model. Figure 2 shows one of that braided multipath routing model & another is disjoint n/w model. The braided multipath n/w model is unicast consist of single source & sink (destination node) & many intermediate nodes. We assume that N is no. of paths, therefore total number of nodes in a cluster is equal to N. There are N-1 backup nodes for each intermediate node.

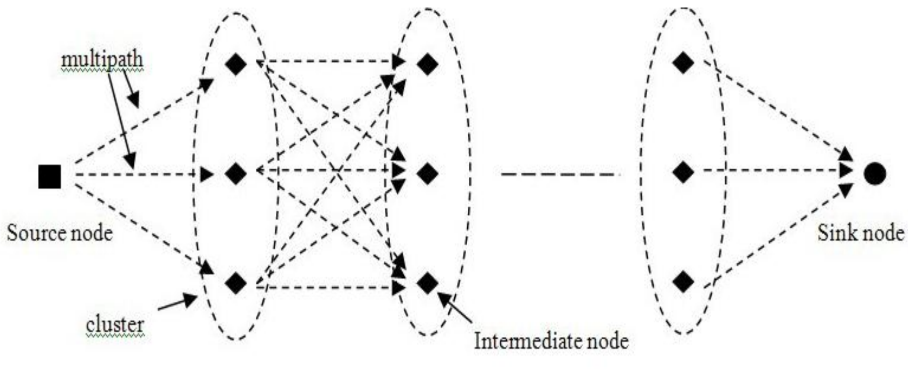

Figure.2.Unicast network model[15]

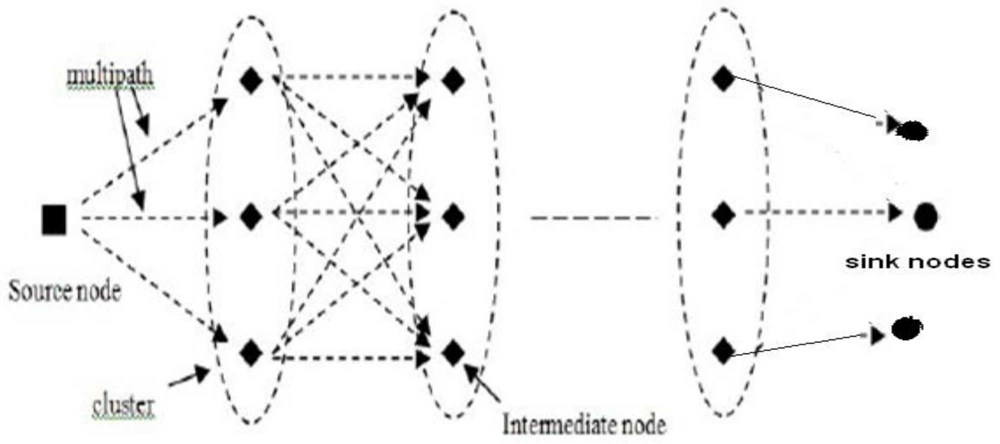

Figure.2.Unicast network model[15]

Multicast Network Model

There is only one source node and sink node in unicast models, and base paper shows that network coding is dominant in both unicast network and multicast network model. Fig.3 shows the network models with single source and multiple sinks are worthwhile to address i.e. multicast Multicast (one to-many) is a communication sample in which a source node sends a message to a group of destination nodes. Again, multicast network can be established by sending different unicast (point-to-point) messages to each of the destination nodes. There are many cause which make the multicasting advisable. The first major advantage of using multicasting is the decreases of the network load**.** There are many applications like ticker applications which are used to transfer packets to different of stations .The packets sent to these stations share a group of links on their paths to their destinations. As multicasting requires the broadcasting of only a single packet by the source and replicates this packets at the sink node. Only drawback is multicast transmission can consume more network bandwidth.

IV. ALGORITHMS FOR PROTOCOL DESIGN

To obtain simulation result we require a protocol to facilitate network coding to be deployed in a braided multipath routing network. Similar to other routing protocols, the protocol also mainly consists of routing discovery algorithm, data disseminating algorithm, and routing maintenance algorithm.[15]

4.1 Algorithm [15]

1: Routing discovery algorithm Demand: It is assume that source node must have knowledge of link quality.
1: //Step 1. To obtain the minimum hops to sink node
2: The destination (sink) nodes overflow a route recognition packet (RRP).
3: For each node except destination node receiving RRP
4: Then transfer ahead the packet.
5: Updates the shortest route to destination and report all the nodes in the shortest route.
6: Report and updates the number of hops of the shortest route (H).
7: End
8: //Step2. Routing founding
9: The source node S calculates the number of essential paths (N) that is equivalent to no. of total nodes.
10: Then node S sends the value of N to its next node in downward direction P which is the first hop in the shortest route to the destination.
11: Node P finds other N - 1 nodes to provide as its (supporting) backup nodes. These N nodes form a (bunch) cluster.
12: Node P sends the value of N to its next downstream node Q, and node Q performs the same role as in step 11.
13: If destination (sink) node is reached
14: Finish routing founding.
15: Else
16: Continue routing founding.
17: End

In routing discovery stage, any intermediate node is used for data transmission must record source nodes in its cache.

4.2 Algorithm 2: Data Disseminating

Demand: Operations on Galois field are previously implemented in sensor nodes.

1: //Step 1. Programming at source node
2: The source node S programmes the original K packets into K' new packets.
3: Send the new packets to next hop.

4: //Step2. Programming at intermediate nodes
5: For each intermediate node
6: If no. of received packets are R>=K%R
7: Then arbitrarily generates a K*K matrix M to be local coding kernel.
8: Encodes these R packets into K new packets with matrix M.
9: Else
10: Arbitrarily generates a R*R matrix M to be local coding kernel
11: Encodes these R packets into R' new packets with matrix M.
12: End
13: Transfer the new packets to next hop.
14: End
15: //Step3. Decoding by the destination node
16: If R > = K
17: The destination node recollect the original packets through Gaussian elimination.
18: End

4.3 Algorithm 3: Routing maintenance

Demand of Algorithm: The routing maintenance packet (RMP) should be broadcast periodically by source node.

1: For each head node of cluster receiving RMP
2: If RMP is from upstream cluster
3: Then forwards it to downstream cluster
4: Else if RMP is from its supporting (backup) nodes.
5: Save the node identification and increment counter with 1
6: Answer a message to the backup node.
7: End
8: Then transfer these RMP to the head node of cluster of next hop.
9: End
10: If counter <N
11: If it selects (N-counter) free nodes to be its backup nodes.
12: End
13: For each supporting (backup) node receiving RMP
14: Transmit the RMP to head node of cluster and waits for a respond.
15: If reply is not received % Cluster-head node get fails.
16: Choose a new head node of cluster and finds a new supporting (backup) node.
17: End
18: At the end, the destination node discards RMP.

4.4 Experimental Set-Up

Parameters	Values	Parameters	Values
Network plot	300 × 100 m2	Mac layer protocol	CSMA
Carrier frequency	2.413e+6Hz	No. of Sink nodes	04
Max sending power	50 mw	Net layer head length	32 bit
Mac layer head length	24 bit	No. of source nodes	01

Table.1 Simulation Parameters

VI. RESULT ANALYSIS

Simulation are done on NCMR unicast and multicast network as well as TMR multicast and comparison is done.The graphical result shows that energy consumption of NCMR multicast is less as compare to NCMR unicast and TMR unicast as well as multicast.Fig.4 shows graph of energy consumption versus bit error rate.Fig.5 shows graph of successful delivery ratio versus bit error rate.It observed that SDR of NCMR for multicast is more than SDR of NCMR for unicast & TMR for unicast as well as multicast. The comparison is also done in terms of end to end delay and packet loss.(Fig.6 & 7)

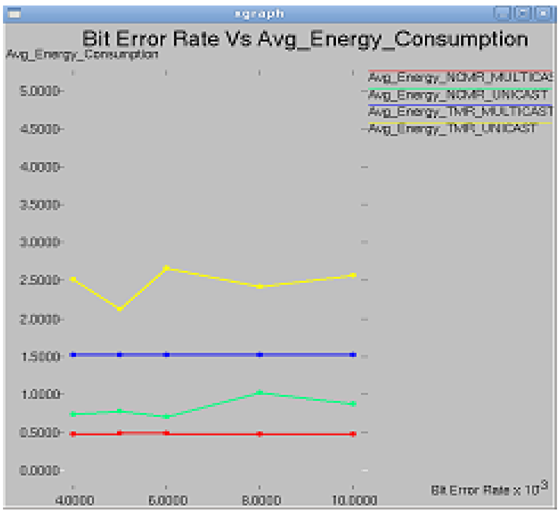

Fig .4. Energy Consumption

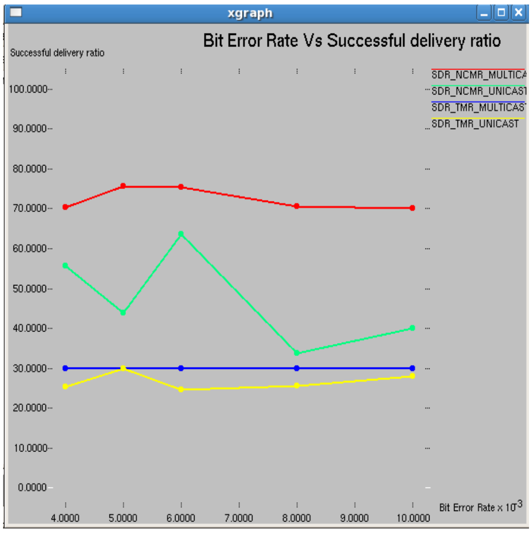

Fig.5.Sucessfull Delivery Ratio

Special simulations are carried out on NCMR for mulicast network .The Fig 8 shows a graph number of nodes Vs end to end delay, packet loss in Fig 9,average energy consumption Fig.10.Graphs shows as no of nodes increases the energy consumption increases ,End to end delay decreases and packet loss also decreases.

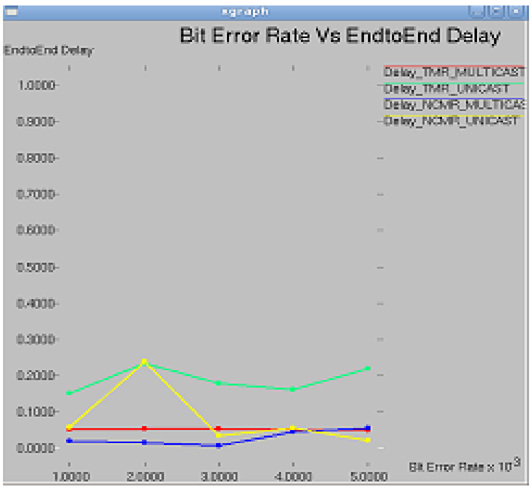

Fig.6.End to End Delay

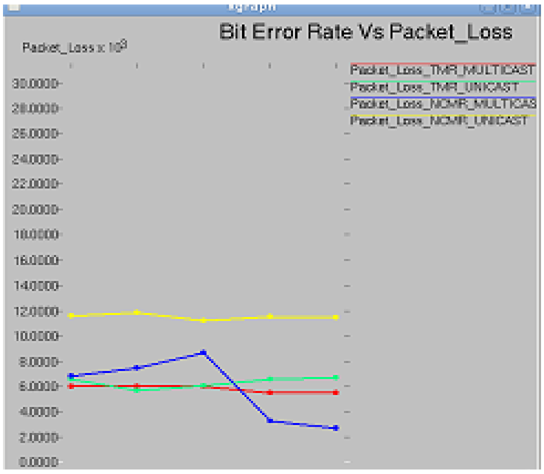

Fig.7.Packet Loss

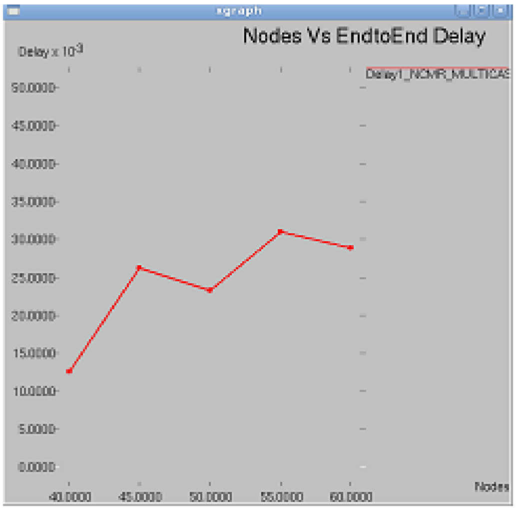

Fig.8.Nodes Vs End to End Delay

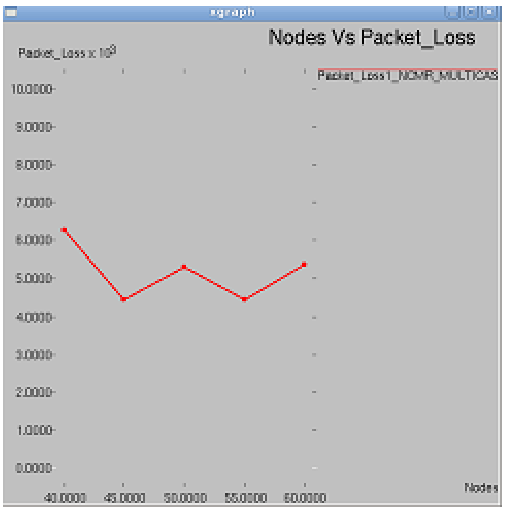

Fig.9.Nodes Vs packet loss

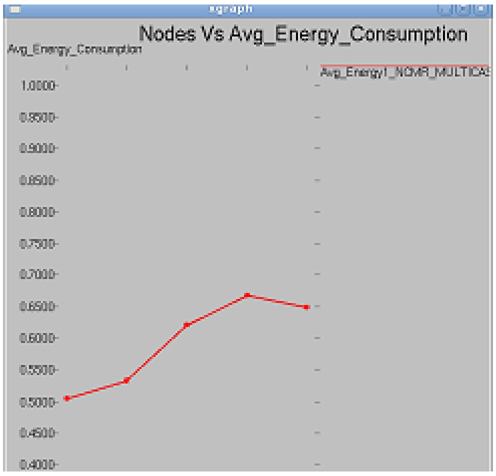

Fig.10.Nodes Vs energy consumption

VII. CONCLUSION

We develop a energy efficient ,network coding based multipath routing protocol for multicast network,which forwards packets through multiple paths dynamically based on path durability and coding opportunity. Comparative study is done interms of different parameters for unicast and multicast networks. And it is observed that NCMR (for multicast) produces higher reliability and energy efficiency. The NCMR with multiple sink & single source node is employed. The results of simulations show that NCMR for multicast is more efficient than NCMR for unicast & TMR. Some special simulations are carried out for NCMR(multicast) to check efficiency.

FUTURE SCOPE

In terms of future work we can consider some other parameters for simulation to prove that NCMR is more reliable and energy efficient than traditional multipath routing protocol. And it is assumed that many intermediate nodes in the network are permitted to carry out network coding, which increases more processing work of nodes. So in future we can decrease the no. of coded nodes.

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