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ENTROPHY BASED NETWORK CODING MULTIPATH ROUTING IN WIRELESS SENSOR NETWORK

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Abstract - Unlike traditional routing schemes that route all traffic along the same path, multipath routing method split the traffic among several paths in order to ease congestion. It has been recognized by many that multipath routing can be fundamentally more efficient than the traditional approach of routing along single paths. Yet, in contrast to the single path routing approach, many research in the context of multipath routing focused on heuristic methods. We demonstrate the significant advantage of optimal (or near optimal) solutions. Hence, we investigate multipath routing. A wireless sensor network is a large collection of sensor nodes with limited power supply and constrained computational capability. Because of the restricted communication range and high density of sensor nodes, packet forwarding in sensor networks is usually performed through multi-hop data transmission. We present a comprehensive taxonomy on the existing multipath routing protocol called network coding based multipath routing, which is especially designed for wireless sensor network and provide an enhancement to that algorithm that gives better packet delivery, packet delivery delay, less packet loss probability and network life time.

Keywords : Multipath routing, Routing, Wireless Sensor Network, Network coding based multipath routing, NCMR

1 INTRODUCTION

Multipath routing can be fundamentally more efficient than the currently used single path routing protocols. It can significantly reduce congestion in “hot spots,” by deviating traffic to unused network resources, thus, improving network utilization and providing load balancing [1].Moreover, congested links usually result in poor performance and high variance. For such circumstances, multipath routing can offer steady and smooth data streams [2].

Most routing protocols use only single route for each source and destination nodes. Due to node power, node failures, and the dynamic characteristics of the radio channel, links in a route may become temporarily unavailable, making the route invalid. Multipath routing addresses this problem by providing more than one route to a destination node.

NCMR is used to increase the reliability of data transmission or to provide load balancing.

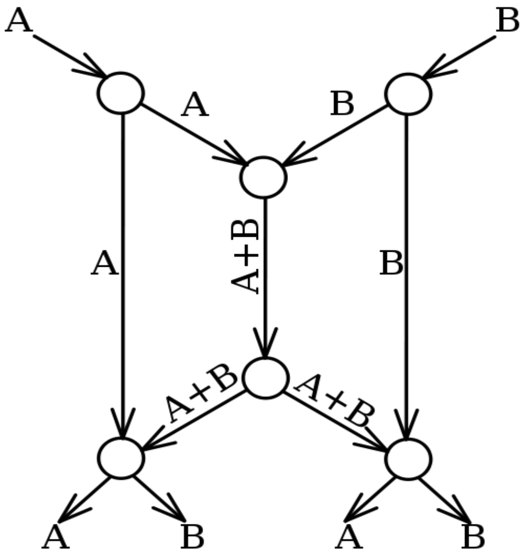
NCMR routing protocol provide an accurate and efficient method of estimating and evaluating the route stability in dynamic Wireless sensor networks (WSN). A wireless sensor network is a large collection of sensor nodes with limited power supply and constrained computational capability. Due to the restricted communication range and high density of sensor nodes, packet forwarding in sensor networks is usually performed through multi-hop data transmission. A technique called entrophy is used in the NCMR and the packet delivery rate is increased and the packet loss probability is decreased. Entrophy is the measure of the level of disorder in a closed but changing system, a system in which energy can only be transferred in one direction from an ordered state to a disordered state. Its simulation result is given in this paper.

2 RELATED WORK

Network coding is a technique which might be accustomed to improve a network's throughput, scalability and efficiency, as well as resilience to attacks and eavesdropping, as compared to ancient strategies of OSI model or TCP/IP model separation between network layers with physical layer working on principles of Shannon Information Theory. rather than simply relaying the packets of information they get, the nodes of a network take *several* packets and combine them together for transmission. This can be used to get the maximum possible information flow in a network. The butterfly network [3] is often used to illustrate how linear network coding can outperform routing. Two source nodes (at the top of the picture) have information A and B that must be transmitted to the two destination nodes (at the bottom), which individually want to know both A and B. Each edge can carry only one value (we can think of an edge transmitting a bit in every time slot).

If only routing were allowed, then the central link would be only ready to carry A or B, but not both. If we send A through the center; then the left destination would receive A twice and not know B at all. Sending B poses a similar drawback for the right destination. We say that routing is not sufficient because no routing scheme can transmit both A and B at the same time to both destinations.

Using a simple code, as shown, A and B can be transmitted to both destinations simultaneously by sending the sum of the symbols through the center – in other words, we encode A and B using the formula "A+B". The left destination receives A and A + B, and can calculate B by subtracting the two values. Similarly, the destination on the right side will receive B and A + B, and will also be able to determine both A and B.



Generally, routing refers to the flow of data packets from source node(s) to destination node(s) where intermediate node(s) simply replicate and forward without any processing on received packets. NC allows each node to perform an operation, for example linear combinations of received data packets before forwarding on different transmission lines. Therefore, NC-aware routing is a special case of NC. NC-aware routing techniques take into account the availability of NC opportunities within a network during route selection for data transmission. Combining data packets from different flows along routes with more coding opportunities further improves network throughput. Simply, NC-based routing deals with the recoding of packets belonging to the same flow and is also known as intra-flow or intra-session coding. Protocols, i.e. NC-RMR [4], and PipelineOR [5] are related to NC-based routing and the use of NC reduces redundant data transmissions that lead to energy consumption reduction within WSNs.

To address the issues related to the coding conditions and the number of packets to be coded Guo *et al*. [6] and Le *et al*. [7] analyzed the performance of practical coding schemes to determine the number of packets that can been coded. They also defined generalized conditions that sufficiently identify actual coding points within a wireless network which ultimately possess compatibility and availability.

3. NETWORK CODING WITH ENTROPY

Routing in sensor networks is very challenging because of several characteristics that distinguish them from contemporary communication and wireless ad-hoc networks. First, it is not possible to build a global addressing scheme for the deployment of sheer number of sensor nodes. Therefore, traditional IP-based protocols cannot be applied to sensor networks. Secondly, in contrary to typical communication networks almost all applications of sensor networks require the flow of sensed data from multiple regions (sources) to a particular sink. Next, generated data traffic has significant redundancy in it because multiple sensors may generate same data within the vicinity of a phenomenon. Such redundancy needs to be exploited by the routing protocols to improve energy and bandwidth utilization. Finally, sensor nodes are tightly constrained in terms of transmission power, processing capacity, on-board energy and storage and thus require careful resource management. This makes the routing process very challenging one.

Entropy is used to determine how much energy is required to complete the routing protocol at a particular route the destination route based protocol with multipath routing in network coding, In this system utilization of energy entropy results was measured after that best utilization of energy results are measured from that particular route path are assigned to user /node in the network model then network coding with multipath routing was performed by using path.

Energy Entropy on network coding multipath routing protocol. The essential idea of the protocol is to find every route which can minimize the node residual energy in the process of selecting path. It balances individual node battery energy utilization and hence prolongs the entire network lifetime. The results of simulation show that, with the proposed Energy Entropy on network coding multipath routing protocol,packet delivery rate, packet delivery delay, packet loss probability ratio and networks lifetime can be improved in most of cases..

Maximum Entropy estimation is a framework for obtaining a parametric probability distribution model from the training data and a set of constraints on the model. Maximum Entropy estimation produces a model with the most 'uniform' distribution among all the distributions satisfying the given constraints. A mathematical metric of the uniformity of a distribution P is its entropy:

$$H(P) = -\sum_{\omega\in\Omega} P(\omega)\log P(\omega) \qquad (1)$$

Let be the set of packet classes defined in the previous section. Given a sequence of packets S = {x1,…,x_n} the training data, the empirical distribution ~ P over in this training data is

$$\tilde{P}(\omega) = \frac{\sum 1(xi \in\omega)}{n} \qquad (2)$$

where 1(X) is an indicator function that takes value 1 if X is true and 0 otherwise.

Suppose we are given a set of feature functions $\mathcal{F}$ = {f_i}, and let fi be an indicator function fi: Ω↦{0,1}.By using Maximum Entropy estimation, we are looking for a density model P that satisfies $E_P(f_i) = E_{\tilde{p}}(f_i)$ for all $f_i \in \mathcal{F}$ and has maximum entropy. In [11], it has been proved that under such constraints, the Maximum Entropy estimate is guaranteed to be (a) unique, and (b) the same as the maximum likelihood estimate using the generalized Gibbs distribution, having the following log-linear form

$$P(\omega) = (1/Z)\exp(\sum \lambda_i f_i(\omega)). \qquad (3)$$

For each feature fi, a parameter λi ∈ Λ determines its weight in the model, ∧ is the set of parameters for the feature functions. Z is a normalization constant that ensures that the sum of the probabilities over Ω is 1. The difference between two given distributions P and Q is commonly determined using the *relative entropy* or *Kullback-Leibler (KL) divergence*:

$$D(P||Q) = \sum_{\omega\epsilon\Omega} P(\omega) log \frac{P(\omega)}{Q(\omega)}$$

Maximizing the likelihood of the distribution in the form of (3) with respect to ~ P is equivalent to minimizing the K-L divergence of $\tilde{P}$ with respect to P

$P = \arg min_p D(\tilde{P}||P)$

As

$$\prod_{\omega\epsilon\Omega} P(\omega) \sum 1(xi\epsilon\omega)\alpha exp - D(\tilde{}P||P)$$

For the sake of efficiency, feature functions are often selected to express the most important characteristics of the training data in the learned log-linear model, and in return, the log-linear model expresses the empirical distribution with the fewest feature functions and parameters. The Maximum Entropy estimation procedure consists of two parts: feature selection and parameter estimation. The feature selection part selects the most important features of the log-linear model, and the parameter estimation part assigns a proper weight to each of the feature functions. These two parts are performed iteratively to reach the final model.

LINEAR NETWOK CODING SCHEMA

Encoding: The coding operation performed by each node is simple to describe and is the same for every node: received packets are stored into the node's memory, and packets are formed for injection with random linear combinations of its memory contents whenever a packet injection occurs on an outgoing link. The coefficients of the combination are drawn uniformly from Fq. The linear network coding scheme is an encoding method such that coding vector $g_i = (g_{i1}, g_{i2},\ldots, g_{iN})$ is given, and input packet $M = (M_1, M_2,\ldots, M_N)$ is converted into output packet Pi by the following expression
The destination node can decode input packets because the coding vector $G = (g_1, g_2 , \ldots , g_N)$ and output packet data $P = (P_1, P_2, \ldots, P_N)$ are obtained from the received packets, and an inverse matrix exists in G.
Decoding: Decoding at any receiver is performed by collecting packets of a given generation. These packets yield a system of linear equations that need to be solved to retrieve the original native packets. Suppose a node has received v encoded packets $X_1, X_2, \ldots, X_s$ belonging to a given generation, with $v \leq N$ while $g'_1, g'_2 , \ldots , g'_v$ represent the coding vectors corresponding to the encoded packets. The generic element of the decoding matrix G is given by: $G_{ij} = g_{ij}$ where i = 1, ..., s and j = 1, ..., N. Let us denote the rank of G by R. When the matrix has full rank, i.e., R = s = N, for a given generation, then the node can solve the linear equations to retrieve all native packets belonging to that generation. In this case, the receiver can recover part of the source native packets belonging to the given generation. We finally observe that when a node receives a packet, it must check whether it is innovative or not, i.e., whether it increases the rank of the decoding matrix G.

4. SIMULATION EXPERIMENTS

4.1. SIMULATION MODEL AND PERFORMANCE METRICS

To conduct the simulation studies, we use randomly generated networks in which advanced_network coding based multipath routing(a_ncmr) is implemented. This ensures that the simulation result is independent of any network topology.

A wireless sensor network is generated as follows: The Distributed Coordination Function (DCF) of IEEE 802.11 for wireless Local Area Networks is used as the MAC layer protocols. There are 100 nodes in the network and they are confined in a square area of 1000m × 1000m; WSN is modeled as a shared media radio with a nominal bit-rate of 2 Mbps and a nominal radio range of 250 meters. In the beginning, the nodes are randomly placed in the area. Each node remains stationary for a pause time that is exponentially distributed with a mean of 600 seconds. We chose our traffic sources to be constant bit rate (CBR) source. When defining the parameters of communication mode, we tested it with the packet sending rate 4 packets per seconds, and packet size of 64 bytes.
Here the performance of a_ncmr is compared with ncmr. We evaluate the performance according to the following metrics: packet delivery rate, average packet delivery rate and packet loss probability.

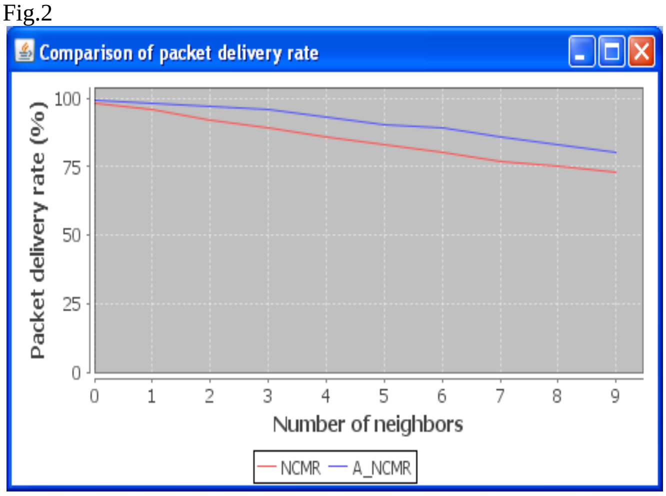
4.2. SIMULATION RESULTS

To assess and compare the performance of a_ncmr with ncmr we implemented it in the java.
In fig 2, packet delivery rate is increased in a_ncmr compared to ncmr. Delivery rate is increased with increase in neighbours regardless of block size, packet drop probability.

Packet delivery delay and packet loss probability is also improved in our enhancement. It is shown in the fig 2,3 &4

Increase in networks lifetime is shown in fig 5. Basically networks lifetime is more in A_NCMR compared to NCMR. The entrophy method increases the networks lifetime.

Fig.2



In fig.2, we see that in NCMR packet delivery rate decreases with increase in neighbours. But decrease in packet delivery rate is controlled well in A_NCMR.

Fig 3.

Fig 3 shows that average packet delivery delay is less in A_NCMR compared to NCMR.

Fig 4.

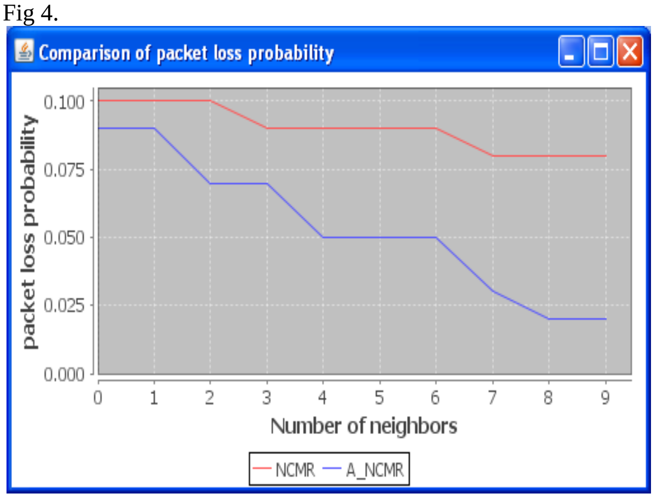


Fig 4 shows that packet loss probability is decreased heavily compared to NCMR. In A_NCMR packet loss probability decreases with increase in neighbours.

Fig 5

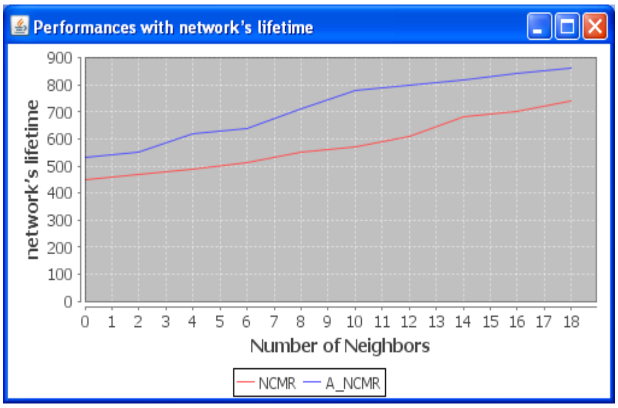


Fig 5 shows that networks lifetime is improved in A_NCMR compared to NCMR. And the networks lifetime increases with increase in neighbours.

5. CONCLUSION AND FUTURE WORK

In this research the paper proposed a entropy based network coding schema with multipath routing and it can deal with the network coding model for researching the WSN multipath routing problem. It proposes a Network entropy Coding in WSN multipath routing protocol. It is typically proposed in order to increase the reliability of data transmission, and by applying network coding, which allows packet encoding at a relay node. They compare the performance of NCMR with A_NCMR routing protocol. Simulation results show that, with the proposed network coding in WSN multipath routing protocol (NCMR), packet delivery rate, average packet delivery delay and packet loss probability can be improved in most of cases. In terms of future work, we would definitely consider optimizing the timeout values and other parameters for further evaluation via simulation. Use of the node-disjoint paths in parallel to improve the QoS performance and increase the network utilization, is left and further studies should be carried with it.

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AUTHOR PROFILE

Dhivya.G received her BCA and M.Sc[cs] from Bharathiar University and is pursuing her M.Phil in RVS college from Bharathiar University. She presented her research papers in three national and international conferences and is having great interest in network models and routing in different networks. Her personal interest in doing the research made to publish this journal.

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