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A Novel Method for Energy Efficiency Comparison using Optimization Methods in Manet

Nathiya. K[1], Raja. R[2]

[1]ME-Computer Science and Engineering, Dhanalakshmi Srinivasan Engineering College, Perambalur, Tamil Nadu, India

[2]Assistant Professor, Dhanalakshmi Srinivasan Engineering College, Perambalur, Tamil Nadu, India

ABSTRACT

Mobile Adhoc Network (MANET) are resource constrained. Energy is one of the most important resources in such networks. Therefore, optimal use of energy is necessary. In this project, we present a novel energy-efficient routing protocol for MANETs. We propose a Scattered Based Energy-aware Fuzzy Logic based routing algorithm (SBFL) that simultaneously addresses energy efficiency and energy balancing. Our design captures network status through appropriate energy metrics and maps them into corresponding cost values for the shortest path calculation. We seek fuzzy logic approach for the mapping to incorporate human logic. We compare the network lifetime performance of SBFL with other popular solutions including GA and ACO. Rigorous simulation results depict the energy efficiency, throughput, and prolonged lifetime of the nodes under the influence of the proposed protocol. Future scope of this work is outlined.

Keywords : MANET, Minimum Cost Routing, Energy Balancing, Network Lifetime Improvement, Fuzzy Logic.

I. INTRODUCTION

Mobile Adhoc Network (MANET) is formed by small autonomous nodes communicating over wireless links. Nodes have sensing, processing and communicating capabilities. They are mainly battery powered and tightly constrained in terms of energy, processing, and storage capacities, therefore requiring careful resource management. Applications of such networks include exploration, surveillance, and environmental monitoring. Power consumption is a key issue in MANETs, since it directly impacts their lifetime in the likely absence of human intervention for most applications of interest. Since the majority of power consumption is due to the radio component, nodes rely on short-range communication and form a multi-hop network to deliver information to a base station.

While focusing on energy efficiency alone minimizes the energy consumption of individual sensor nodes, it does not guarantee an even distribution of energy consumption across all sensors in the network. Energy consumption balancing (ECB) is an important feature to achieve maximum network lifetime, where ideally all sensor nodes should consume energy such that they reach the end of their operational lifetime at the same time. In MANETs, multi-hop communication is widely adopted to achieve energy efficiency by ensuring short range transmissions. On the other hand, this mode of communication may also induce an energy imbalance across a MANET, as multi-hop communication paths naturally cause an unequal communication load on sensors, especially higher on those sensors closer to the data sinks. As such, in order to maximize a MANET's lifetime, besides reducing transmission ranges via multihop communication paths, it is also necessary to balance energy consumption in the MANET.

Designing appropriate mapping functions for various input metrics is not an easy task. However, we see opportunity in applying fuzzy logic for this purpose. FL has the potential of dealing with conflicting situations and nonlinearity in data, using heuristic human reasoning without the need for a complex mathematical model [8]. Despite the obvious advantages of FL and its wide and successful deployment in many fields, there is a limited number of routing algorithms that consider FL in their design. Many routing algorithms require only simple decision making process, and hence the use of fuzzy logic is unnecessary. However, for energy-aware routing demanding comprehensive decision making process, fuzzy logic represents an effective approach. Motivated by the aforementioned shortcomings in the literature and the stated design challenges, we propose a novel Scattered Based Energy-aware cost function based routing algorithm (SBFL) that uses Fuzzy Logic approach to improve network lifetime in dynamic network conditions.

We provide a generic framework for designing energy-related cost functions. Our algorithm includes energy consumption rate and node remaining energy metrics in its cost function. Energy consumption rate is represented by the combination of transmission energy and energy drain rate. Instead of using rigid computation model to blend different metrics, we apply soft human logic through fuzzy logic approach. We first use two fuzzy logic systems to map the crisp values of the metrics and then aggregate the costs using a weighted product function to produce the final link cost. A shortest path method, Bellman-Ford algorithm, is then used to determine the minimum cost route from any sensor node to the sink node. We evaluate the performance of our routing algorithm (SBFL) through extensive simulation using various performance metrics.

II. RELATED WORKS

J. Habibi, A el.at, Energy-efficient routing in wireless sensor networks. Most of the existing routing schemes assign energy-related costs to network links and obtain the shortest paths for the nodes in order to balance the flowing traffic within the network and increase its lifetime. However, the optimal link cost values and the maximum achievable lifetime are not known for the majority of the existing schemes. A framework is provided in this work to analytically derive the best achievable performance that can be obtained by any distributed routing algorithm based on the shortest-path approach. Given a network configuration and an energy consumption model, the presented framework provides the optimal link cost assignment which yields the maximum lifetime in a distributed shortestpath routing strategy. The results are extended to the case of variable link cost assignment as well. A heuristic algorithm is also developed to obtain approximate solutions to the best performance problem with limited computational complexity.

A Shawi, L. Yan proposed the MANET are used in many applications to gather sensitive information which is then forwarded to an analysis center. Resource limitations have to be taken into account when designing a MANET infrastructure. Unbalanced energy consumption is an inherent problem in MANETs, characterized by multihop routing and a many-to-one traffic pattern. This uneven energy dissipation can significantly reduce network lifetime. This paper proposes a new routing method for MANETs to extend network lifetime using a combination of a fuzzy approach and an A-star algorithm. The proposal is to determine an optimal routing path from the source to the destination by favouring the highest remaining battery power, minimum number of hops, and minimum traffic loads. To demonstrate the effectiveness of the proposed method in terms of balancing energy consumption and maximization of network lifetime, we compare our approach with the A-star search algorithm and fuzzy approach using the same routing criteria in two different topographical areas. Simulation results demonstrate that the network lifetime achieved by the proposed method could be increased by nearly 25% more than that obtained by the A-star algorithm and by nearly 20% more than that obtained by the fuzzy approach.

G. K. Venayagamoorthy, the networks of distributed autonomous devices that can sense or monitor physical or environmental conditions cooperatively. MANETs face many challenges, mainly caused by communication failures, storage and computational constraints and limited power supply. Paradigms of computational intelligence (CI) have been successfully used in recent years to address various challenges such as data aggregation and fusion, energy aware routing, task scheduling, security, optimal deployment and localization. CI provides adaptive mechanisms that exhibit intelligent behavior in complex and dynamic environments like MANETs. CI brings about flexibility, autonomous behavior, and robustness against topology changes, communication failures and scenario changes. However, MANET developers are usually not or not completely aware of the potential CI algorithms offer. On the other side, CI researchers are not familiar with all real problems and subtle requirements of MANETs. This mismatch makes collaboration and development difficult. This paper intends to close this gap and foster collaboration by offering a detailed introduction to MANETs and their properties. An extensive survey of CI applications to various problems in MANETs from various research areas and publication venues is presented in the paper. Besides, a discussion on advantages and disadvantages of CI algorithms over traditional MANET solutions is offered. In addition, a general evaluation of CI algorithms is presented, which will serve as a guide for using CI algorithms for MANETs.

D. Kim, J. Garcia-Luna-Aceves in mobile ad hoc networks strongly depend on the efficient use of their batteries. In this paper, we propose a new metric, the drain rate, to forecast the lifetime of nodes according to current traffic conditions. This metric is combined with the value of the remaining battery capacity to determine which nodes can be part of an active route. We describe new route selection mechanisms for MANET routing protocols, which we call the Minimum Drain Rate (MDR) and the Conditional Minimum Drain Rate (CMDR). MDR extends nodal battery life and the duration of paths, while CMDR also minimizes the total transmission energy consumed per packet. Using the ns-2 simulator and the dynamic source routing (DSR) protocol, we compare MDR and CMDR against prior proposals for energy-aware routing and show that using the drain rate for energy-aware route selection offers superior performance results. Methods keywords are system design and simulations.

C. Cassandras, an optimal control approach is used to solve the problem of routing in sensor networks where the goal is to maximize the network's lifetime. In our analysis, the energy sources (batteries) at nodes are not assumed to be "ideal" but rather behaving according to a dynamic energy consumption model, which captures the nonlinear behavior of actual batteries. We show that in a fixed topology case there exists an optimal policy consisting of time invariant routing probabilities, which may be obtained by solving a set of relatively simple nonlinear programming (NLP) problems.

Y. Tian, Q. Zhou, have been widely used in modern life especially in Internet of Things. Since battery energy of sensor nodes is limited, balancing the energy consumption of each node on a transmitting path is an important issue. In this article, we propose a multi-hop clustering routing method with fuzzy inference and multi-path tree. The algorithm identifies the best path from the source node to the destination node by following two steps: (1) dividing the wireless sensor nodes by an efficient clustering routing method and (2) determining the optimal path by a combination of the fuzzy inference approach and multi-path method, taking into account the remaining energy, the minimum hops, and the traffic load of node.

III. PROPOSED APPROACH

A. Network Topology

Sensor nodes deliver their sensed data to the data sink over multihop paths, which are formed as a result of next hop choices made by nodes independently, i.e. using a distributed routing algorithm. The choice of a particular next hop influences a nodes transmission power consumption, hence its energy efficiency in routing. Sensor nodes that can receive a nodes packet transmission, when using its maximum transmission power, are referred to as its neighbours. Nodes exchange control packets with their neighbours to provide updated information on their energy status. Such updates ensure the availability of the required information

B. Traffic Model

The majority of studies in the current literature of MANET routing algorithms assume that all network nodes have uniform data generation rates. In monitoring applications, this assumption generally holds, as sensors perform sensing tasks at regular time intervals and hence they have similar data generation rates. However, in many applications, this assumption becomes unrealistic. For instance, in event-triggered sensing tasks, which are common in applications such as target tracking and forest fire detection, it is not uncommon to observe high data generation rates at particular nodes located in the vicinity of the event. Therefore, in order to evaluate the robustness of a routing algorithm, it is important to consider a diverse set of data generation patterns. As such, in this study, we consider the presence of two generation patterns: periodic and event-triggered. Traffic patterns can change from one type to the other over time.

C. Energy Consumption Model

For energy dissipation, we employ the model adopted in which energy required to transmit one unit of information from a node i to node j.

D. Lifetime of Sensor Network

Unbalanced energy consumption is an inherent problem in MANETs, which is characterized by multi-hop routing and a many-to-one traffic pattern. This uneven energy dissipation can significantly reduce network lifetime. Battery energy depletion at network nodes may cause network partitions, i.e. certain parts of the network may become disconnected, which is undesirable in MANETs, especially when it matters to collect data from all parts of the network to a data sink.

IV. THE PROPOSED ROUTING ALGORITHM-SBFL

In this proposed system, a heuristic Scattered Based Energy aware Fuzzy Logic based routing algorithm (SBFL) to significantly improve the network lifetime of wireless sensor networks with heterogeneous nodes and variable traffic loads.

Our algorithm is based on shortest path routing strategy with minimum cost. This strategy permits distributed implementation where each node gathers only local information to make independent routing decisions. This approach greatly reduces the communication cost and improves scalability

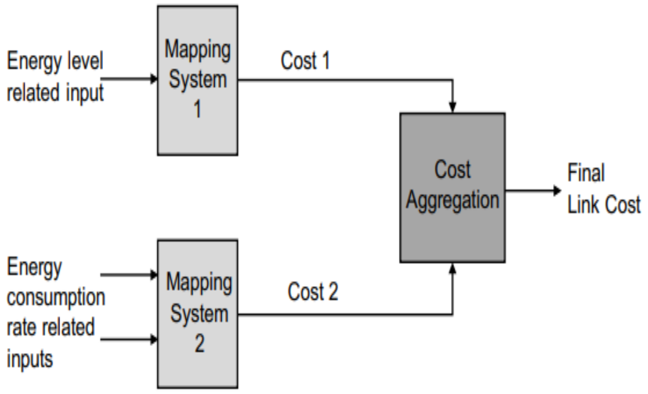

Fig.1. Shortest Path Routing Strategy with Minimum Cost

As in typical minimum cost energy-aware routing algorithms, SBFL algorithm assigns energy related cost values to the network links, and then utilizes shortest path strategies to find a set of routes which yield the minimum total path cost from the source to the destination. The assigned link cost values are adaptively updated based on energy related inputs.

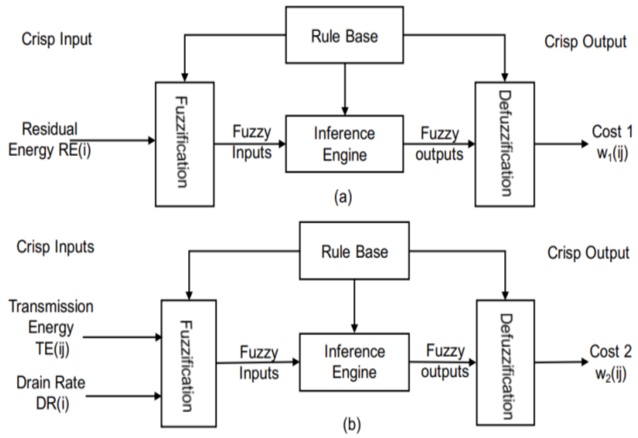

Fig.2. Fuzzy Logic Approach

To jointly utilize the inputs, a mapping mechanism is needed to map multiple inputs into a single cost value. Instead of using crisp values directly to compute the cost, here we use fuzzy logic approach for the mapping mechanism. Fuzzy logic can easily unify units of different inputs. Besides, it has the ability to deal with conflicting inputs. The design also involves human logic which provides more rational decision making. Our proposed algorithm SBFL has the following features:

- It is a distributed algorithm. All the components of the algorithm-shortest path algorithm and fuzzy logic are agreeable to distributed implementation. Each node utilizes local knowledge from its one hop neighbours to make independent routing decisions resulting in a more scalable and energy efficient solution.
- It is adaptive to network conditions. Link cost values are dynamically computed and assigned to reflect the spatial and temporal variation in node operations and traffic conditions. Optimal routes are always sought by periodic route recalculation.
- It is flexible to cope with various inputs. Our design utilizes fuzzy logic approach where inputs and rules can be easily redefined and tuned making the system design flexible.

In determining the link cost from node i to node j, the following input variables are used:

- The normalized residual energy RE(i) for FS1. It indicates the energy level of node i. Intuitively, nodes with low value of residual energy should be avoided as next hop nodes, hence its low value results in low value of relay probability RP1(ij), output of FS1, and accordingly high link cost w1(ij). In the total link cost calculation wij , this value is given additional weight using the parameter τ .
- The transmission energy TE(ij) for FS2. It represents the energy needed to transmit a data unit from node i to node j. Lower value of transmission energy gives link ij higher chances in being selected for data forwarding which means high relay probability RP2(ij), output of FS2, and accordingly low link cost w2(ij).
- The energy drain rate DR(i) for FS2. It indicates the rate of energy consumption of node i based on its traffic conditions. Nodes with high rate of energy consumption should be avoided as next hop nodes which results in low relay probability RP2(ij), output of FS2, and accordingly high link cost w2(ij).

The performance of our proposed algorithm (SBFL) is evaluated in terms of network lifetime, energy efficiency and energy consumption balancing properties, for different traffic load conditions.

V. PERFORMANCE EVALUATION

A. Simulation Parameters

The MATLAB simulation tool is used to study the performance of our SBFL scheme. We employ the IEEE 802.11 MAC with a channel data rate of 11 Mb/s. In our simulation, the SBFL default threshold is set to 90%. All remaining simulation parameters are captured below discussion. We assume that residual energy levels, energy consumption rates and sink access cost values of neighboring nodes are updated and the shortest path computation is completed within the routing update period σ. To focus on the energy consumed in data communications, we omit the energy consumed in the communication of routing control packets and in the computation of the shortest path and fuzzy system outputs

B. Modules

1. Implementation of Wireless Network

In this module, a wireless sensor network is created. All the nodes are configured and randomly deployed in the network area. Since our network is a wireless sensor network, nodes are assigned with initial energy, transmitting energy and receiving energy. A routing protocol is implemented in the network. Sender and receiver nodes are randomly selected and the communication is initiated.

2. Network Deployment

All the nodes are configured to exchange the location and initial energy information among all the nodes.

3. Implementation of SBFL fuzzy scheme

In this module, to enable all the nodes to get the global energy model, we propose a proposed algorithm, that under this general dynamic battery model, there exists an optimal policy consisting of time-invariant routing probabilities in a fixed topology network and these can be obtained by solving a set of problems.

This is motivated by the fact that energy-aware routing policies are often probabilistic in nature, thus making it harder for attackers to identify an “ideal node” to take over. At the same time, such a probabilistic routing policy can easily be implemented as a deterministic policy as well by simply transforming these probabilities to packet flows over links.

4. Performance analysis

In this module, the performance of the proposed network coding method is analyzed. Based on the analyzed results X-graphs are plotted. Throughput, delay, energy consumption are the basic parameters considered here and X-graphs are plotted for these parameters. Finally, the results obtained from this module is compared with previous results and comparison X-graphs are plotted. Form the comparison result, final RESULT is concluded.

SIMULATION PARAMETERS

Parameter	Value
Application Traffic	10 CBR
Transmission rate	1000 packets/s
Packet Size	512 bytes
Channel data rate	10Mbps
Pause time	0s
Simulation time	10s
Number of node	25
Area	300X300
Threshold	Dynamic

C. Performance Metrics

1. Packet Delivery Ratio

This is defined as the ratio of the number of packets received at the destination and the number of packets sent by the source. Here, pkt di is the number of packets received by the destination node in the ith application, and pktsiis the number of packets sent by the source node in the ith application.

2. Routing Overhead

This metric represents the ratio of the amount of routing-related control packet transmissions to the amount of data transmissions. Here, cpkiis the number of control packets transmitted in the ith application traffic, and pkti is the number of data packets transmitted in the ith application traffic.

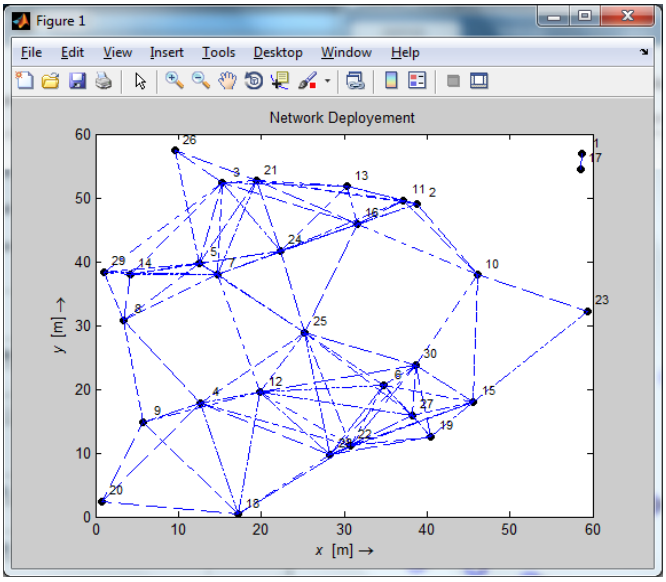

Fig.3.Output window network deployment

3. Average End-to-End Delay

This is defined as the average time taken for a packet to be transmitted from the source to the destination. The total delay of packets received by the destination node is di, and the number of packets received by the destination node is pktdi.

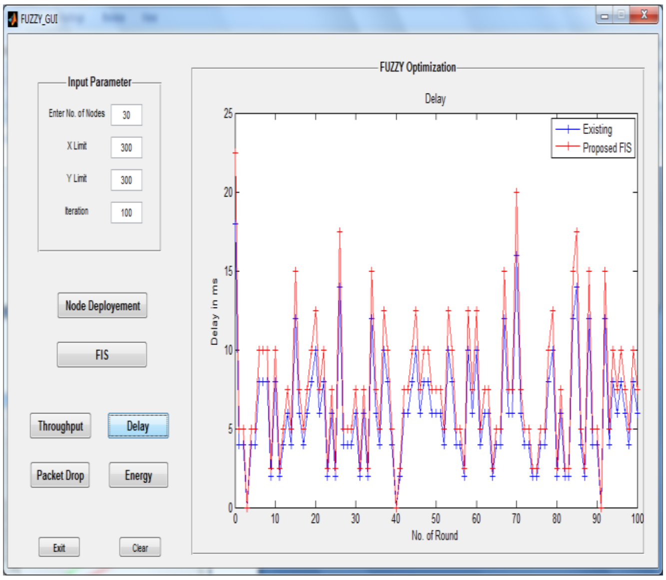

Fig.4. Delay

4. Throughput

This is defined as the total amount of data (bi) that the destination receives them from the source divided by the time (ti) it takes for the destination to get the final packet. The throughput is the number of bits transmitted per second.

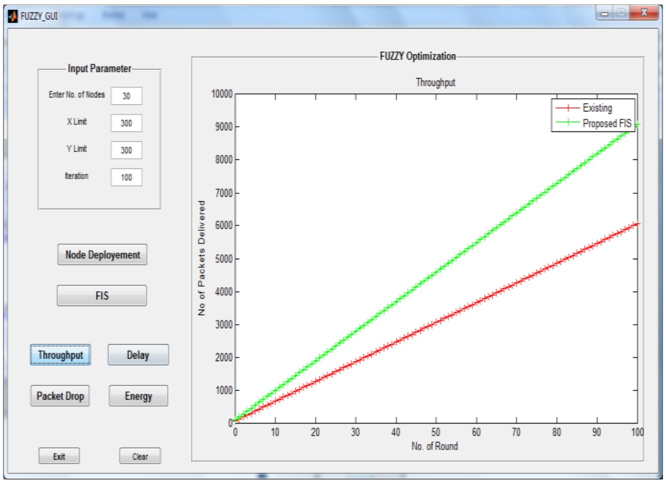

Fig.5. Throughput

VI. CONCLUSION

In most MANET deployments, extending network lifetime is the main design objective of routing protocols. To achieve this objective, energy-aware routing protocols should be designed to make an appropriate trade-off between energy efficiency and energy consumption balancing among the sensor nodes. An innovative solution for energy balanced traffic control was presented, in the presence of sink mobility in SBFL -based MANET. The centralized SBFL control features were exploited to overcome the difficulty of handling energy issues in MANET networks. Specifically, topology based prediction scheme was designed, followed by a route selection scheme, based on the centralized traffic engineering in control plane. The proposed algorithm has several desirable features. First, it is distributed and hence supports scalability. Second, it successfully trades off energy efficiency for improved energy balancing performance. Third, SBFL is adaptive to network conditions. Last, it provides flexible system design by using easily tune-able fuzzy rules.

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