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Routing In Mobile Ad-Hoc Networks Using Energy Efficient Protocols

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ABSTRACT
Although establishing correct and efficient routes is an important design issue in mobile ad hoc networks (MANETs), a more challenging goal is to provide energy efficient routes because mobile nodes' operation time is the most critical limiting factor. This article surveys and classifies the energy-aware routing protocols proposed for MANETs. They minimize either the active communication energy required to transmit or receive packets or the inactive energy consumed when a mobile node stays idle but listens to the wireless medium for any possible communication requests from other nodes. In this paper five different types of routing protocols are compared. Number of alive nodes and the residual energy is obtained by using different protocols. The simulation results indicate that PEGASIS outperforms other clustering based routing algorithms under the scenario. The performance is simulated using Matlab tool.
Keywords: WSN, MANETS, LEACH, TEAR, PEGASIS

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I. INTRODUCTION

Wireless ad-hoc networks do not require any pre-established network infrastructure. They are more suitable for deployment in areas where a fixed backbone network infrastructure is inflexible and/or economically nonviable. Mobile ad hoc networks (MANETs) have variety of applications such as emergency communication services, military communication, and environmental monitoring. However, they suffer from many challenges such as unpredictable mobility, restricted battery power, limited bandwidth, multihop routing, and security. Efforts are being made to address the above issues.

As nodes in MANETs are battery operated, energy efficiency is important design criteria for the longevity of the network. If a node runs out of battery, its ability to route the network traffic gets affected which in turn adversely affects the network lifetime. Network lifetime of MANETs can be enhanced by either maximizing the battery power of nodes or minimizing the total power consumption in the network. Though a considerable progress has been made in the battery technologies in recent years, it is incomparable with the progress made in semiconductor technology yet. This difference has created a gap between the amount of energy needed to operate in a wireless environment and the battery capacity that powered the nodes. Hence, it necessitates the requirement of power conservation techniques to enhance the network lifetime. Such techniques can be applied at different layers of protocol stack.

Nodes in MANET usually transmit packets with maximum power. A packet transmitted with maximum power may reach the destination with lesser number of hops but can decrease the channel utilization and the remaining energy of the node to a greater extent. Energy saving can be done at the node level by adjusting the transmission power to a lower level [1–4]. In recent years, many techniques have been proposed to conserve energy in MANETs. Topology control approach is one among them. The primary objective of topology control algorithms is to adjust the network topology by reducing the transmission power at node level and at the same time maintaining the network connectivity. In other words the objective of topology control approach is to remove the energy inefficient links at the node level by reducing the transmission power. The major design goal in most of the topology control protocols is to minimize the maximum power used by a node. Other design goals are to improve the network performance such as throughput, network lifetime by alleviating contention, and interference in the network.

In this paper we present an improved protocol called PEGASIS (Power-Efficient Gathering in Sensor Information Systems), which is near optimal for this data gathering application in sensor networks. The key idea in PEGASIS is to form a chain among the sensor nodes so that each node will receive from and transmit to a close neighbour. Gathered data moves from node to node, get fused, and eventually a designated node transmits to the BS.

We proposed different routing protocols for finding number of alive nodes for performing transmission of data. The energy calculation is performed for each protocol. This letter considers both, energy and traffic heterogeneities, with multiple random levels. An energy model is presented for the multi-heterogeneity scenario, where consideration of multi-level traffic heterogeneity is a novel concept. A novel routing algorithm named Traffic and Energy Aware Routing (TEAR) is presented and compared with PEGASIS, which considers node's traffic requirements along with its energy levels while making CH selection. PEGASIS shows improvements in terms of stability period (reliable lifespan of the manets before the death of its first node) over existing algorithms (LEACH, SEP and DEEC) under the scenario.

II. RELATED WORK

Routing is one of the key issues in MANETs due to their highly dynamic and distributed nature. In particular, energy efficient routing may be the most important design criteria for MANETs, since mobile nodes will be powered by batteries with limited capacity. Power failure of a mobile node not only affects the node itself but also its ability to forward packets on behalf of others and thus the overall network lifetime. For this reason, many research efforts have been devoted to developing energy-aware routing protocols. Based on the aforementioned discussions, this paper surveys and classifies numerous energy-efficient routing mechanisms proposed for MANETs [5,6]. They can be broadly categorized based on when the energy optimization is performed. A mobile node consumes its battery energy not only when it actively sends or receives packets, but also when it stays idle listening to the wireless medium for any possible communication requests from other nodes. Thus, energy-efficient routing protocols minimize either the active communication energy required to transmit and receive data packets or the energy during inactive periods.

For protocols that belong to the former category, the active communication energy can be reduced by adjusting each node's radio power just enough to reach the receiving node, but not more than that. This transmission power control approach can be extended to determine the optimal routing path that minimizes the total transmission energy required to deliver data packets to the destination. For protocols that belong to the latter category, each node can save the inactivity energy by switching its mode of operation into sleep/power-down mode or simply turns it off when there is no data to transmit or receive. This leads to considerable energy savings, especially when the network environment is characterized with low duty cycle of communication activities. However, it requires a well-designed routing protocol to guarantee data delivery even if most of the nodes sleep and do not forward packets for other nodes. Another important approach to optimizing active communication energy is load distribution approach. While the primary focus of the above two approaches is to minimize energy consumption of individual nodes, the main goal of the load distribution method is to balance the energy usage among the nodes and to maximize the network lifetime by avoiding over-utilized nodes when selecting a routing path. While it is not clear which algorithm is the best for all scenarios, each protocol has definite advantages/disadvantages and is well-suited for certain situations. However, it is possible to combine and integrate the existing solutions to offer a more energy-efficient routing mechanism. Since energy efficiency is also a critical issue in other network layers, considerable efforts have been devoted to developing energy-aware MAC and transport protocols [7]. Each layer is supposed to operate in isolation in layered network architecture but, as some recent studies suggested, the cross-layer design is essential to maximize the energy performance [8,9]. In fact, many routing protocols introduced in this paper use the same concept, i.e. they exploit lower layer mechanisms, such as transmission power control and sleep mode operation, in their routing layer algorithms.

III. ENERGY EFFICIENT MANET ROUTING

In contrast to simply establishing correct and efficient routes between pair of nodes, one important goal of a routing protocol is to keep the network functioning as long as possible. As discussed in the Introduction, this goal can be accomplished by minimizing mobile nodes' energy not only during active communication but also when they are inactive.

A. Traffic and Energy Aware Routing (TEAR)

The CH selection in TEAR is based on the CH role rotation approach [2-4], where the node i becomes a CH in the current round r, if the random number selected by the node i is less than the threshold T(i, r).

$$T(i,r) = \begin{cases} \frac{p_i(r)}{1-p_i(r)\left(r \bmod \frac{1}{p_i(r)}\right)} & \text{if node } i \in G(r) \\ 0 & \text{Otherwise} \end{cases}$$

Where $pi(r)$ is the CH selection probability for node i during round r. $G(r)$ is a set of eligible nodes for the round r, where the rotating epoch for node i to become eligible again is $1/pi(r)$. DEEC considers randomly distributed energy heterogeneity and prefers nodes with higher initial and residual energies for CH role, i.e. an energy-rich node has higher $pi(r)$ and higher chances of becoming CH. As the operations of a CH are energy intensive, preferring nodes with higher initial energies and higher residual energies improves the life of energy weaker nodes and hence it improves the WSN stability period.

For a realistic MANET model, with the nodes having heterogeneous initial energies and data traffic requirements, the proposed algorithm (TEAR) prefers the nodes with higher energies (initial and residual) and avoids the nodes with higher traffic loads for CH role. In TEAR, the probability of becoming CH for node i during round r is defined as

$$p_i(r) = \frac{p_{opt}.N(1+\alpha_{ehi})N(1+\alpha_{th}-\alpha_{ehi})E_i(r)}{(N+\sum_{i=1}^{N}\alpha_{ehi})(N+N\alpha_{th}-\alpha Tot)E_{Avg}(r)}$$

Where $EAvg(r)$ is average energy of the round and $popt$ is optimal probability of a node to become CH, given by $popt= koptN$. The remaining functionality of TEAR is similar to DEEC. Further, in the absence of traffic heterogeneity, TEAR falls back to DEEC behaviour. Based on DEEC, the $EAvg(r)$ is given by

$$E_{Avg}(r) = \frac{1}{N} E_{Tot}\left(1-\frac{r}{R}\right);\ \text{where } R = \frac{E_{TOT}}{E_{Round}}$$

Where R is the estimated value of network lifetime in terms of the number of rounds based on uniform energy drainage in each round.

B. PEGASIS

The main idea in PEGASIS is for each node to receive from and transmit to close neighbours and take turns being the leader for transmission to the BS. This approach will distribute the energy load evenly among the sensor nodes in the network. We initially place the nodes randomly in the play field, and therefore, the i –th node is at a random location. The node will be organized to form a chain, which can either be accomplished by the sensor nodes themselves using a greedy algorithm starting from some node. Alternatively, the BS can compute this chain and broadcast it to all the sensor nodes. We use the same radio model as discussed in which is the first order radio model[10]. In this model, a radio dissipates E_{elec} = 50 nJ/bit to run the transmitter or receiver circuitry and ϵ_{amp} = 100 pJ/bit/m2 for the transmitter amplifier. The radios have power control and can expend the minimum required energy to reach the intended recipients. The radios can be
turned off to avoid receiving unintended transmissions. An r^2 energy loss is used due to channel transmission [11,12].

The equations used to calculate transmission costs and receiving costs for a k-bit message and a distance d are shown below:

Transmitting

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$$

$$E_{Tx}(k,d) = E_{elec} * k + \epsilon_{amp} * k * d^2$$

Receiving

$$E_{Rx}(k,d) = E_{Rx-elec}(k)$$

$$E_{Rx}(k,d) = E_{elec} * k$$

4. RESULTS AND DISCUSSION

The simulation setup considers 100 nodes (N), with randomness in energy and traffic levels, deployed uniformly in a 100m x 100m (R×R) area with BS located at the centre of the region. The system model for the multi-heterogeneity approach have been simulated in MATLAB.

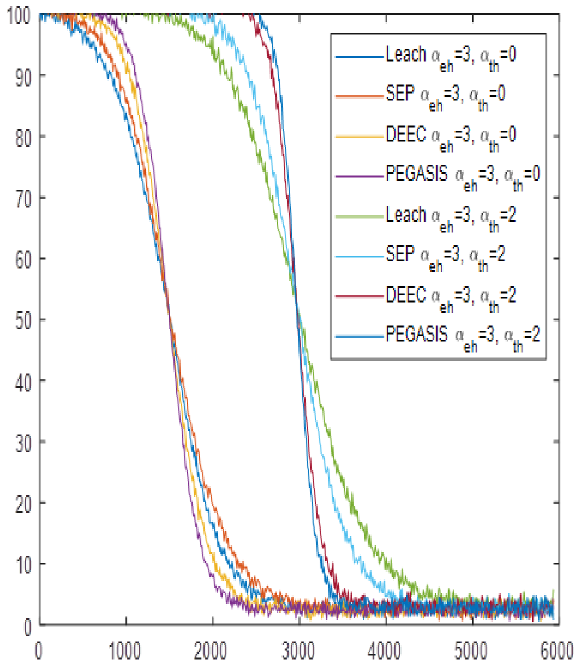

Fig 1. Effect of traffic heterogeneity on WSN routing algorithms

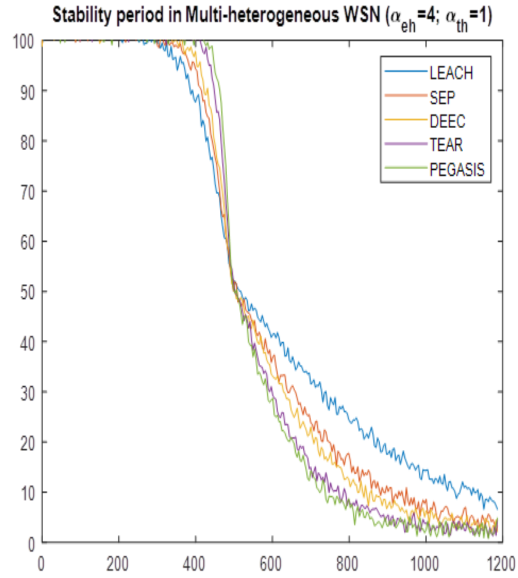

Fig 2. Stability period in Multi-heterogeneous WSN (αth=4; αeh=1)

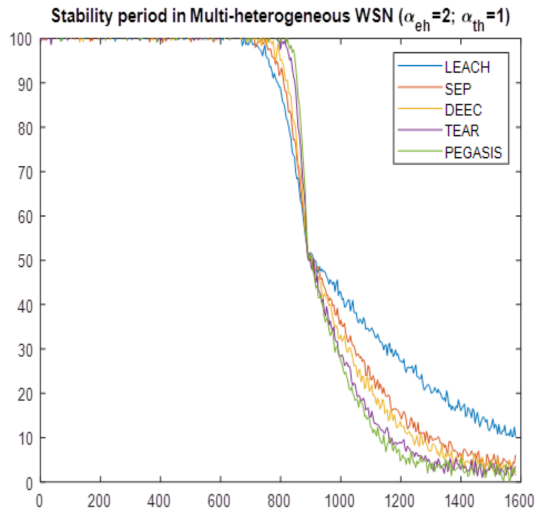

Fig 3. Stability period in Multi-heterogeneous WSN (αth=2; αeh=1)

The energy calculation for each protocol is performed. Energy calculation of proposed results prove that pegasis routing protocol having good energy left at 1200 rounds as well as at 1600 rounds.

Table 1. Energy at 1200 rounds

Routing Protocol	Residual Energy (Joules)
LEACH	0.197
SEP	3.084
DEEC	3.580
TEAR	17.60
PEGASIS	20.22

Table 2. Energy at 1600 rounds

Routing Protocol	Residual Energy (Joules)
LEACH	0.00
SEP	0
DEEC	0
TEAR	6.80
PEGASIS	10.31

IV. CONCLUSION

A MANET consists of autonomous, self-organizing and self-operating nodes, each of which communicates directly with the nodes within its wireless range or indirectly with other nodes via a dynamically computed, multi-hop route. Due to its many advantages and different application areas, the field of MANETs is rapidly growing and changing. While there are still many challenges that need to be met, it is likely that MANETs will see wide-spread use within the next few years.

In this paper, we describe PEGASIS and TEAR, a greedy chain protocol that is near optimal for a data-gathering problem in sensor networks. PEGASIS outperforms TEAR and existing protocols like LEACH, SEP, DEEC by eliminating the overhead of dynamic cluster formation, minimizing the distance non leader-nodes must transmit, limiting the number of transmissions and receives among all nodes, and using only one transmission to the BS per round

A MANET consists of autonomous, self-organizing and self-operating nodes, each of which communicates directly with the nodes within its wireless range or indirectly with other nodes via a dynamically computed, multi-hop route. Due to its many advantages and different application areas, the field of MANETs is rapidly growing and changing. While there are still many challenges that need to be met, it is likely that MANETs will see wide-spread use within the next few years. In order to facilitate communication within an MANET, an efficient routing protocol is required to discover routes between mobile nodes. Energy efficiency is one of the main problems in an MANET, especially in designing a routing protocol. In this paper, we implemented PEGASIS routing protocol and TEAR Protocol. These two protocols help in improve the energy efficiency of the system. These techniques are compared with other existing techniques like LEACH, SEP, DEES. From the results it is proved that PEGASIS routing protocol has good energy efficiency.

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