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MINIMIZING COMMUNICATION COST IN WIRELESS SENSOR NETWORKS TO AVOID PACKET RETRANSMISSION

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ABSTRACT
Introducing n number of source nodes and 2^k relay nodes to reduce the number of packet retransmissions by identifying the shortest path to minimize the communication cost. We model the optimal relay nodes topology problem allowing for simultaneous optimization of the relay nodes locations and traffic through the network, so that the overall number of packet retransmissions is minimized. Exploiting convexity in a special case of the network communication cost function, introduce an optimal algorithm for the relay nodes. However, the algorithm is exponential on the number of relay nodes in the network. Propose a practical heuristic algorithm for relay nodes and compare relay node numerically to the optimal algorithm. It shows that relay nodes achieves the optimal or almost optimal solutions. To implement the relay nodes in the NS2 software. The relay nodes topologies generated by relay nodes to eliminate overhead communication cost almost entirely. There is no loss in data transmission by increasing the relay nodes.

KEYWORDS-Communication Cost, Optimal Algorithm, Relays nodes, Throughput Maximization, Wireless Networks,

I.INTRODUCTION

Networks of wireless sensors are used to monitor various physical processes, ranging from measuring soil moisture for precision agriculture. In many of these applications, the deployment success depends on network communication efficiency. For instance, a higher number of packet retransmissions leads to drastically reduced network lifetime. Intuitively, growing number of packet (re)transmissions drives network communication costs up, for instance, via growing energy depletion. An important factor determining the number of packet retransmissions is the network links quality. Among others, presence of obstacles between nodes; increasing interference as the density of nodes grows; and separation distance between wireless devices may all influence links' quality. The relative impact of each of these factors on network performance depends on the particular network scenario. A main cause of poor link quality in sparsely deployed outdoor sensor networks is the large separation distance between sensing nodes. This induces low SNR and low packet reception rate (PRR). To improve links' quality and decrease network communication costs, the latter formally defined, network designers often rely on the placement of relay nodes. Relay nodes do not introduce new traffic in the network and only re-transmit the packets received from a set of source nodes.

A Wireless Sensor Network (WSN) is a distributed network and it comprises a large number of distributed, self-directed, tiny, low powered devices called sensor nodes alias motes. WSN naturally encompasses a large number of spatially dispersed, petite, battery-operated, embedded devices that are networked to supportively collect, process, and convey data to the users, and it has restricted computing and processing capabilities. Motes are the small computers, which work collectively to form the networks. Motes are energy efficient, multi-functional wireless device. The necessities for motes in industrial applications are widespread.

Network Simulator Version 2, widely known as NS2, is an event driven simulation tool that is useful in studying the dynamic nature of communication networks. Simulation of wired as well as wireless network functions and protocols (e.g., routing algorithms, TCP, UDP) can be done using NS2. In general, NS2 provides users with a way of specifying such network protocols and simulating their corresponding behaviors. Due to its flexibility and modular nature, NS2 has gained constant popularity in the networking research community since its birth in 1989. Ever since, several revolutions and revisions have marked the growing maturity of the tool, thanks to substantial contributions from the players in the field.

II.RELATED WORK

2.1 Relay Placement in Wireless Networks: Minimizing Communication Cost.

Given n source nodes and k relay nodes, we model the optimal relay topology problem allowing for simultaneous optimization of the relay node locations and traffic through the network, so that the overall number of packet retransmissions is minimized. We do not constrain the position of relays to a finite set of discrete points, as the latter may not be feasible in practical networks. Exploiting convexity in a special case of the network communication cost function, we give an optimal algorithm for the relay placement problem. However, the algorithm is exponential on the number of nodes in the network. We suggest a practical heuristic algorithm for relay placement: RePlace. We compare RePlace numerically to the optimal algorithm and show that RePlace achieves the optimal or almost optimal solutions. We implement RePlace in the full network stack simulator JiST/SWANS. The relay topologies generated by RePlace eliminate overhead communication cost almost entirely.

2.2 Near-optimal sensor placements: Maximizing information while minimizing communication cost.

When monitoring spatial phenomena with wireless sensor networks, selecting the best sensor placements is a fundamental task. Not only should the sensors be informative, but they should also be able to communicate efficiently. In this project, we present a data-driven approach that addresses the three central aspects of this problem: measuring the predictive quality of a set of sensor locations, predicting the communication cost involved with these placements, and designing an algorithm with provable quality guarantees that optimizes the NP-hard trade off. Specifically, we use data from a pilot deployment to build non-parametric probabilistic models called Gaussian Processes (GPs) both for the spatial phenomena of interest and for the spatial variability of link qualities, which allows us to estimate predictive power and communication cost of un-sensed locations. Surprisingly, uncertainty in the representation of link qualities plays an important role in estimating communication costs. Using these models, we present a novel, polynomial-time, data-driven algorithm, spiel, which selects Sensor Placements at Informative and cost-Effective Locations. Our approach exploits two important properties of this problem: sub modularity, formalizing the intuition that adding a node to a small deployment can help more than adding a node to a large deployment; and locality, under which nodes that are far from each other provide almost independent information. Exploiting these properties, we prove strong approximation guarantees for our spiel approach. We also provide extensive experimental validation of this practical approach on several real-world placement problems, and built a complete system implementation on 46 Tome Sky motes, demonstrating significant advantages over existing methods.

2.3 Relay sensor placement in wireless sensor networks

Controlled relay node placement in wireless sensor networks (WSN) is paramount to achieving desired performance goals of improving communication while reducing energy consumption. The network topology should be structured such that the relay nodes (RN) cater for appropriate node densities to the formation of an optimal communication network. This work presents an Optimal Greedy RN Placement (OGRNP) algorithm that selects a subset of sensors node (SN) from a pool according to matroid constraint based greedy algorithm. The algorithm exploits sub-modularity and monotonicity to guarantee a near-optimal placement of SN when the matroid rank function is sub-modular and monotonic. The algorithm achieves a near-optimal solution by minimizing the communication cost function. Performance results demonstrate the superior performance of the OGRNP algorithm over competing techniques based on random placement and conventional greedy algorithm

2.4 Relay node placement in heterogeneous wireless sensor networks with base stations

Two fundamental functions of the sensor nodes in a wireless sensor network are to sense its environment and to transmit sensed information to a base station. Heterogeneous wireless sensor networks are composed of a large number of sensors equipped with different transmission and sensing capabilities. The base stations are more powerful than sensors. In this paper, we study a relay node placement problem, which aims to deploy a minimum number of relay nodes to establish directed paths from any sensor node to a base station, in heterogeneous wireless sensor networks with base stations
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III.RELAY PLACEMENT IN WSN

Given n source nodes and k relay nodes, we model the optimal relay topology problem allowing for simultaneous optimization of the relay node locations and traffic through the network, so that the overall number of packet retransmissions is minimized. We argue that state-of-the-art models and algorithms for relay placement in wireless networks do not reflect salient characteristics of the optimal relays topology and lead to suboptimal solutions. We do not constrain the position of relays to a finite set of discrete points, as the latter may not be feasible in practical networks. In this case, we show that just listing a set of feasible sites for the relays is already at least APX-hard. Exploiting convexity in a special case of the network communication cost function, we give an optimal algorithm for the relay placement problem. However, the algorithm is exponential on the number of nodes in the network. We suggest a practical heuristic algorithm for relay placement: Replace.

Aside from the optimal and random placement, fig. 1 illustrates the relay nodes topologies generated by two other algorithms typically utilized in various studies and applications requiring relay nodes deployment. The first algorithm solves the Euclidean Steiner tree problem and the second solves the General Steiner tree problem on the given sample topology. These algorithms how ever do not truly solve the optimal relay placement problem. The inefficiencies of these algorithms' outputs compared to the optimal relay placement stem from somewhat subtle but fundamental difference between the corresponding problem models. The Euclidean Steiner Tree (EST) consists of locations and links that interconnect then given fixed nodes in the plane. Each connecting link has an associated weight equal to the Euclidean distance between its vertices. The goal is to pick the locations on the plane that will minimize the sum weight of the interconnecting links. The relay nodes are placed at these locations.

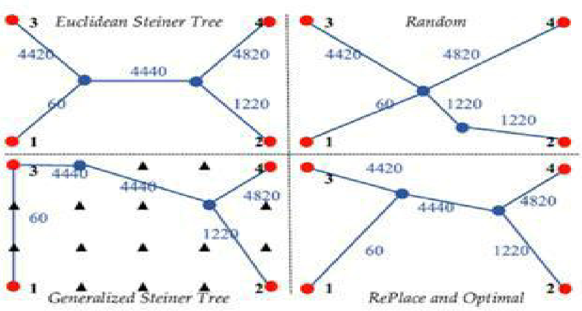

Fig.1. Network Topology

First, the EST does not account for the traffic loads on links: heavily utilized links may require more relay nodes placed closer to them. For instance, in fig. 1, the traffic between sources 3 and 4 is significantly larger than the rest of the links, shifting the optimal positions of the relay nodes away from the EST. Second, the SNR and respectively the number of packet retransmissions due to poor PRR do not depend linearly on the distance between receiver and transmitter.

IV. MINIMIZING COMMUNICATION COST

Given n source nodes and 2^K relay nodes, we model the optimal relay topology problem allowing for simultaneous optimization of the relay node locations and traffic through the network, so that the overall number of packet retransmissions is minimized. We argue that state-of-the-art models and algorithms for relay placement in wireless networks do not reflect salient characteristics of the optimal relays topology and lead to suboptimal solutions. We do not constrain the position of relays to a finite set of discrete points, as the latter may not be feasible in practical networks. Exploiting convexity in a special case of the network communication cost function, we give an optimal algorithm for the relay placement problem. However, the algorithm is exponential on the number of nodes in the network. We suggest a practical heuristic algorithm for relay placement. We compare Relay nodes numerically to the optimal algorithm and show that Relay nodes achieve the optimal or almost optimal solutions. We implement Relay nodes in the full network stack simulator in NS2. The relay topologies generated by Relay nodes to eliminate overhead communication cost almost entirely.

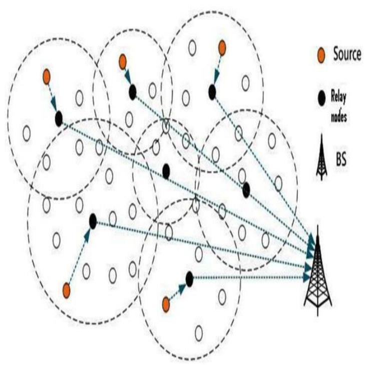

Fig.2. Relay node topology

The source nodes reach the destination without packet retransmission by using the relay nodes. The source nodes send the information to the relay nodes and the received message directly reach the destination without any packet retransmission, so the overall communication cost to be reduced.

V. SIMULATION RESULTS

The communication cost reduction obtained by Replace**.** The communication cost metric accounts for the number of dropped packets due to low SINR at each receiver in the network.

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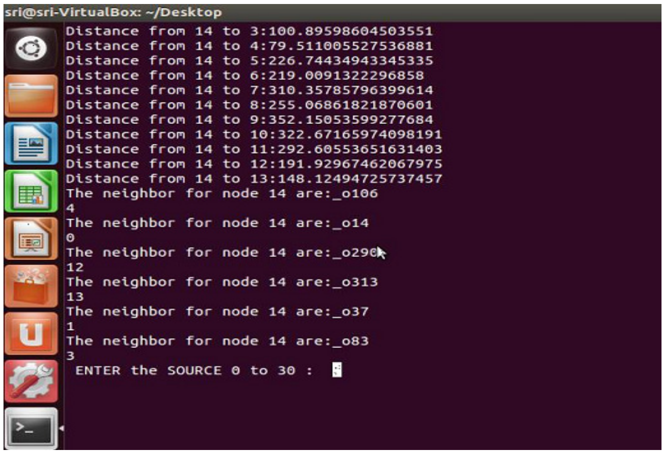

Fig.3. Virtual box

In smaller networks operating in mid-SNR regime, interference does not affect critically the packet loss in the network.

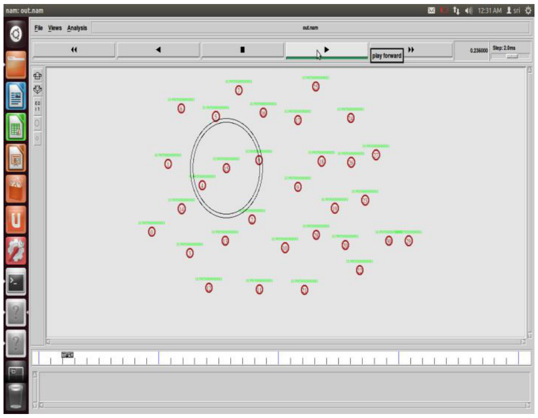

Fig.4. Communication Between relay

The communication cost reduction leads to substantial decrease of average packet delay in the network when relay nodes are optimally deployed.

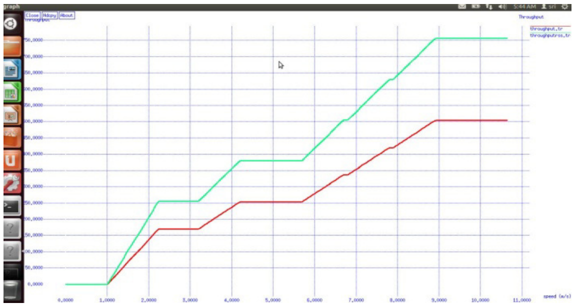

Fig 5 Throughput

This is due to the retransmission backoff mechanism in the IEEE 802.11 MAC protocol. Reducing the number of retransmissions effectively reduces the packet delay.

VI.CONCLUSION

A number of works on sensor networks have considered a form of sensor nodes placement in order to optimize network communication cost. For instance, the authors utilize relay nodes in a sparse network and increase links' reliability. They observe that in the latter setting the log-normal path-loss model is rather accurate and interference does not contribute significantly to reduce the PRR. This conclusion is also corroborated by the simulations presented. The authors of consider the placement of relay nodes, so that overall link cost is minimized while the gathered information by sensor nodes is maximized. Their heuristic algorithm approximates to suggest locations for the communication relay nodes.

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