AMALGAM APPROACHES FOR CONTRIVANCE PLACEMENT IN SPATIALLY DISTRIBUTED AUTONOMOUS SENSORS

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ABSTRACT

The fundamental factor in determining the coverage, and connectivity, cost and lifetime of a Wireless Sensor Network (WSN). Here we explore the Problem of relay node placement in heterogeneous wireless sensor networks. Formulate a common node placement optimization problem aimed at minimizing the network Cost with constraints on lifetime and connectivity. Depending on the conditions, two representative scenarios of this problem are described. Characterize the first problem, where relay nodes are not energy constrained, as a minimum set covering problem. Further consider a more challenging scenario, where all nodes are energy limited. As an optimal solution to this problem is difficult to obtain, a two-phase approach is proposed, in which locally optimal design decisions are taken. The placement of the first phase relay nodes (FPRNs), which are directly connected to Sensor Nodes and it modeled as a minimum set covering problem. To ensure the relaying of the traffic from the FPRNs to the base station, three heuristic schemes are proposed to place the second phase relay nodes (SPRNs).

Keywords : Amalgam, Autonomous Sensors, WSN, Heuristic sclaemes.

I. INTRODUCTION

Smart environments represent the next evolutionary development step in Building, utilities, industrial, home, shipboard, and transportation systems automation. Like any sentient organism, the smart environment relies first and fore most on sensory Data from the real world. Sensory data comes from multiple sensors of different modalities in distributed Locations. The smart environment needs information about its surroundings as well as about its internal workings;

The challenges in the hierarchy of: detecting the relevant quantities, monitoring and collecting the data, assessing and evaluating the information, formulating meaningful user displays, and performing decision-making and alarm functions are enormous.

Sensor nodes can be imagined as small computers, extremely basic in terms of their interfaces and their components. They usually consist of a processing unit with limited computational power and limited memory, sensors (including specific conditioning circuitry), a communication device (usually radio transceivers or alternatively optical), and a power source usually in the form of a battery.

The applications for WSNs are many and varied. They are used in commercial and Industrial applications to monitor data that would be difficult or expensive to monitor remain for many years (monitoring some environmental variables) without the need to recharge/ replace their power supplies. They could form a perimeter about a property and monitor the progression of intruders (passing information from one node to the next).

A sensor node, also known as a mote (chiefly in North America), is a node in a wireless Sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.

Extending lifetime and conserving cost/energy are of paramount concern in WSN design. Conventionally, such issues have been addressed by devising various energy efficient networking protocols, whose objectives are to reduce energy wastage and/or balance the energy consumption ([1]-[7]). Promising performance is observed in analytical studies and simulations. On the other hand, device placement is another design space for WSNs, which has significant impact on energy efficiency and lifetime. Therefore, our interest is to study the placement problem in the context of an ideal set of energy efficient networking protocols, by which no energy is wasted.

The research in [4] assumed the location and initial energy of SNs and application nodes (i.e., RNs) were known. In order to maximize the network lifetime, an optimal location was obtained for the BS through theoretical analysis. A relay traffic allocation scheme was developed to further extend the network lifetime.

Upper and lower bounds on the maximum topological lifetime were also derived. In [8], based on a two-tiered network model, RN placement algorithms were proposed to guarantee network connectivity and/or ensure survivability in case of node failure. Lifetime constraints were not considered.

In [2], aiming at maximizing the system lifetime under an energy budget, the joint design problem of energy provisioning and relay node placement was formulated as a mixed-integer nonlinear programming problem. To overcome the computational complexity, heuristic algorithms were introduced.In [5], the heterogeneous node placement problems were formulated with different objectives, i.e., minimizing the number of sensor nodes, minimizing total cost, minimizing energy consumption, maximizing network lifetime, and maximizing nodal utilization. This paper considered a discrete and finite set of feasible placement sites as the solution space. In contrast, paper will search for the optimal solution in a continuous solution space..

In many WSN applications, sensor nodes are expected to operate on duty cycle as low as 1% or less, such as home automation and industrial control [11]. Therefore, the traffic rate is low as compared to the bandwidth. This makes it easier for networking protocols to coordinate packet transmission so that collisions and network congestion are minimized. In other words, Let as assume the network to be energy limited as opposed to bandwidth limited. This paper models such a WSN as follows

II. PLACEMENT OF RELAY NODES WITH ENERGYCONSTRAINTS

In this section, a more general and challenging situation is considered. RNs are assumed to have limited energy and fixed transmission range. Therefore, RNs connecting to SNs can only relay a limited amount of traffic within a restricted range. In general, RNs may not be able to transmit data to the BS by themselves. Thus, a complete RN placement solution should not only provide connectivity to the SNs, but also ensure that each RN has at least one (multi-hop) path to the BS. In addition, the lifetime constraints of RNs, should be satisfied. As RNs are assumed travel identical cost, the optimization objective is to minimize the number of RNs for a given deployment of SNs.As such, propose a two-phase RN placement approach. In each phase the number and locations of RNs to be added are decided in a locally optimal manner. In the first phase, a minimum number FPRNsareplaced to ensure theconnectivity of SNs.Therefore call them First Phase RNs (FPRNs). In the second phase, RNs are placed to provide a complete relay path for the existing RNs. They are called Second Phase RNs (SPRNs). In both phases, lifetime (i.e., capacity) and connectivity requirements have to be satisfied.

The Placement of First Phase Relay Nodes (FPRNs)

The objective of FPRN placement is to ensure the connectivity of SNs as they have limited transmission range. It is a similar problem as that described in the previous section.

However, due to the power limitation on RNs, the amount of traffic that an RN can handle is limited As such; some densest regions may not be energy feasible in the sense that the total traffic volume of SNs associated with a region is greater than the capacity of an RN. For example, Fig 1 the total traffic volume of the SNs associated with regionf={o1, o3, o4}is 13 while the capacity of each RN is only 10.

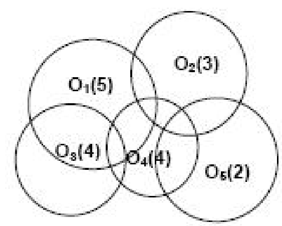


Fig.1FPRN

In illustration of regions, EFRs, and DEFRs. Enhance the criteria of candidate FPRN placement locations with an energy constraint. After finding the eligible candidate locations by applying the enhanced criteria, the minimum set covering model is applicable to the FPRN placement problem. The new candidate locations are called densest energy-feasible regions.

III. DEFINITION

Energy-Feasible Region (EFR) and Densest Energy-Feasible Region (DEFR). For a set of SNs, X = {o1, o2, . . . , oN }, a region is energy feasible if an RN deployed in the intersection corresponding to this region can relay all traffic from the associated SNs while meeting the lifetime constraint. Such a region is called an Energy-Feasible Region (EFR). An EFR Ris a DEFR if there is no other EFR

R such that R⊂ R.

The concepts of region, EFR, and DEFR are illustrated in Fig.1. It is safe to assume that the capacity of an RN is not less than the cumulative traffic volume of any individual SN. Therefore, each SN should be associated with at least one RN in a DEFR. By finding a minimum set covering for X among DEFRs using such algorithms as in the FPRN placement solution can provide the connectivity to all SNs.

Placement of Second Phase Relay Nodes (SPRNs)

By the end of the first phase placement, every SN has found an RN to forward its traffic. Next need to place more RNs so that every FPRN will be able to find the neighbor(s) via which it relays traffic to the BS. There is no existing model for such a problem. Note that with energy and transmission constrained RNs multiple hops are generally required to relay data from SNs to the BS. Therefore, any placement solution depends on the underlying routing protocol taking sufficient advantage of the RN placements to realize the desired network lifetime. Alternatively, in the construction of each principle, then present three heuristic algorithms to implement the principles. Placement solutions the level of traffic on each network link is specified, and a centralized routing scheme that enforced these levels of traffic would ensure the target network lifetime. first identify two essential design.

1) Far-Near and Max-Min Principles:

Far-Near Principle.

This refers to the principle that the placement decision in the second phase should first consider the RN which is farthest from the BS and evolves step-by-step to the RNs that are closest to the BS. The rationale is that data are to be forwarded towards the BS. Hence RNs that are closer to the BS should relay traffic for other farther nodes.

This principle helps to avoid energy wastage incurred due to unnecessary detouring of relayed traffic.

Max-Min Principle

This refers to the principle to maximally utilize the capacity of existing RNs, while introducing a minimum number of new RNs. Specifically, from far to near to the BS, each RN will distribute its workload to other existing neighboring RNs first. Only when the existing neighboring RNs of a given RN cannot handle its traffic load, a new RN will be added. In order to implement this principle, Let as assume that a supportive energy-aware routing protocol or an optimal traffic allocation mechanism is available.

2) Localized Heuristic Algorithms:

Following the principles above, three heuristic algorithms are proposed, which differ in the way the traffic load of an RN is forwarded and distributed to neighboring RNs.Furthermore, let as define the workload, wi, as the sum of vi's relayed traffic loads, and its residual capacity as the difference between its capacity, C, and its workload.

A. Nearest-To-BS-First algorithm (NTBF):

Starting from the farthest RN, say vfar, if the workload of vfar, say wfar , does not exceed the total residual capacity of its adjacent neighbors, then its workload is distributed to its adjacent neighbors, by first fling up the capacity of the node nearest to the BS, then to the node next nearest to the BS, and so on. In case there are two or more neighboring nodes having the same closest distance to BS, one is chosen arbitrarily. Otherwise, a new RN will be introduced as its next hop relay..

B. Max-Residual-Capacity-First algorithm (MRCF)

Let as observe that by using the NTBF algorithm, the workloads among the nodes could become unbalanced, since the traffic distribution is sensitive to the distance between a node and the BS. A tiny difference in distance to the BS could lead to significant variance in the workloads of two nodes. Thus, some potential traffic path segments may become jammed causing more new RNs to be added to set up new paths. As such, introduce the MRCF algorithm to maintain better load balance among the RNs.

C. Best-Effort-Relaying algorithm (BER):

In the previous algorithms, a new RN is added if the neighbors of the farthest RN cannot relay its workload. However, the capacity of its neighbors is potentially wasted as its workload is totally passed to the new RN without bothering the existing neighboring RNs. Therefore, the previous algorithms to utilize the existing RNs to relay traffic in a best-effort manner. That is, the traffic relaying will be arranged even if an RN's neighbors cannot serve it all. In addition, when placing a new RN, the location is picked not only to make the RN be as close to the BS as possible, but also to be strategically placed so as to serve as many existing RNs as possible.

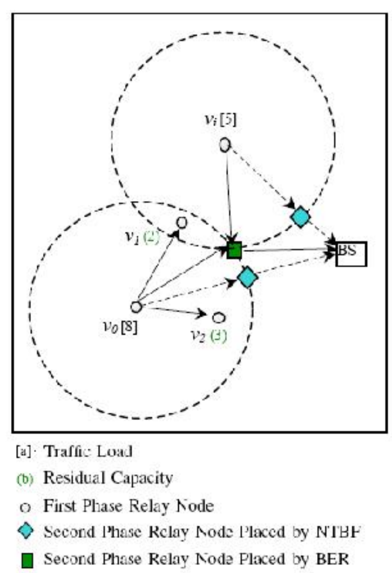
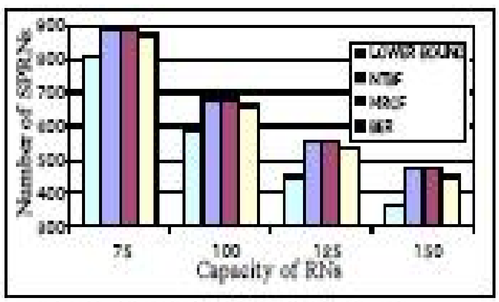


Fig2 Node placement.

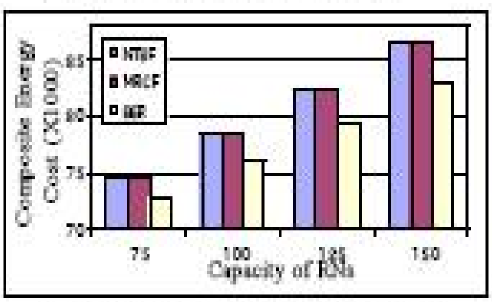
B. Cost Model, Energy Model and System Lifetime

The cost of a device depends on its functionalities and power supply. The more functionality a device has the more complex and, thus, the more expensive it is. Also, there are various means of power supply (e.g., battery, solar panel, wall power) at different costs. In this paper assume that the costs of individual nodes of the same type are the same.

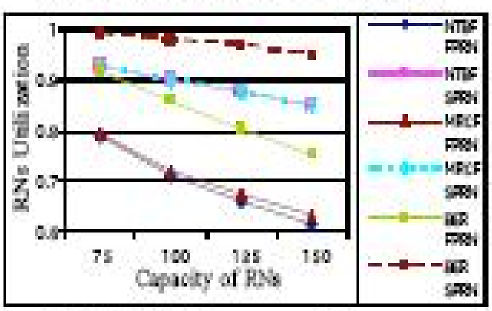
This paper addresses the problem of minimizing cost with constraints on lifetime. In this paper, the nodal lifetime is represented by the cumulative traffic volume until its energy is depleted. In such a way, both synchronous and asynchronous traffic patterns are accommodated. Can be easily modified for other lifetime measurements. From the energy model above, it is clear that the communication energy consumption of a node depends on two factors, namely, the traffic volume1and the transmission distance. .



(A) number of SPRNs vs. capacity



(B) Composite energy cost vs. capacity



(C) RN utilization vs. capacity

Fig 3. Performance Evaluation

IV. CONCLUSION

In this paper, explored the problem of optimal WSN device placement, aiming at minimizing the network cost with constraints on lifetime and connectivity. A general design problem was formulated and discussed. The placement problem with non-energy-constrained relay nodes was modeled as a minimum set covering problem.

Furthermore, taking into account the energy and transmission range constraints on RNs, a comprehensive two phase approach was presented. Solutions for both phases were described. Based on the solution to problem one, an optimal solution was presented to place the first phase relay nodes. For the placement of second phase relay nodes, the Far-Near and Max-Min principles were proposed, and three heuristic schemes were developed accordingly.

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