An Approach Towards Steadiness and Capability of Regular Wireless Networks

[1]S.Sainath Reddy, [2]P. Vijay Kumar
[1]Dept. of MCA, DRK Institute of Science and Technology, Hyderabad, AP, India
[2]Dept. of CSE, DRK Institute of Science and Technology, Hyderabad, AP, India

Abstract
For the position of individual Sensor Nodes (SNs), the node exploitation problem in Wireless Sensor Networks (WSNs) deals with strategies, such that the resultant network satisfies individual constraints. To scatter the sensor nodes randomly across the area to be monitored is a popular method of deploying WSNs. The problem of reasonable rate allocation that maximizes the network throughput in standard topologies of Wireless Sensor Networks (WSNs) is described in this paper. We need to find the optimal rate allocation for the individual end-to-end sessions that maximizes the total proportionally fair throughput of the network in order to monitor the entire coverage area of the WSN while maintaining acceptable network throughput. For the link layer transmission probabilities, we provide closed form expressions for the finest end-to-end session rates for topologies as well as the bounds. For regular WSNs with a slotted Aloha MAC layer we study the aforementioned problem, which provides us with a lower bound for more sensible MAC (Media access control) protocols. By using Telosb nodes our real world experiments validate our theories and results. The different regular topologies as the size of network grows and simulations carried out in Qualnet verify our comparisons.

Keywords
Wireless Sensor Networks, Sensor Nodes, Topologies, Aloha MAC Layer

I. Introduction

The node deployment problem in Wireless Sensor Networks (WSNs) deals with strategies for the placement of individual sensor nodes (SNs), such that the resulting network satisfies specified constraints [1,3]. A popular method of deploying WSNs is to scatter the sensor nodes randomly across the area to be monitored. The idea of sleep scheduling is applied to WSNs to make better use of extra SNs [2]. The cost of node deployment is reduced by an alternate approach to handling redundancy to deploy the sensor nodes in a regular topology. Regular node deployment strategies have been shown to minimize the number of nodes required to completely cover a given area in two dimensional spaces, while maintaining connectivity across the network. Another benefit of a regular network is its simplicity [4-5]. For commercial applications ease of deployment and maintenance is an attractive feature involving WSNs in physically accessible areas that aim to optimize the performance of the network [6].

II. Designing Of Wireless Networks

With optimizing the energy efficiency many works related to regular topologies exist and most of them deal with coverage, connectivity and throughput [8, 10]. Given the emphasis on eliminating redundancy, it is imperative that each SN in a regular WSN be able to adequately send its monitored data to the Base Station (BS) [6-7]. This call for a rate control scheme that is fair to all the nodes in the network is shown in fig. 1.

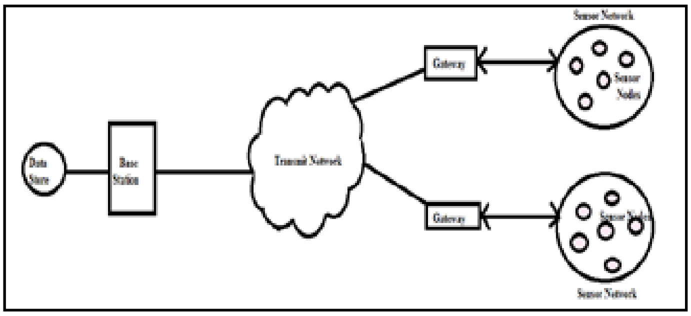

Fig. 1: System Architecture of Wireless Sensor Networks

Absolute fairness among competing sessions, however, may cause the total throughput of the network to significantly decrease, rendering the performance of the network unacceptably poor. Hence, we study the allocation of session rates to maximize the throughput of the WSN, while maintaining proportional fairness in the network [9-10]. In random access WSNs the problem of end-to-end proportionally fair rate allocation is deployed in the three most common regular lattice topologies. We adopt a cross layer solution approach where the session rates at the transport layer and the MAC layer link capacities are inter-dependent, based on the non-convex formulation presented [10-12]. Our main contributions in this paper are as follows: For each of the three regular topologies, we derive optimal session rates and optimal MAC transmission probabilities that maximize the total proportionally fair throughput. Closed form expressions for the total throughput of each regular WSN, in the context of proportional fairness [11-12]. Based on the expressions, we are able to conclude that as the network size grows from mall, to medium, to large, the topology with the best proportionally fair throughput changes from triangular, to square, to hexagonal. Experiments conducted using TELOSB motes support our theoretical findings, as well as highlight some important challenges faced while applying theoretical results to the real world wireless medium. We perform extensive simulations to verify our results for larger WSNs.

III. Reasonable Allocation for Standard Topologies

For smaller network sizes, the triangular topology's proportionally fair throughput is higher than that of the square, which does better than the hexagonal topology. We also see the region where a crossover happens where the hexagonal topology does better than the square, which in turn, does better than the triangular topology, as predicted in our theoretical model. The simulations vary from the theoretical results in three aspects. In the simulations, the first is that the values of proportionally fair throughput are lower than in theory. Secondly, the simulations show the start of the crossover region at larger network sizes the proportionally fair throughput does not increase as sharply as in theory, finally which in theory was expected to occur at a much larger network size of around two hundred hops. This variation between the simulations and theory could be due to a number of causal factors. The first is that for each node in our simulation the proportionally fair throughput is calculated, at the Base Station (BS) by summing the log of the received throughput, while in theory it is calculated as the sum of the log of the session rates of all the sessions. The simulations have lower values, as a much higher value than the actual received rate at the BS. Due to collision or dropped packets along the path as the second factor is that in the simulations as we move farther away from the BS, there is a higher probability that the nodes packet will not reach the BS. We observed that as the network grew in size the number of nodes that could not send any packets to the sink increased. Our theoretical model does not take into account this more realistic collision model which could contribute to the difference in the results.

IV. Results

For smaller network a size, the triangular topology is proportionally reasonable throughput is superior to that of the square, which is enhanced than the hexagonal topology. The area where a crossover take place and the area where the hexagonal topology shows improvement than that of the square and do enhanced than the triangular topology. The simulations differ from the hypothetical results in three features such as the standards of proportionally fair throughput in the simulations are inferior to the values in theory. By superior network sizes the proportionally fair throughput does not enlarge as stridently. The simulations explain the begin of the crossover region, which was predicted to happen at a great extent better network size of approximately two hundred hops. This difference between the simulations is possibly due to a number of contributing aspects. The initial aspect is that simulation the proportionally fair throughput is considered for every node in our simulation, by the sum of the log received throughput at the Base Station. The next aspect is that in the simulations as we go further than away from the Base Station, there will be an advanced possibility of the nodes packet not attaining to the Base Stations, because of collision along the path. As the network grows up in size the number of nodes which may not send the packets to the sink gets increased.

V. Conclusion

End-to-end proportionally reasonable rate portion problem in standard lattice topologies of WSNs is described in this paper. In each regular topology, the optimal session rates and channel access probabilities of every node are derived, so that it would achieve the maximum proportionally fair throughput. To regular node deployments our solution is counter-intuitive and reveals special characteristics which are unique, and can be exploited during network design. Using TELOSB sensors we execute experiments in order to evaluate how our results would contact a WSN in a real-world environment, and find that our solution optimizes the reasonable throughput of the network. With a better representation of the physical layer, our finding from experiments and simulations indicates that promising future work could include enhancing our theoretical model and this include using a more sensible path loss model, capture model and multi packet reception model.

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S Sainath Reddy has completed B.SC (Computers) from Sri Sai Degree College, Anantapur, Andhra Pradesh, India, and pursuing MCA in DRK institute of science and technology, JNTUH, Hyderabad. His main research interest includes Wireless Sensor Networks & Computer Networks.

P. Vijaykumar is working as an Associate Professor in DRK Institute of science and Technology received his M.Tech(C.S.E) from JNTUH, Hyderabad, India.