

TOPOLOGY CONTROL IN WIRELESS SENSOR NETWORKS

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ABSTRACT

Ad hoc networks are considered to be a very promising technology. Despite the importance and the variety of possible applications, they still suffer from some basic problems. One of the most important issues of wireless sensor networks is their restricted amount of energy resources, and therefore their restricted autonomy. This paper tries to reduce that problem by introducing topology control into the Wireless Sensor Networks (WSN). Many studies have been performed on topology control. This paper gives an overview of the most important algorithms for topology control. The performance of the different algorithms will be compared and their practicability will be discussed. Most of the literature about the topic of topology control stays focuses only on the theoretical part. This paper goes further and discusses an implementation of an algorithm for topology control on a real sensor network.

INTRODUCTION

A Wireless Sensor Network (see figure 1) is a special kind of ad hoc network. An ad hoc network is formed by a group of mobile clients communicating, using wireless connections. Wireless sensor networks are in most cases composed by a huge number of clients sending measurement results to a central node, called the sink. These networks possess some specific characteristics. In most cases they are dense, the network topology can change, the nodes only have a restricted view on the entire network, the energy resources are often batteries and therefore limited in lifetime. In order to improve those networks, an answer has to be found to the problem of the restricted power supply.



Figure 1. Wireless Sensor Network

In the paper we will first introduce topology control and explain how topology control can reduce the energy consumption while sending messages. In the literature many topology control algorithms are discussed. In this paper, some of those algorithms will be presented and classified according to their practicability. The topology control algorithms are implemented in Matlab in order to study and compare their ability to reduce the overall power consumption when all nodes in the network are sending messages to a sink. The purpose of this study was to pinpoint the most promising topology control algorithm to be implemented on a real sensor network. In the last part of the paper we will focus on the implementation of that algorithm on a real sensor network, using Tmote Sky modules as sensor nodes and Contiki as operating system on those nodes. The paper will conclude with some important remarks and recommendations for future studies.

Topology Control In Wireless Sensor Networks

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Kevin M. Lillis



Topology Control In Wireless Sensor Networks Topology Control In Wireless Sensor Networks:

Topology Control in Wireless Sensor Networks Miguel A. Labrador, Pedro M. Wightman, 2009-02-27 The eld of wireless sensor networks continues to evolve and grow in both practical and research domains More and more wireless sensor networks are being used to gather information in real life applications It is common to see how this technology is being applied in irrigation systems intelligent buildings bridges security mechanisms military operations transportation related applications etc At the same time new developments in hardware software and communication technologies are panding these possibilities As in any other technology research brings new developments and refinements and continuous improvements of current approaches that push the technology even further Looking toward the future the technology seems even more promising in two directions First a few years from now more powerful wireless sensor devices will be available and wireless sensor networks will have applicability in an endless number of scenarios as they will be able to handle traffic loads not possible today make more computations store more data and live longer because of better energy sources Second a few years from now the opposite scenario might also be possible The availability of very constrained nanotechnology made wireless sensor devices will bring a whole new world of applications as they will be able to operate in environments and places unimaginable today These two scenarios at the same time will both bring new research challenges that are always welcome to researchers

Topology Control in Wireless Ad Hoc and Sensor Networks Paolo Santi, 2005-08-05 Topology control is fundamental to solving scalability and capacity problems in large scale wireless ad hoc and sensor networks Forthcoming wireless multi hop networks such as ad hoc and sensor networks will allow network nodes to control the communication topology by choosing their transmitting ranges Briefly topology control TC is the art of coordinating nodes decisions regarding their transmitting ranges to generate a network with the desired features Building an optimized network topology helps surpass the prevalent scalability and capacity problems Topology Control in Wireless Ad Hoc and Sensor Networks makes the case for topology control and provides an exhaustive coverage of TC techniques in wireless ad hoc and sensor networks considering both stationary networks to which most of the existing solutions are tailored and mobile networks The author introduces a new taxonomy of topology control and gives a full explication of the applications and challenges of this important topic Topology Control in Wireless Ad Hoc and Sensor Networks Defines topology control and explains its necessity considering both stationary and mobile networks Describes the most representative TC protocols and their performance Covers the critical transmitting range for stationary and mobile networks topology optimization problems such as energy efficiency and distributed topology control Discusses implementation and open issues including realistic models and the effect of multi hop data traffic Presents a case study on routing protocol design to demonstrate how TC can ease the design of cooperative routing protocols This invaluable text will provide graduate students in Computer Science Electrical and Computer Engineering Applied Mathematics and Physics researchers in the field of ad hoc networking and professionals

in wireless telecoms as well as networking system developers with a single reference resource on topology control

Probabilistic Topology Control in Wireless Sensor Networks Yunhuai Liu, 2010-01 For a wide spectrum of applications the wireless sensor network WSN technology exhibited revolutionary advantages when compared to traditional solutions Among all the energy saving and network throughput improvement schemes topology control has been well recognized as an effective one In traditional topology control a wireless network is represented using the deterministic model that assumes a pair of nodes is either connected or disconnected Rich empirical studies have shown that in most practical environments lossy links of intermittent connections account the dominating majority of WSNs because various reasons By successfully leveraging these lossy links higher energy efficiency and network capacities are feasible By traditional approaches however WSN topologies can hardly be well characterized Motivated by this we in this book discuss a new model call probabilistic topology control fully taking the lossy links into account We prove that in general PTC is a NP hard problem Based PTC we propose two algorithms CONREAP and BRASP and one routing algorithm Analysis and experimental results showed that these algorithms are very effectively

Probabilistic Topology Control in Wireless Sensor Networks Yunhuai Liu, 2008 *Adaptive Clustering and Transmission Range Adjustment for Topology Control in Wireless Sensor Networks* Bolian Yin, 2006 A wireless sensor network WSN is characterized by a limited energy supply and a large number of nodes Topology control TC as one of the main ways to control energy consumption in WSNs has been the focus of a considerable body of research Topology control algorithms can be divided into duty cycle based algorithms and transmission power based algorithms according to their energy saving approaches By dynamically integrating the two approaches I have developed a two level topology control strategy to achieve further energy saving Connected dominating set CDS as a very promising energy saving technique can be used with either a transmission power based algorithm or a dutycycle based algorithm I have designed a distributed algorithm DSP CDS for constructing CDS quickly in a single phase I have developed an energy consumption model for clustered WSNs and use it to solve the optimal transmission range problem This model provides us an insight into the energy consumption behavior in clustered wireless sensor networks and the relationship among major factors Observing that traffic load often has unpredictable changes after deployment and has great impact on the optimal transmission range I have designed a traffic adaptive clustering algorithm RDSP CDS RDSP CDS is suitable for dynamic network topologies due to transmission range changes node mobility and or node failure As a summary the contributions of the dissertation include a two level topology control strategy a distributed connected dominating set construction algorithm DSP CDS an energy consumption analysis model to solve the optimal transmission range problem in clustered WSNs and a distributed traffic adaptive clustering algorithm RDSP CDS for non uniform traffic networks

Topology Control and Data Handling in Wireless Sensor Networks L. L. Shum, 2009 Our work in this thesis have provided two distinctive contributions to WSNs in the areas of data handling and topology control In the area of data handling we have

demonstrated a solution to improve the power efficiency whilst preserving the important data features by data compression and the use of an adaptive sampling strategy which are applicable to the specific application for oceanography monitoring required by the SECOAS project Our work on oceanographic data analysis is important for the understanding of the data we are dealing with such that suitable strategies can be deployed and system performance can be analysed The Basic Adaptive Sampling Scheduler BASS algorithm uses the statistics of the data to adjust the sampling behaviour in a sensor node according to the environment in order to conserve energy and minimise detection delay The motivation of topology control TC is to maintain the connectivity of the network to reduce node degree to ease congestion in a collision based medium access scheme and to reduce power consumption in the sensor nodes We have developed an algorithm Subgraph Topology Control STC that is distributed and does not require additional equipment to be implemented on the SECOAS nodes STC uses a metric called subgraph number which measures the 2 hops connectivity in the neighbourhood of a node It is found that STC consistently forms topologies that have lower node degrees and higher probabilities of connectivity as compared to k Neighbours an alternative algorithm that does not rely on special hardware on sensor node Moreover STC also gives better results in terms of the minimum degree in the network which implies that the network structure is more robust to a single point of failure As STC is an iterative algorithm it is very scalable and adaptive and is well suited for the SECOAS applications

Wireless Sensor And Robot Networks: From Topology Control To Communication Aspects Nathalie Mitton, David Simplot-ryl, 2013-12-19 Wireless sensor networks have gained much attention these last years thanks to the great set of applications that accelerated the technological advances Such networks have been widely investigated and many books and articles have been published about the new challenges they pose and how to address them One of these challenges is node mobility sensors could be moved unexpectedly if deployed in an uncontrolled environment or hold by moving object animals Beyond all this a new dimension arises when this mobility is controlled i e if these sensors are embedded in robots These robots cohabit with sensors and cooperate together to perform a given task collectively by presenting hardware constraints they still rely on batteries they communicate through short radio links and have limited capacities In this book we propose to review new challenges brought about by controlled mobility for different goals and how they are addressed in the literature in wireless sensor and Robot networks ranging from deployment to communications *Distributed Topology Control for Wireless Sensor Network*, 2007 **Topology Control and Data Handling in Wireless Sensor Networks** Lam Ling Shum, 2009 **Hierarchical Topology Control for Wireless Networks** Jiguo Yu, Cheng Xiuzhen, Jiang Honglu, Dongxiao Yu, 2018-02-05 First Published in 2018 This book covers the concepts of architecture and applications on wireless ad hoc networks and wireless sensor networks including topology control the clustering algorithm in topology control and virtual backbone construction algorithms focusing on connected dominating set construction including various transformations for dominating sets *Energy Aware Topology Control Protocols for Wireless Sensor Networks* Shilpa

Dhar,2005 **Distributed Connected Dominating Set Techniques for Energy-efficient Topology Control in Wireless Sensor Networks** Azrina Abd Aziz,2012 Despite the considerable research efforts devoted to extending the lifetime of wireless sensor networks WSNs by making them more energy efficient there are still a number of unresolved issues Among the possible solutions for improving their overall energy efficiency topology control has significant potential Distributed topology control is a difficult problem and optimal solutions are not possible except for very simple topologies Because of this heuristic methods are used but the solutions proposed in the research literature are usually tested with overly simplistic simulation models and consequently they fail to perform satisfactorily in real networks The research project reported in this thesis proposes three new topology control methods that are tested on highly realistic simulation models calibrated with data collected on an experimental wireless sensor network These models accurately handle interference effects realistic transmission ranges and imperfect communication links Additionally the correctness of the proposed methods was verified using theoretical analysis Two leading algorithms were used as benchmarks Based on the outcomes of a thorough literature review and analysis of existing techniques distributed connected dominating set CDS approach was selected as the starting point for the design of the proposed algorithms The proposed algorithms are not only distributed but also use localized information for computing a CDS Given that the CDS serves various tasks in a WSN a fair load distribution strategy was adopted to prolong the network lifetime This strategy takes into account the remaining energy levels at each node when choosing the eligible CDS nodes The first topology control technique called the three phase single initiator TPSI was developed to form a small CDS for medium and dense networks i e in deployments when average node degree is relatively high with minimal communication overhead computational complexity and energy consumption The simulation results demonstrate that the TPSI algorithm generates a small CDS for both medium and dense networks but not for sparse networks These results also prove that the impact of network density on performance of an algorithm is significant and cannot be ignored The second technique single phase single initiator SPSI on the other hand was proposed for applications that require fast convergence and is best suited to WSN applications that have sparse topologies The simulation results show that SPSI can generate a small CDS for sparse networks using low message overhead and energy consumption and compute a CDS faster than the TPSI algorithm The third one the Two phase multiple initiator TPMI algorithm adapts well to dynamic topology changes thus it is suitable for applications that require frequent topology updates Instead of relying on a single initiator to construct the CDS as in the TPSI and SPSI the TPMI algorithm uses multiple initiators The simulation results show that although the CDS size of TPMI is larger than the ones generated by TPSI or SPSI it outperforms them in terms of energy consumption network lifetime and convergence time in networks with rapidly changing topologies Best suited algorithm for a particular installation can be selected manually or by using some measurement techniques the structure of a network can be probed to activate the optimal method automatically **ADAPTIVE CLUSTERING AND TRANSMISSION**

RANGE ADJUSTMENT Bolian Yin,2010-01 *Energy Efficient Topology Control Algorithm for Wireless Sensor Networks*

Nedal Hussein Ahmad Ababneh,2008 **Wireless Sensor Networks and Applications** Yingshu Li,My T. Thai,2008-02-10

Wireless sensor networks are being employed in a variety applications ranging from medical to military and from home to industry The principle aim of this book is to provide a reference tool for the increasing number of scientists who depend upon sensor networks in some way The book is organized into several sections each including chapters exploring a specific topic Wireless sensor networks are attracting great attention and there are many research topics yet to be studied In this book the topics covered include network design and modelling network management data management security and applications The articles presented in the book are expository but of a scholarly nature including the appropriate history background a review of the state of the art thinking relative to the topic as well as a discussion of unsolved problems that are of special interest The target readers of this book include the researchers in computer science computer engineering and applied mathematics as well as students in these subjects Specialists as well as general readers will find the articles stimulating and helpful Book Organization The book is organized into five sections Section I introduces the design and modelling of sensor networks Chapter 1 by Iyer Kulkarni Mhatre and Rosenberg presents a taxonomy of wireless sensor networks based on their application level objectives traffic characteristics and data delivery requirements Popa and Lewis in Chapter 2 describe some algorithms for systematic exploration of unknown environments using a mobile wireless sensor network *Distributed Topology Control with Energy-Efficiency in Wireless Sensor Networks* [13],2013 **Energy Efficient Topology Control**

Algorithms for Sensor Networks Nedal Ababneh,2011-07 Lifetime extension is one of the most critical research issues in the area of wireless sensor networks due to the severe resource limitations of the sensor nodes e.g small battery limited computation capabilities inexpensive transceiver etc One of the key approaches for prolonging the sensor network operable lifetime is to deploy an effective topology control protocol This book proposes solutions pertinent the topology control issues and challenges in sensor networks in particular the design of energy aware topology control algorithms **Improved**

Robustness of Topology Control and Routing Algorithms for Ad-hoc Wireless Sensor Networks Kevin M. Lillis,2008

Energy-aware Topology Control and Data Delivery in Wireless Sensor Networks Seung-Jong Park,2004 The objective of this thesis is to address the problem of energy conservation in wireless sensor networks by tackling two fundamental problems topology control and data delivery We first address energy aware topology control taking into account throughput per unit energy as the primary metric of interest Through both experimental observations and analysis we show that the optimal topology is a function of traffic load in the network We then propose a new topology control scheme Adaptive Topology Control ATC which increases throughput per unit energy Based on different coordinations among nodes we proposed three ATC schemes ATC CP ATC IP and ATC MS Through simulations we show that three ATC schemes outperform static topology control schemes and particularly the ATC MS has the best performance under all environments Secondly we

explore an energy aware data delivery problem consisting of two sub problems downstream from a sink to sensors and upstream from sensors to a sink data delivery Although we address the problems as two independent ones we eventually solve those problems with two approaches GARUDA DN and GARUDA UP which share a common structure the minimum dominating set For the downstream data delivery we consider reliability as well as energy conservation since unreliable data delivery can increase energy consumption under high data loss rates To reduce energy consumption and achieve robustness we propose GARUDA DN which is scalable to the network size message characteristics loss rate and the reliable delivery semantics From ns2 based simulations we show that GARUDA DN performs significantly better than the basic schemes proposed thus far in terms of latency and energy consumption For the upstream data delivery we address an energy efficient aggregation scheme to gather correlated data with theoretical solutions the shortest path tree SPT the minimum spanning tree MST and the Steiner minimum tree SMT To approximate the optimal solution in case of perfect correlation among data we propose GARUDA UP which combines the minimum dominating set MDS with SPT in order to aggregate correlated data From discrete event simulations we show that GARUDA UP outperforms the SPT and closely approximates the centralized optimal solution SMT with less amount of overhead and in a decentralized fashion

Sink Localization and Topology Control in Large Scale Heterogeneous Wireless Sensor Networks Rui Zhang, 2007 ABSTRACT Wireless Sensor Networks WSNs continue to evolve as new applications emerge In the recent past WSNs were mostly single sink networks with a few number of homogeneous and static sensor nodes Now several applications require networks with multiple and moving sinks and targets as well as thousands of heterogeneous devices However the same constraints remain sensor nodes continue to be very limited in resources posing new challenges in the design of scalable and energy efficient algorithms and communication protocols to support these new applications This dissertation first addresses the problem of sink localization in large scale WSNs A scalable and energy efficient sink localization mechanism called the Anchor Location Service ALS is introduced to support the use of location based routing protocols ALS avoids frequent and costly flooding procedures derived from the mobility of the sinks and targets and utilizes face routing to guarantee the success of localization The problem of topology control in heterogeneous environments is addressed next A new topology control mechanism the Residual Energy Aware Dynamic READ algorithm is devised to extend the lifetime of the network while maintaining connectivity READ extends the lifetime of the network by assigning a more prominent role to more powerful devices ALS and READ are evaluated and compared with other well known protocols using analytical means and simulations Results show that ALS provides a scalable sink location service and reduces the communication overhead in scenarios with multiple and moving sinks and targets Results also show that READ increases both the network lifetime and the packet delivery rate

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