ISTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

ENERGY AWARE NEGOTIATION BASED DATA DISSEMINATION PROTOCOL FOR WIRELESS SENSOR NETWORKS

M.Sc. Thesis by

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PREFACE

I would like to thank to Assist. Prof. Dr. Feza BUZLUCA for all support, supervision, and motivation during my graduate studies.

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ABBREVIATIONS

WSN	: Wireless Sensor Network
MANET	: Mobile Ad Hoc Networks
EAR	: Energy Aware Routing
SPIN	: Sensor Protocols for Information via Negotiation
EASPIN	: Energy Aware SPIN

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TELSİZ DUYARGA AĞLAR İÇİN ENERJİNİN FARKINDA MÜZAKERE TABANLI VERİ YAYMA PROTOKOLÜ

ÖZET

Düşük maliyetli cihazların geliştirilmesi ile telsiz duyarga ağları için yapılan uygulamaların sayısı da artmıştır. Bu küçük cihazların duyma, işleme ve iletişim birimleri vardır. Sınırlı güç kaynakları ile iletişim mesafeleri kısadır. Bu sınırlar yüzünden telsiz duyarga ağlarının bütün katmanlarında enerji yönetimi ve hata bağışıklığı düşünülmelidir. Bu tezde ağ katmanı düşünülmüştür. Tasarsız ağlar ve telsiz duyarga ağları için bir çok yönlendirme protokolü tanımlanmıştır. Duyarga ağlar, tasarsız ağların bir çeşidi olmasına rağmen, tasarsız ağlar için düşünülmüş olan bazı protokoller telsiz duyarga ağları için uygun değildir, çünkü telsiz duyarga ağları veri merkezlidir. Bu tezde enerjinin farkında bir veri yayma protokolü tanımlanmıştır. SPIN temel olarak alınmış ve üzerine yönlendirme sırasında maliyetin düşünüldüğü, EAR protokolündekine benzer bir mekanizma getirilmiştir. Sonuçlar bu yöntemin toplam enerji kullanımını azalttığını ve ağın ömrünü uzattığını göstermiştir.

ENERGY AWARE NEGOTIATION BASED DATA DISSEMINATION PROTOCOL FOR WIRELESS SENSOR NETWORKS

SUMMARY

Wireless Sensor Network (WSN) applications are increased with development of low-cost devices. These tiny sensor nodes have sensing, data processing, and communication units. They have limited power and can communicate in short distances. Because of the limitations of these nodes, energy management and fault tolerance must be thought in all communication layers of sensor networks. In this thesis, network layer issues of a WSN are considered. There are lots of routing protocols for Ad-hoc networks and WSN. Although sensor networks are some kind of Ad-hoc networks, some protocols for Ad-hoc networks are not suitable for WSN, because WSNs are data-centric. In this thesis an energy aware fault tolerant data dissemination protocol called EA-SPIN (Energy Aware SPIN) is introduced for sensor networks. It is based on SPIN (Sensor Protocols for Information via Negotiation) protocol, but it has also a multi-hop cost effective routing mechanism, which is similar to EAR (Energy Aware Routing). The experimental results show that the proposed protocol can reduce total energy consumption and increase the network lifetime.

1. INTRODUCTION

Improvements in sensor devices and wireless network technology have increased the importance of the wireless sensor network (WSN) applications, such as habitat monitoring, enemy tracking in battlefield, surveillance, etc. [1].

Mobile Ad Hoc Network (MANET) is the closest network model to the WSN with non-fixed network topology, limited power, and wireless communication. Although there are some similarities, the protocols of MANET may not be applied directly to the sensor networks because of the below differences [1,2].

- Sensor networks are data centric, so they are involved gathering data, but MANETs are used for distributed computing.
- In sensor networks data flow from the sensor nodes to the sink. In MANET, data flow is irregular.
- The number of nodes in a WSN is more than of MANET.
- Sensor nodes are much more limited in terms of computation and communication capabilities. They have very limited power resource, while MANET can have rechargeable nodes.
- Sensor nodes are cheaper than the MANET nodes.

WSNs are usually deployed in densely in a sensor field. They contain lots of nodes. The nodes have sensing, computing and wireless communication capabilities [4]. Some additional capabilities can be add to sensor node with hardware units. Some of these units are mobilizer, global positioning system, or power generator [5].

These sensor nodes usually are assigned with gathering data from the sensor field. The collected data are sent to sink node, which is connected to the user terminal over Satellite or Internet link. The routes from sensor nodes to sink node is a multi-hop path in an infrastructureless architecture.

There are some requirements and constraints for wireless sensor networks [4,5]. First of all, sensor nodes shall be cheap, because they are deployed densely. Because of the hardware constraints, the sensor nodes have limited energy and storage capacity.

Routing is an issue for WSNs. There are three categories. Depending on how the protocol finds the route, namely proactive, reactive, and hybrid. In proactive approach, the route is determined before it is required, such as directed diffusion [6]. Whereas in reactive routing, the route is found on demand, such as PEGASIS [7] and EAR [8], hybrid routing protocols are the combination of these two approaches, such as Rumor Routing [9].

Direct communication, flat, and clustering protocols are the classes of routing protocols according to the participating style of a node. In direct communication, nodes send their data to sink directly. All nodes have same roles in flat routing, but in hierarchical routing the nodes can be assigned with different roles.

Negotiation-based, multipath-based, query-based, and location-based are the categories of the protocols according to the protocol operation. Before data is send to nodes, the receivers are asked, whether they require this data or not, so the redundant data transmission is reduced in negotiation based protocols [10]. In multipath routing, more than one path is used to send data. Sink node requires data via a query in query-based protocols [6,8]. Some protocols require the location information of the nodes. They are called location-aware protocols.

1.1 Problem Statement and Proposed Solution

In this thesis, a new data dissemination protocol based on Sensor Protocols for Information via Negotiation (SPIN) [10] is introduced for wireless sensor networks. It is called Energy Aware SPIN (EA-SPIN).

SPIN is a negotiation based data dissemination protocol. It is designed for resolving the problems in classic data dissemination protocols, such as flooding and gossiping. The classic data dissemination protocols have three main problems, implosion, overlap, and resource blindness. Implosion problem states that a node can receive same data from two nodes. Overlap means that two nodes can sense same data and send this data to same sensor node. Because the receiver node does not know whether it has data, redundant data transmissions occur. Also, flooding does not

check the resources. SPIN solves these problems with a negotiation and resource management mechanism. In SPIN, a sender asks to the receiver before sending data whether the receiver has data. If the receiver has this data, sender does not send this advertised data.

Although SPIN solves these problems, it has also a problem. All nodes can be sink in SPIN, so is not energy and sink aware. The aim of the SPIN is sending a data to all nodes in the network, so nodes still can send redundant data in SPIN. We thought that this not a cost effective approach, because the deployment cost increases, if we designed all nodes as sink.

We designed EASPIN for a network, which contains different types of nodes. Unlike SPIN, its goal is transmitting data to sink node with minimum cost. It gets the cost calculation mechanism of EAR [11] and modifies some steps of the mechanism. Also, the message structures are different. In EAR, destination node starts the messaging for establishment, but in EA-SPIN source node sends first message to start route-finding phase. Its data communication phase is similar to SPIN, but it maintains its routing table during communication.

The main goal of EASPIN is increasing the network lifetime, so it reduces the redundant data transmissions with using cost effective paths to sink. It does not use only the path with minimum cost. Paths are selected with a inverse probability according to their costs, so the energy consumption is distributed to all network. This mechanism increases the network lifetime.

1.2 Summary Of Chapters

The thesis is presented in 6 chapters. The summary of chapters are given below :

- Chapter 2 describes the WSN architecture and design challenges.
- Chapter 3 describes the routing protocols for WSN. The classification of routing protocols is explained and the routing protocols, which are used in our study, are analyzed.
- Chapter 4 describes our proposed protocol EASPIN. The messages, phases and communication scenarios are given in this chapter.

- Simulation environment is presented in chapter 5. Also, the simulations we have run and the results of these simulations.
- The aim and the result of this thesis is presented in conclusion chapter. The suggestions for the future work are given also.