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A Survey on Energy Efficiency Distributed Topology Control Algorithm For Low Power Wireless Networks

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Abstract

Topology Control is one of the significant research topics in traditional wireless networks. The primary purpose of topology control ensures the connectivity of wireless nodes participated in the network. Wireless network environments in which the main communication devices are wireless devices with limited energy like battery. In this paper we examine the neighbor discovery algorithm for energy efficiency in low power wireless networks. asymmetric neighbor discovery by mixing the concept of the combinatorial block design and the multiples of 2. One of the biggest challenges of the block design cannot guarantee proper generation of neighbor discovery schedules when a desired duty cycle is presented. Neighbor discovery algorithm has minimum number of total and wake-up slots. This implies that Combinatorial +M2 protocol finds neighboring nodes faster and spends less energy resource than other protocols.

Keywords: ***Machine to Machine Communications, Neighbor Discovery, Latency, WS***

I.INTRODUCTION

One of the primary features of topology control is connectivity between nodes in general network environments. Furthermore, low power wireless communications require an energy-efficient solution. wireless communication networks primarily consist of Machine to Machine (M2M) communication. The M2M communication is likely to the communication of wireless sensors in sensor networks. Usually, the sensor network assumes that wireless devices are stationary during their lifetime in the network, but this assumption might not work in low-power IoT communication networks. Frequently, nodes join into the network and leave at any time in low power wireless networks. In this situation, the management of network topology is slightly more difficult than that of a static network topology. To make matters worse, each node only has limited battery power in low-power networks. Therefore, a network topology mechanism should deal with the energy constraints efficiently. When physical devices join the network, one of the first job they perform might find their neighboring machines to make a connection between them. We traditionally call this process neighbor discovery. In low-power communication networks, all of the nodes have restricted energy. Therefore, they have their own power-saving mechanism. Generally accepted battery-saving technique is to turn off a radio interface because transmission and idle listening consume most of the energy instead of sensing and computation. If nodes cannot find their neighbors within a certain amount of time then the communication channel of nodes cannot be established properly and the topology control management may not be successful. Non-power-saving mechanism could be used for fast neighbor discovery, but physical devices could be died before they find their neighbors, or they could survive at a shot time only. Therefore, this simple solution does not work in low-power wireless communication networks because each node is an energy-constraint device. Consequently, the entire network may be disconnected and useless at a worst case. One of the key challenges of topology control in low-power wireless network platforms is to manage limited energy efficiently in a distributed manner. There are a variety of ways to overcome this obstacle in previous neighbor discovery research. One fundamental feature of the previous works is asynchronous neighbor discovery.. The combinatorial block design has the minimum value of cycle when the same duty cycle is given among existing neighbor discovery protocols. In addition, the combination of block designs and multiples of 2 guarantee the minimum wake-up slots when various asymmetric cases are presented. We need to confirm that the result of numerical analysis corresponds with a simulation study or an actual experiment in the near future. In addition, we could choose and apply the multiples of other numbers to asynchronous and asymmetric neighbor discovery for further energy consumption. Consequently, we can find the best parameter of the multiples for both fast neighbor discovery and minimum energy consumption. This paper is organized as follows. Section 2 reviews relevant literature regarding neighbor discovery for distributed network topology management. We describe the background and main idea of our proposed algorithm and explain how to accomplish fast neighbor discovery and energy efficiency in detail in section 3. Next, section 4 shows our numerical analysis to compare representative discovery schemes with the proposed technique based on discovery latency and energy consumption. The last section provides the conclusions of the paper and guides the future research direction.

II. Related Work

There have been a number of research works of neighbor discovery since a neighbor discovery problem was introduced. In mobile network environments, the topology of networks keep changing. Frequent node join and leave happens during network lifetime. Therefore, continuous node discovery is crucial in order to manage network topology successfully. In this section, we present the literature review of representative neighbor discovery protocols.

II a)The *Birthday* protocol was proposed for neighbor discovery in static ad hoc networks. The main idea of *Birthday* is to use a probabilistic method in order to reduce the energy of wireless nodes.

***II.b)Quorum*-based neighbor discovery protocol** Given a two dimensional array $m \times m$, a wireless node can choose one row and one column randomly and wake up all the slots of chosen row and column.

***II.c)Searchlight*,** there are two wake-up slots in each cycle, one static slot (the anchor slot) in the beginning of the cycle and one floating slot (the probe slot) searching for the anchor slots of the other node.

II.d)BlindDate maintains multiple probe slots with opposite directions in order to increase the chances of the overlaps between two probe slots. This idea can reduce the time of discovery latency. The researchers showed that *BlindDate* protocol reduced the worst case discovery latency and accomplished a better average performance compared with other primary discovery protocols. However, *BlindDate* has a similar problem *Searchlight* has.

III. Distributed Topology Control Algorithm

One of the most significant tasks for topology control in a traditional wireless network environment maintains network connectivity among a number of wireless devices. If networked devices lose their connection between their neighboring nodes then it might affect the performance and throughput of the entire network. In the worst case, most of the communications in the network may be broken. Consequently, it is impossible to sustain network life cycle. It is well known that wireless nodes frequently join and leave the network in a mobile computing environment. In addition, the nodes cannot survive for a long time in the network because of battery constraint. Therefore, one of the primary responsibilities of topology control is finding the colleagues of networked devices and connecting them each other in a distributed manner. Fining neighboring nodes is an active research area in mobile and wireless networks. Furthermore, low-power communication networks could have the problem of energy consumption and frequent node movement we discussed in this section. 3.1. Neighbor Discovery As we mentioned above, wireless nodes continuously find their nearby neighboring nodes in order to maintain network connectivity because each node has battery constraint and the node joins and leaves the network frequently. In other words, a network environment keeps changing. Hence, we need a well-defined network topology mechanism. First of all, we introduce what neighbor discovery is in this section. Most wireless devices perform their task with limited battery power. Therefore, an energy efficient battery control technique is required. IEEE 802.11 and 802.15.4 standards provide a power saving (PS) mode for wireless network environments. The main idea of PS mode is to turn off the radio interface of networked devices when there is no communication. One study discovered that wireless communication (sending and receiving packets) spends a lot of battery compared to other activities. As a result, there are two conditions like 'on' and 'off' in the PS mechanism. In this paper, we call 'on' a wake-up mode and 'off' a sleep mode. That is, a wireless node can send or receive data packets in a wake-up mode and it cannot communicate with its neighbors in a sleep mode. With binary numbers zero and one, a number one can illustrate the wake-up mode and a number zero can denote the sleep mode. A wake-up mode represents a wireless device turns on its radio interface to communicate with its neighbors. A sleep mode denotes a networked device turns off its radio interface to save its battery power. However, wireless nodes cannot remain in a sleep mode most of their lifetime for saving their energy. Periodically, they need to wake up and listen to the message from their neighboring nodes_not have data packets to send in order to maintain network connectivity. Otherwise, the network is useless. Therefore, nodes keep changing their PS mode from wake-up to sleep, and vice versa during their lifetime in the network. Additionally, changing the PS mode requires a certain of periodic pattern for efficient communication.

IV. Distribute Asymmetric Neighbor Discovery Algorithm

An ideal asynchronous and asymmetric neighbor discovery solution should take care of creating flexible discovery schedules and discovering wireless nodes in a distributed manner. As we mentioned before, the combinatorial neighbor discovery has been considered as an optimal solution, but the problem is that it cannot support asymmetric operation. In addition, we cannot guarantee that a certain symmetric design exists for constructing a WS. The latter problem can be easily solved by the proposed block combination technique. In this section, we focus on how to maintain the former problem. We propose a new distributed asymmetric neighbor discovery algorithm for topology control in IoT communication networks. The primary idea of the solution is to integrate a symmetric design with the multiples of 2 (M2). M2 is introduced to the new algorithm in order to deal with the problem of asymmetric neighbor discovery. If a slot number is equal to M2 starting from the beginning of the schedule then the new algorithm wakes that slot up and make it find its neighbors. That is, M2 synchronizes the wake-up time of two nodes working with asymmetric duty cycles and make them meet each other at a certain amount of time.

Discovery Latency is a total amount of time used by each node until it finds its neighbor(s) during neighbor discovery.

Energy Consumption is a total amount of energy spent by each node until it finds its neighbor(s) during neighbor discovery

Table .1 Comparision of different protocol in different slots

Protocol	10%	5%	2%	1%
Quorum	361	1,521	9,801	39,601
Disco	391	1,591	9,579	39,203
U-Connect	169	841	5,329	22,201
Searchlight	200	800	5,000	20,000
Combinatorial+M2	91	381	2451	9507

V.CONCLUSION

This paper surveys on energy efficient distributed topology control algorithm based finding the neighbor discovery low power wireless networks. In wireless network energy is a valuable resource which is to be used efficiently. The algorithms present in this paper offer a prominent improvement in energy efficiency.

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