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Protocol Design for Neighbor Discovery in AD-HOC Network

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Abstract

Neighbour Discovery (ND) is a basic and crucial step for initializing wireless ad hoc networks. A fast, precise, and energy-efficient ND protocol has significant importance to subsequent operations in wireless networks. However, many existing protocols have high probabilities to generate idle slots in their neighbour discovering processes, which prolongs the executing duration, and thus compromises their performance. We propose a novel randomized protocol FRIEND, a pre-handshaking neighbour discovery protocol, to initialize synchronous full duplex wireless ad hoc networks. By introducing a pre-handshaking strategy to help each node be aware of activities of its neighbourhood, we significantly reduce the probabilities of generating idle slots and collisions. Moreover, with the development of single channel full duplex communication technology [1, 2], we further decrease the processing time needed in FRIEND, and construct the first full duplex neighbour discovery protocol. Our theoretical analysis proves that FRIEND can decrease the duration of ND by up to 68% in comparison to the classical ALOHA-like protocols [3, 4]. In addition, we propose HD-FRIEND for half duplex networks and variants of FRIEND for multi-hop networks and duty cycled networks. Both theoretical analysis and simulation results show that FRIEND can adapt to various scenarios, and significantly decrease the duration of ND.

Keywords— Wireless Ad Hoc Networks, Neighbor Discovery, Full Duplex Technology, Randomized Algorithm.

Introduction

The emergence of wireless sensor nodes has allowed practitioners to foresee networking a large set of nodes scattered over a wide area of interest into a Wireless Sensor Networks (WSNs) for large-scale event monitoring and data collection and filtering. Confidentiality, authenticity, availability, and integrity are typical security goals for WSNs. Neighbour Discovery (ND) is a basic and crucial step for initializing wireless ad hoc networks. A fast, precise, and energy-efficient ND protocol has significant importance to subsequent operations in wireless networks. However, many existing protocols have high probabilities to generate idle slots in their neighbour discovering processes, which prolongs the executing duration, and thus compromises their performance.

Wireless ad hoc networks have attracted a lot of interest from both academia and industry due to their wide range of applications. In many scenarios, nodes are deployed without the support of pre-existing infrastructures for communication. As a result, nodes in a wireless ad hoc network need to configure themselves through their own communication activities to form a reliable infrastructure during the initialization for further operations. For each node, the knowledge of its one-hop neighbour's (the nodes it can directly communicate with) has significant importance to the upper layer protocols like MAC protocols, routing protocols, etc. Consequently, Neighbour Discovery (ND) is designed to discover a node's one-hop neighbour's and thus is momentous and crucial for configuring wireless networks. Compared with existing deterministic [11] and multi-user detection-based [12] protocols, randomized protocols are most commonly used to conduct ND process in wireless networks [3–8]. In those protocols, each node transmits at different randomly chosen time instants to reduce the possibility of the collision with other nodes. Usually, researchers discuss ND protocols under a synchronous system, and focus on a clique with n nodes, e.g., the famous Birthday Protocols [3]. In birthday protocols, at each single slot every node independently chooses to transmit discovery message by probability p and listen by probability 1p (the optimal value of p is proven to be 1=n). By reducing the ND problem to Coupon Collector's Problem [16], Vasudevan et al. [4] proved that the upper bound of expected time of birthday protocol is Hn, where Hn is the n-th Harmonic number. Many subsequent researches on ND are based on birthday protocols. For example, the authors in [4] proposed solutions to scenarios for unknown neighbour numbers, asynchronous systems, and systems with reception status feedback mechanisms. Zeng et al. [5] discussed the performance of birthday protocols with multi packet reception (MPR). You et al. [8] discussed discovery time's upper bound when nodes have a low duty cycle by reducing the problem. For energy-constrained wireless networks of sensors and actuators, selection of links with high packet success rate helps to ensure reliable long-term operation. During the implementation of a protocol targeting industrial applications of such systems, it was found that it is advantageous to acquire accurate information about the availability and quality of the RF communication links prior to the network topology formation. Link assessment as part of the initialization process, accomplishes this task by assessing a sufficient number of packets exchanged between neighboring nodes. We propose a novel randomized protocol FRIEND, a pre-handshaking neighbour discovery protocol, to initialize synchronous full duplex wireless ad hoc networks. By introducing a pre-handshaking strategy to help each node be aware of activities of its neighbourhood, we significantly reduce the probabilities of generating idle slots and collisions. Moreover, with the development of single channel full duplex communication technology [1, 2], we further decrease the processing time needed in FRIEND, and construct the first full duplex neighbour discovery protocol. The major problem in key management is to establish the secure keys between the sensor nodes. This problem is known as the key agreement problem. However, it is not possible to use general key agreement protocols for WSNs since sensor nodes are resource constrained and security measures are required [2].

Previous work.

A large number of works have focused on the problem of accelerating the process of ND in wireless networks and various protocols have been proposed to adapt to different situations [3–15]. Compared with existing deterministic [11] and multi-user detection-based [12] protocols, randomized protocols are most commonly used to conduct ND process in wireless networks [3–8]. In those protocols, each node transmits at different randomly chosen time instants to reduce the possibility of the collision with other nodes. Usually, researchers discuss ND protocols under a synchronous system, and focus on a clique with n nodes.

[3]Birthday Protocols for Low Energy Deployment and Flexible Neighbour Discovery in Ad Hoc Wireless Networks.

Birthday protocols in [3] use a randomized strategy for nodes in a synchronous system to choose their actions in a slot independently and randomly. The authors proved that for a clique with ***n*** nodes, the optimal probability that a node transmits is ***1/n***.

we address two problem associated with static ad hoc wireless network method of saving energy during a deployment of the nodes and efficient methods of performing adjacent neighbour discovery .to meet these goals we introduce a family of “birthday protocols “which use random independent transmission of discover adjacent nodes various mode of the birthday protocol are used to solve the two problems.

We provide a mathematical model and analysis of two modes of the protocol and are led to a third mode which is problistic analogue of the deterministic round robin scheduling algorithm.

We show by analysis and simulation that the birthday protocols are a promising tool for saving energy during the deployment of an ad hoc network as well as an efficient and flexible means of having the nodes discover their neighbours.

Advantage:

- First ever proposed ND protocol

Disadvantages:

- This applies only for ideal assumptions and systems.

  This method is proposed only for synchronous systems.

Proposed Method

First we introduce a pre-handshaking strategy to help each node be aware of activities of its neighborhood before normal transmissions, such that the system can have higher probabilities to avoid collisions and idle slots. To conduct this pre-handshaking, we add some tiny sub-slots before each normal slot. With the help of full duplex technology, at each sub-slot, every node will decide whether to transmit the discovery message in a normal slot by transmitting an anonymous election signal and catch its neighbor's signals simultaneously. With different transmitting-receiving scenarios, we design an effective strategy for each node to determine how to behave in normal slots. Correspondingly, we assign the behaviors of each node in the normal slots to complete the ND process.

On the other hand, the reception status feedback mechanism is ameliorated by using full duplex wireless radios. Originally in [6], a sub-slot is added after the normal slot, and receivers will give feedback signals to transmitters in this sub-slot. In our design this overhead can be eliminated by using full duplex nodes. If a receiver finds that two or more nodes are transmitting simultaneously, it will transmit a warning message immediately to inform other transmitters the failure of their transmissions.

Detailed Design

Detailed design of the proposed key pre-distribution approach work gives in depth picture of the most components described in the system architecture. In this section details and flow chart of each module has been described. The control flow is shown by the structure chart, the functional description of which are presented in the flow chart diagrams.

There are three main modules in the project.

- Pre-Handshaking(FRIEND-GR)
- Neighbor Discovery(FRIEND-TR)
- Multiple Pre-handshaking (FRIEND tGR)
- Half Duplex

Protocol design:

FRIEND-GR:

At the beginning of a sub-slot, each node should determine its action in the following normal slot.

Note that each node should run a copy of FRIEND-GR.

To simplify our description, assume that we run FRIEND-GR on node **A and *Ms*** is the election signal and ***Md*** is the discovery message.

- If *A* sends an *Ms*, it implies A hopes to send Md in TR
- – At this moment, if A does not receive Ms during GR, it means A wins the election and will definitely send Md in the following TR.
- – If A receives Ms. It means there exist other candidates within A's direct communication range. Therefore A can only send Md by probability ½.

- If A does not send Ms, it implies that A hopes to keep silent in the following TR.
  - At this moment, if A does not receive Ms in GR,it means no nodes decide to send Md in TR. A will reconsider sending Md by probability 1/An.

If A receives Ms. It means that there are nodes intending to transmit and thus A will keep silent.

FRIEND-TR:
In FRIEND-TR, there are two scenarios:

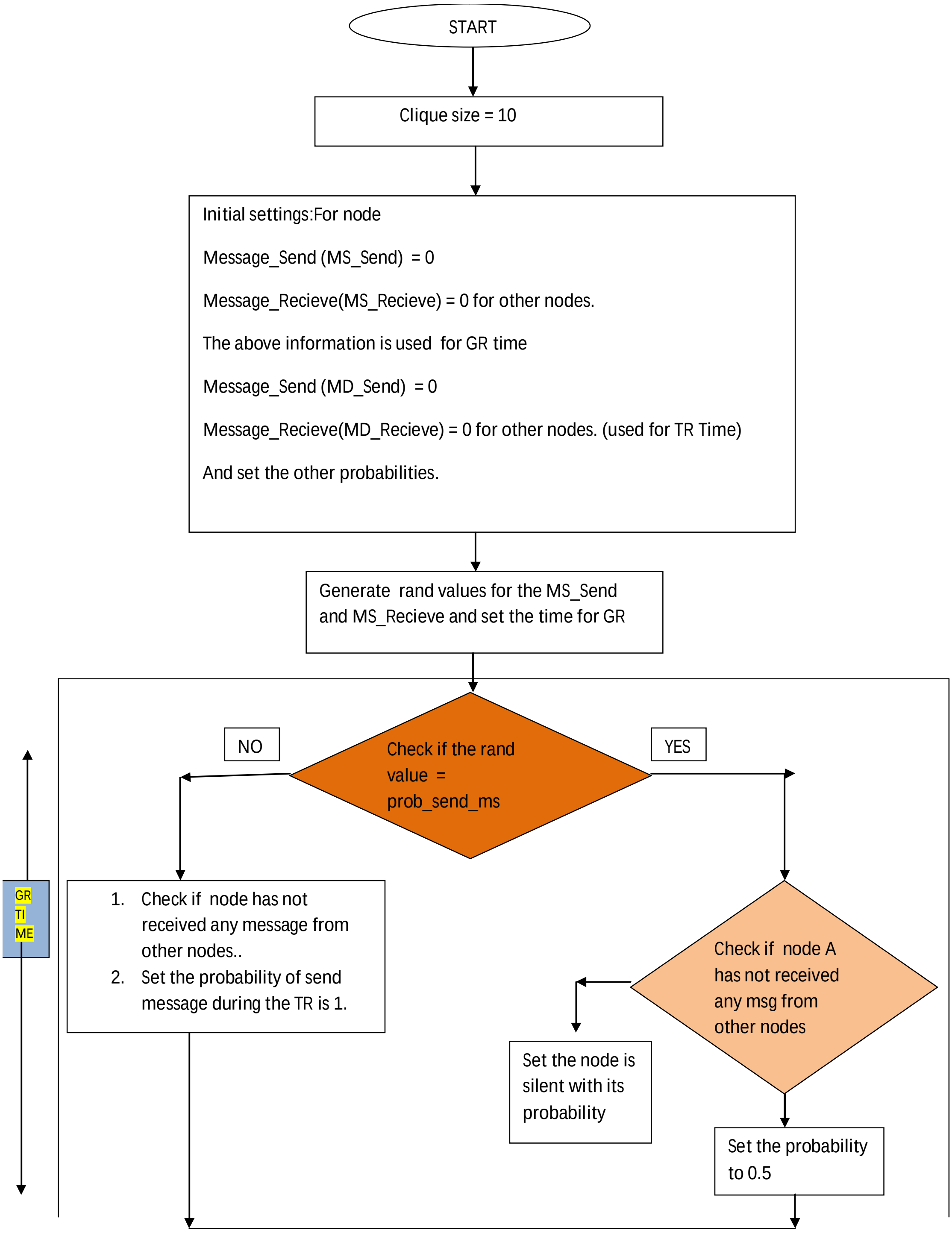
- If A sends Md, A will meanwhile check the existence of other signals
  - If A does not receive Md during TR, it means that A's transmission is successful. Consequently A will keep silent during the rest of ND process.
  - If A receives Md from other nodes, it means that the current transmission is failed.
- If A does not send Md, A will check the number of transmitters
  - If A does not receive Md during TR, it implies that no nodes send Md in TR. Therefore the current iteration is invalid.
  - If A receives a single Md during TR, it means that there is one node successfully transmitting its Md. A will record the ID in Md and decrease the value of An by 1.
  - If there is a collision at A, it means that the current transmission is failed.

Flow chart:
The flow chart in Deployment Module is divided into 3 parts Deployment process, Identifying sink neighbor and node neighbor.

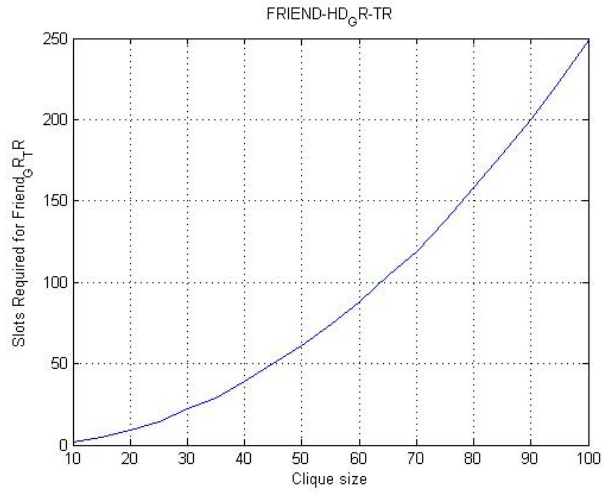
Deployment Process
Input: Gets the input as the Massage discovery value.
Output: Deployment of the slots required for the FRIENDGR TR and Clique size.

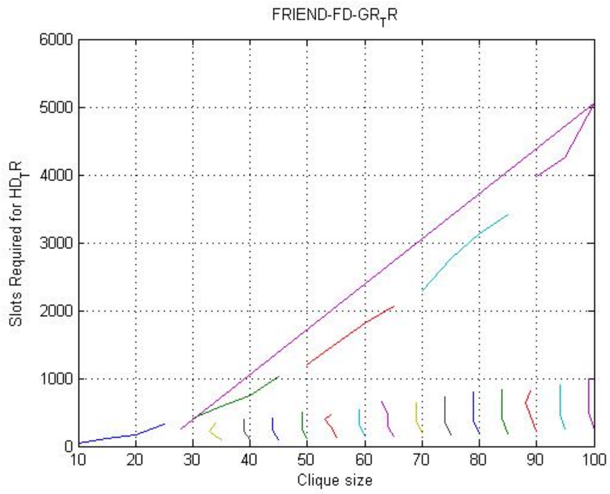
Identifying Sink Neighbors
Input: Gets the input as the number of nodes and the Transmission Range
Output: Number of neighboring nodes connected to the sink.

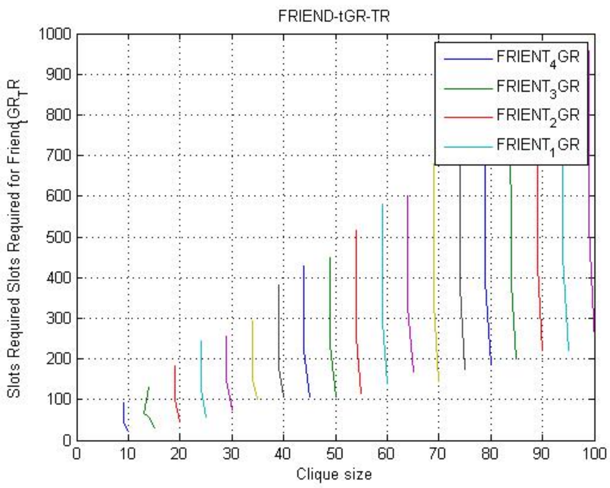
Identifying Node Neighbors
Input: Gets the input as the number of nodes, node id and the Transmission Range.
Output: Number of neighboring nodes with respect to the node Id.


START
Clique size = 10
Initial settings:For node
Message_Send (MS_Send) = 0
Message_Recieve(MS_Recieve) = 0 for other nodes.
The above information is used for GR time
Message_Send (MD_Send) = 0
Message_Recieve(MD_Recieve) = 0 for other nodes. (used for TR Time)
And set the other probabilities.
Generate rand values for the MS_Send and MS_Recieve and set the time for GR
NO
Check if the rand value = prob_send_ms
YES
GR TI ME
1. Check if node has not received any message from other nodes..
2. Set the probability of send message during the TR is 1.
Check if node A has not received any msg from other nodes
Set the node is silent with its probability
Set the probability to 0.5

Expected Result.







V. Conclusion

In this paper, we proposed a pre-handshaking neighbor discovery protocol FRIEND by adding pre-handshaking subslots before the traditional slots. Furthermore, we applied the full duplex technology and used it to conduct pre-handshaking with new feedback mechanisms. We analyzed the expected value and upper bound of ND processing time theoretically, and validated our analysis by simulation compared with the ALOHA-like protocol proposed in [4]. Both theoretical analysis and simulations proved that FRIEND significantly decreases the time needed to finish the ND process. Furthermore, we discussed some implementation issues and extensions of FRIEND, and showed that the half duplex counterpart of FRIEND, i.e., HD-FRIEND, also significantly decreases time consumption.

In the future, we would like to evaluate the performance of FRIEND by test-bed experiments. We also want to consider more realistic models, e.g., nodes with multipacket reception techniques, nodes with low duty cycles and asynchronous models.

References

[1] S. A. Borbash, A. Ephremides, and M. J. McGlynn. “An Asynchronous Neighbor Discovery Algorithm for Wireless Sensor Networks”. Elsevier Ad Hoc Networks, 5(7): 998-1016, 2007.

[2] L. You, Z. Yuan, P. Yang, and G. Chen. “ALOHA-Like Neighbor Discovery in Low-Duty-Cycle Wireless Sensor Networks”. In Proc. of IEEE WCNC, 749-754, 2011.

[3] X. An, R. Venkatesha Prasad, and I. Niemegeers. “Impact of Antenna Pattern and Link Model on Directional Neighbor Discovery in 60 GHz Networks”. In IEEE TWC, (10)5:1435-1447, 2011.

[4] R. Cohen and B. Kapchits. “Continuous Neighbor Discovery in Asynchronous Sensor Networks”. In IEEE TON, (19)1:69-79, 2011.

[5] A. Keshavarzian and E. Uysal-Biyikoglu. “Energy-Efficient Link Assessment in Wireless Sensor Networks”. In Proc. of IEEE INFOCOM, 2004.

[6] D. Angelosante, E. Biglieri, and M. Lops. “Neighbor Discovery in Wireless Networks: A Multiuser-Detection Approach”. In Information Theory and Applications Workshop, 46-53, 2007.

[7] Z. Zhang and B. L., “Neighbor Discovery in Mobile Ad Hoc Self-Configuring Networks with Directional Antennas: Algorithms and Comparisons”. In IEEE TWC, (7)5:1540-1549, 2008.

[8] N. Karowski, A. Viana, and A. Wolisz. “Optimized Asynchronous Multi-Channel Neighbor Discovery”. In IEEE INFOCOM, 2011.

[9] G. Jakllari, W. Luo, and V. Krishnamurthy. “An Integrated Neighbor Discovery and MAC Protocol for Ad Hoc Networks Using Directional Antennas”. In IEEE TWC, 2007.

[10] S. Vasudevan, D. Towsley, D. Goeckel, and R. Khalili. “Neighbor Discovery in Wireless Networks and the Coupon Collector’s Problem”. In Proc. of ACM MobiCom, 181-192, 2009.

[11] W. Zeng, X. Chen, A. Russell, S. Vasudevan, B. Wang, and W. Wei. “Neighbor Discovery in Wireless Networks with Multipacket Reception”. In Proc. of ACM MobiHoc, 3:1-10, 2011.