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Analyzing Reliability And Flooding Mechanism In Multi-Hop Wireless Networks

J.S.Ashwin[1], D.Vani[2], Dr. P.Siva Perumal[3], S. Satish Kumar[4]

[1,4,3]Assistant Professor, Department of Electrical and Electronics Engineering, AMET Deemed to be University, Chennai
[2]Assistant Professor, Department of Electronics and communication Engineering, SVCET, Chittoor.

Email: [1]ashwin.js@ametuniv.ac.in, [2]dvani@svcet.in, [3]sivaperumal@ametuniv.ac.in, [4]satishkumar.s@ametuniv.ac.in

ABSTRACT: A wireless multi-hop network is made up of seamlessly operating nodes that function together either to monitor an application field from a remote location or perform communication. To obtain the routes to the destination, generally, the route request messages are flooded across the network. Not all RREQs are replied with a route reply, which indicates the number of wasted RREQ and RREP messages. All wireless nodes inform about various conditions at the sensing field to the control station through multi-hop routing because of the random deployment of nodes in the sensing field. In this paper, we analyse the Reliability and Flooding mechanism Algorithm for a Wireless multi-hop network that improves the reliability while flooding control messages in the system and also performs an authentication check while routing data. The performance of RCF is compared with the Reliability Aware Flooding Algorithm using simulations in the network simulator.

Keywords: Wireless multi-hop networks, flooding, latency, packet delivery rate, reliability.

1. INTRODUCTION

Wireless Sensor Networks (WSNs) have found a deep place in the emerging technological advancements and are used in incredible application areas [1, 2]. It is hardly possible to perform direct communication in wireless sensor networks where the nodes are deployed randomly in a vast sensing field. Wireless multi-hop communication is one of the most excellent reasons why wireless connection has dramatically advanced serving in an extensive range of applications. Some multi-hop communication protocols have evolved for the communication among the nodes in the wireless sensor networks like Ad hoc On-Demand Distance Vector Routing (AODV) [3] and Dynamic Source Routing (DSR) [4] which work in a reactive way for providing multi-hop routes in a WSN. Since both the protocols use flooding for route discovery and maintenance, a protocol to control flooding was proposed by Robust Broadcast Propagation (RBP) [5], which suggests reliability improvement by retransmission of messages. An optimised flooding protocol called the Reliability Aware Flooding Algorithm [RAFA] was proposed [6].

Although the RAFA algorithm uses the expected reliability comparison to reduce the number of retransmissions, there is the need for accuracy in reliability estimation. In this paper, we analyse the Reliability and Flooding mechanism in Multi-hop Wireless Networks. There are two main contributions in this article, a reliability analysis and flooding mechanism scheme to predict reliability accurately and hence control retransmissions.

Cooperative transmission [8], [9], [10], [11], [12] using Opportunistic Large Arrays (OLA) [13] in wireless ad hoc networks adapts techniques from phased array antennas, in which the same signal is fed to different antennas with a different phase. In phased array antennas, this results in interference being constructive in specific directions and destructive in others, giving the ability to steer the signal electronically. In cooperative transmission, the goal is to have different transmitters send the same message, and the ether itself is the only medium through which various nodes can coordinate. Because of this, it is hard to accomplish synchronisation at the phase level, and relative phases from different transmitters are random. This leads to intensification in some directions, and destructive interference in others and these trends may change over time as relative phases shift.

To summarise this in networking terms, broadcasting using OLAs, which in this paper will be referred to as Collaborative Diversity Broadcasting or CDB, has the following benefits [14]:

- lower latency due to fewer hops
- lower latency due to not needing a random jitter to avoid collisions
- fewer lost packets due to fewer accidents and no self-interference
- better connectivity due to longer flights.

The last property is particularly useful in an ad hoc wireless network and has been studied in some detail by Krohn et al. [15], but will not be further considered here except when remarking on the asymmetry of the communications.

2. RELATED WORK

3.1 Flooding Mechanism in AODV

In [7] Ad-hoc on-demand distance vector routing (AODV), the source node that wishes to send data to any destination node will send a request message (RREQ) to all adjacent nodes. These neighbouring nodes in turn reply with a reply message (RREP) that is sent back to the node depending on the liveliness of the RREP word with the availability of routes. This is the reactive route discovery process in the network. Although only non-duplicate RREQs are replied with the RREP, there are still RREQ and RREP messages that are sent in vain which reduce the network performance because of the high amount of overhead in the network. Route maintenance process is performed by sending a route error message (RERR) which is only an indication of the failure of data delivery due to broken links somewhere on the way to the destination. This will just initiate another route discovery process from the source, which again does not help in providing efficiency while flooding.

3.2 Flooding Mechanism in DSR

The RREQ propagation is similar to that of AODV, and hence the number of wasted RREQs is higher in DSR as well. The RREP propagation, however, is optimised by sending the route information from the cache memory if any are available. Although the number of RREPs is reduced in the route reply, still a right amount of RREQ messages are flooded across the network. Another disadvantage of this mechanism is that the routes provided by the cache memory are sometimes outdated and are not very efficient.

3.3 Flooding Mechanism in RAFA

Reliability-Aware Flooding Algorithm (RAFA) estimates the expected reliability using two-hop topology knowledge. This information is used to decide whether to perform retransmission of a packet or not. A scheduled reliability is compared with the achieved reliability to make this decision.

The Expected Reliability *ER*A is calculated from the link quality L_{ai} and the individual expected reliabilities (ER_a) of the immediate neighbours in the neighbour list NL_i using the equation 1.

$$ER_i = 1 - \prod_{\forall a \in NL_i} (1 - L_{ai}.ER_a) \qquad (1)$$

The main disadvantage of this scheme is that the reliability estimation is predictive and does not consider the previously achieved reliability.

3. PROPOSED METHOD

As explained earlier two contributions of this article are: 1) Reliability Check Flooding Algorithm and 2) A novel single hop authentication technique for data communication. The overall architecture of the work proposed in this paper is illustrated in figure 1.

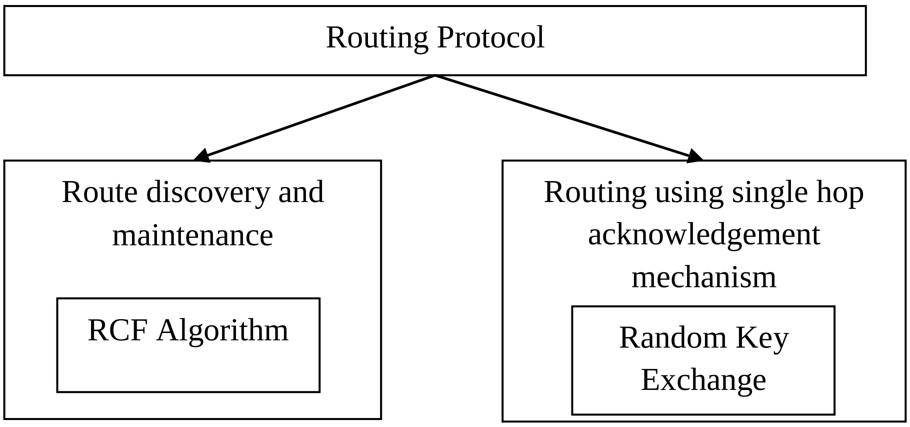

Figure 1. The architecture of proposed work.

The expected and target reliability is calculated similar to the RAFA [5], but a new condition for evaluation of retransmission is proposed here. The new reliability check scheme estimates the minimum expected reliability and the previously obtained reliability with the target reliability to decide whether a RREQ needs to be retransmitted or not.

The achieved reliability between two current nodes has an impact on the next few transmissions through the same nodes. Hence the safety executed during one flooding operation would impact the following flooding operations. Since flooding of RREQs and RREPs take place for every communication requirement, it is essential to include previous reliability achieved by a node for successive transmissions. The achiever reliability (AR) and Predicted Reliability (PR) are shown in the equations 2 and 3.

$$AR\ (a,i) = [PRR(RREQ_a)+PRR(RREP_i)].LQ_{ai} \qquad (2)$$
$$PR\ (a,i) = \sum (AR_{ai}*W)+ER_{ai} \qquad (3)$$

Where W is a weight that shows how much the previously achieved reliability matters to the present predicted reliability estimation. For our simulation W has been fixed to 0.5 with an assumption that the previous reliability has at least 50% impact on the next predicted reliability.

The algorithm for the reliability check flooding algorithm is shown below:

Line No	Algorithm
1	LQ_{ai} ← Link Quality between *a* and *i*
2	ER_{ai} ← Expected Reliability of *a* while RREQ
3	AR_{ai} ← Achieved Reliability of *a* while RREP
4	For (i=0 to n) {
5	Estimate Predicted Reliability PR_{ai}
6	If PR_{ai} < Target Reliability {
7	Retransmission
8	}
9	}

The RCF mechanism is a simple and straightforward mechanism used to limit retransmission methods. Link quality is obtained from the MAC layer of the network.

4.1 Single Hop Acknowledgement method

For every communication, hop-by-hop authentication and acknowledgement are proposed. The authentication is performed using cryptographic key generation. The authentication is performed according to (4), which produces a random key using the energy and distance between the nodes. The route request is sent by any node in the network, and it receives a reply with an energy field included in the RREP.

$$K= \log10(\text{current energy} * \text{distance from BS}) \qquad (4)$$

The value K is given as one of the authentication factors in the network. By verifying K, the node starts sending data to the node in a hop by hop manner until the entire data reaches the destination.

4. PERFORMANCE EVALUATION

To evaluate the proposed scheme with the existing RAFA method, simulations of the RCF against the RAFA algorithm are performed using the network simulator. The routing protocol used is user datagram protocol. Constant bit rate is used in data transmission.

5. CONCLUSION

A method to improve reliability during flooding is proposed in this paper for better operation of multi-hop networks. All nodes flood the RREQ and RREP messages depending on the predicted reliability in each node. Although RAFA has controlled flooding and reduced retransmissions, the expected reliability estimation accuracy is low. Hence, the proposed RCF algorithm has used the previously achieved reliability to estimate the predicted reliability instead accurately. The check operation performed while routing data uses a different random key for authentication which improves data reliability as well. This has improved the packet delivery and reduced latency which means that the security is increased. Further work can extend RCF into other hybrid multi-hop networks as well.

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