Enhanced DESYNC-TDMA Algorithm for Efficient Packet Delivery in Distributed MANETs

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ABSTRACT
In MANET environments, resource sharing among nodes will be one of the problems to be solved. To solve the problems, the desynchronization algorithm, called DESYNC-TDMA, has been proposed as a variation of firefly-inspired algorithm. However, it has still problems of slow convergence and resource wastes as the number of nodes increases. In this paper, we propose an enhanced DESYNC-TDMA not only to reduce the convergence time, but also to enhance the packet delivery efficiency. The effectiveness of the proposed method has been shown by implementing the method using OPNET simulator.

Categories and Subject Descriptors
C.2.1 [**Computer Communication Networks**]: Network Architecture and Design – *Distributed networks*

General Terms
Algorithm, Design, Performance

Keywords
Desynchronization, self-organizing, MANET, Medium Access Control, TDMA, resource scheduling

1. INTRODUCTION
Mobile ad hoc networks (MANETs) will play a significant role in communication networks without the help of fixed infrastructure, which require self-organizing, self-maintaining, and self-healing capabilities even while nodes are moving. It is expected that numerous number of nodes are distributed and involved in communications in MANET environments.

In such MANET environments, resource sharing among nodes will be one of the problems to be solved. Contention based resource sharing schemes adapting IEEE 802.11 distributed coordination function (DCF) wasted much bandwidth to avoid collisions, which degraded the quality of packet delivery. Time division multiple access (TDMA)-based methods assign dedicated slots to each node, but finding effective ways for slot assignments is still challenging problem to deploy TDMA-based schemes in MANETs. Fixed slot assignments can provide simple operational architectures, have been proposed. However, they require central agents to schedule slot assignments and have still bandwidth waste problem when no data is sent in assigned slots. In dynamic slot assignment schemes [1][2][3] in MANET, only nodes that have data to send reserve slots adaptively without central agents to control them, and hence the bandwidth waste problem can be solved. However, in most of dynamic slot assignment schemes, synchronization issues, that is the most important problem in distributed TDMA-based networks, when there are a lot of nodes in the networks, have been ignored.

Recently, researches inspired by nature such as ant colony, bee, or firefly have been carried out to apply to MANETs with numerous nodes. Among those, the desynchronization algorithm, called DESYNC-TDMA [4][5], has been proposed as a variation of firefly-inspired algorithm, which evenly distributes all *fires* and makes it reference time of each node. In DESYNC-TDMA, each node adjusts its firing time using pulse-coupled oscillation (PCO) mechanism, by reflecting neighbors' firing times. However, though DESYNC-TDMA provides a simple concept of self-synchronization in a distributed sensor networks, it is not suitable to apply to large-scale MANET environment, which incorporates numerous nodes, directly. Since all nodes *must* participate in the *firing process* to have slots and even nodes that don't have data to send also take part into the *firing process*, which result in severe waste of resource.

In this paper, we propose an enhanced DESYNC-TDMA for MANETs, which not only reduces the convergence time to desynchronization state, but also enhances the packet delivery efficiency.

The rest of the paper is organized as follows. Section 2 briefly describes DESYNC-TDMA. Section 3 and 4 present the proposed algorithm, and its experimental results, respectively. Finally, Section 5 concludes the paper.

2. DESYNC-TDMA [4][5] Overview
DESYNC-TDMA has been inspired by firefly, and proposed for sensor networks to synchronize each node's transmission time with others. DESYNC-TDMA uses PCO mechanism to adjust firing time of each node. Every node *fires* at its firing time in a cycle, which is calculated in a distributed way as a midpoint between firing times of its adjacent neighbor nodes in the previous cycle. Then the slots for the node to transmit its data in the cycle are determined using the firing time information of it as well as its neighbors.

The DESYNC-TDMA is surely good for operating in wireless sensor networks, and has advantages from the viewpoints of fairness to slot assignments in full saturated traffic loads. However, it has the following basic problem to be used in large-

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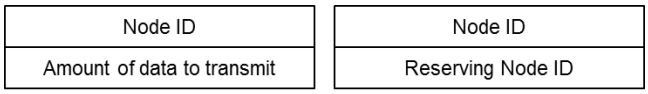
scale MANET environments directly. That is, all nodes participate into the *firing process* even though they have no data to send. It causes too slow convergence time entering the desynchronization state as well as the waste of the slots when they are assigned to nodes that have no data to send. As the number of nodes increases, the problem becomes much more severe.

3. ENHANCED DESYNC-TDMA

The enhanced DESYNC-TDMA classifies the state of a node into active or passive according to the situation whether it has data to send or not, respectively.



(a) *Fire* (b) *Reserving Fire*

Figure 1. Message formats of enhanced DESYNC-TDMA

Only nodes in active states can have slots to transmit data, which enhances the packet delivery performances. In every cycle, an active node notifies its amount of remaining data to send within its *fire* message, which is used to notify its usage plan of slots. We extended the *fire* message from the one of DESYNC-TDMA as shown in Figure 1(a). With the *fire* messages exchanged in a cycle, all nodes can construct the map of the *fires*, and can acknowledge which nodes will end the transmissions in a given cycle.

When a passive node has messages to transmit, it needs to find an appropriate time to send its *Reserving fire* message, as shown in Figure 1(b), to participate into the *firing process* after the *reserved slot* is released. By overhearing the information of active nodes' amounts of remaining data included in their *fire* messages, it can make a history of *firing* of all active nodes.

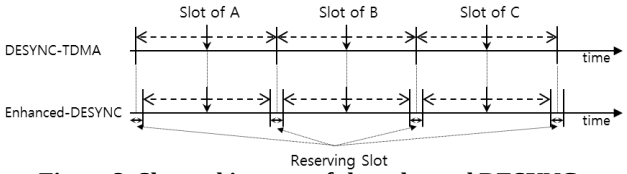


Figure 2. Slot architecture of the enhanced DESYNC-TDMA with comparison of DESYNC-TDMA

In order for passive nodes to join the *firing process*, we introduce a very short *reserving slot* at the end of each slot as shown in Figure 2. The *reserving slots* are used not to disturb the transmission of other active nodes when passive nodes are newly joining the *firing process*. All active and passive nodes calculate the slots it can use as following:

$$slot_{start} = T + (fire(t-1) + fire(t))/2 + (slot_{resrv}/2) \quad (1)$$

$$slot_{end} = T + (fire(t+1) + fire(t))/2 - (slot_{resrv}/2) \quad (2)$$

where T is the period of a cycle, and $fire(t)$ denotes the active node's firing time. The $fire(t\text{-}1)$ and $fire(t\text{+}1)$ are firing times of the adjacent previous and next active nodes, respectively, and $slot_{resrv}$ refers the time duration of a *reserving slot*. Each active node can calculate the $slot_{start}$ and $slot_{end}$ time to use their slots.

4. EXPERIMENTAL RESULTS

We deploy 10 to 100 nodes in the network, and some ratio of the nodes, p is the ratio of the active nodes to total nodes, only can generate saturated traffic to show the efficiency of our proposed scheme. The original DESYNC-TDMA assigned bandwidth evenly and their overhead is equal to the ratio of passive nodes. (i.e. 90% overhead for p=0.1, 50% for p=0.5, and 30% for p=0.7) However, our scheme can utilize bandwidth fully except *reserving slot*, and the overhead is much lower than original one, which is shown in Figure 3.

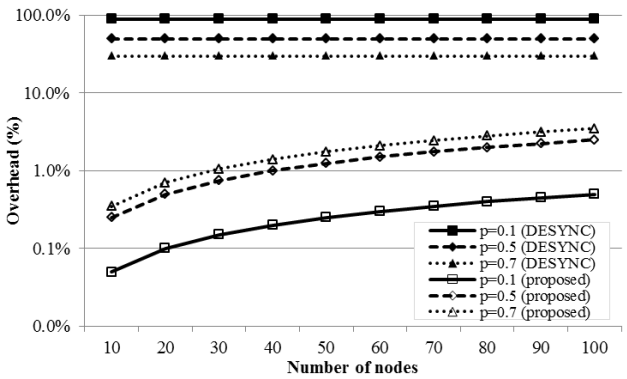


Figure 3. Protocol overhead vs number of nodes varying ratio to number of active nodes

5. CONCLUSION

In this paper, we proposed an enhanced DESYNC-TDMA for large-scale MANETs. As mentioned, the traditional DESYNC-TDMA has severe problem on slow convergence and waste of resources. The proposed method solved the problem that DESYNC-TDMA by participating only active nodes into the *firing process*. It is expected that the proposed method can apply very large-scale sensor networks as well as MANETs.

6. ACKNOWLEDGMENTS

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