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# Token-MAC: Inactive RFID Systems for A light MAC Protocol

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**Abstract- Passive RFID systems used for list organization and benefit tracking normally use contention-based MAC protocols, such as the normal C1G2 protocol. Although the C1G2 protocol has the benefit that it is easy to apply, it suffers from wrongness and relatively low throughput when the number of tags in the network increases. It proposes a token-based MAC protocol called Token-MAC for passive RFID systems, which aims a) to provide a fair chance for tags in the network to access the average without requiring management of the tags, b) to increase the overall throughput, i.e., the tag rate, and c) to enable a high number of tags to be read under incomplete tag read time availability, which is an especially important challenge for mobile applications. We apply Token-MAC as well as C1G2 and a TDMA-based protocol using Intel WISP passive RFID tags and perform experiments. Additionally, based on our experimental results, we develop energy harvesting and communication models for tags that we then use in simulations of the three protocols. Our experimental and simulation results all show that Token-MAC can achieve a higher tag rate and better fairness than C1G2, and it can provide better performance over a longer range compared with the TDMA-based protocol. It is also shown that Token-MAC achieves much lower tag finding delay, particularly for high numbers of tags. Token-MAC is, therefore, a promising solution for passive RFID systems.**

**Keywords- Passive RFID, MAC protocol, C1G2 protocol.**

## I. INTRODUCTION

Radio-frequency identification (RFID) systems are broadly used for managing people and assets.RFID systems consist of RFID tags attached to the objects and RFID readers are used to read the RFID tags to identify the associated object. The RFID tags may be either active, using a battery to operate, or passive, using energy harvested from the reader to operate. The passive tags has the advantage of not requiring batteries, providing a near-infinite lifetime for the tags [1]. Tag rate, which represent the number of tags that can be read in a unit time, is an important metric in passive RFID systems [2], as it represents the possible throughput of the system. High throughput ensure the fast access of large number of tags in a short time, which can be crucial for application such as inventory tracking. The important metric for passive RFID systems is delay of time between when a new tag enter the read range of an RFID reader and the reader detects the new tag. This metric is particularly crucial when the mobile tags in the network or when the reader is mobile. If the reader requires a long time to detect a new tag, it is possible that those tags with the high velocity will be missed by the reader. RFID standards define mostly contention-based MAC protocols, where all tags compete with each other for the possibility to communicate with the reader. The widely used RFID protocol, ISO 18000-6C, also known as the Class 1 Generation 2 UHF Air Interface Protocol (C1G2 protocol) defines that tags compete to reply to the reader after they receive a Query command sent from the reader [3].

## II. RELATED WORK

Listen-Before-Talk[4] is a multiple access scheme which is based on CSMA, requiring all readers and tags to "listen" to the channel before transmitting data. If the channel is idle, then the reader begins reading tags, otherwise, reader waits for a certain amount of time. The carrier sensing do not solve the tag collision problem.

Simplot-ryl[5] et al. proposed a hybrid protocol which is used to solve the collision problem. The protocol is a TDMA-based algorithm and assumes that the number of tags is known in advance, since the algorithm allocates a slot for each tag based up on the number of tags. Protocol can lead to good presentation in a static RFID system.

Dong Wang proposed Reader Collision Problem (RCP) problems can be divided into two categories scheduling based approach and coverage based approach. As for the scheduling based approach, the available system resources, such as time and frequencies are allocated properly among readers to prevent readers from transmitting concurrently. This kind of approach can decrease the possibility of reader collisions efficiently, it requires the system to established and maintaining the information over the network, which will be time and energy consuming. N.Abramson developed a ALOHA protocol for radio system in the field of medium access control in computer network. The main aim of this protocol is simple and stated as follows. If a station transmits a message as soon as it is ready to do so. If any collision is occur at message transmittal in the case of local network, then the station perform a check by listening to channel the station wait for a random period before re-attempting more transmittal. The station make further attempts until it can transmits the entire message. The contention-based MAC protocol of C1G2 is based up on Framed Slotted ALOHA . Each frame has many number of slots, and each tag replies to a reader "Query" message in a arbitrarily selected slot. The number of slots in a frame is determined by the reader and can be varied on a per frame basis by announcing the number of slots in the Query message. When this protocols are used in a dense network, the collision probability is very high and the throughput is low. The C1G2 suffers from the capture effect, where one or more powerful tags may capture the channel and prevent the reader from receiving the replies from the weaker tags.

Kalinowski et al.[6] provide a simulation-based evaluation of round-based tag access algorithms such as polling or TDMA, and ALOHA-based algorithms. It shows that ALOHA does not work well in dense networks, and the round-based methods perform better. The evaluation assumes that the energy of the tags is enough for continuous operation. RFID MAC protocols mainly focus on anti-collision strategies for multi-reader scenarios.

Birari et al[7]. proposed the PUSLE protocol for RFID networks to reduce the collisions of readers when more readers are located in the same area. The Multi-Channel MAC Protocol proposed by Dai et al. also focused on the communication method between readers. These protocols deal with the fairness aspect of multi-reader RFID systems. To the best of our knowledge, our approach is the first protocol that focuses on the fairness between RFID tags.

## III. THE TOKEN-MAC PROTOCOL

Tokens represents permission to the reader for a tag to send data. The number of tokens in a tag holds to represents the number of packets that the tag is allowed to send to the reader. The protocol ensures that the reader properly allocates tokens to different tags according to the changes in the system . The C1G2 protocol, Token-MAC divides the time into "Query" rounds, as illustrated in Fig. 1. In each Query round, the reader access one particular tag through a set of Query-Response exchanges. Query rounds are grouped into "Inventory" rounds, throughout which the reader access every tag that is known to the reader.

### a) Tokens

There are two types of tokens in Token-MAC: allocated tokens and random tokens. Allocated tokens are distributed by "Token" commands via reader. The reader allocates tokens to tags such that tags with lower historical success rates are assigned more tokens so that they have more chances to access the channel in the next round. The fairness of the medium access is improved. Random tokens are produced by tags themselves. The purpose of the random tokens is to give the permission to respond to the reader tags when the reader sends "Query" commands to other tags.

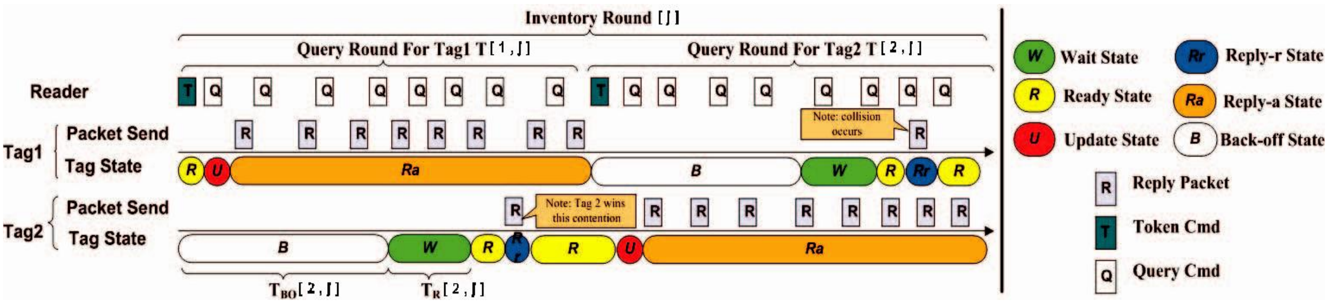



Fig. 1. Illustration of the operation of the Token-MAC protocol.

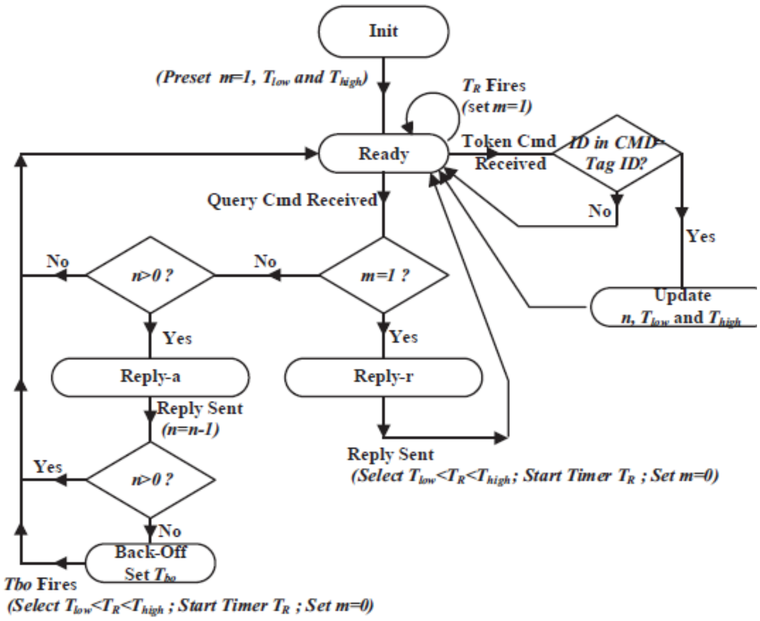



Fig. 2. Tag operation flowchart.

### b) Tag Operation

Tags running Token-MAC follows the flowchart shown in Fig. 2. Each tag has two sets of tokens: m represent the number of random tokens and n represent the number of tokens allocated. The tag begins its operation in the initial state. In this state, the tag sets its internal parameters Tlow and Thigh to defaulting values, and sets m = 1 so the tag has a random token. Then tag enters to the ready state, where reader waited to receive packets . There are two types of packets in the ready state which can be received by a tag: "Token" packets and "Query" packets. When a tag receive a Token packet, is not in the intended destination. Then tag goes back to the ready state. If the tag is the intended destination of the Token packet, the tag transitions to the update state, where it updates its allocated tokens, n, as well as the other parameters Tlow, Thigh, and TBO, as specified in the Token packet. These parameter are set by the reader based on the tag density. After updating its own internal parameters accordingly, the tag goes back to the ready state.

### c) Reader Operation

In Token-MAC, the RFID reader has the following responsibilities: tag list maintenance, token allocation, tag parameter settings, and reader parameter settings. The reader maintains a tag list that which specifies all known tags currently in the range of the reader. New tags are added to the list when the reader receives a Reply packet that contains a tag ID which does not exist in the current tag list. Tags that are not longer available, determine through lack of response from the tag for a timeout period, are removed from the list. The amount of time required to wait before removing a tag from the tag list represents the trade-off between the waiting for a tag that is low in energy and it should still be accessed and continuously trying to read a tag that has left in the network.

## IV. Energy Harvesting And Communication Models For The Simulation Framework

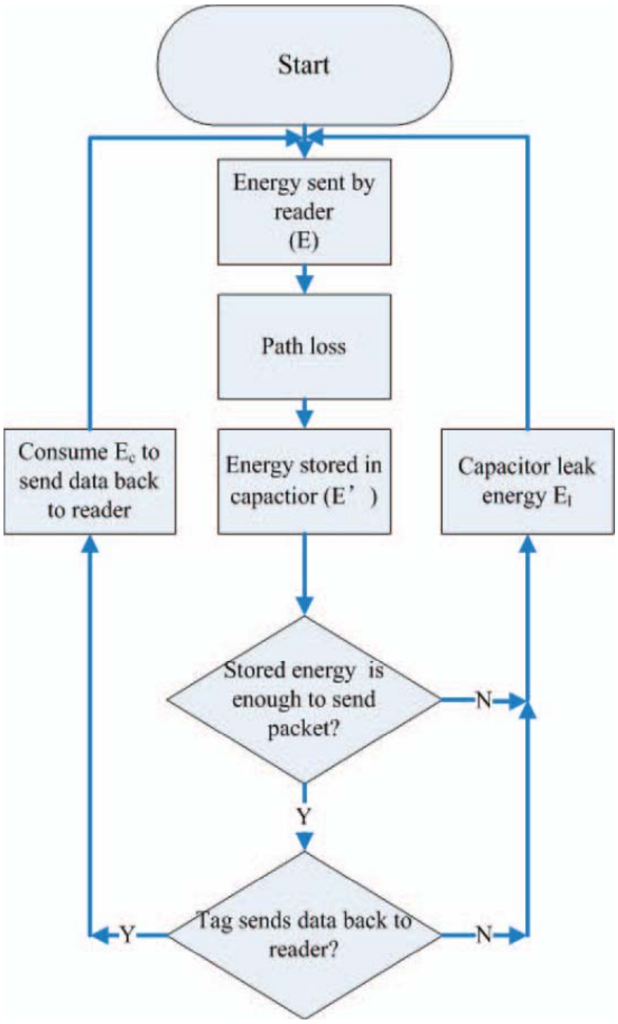
We are imperfect in our test-bed to the four WISP nodes to which we are currently having to access in order to additional explore the performance of Token-MAC in relation to C1G2 and the TDMA protocol, we implemented the three protocols to conduct extensive simulation evaluations in order to make the simulations as sensible as possible, we devised energy harvesting and communication models based on the experimental results, which are used in the simulations. First the physical characteristics of our hardware platforms by measuring the amount of energy harvested by the tags and creating an energy harvesting model.

### a. Energy Harvesting Model

The assumptions for the energy harvesting model is First, we assume that the amount of energy that which is sent from the reader in a unit time is a constant *E*. Tags at the same distance received an equal amount of energy, with the *E* times the path loss. We assume the path loss in the free-space path loss formula. Also, we assumed that the amount of energy that which is stored in the capacitor of a tag is the energy-saving efficiency, *Q*, times the energy which is received by the tag. As we will see, the assumptions are very close to the real scenario. The energy that can be stored by the tag is thus

$$E` = E \times Q \times \lambda / R2 ,$$

where $E`$ is the total amount of energy that is stored by the capacitor on the tag per unit time, $R$ is the distance from the reader to the tag, and $\lambda$ is a weight parameter. In our simulations, each RFID tag is assigned




### b. Communication Model

We use the energy harvesting model as a fundamental tool to build the communication model. we represent the channel using the free space model. The free space model is based on the transmission model of sending one bit of data. The C1G2 protocol is based on the modulation method, which uses double side-band, amplitude shift keying (DSB-ASK) as the modulation method to modulate a bit of data and send it through the channel.

### c. Simulation Model Validation

We implemented the Token-MAC, C1G2 and TDMA protocols using our simulation model, and we compared the results with the experimental results in terms of tag rate. our energy harvesting and communication models and use these to explore the behavior of the protocols with a larger number of tags.

## CONCLUSION

MAC protocol to improve the fairness and throughput performance of RFID systems compared with existing protocols. We compare the performance of Token-MAC with the standard C1G2 protocol as well as a TDMA protocol using both small-scale implementation experiments and larger-scale simulations. The results of the experiments and the simulations show that Token-MAC can provide higher tag rates, better fairness, and much shorter delay to detect an entering tag compared with C1G2.

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