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Instant collision resolution for tag identification in RFID networks

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Abstract

In this paper, we approach the problem of identifying a set of objects in an RFID network. We propose a modified version of Slotted Aloha protocol to reduce the number of transmission collisions. All tags select a slot to transmit their ID by generating a random number. If there is a collision in a slot, the reader broadcasts the next identification request only to tags which collided in that slot. Besides, we present an extensive comparative evaluation of collision resolution protocols for tag identification problem in RFID networks. After a quick survey of the best performing RFID tag identification protocols, both deterministic and probabilistic, we present the outcome of intensive simulation experiments set up to evaluate several metrics, such as the total delay of identification process and the bit complexity of reader and tags. The last metric is strictly related to energy constraints required by an RFID system. The experiments point out that our protocol outperform all the other protocols in most cases, and matches them in the others.

Keywords: Radio frequency identification networks; Collision resolution; Medium access control; Aloha-based protocols; Tree-based protocols

1. Introduction

Fast and reliable identification of multiple objects that are present at the same time is very important in many applications. A very promising technology for this purpose is radio frequency identification (RFID), which is fast pervading many application fields, like public transportation and ticketing, access control, production control, animal identification, localization of objects and people. An RFID system consists of radio frequency (RF) tags attached to objects that need to be identified and one or more networked electromagnetic readers. The great appeal of RFID technology is that it allows information to be stored and read without requiring either contact or a line of sight between the tag and the reader. For this contact-less feature, RFID technology is an attractive alternative to bar code in the distribution industry and supply chain, since it can hold more data.

In RFID systems, tags can be active or passive. Active tags have storage capabilities and are provided with power sources for computing and

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transmitting data. Due to the complexity and cost of mounting a power source onto a tag, active tags are not practical for use with disposable consumer products. Passive tags instead rely only on RF energy induced by the electromagnetic waves emitted by the reader, and can have limited storage functionality. In a typical communication sequence, the reader emits a continuous radio frequency wave. When a tag enters in the RF field of the reader, it receives energy from the field, for modulating the signal according to its stored data. Due to more advanced protocols and circuit design development, the reliability and the read range of passive RFID networks continue to improve, and their cost continue to decrease, which leads to an increase of passive tags applications.

A very important issue in RFID systems with passive tags, is complexity, and computing and transmitting capacity of tags in the identification process. The reader, containing internal storage capacity and processing power, broadcasts a request message to tags asking for the unique tag ID, or detailed information saved in them. After receiving this message, all or some tags send their response back to the reader. If only one tag answers, the reader receives just one message which is correctly decoded. If two or more tags answer, their messages will collide on the RF communication channel and cannot be correctly received by the reader. An effective system must avoid, or at least limit, these collisions by using anti-collision protocols in the identification process. In this paper, we present a new protocol for limiting such collisions, and evaluate the complexity of reader and tags required by our and several different tag identification protocols. The evaluation is about communication complexity in terms of number of reader queries and bits sent by reader and tags. Another commonly used metric that we evaluate is the number of time units needed to identify all tags, that is strictly related to delay of the identification process. This evaluation is very useful when designing an RFID system to foresee energy constraints and resource requirements.

Thus, a very important issue in RFID applications is the fast and reliable identification of multiple tagged objects simultaneously, assuming that the exact number of tags is not known in advance. This is a special case of multiple access communication problem that has been studied extensively in the past. The solution to this problem is given by different collision resolution protocols [1]. However, in RFID applications, the problem is more challenging and complex, because of the memory and energy constraints of tags [2–7]. We do not assume that passive tags can have sensing capabilities to detect collision, or that they can communicate with other tags directly, since such assumptions are not realistic. In [3] tags are assumed to have collisions detection capability, which implies a more expensive and power consuming hardware. In that paper, it is also assumed that the reader knows the exact number of tags to be identified. These assumptions help in solving the collision problem in tag identification process but are not realistic. The purpose of this paper is twofold: We present a new tags identification protocol, and we compare the performance of the best performing protocols presented so far. This last aspect of the paper is very useful since no such comparison has ever been made. When a new protocol has been proposed, it has been compared with at most one other protocol. As we shall see in the paper, the results of our comparison substantially confirm the performances that were originally presented along with the protocols.

The paper is organized as follows. In Section 2, we survey the main known protocols for the tag identification problem, with more details for the behavior of those selected to be evaluated (by means of simulation trials) in this paper. In Section 3, we describe our approach, by highlighting the assumptions we made. In Section 4 we present simulation setting, while in Section 5 we show the results of our simulative evaluation. In Section 6, conclusion and future work complete the paper.

2. Related work

As usual in medium access control problems, the proposed protocols for collision resolution in RFID systems are either *probabilistic* and *deterministic*. The first ones are *Aloha-based* protocols, the last ones are *Tree-based* protocols. There are also hybrid approaches, where randomization is applied in tree schemes [3,8].

In Slotted Aloha-based-identification protocols, the time is assumed to be slotted and all tags have a local clock for synchronization. A time slot is a time interval in which tags transmit their serial number or a detailed information saved in them. A read cycle is a tag identifying process that consists of a frame. A frame is a time interval between requests of a reader and consists of a number of slots. Each tag transmits its serial number to the reader in a slot