Introduction to Anti-Collision Algorithms and Estimation Methods in RFID Systems

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Introduction to Anti-Collision Algorithms and Estimation Methods in RFID Systems

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Abstract:

The main objective of Radio Frequency Identification (RFID) systems is to provide fast identification for tagged objects. The noteworthy advantage of RFID technology, is its capability to identify objects simultaneously. However, when radio frequency signals are emitted simultaneously, there is a probability of collision occurrence, and thereby resulting in a waste of resources. Collision is a time-consuming event that reduces the performance of RFID systems. Consequently, several anti-collision algorithms have been proposed in the literature, attempt to decrease the collision occurrence probability. In almost all the existing anti-collision algorithms, a prior knowledge of the number of tags has a significant role in the efficiency of the algorithms. Since the real number of tags is unknown, it needs to be estimated. Therefore, the more accurate estimation method results in more efficient identification process. Although, there are some proposed estimation methods in previous researches, almost all of them suffer from either the low accuracy level or high computational complexity. Moreover, most of the existing estimation methods assume the reader and tags communication channel as an error free channel. Hence, in the real communication environment, which is error-prone, their results are not trustworthy. In this presentation we will focus on a general introduction for Anti-Collision algorithms and tag estimation methods to present the advantages and disadvantages of existing methods.

Keywords: RFID, Anti-Collision algorithms, Tag Estimation Methods
Introduction to RFID

Definition

Introduction:

Radio Frequency Identification (RFID) is an automated data capture technology that can be used to electronically identify, track, and store information contained on a tag that is attached to or embedded in an object, such as a product, case or pallet. - May 2005, US Government Accountability Office.
Components

**Tags**
- Transponder device made of an electronic circuit (chip) and integrated antenna
- RF used to transfer data between tag & antenna
- Portable memory
- Active or passive
- Disposable or Reusable
- Read-only or read/write
- Packaged in a number of form factors to accommodate environment

**Antenna**
- Transmits RF command signal to tags
- Provides energy via RF to passive tags
- Reads returned RF signal from tag

**Reader**
- Controls one or more Antennae
- Controls tag reading process, guarding against collision, misreads.
- Contains lowest level of business logic for tag types to read
- Receives commands from application software

**Host Computer**
- A device controlling PC, managing one or more readers.
- Contains some application logic to control reader operation
- Temporal storage of read data.
- Link to the Enterprise and Business Applications.
How does an RFID system work?

- **Tag or Transponder**
- **Antenna**
- **Reader or interrogator**
- **Reader’s signal**
- **Tag’s signal**
- **Computer**
# History of RFID

<table>
<thead>
<tr>
<th>DATA</th>
<th>OCCURRENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800s</td>
<td>Fundamentals of Electromagnetic</td>
</tr>
<tr>
<td>1896</td>
<td>Radio invented</td>
</tr>
<tr>
<td>1906</td>
<td>Radio continuous wave and radio signals transmission Generated</td>
</tr>
<tr>
<td>1935</td>
<td>Radar invented</td>
</tr>
<tr>
<td>1937</td>
<td>IFF System used in WWII</td>
</tr>
<tr>
<td>1950s</td>
<td>Commercial air traffic control system</td>
</tr>
<tr>
<td>1958</td>
<td>IC developed</td>
</tr>
<tr>
<td>1960s</td>
<td>Commercial activities started</td>
</tr>
<tr>
<td>1970s</td>
<td>Scientists, companies, universities, and government laboratories were intensively laboring on RFID</td>
</tr>
<tr>
<td>1980s</td>
<td>Use RFID for commercial purposes railroad cars and track animals</td>
</tr>
<tr>
<td>1990</td>
<td>Use of RFID in the wide scale on navigation system and toll collection</td>
</tr>
<tr>
<td>1992-1995</td>
<td>Contactless Smartcard  standard developed</td>
</tr>
<tr>
<td>1999</td>
<td>One of the first RFID books was wrote by Klavs Finkenzeller</td>
</tr>
<tr>
<td>1999</td>
<td>MIT Auto-ID center formed EPC developed</td>
</tr>
<tr>
<td>2000s</td>
<td>Spectrum in the 5.9 GHz band is dedicated by U.S. Federal Communications Commission (FCC) to develop the RFID systems.</td>
</tr>
<tr>
<td>2000s</td>
<td>This new generation of short-range communication system is standardized by Institute of Electrical and Electronics Engineers (IEEE).</td>
</tr>
<tr>
<td>2003</td>
<td>EPC global formed</td>
</tr>
</tbody>
</table>
## RFID Tag vs. Barcode

<table>
<thead>
<tr>
<th></th>
<th>RFID</th>
<th>Barcode</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Line of sight</strong></td>
<td>Not required</td>
<td>Required</td>
</tr>
<tr>
<td><strong>Reading distance</strong></td>
<td>From 1 mm to dozens of meters</td>
<td>Few centimeters</td>
</tr>
<tr>
<td><strong>Read rate</strong></td>
<td>Hundreds of tags can be read simultaneously</td>
<td>One at a time</td>
</tr>
<tr>
<td><strong>Dynamic updates</strong></td>
<td>Can be always updated</td>
<td>Static data</td>
</tr>
<tr>
<td><strong>Amount of data storage</strong></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Human assistance</strong></td>
<td>Virtually none</td>
<td>High</td>
</tr>
<tr>
<td><strong>Type of identification</strong></td>
<td>Can univocally identify each item</td>
<td>Can typically identify only the type of the item</td>
</tr>
<tr>
<td><strong>Counterfeiting</strong></td>
<td>Very difficult (using unique tag ID)</td>
<td>Quite simple</td>
</tr>
<tr>
<td><strong>Durability in harsh environment</strong></td>
<td>High (converted tags)</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Problems due to metals and liquids presence</strong></td>
<td>High for some types of tags</td>
<td>None</td>
</tr>
<tr>
<td><strong>Capability to be read when dirty</strong></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Event triggering</strong></td>
<td>Capable to trigger events such as door opening, alarms etc.</td>
<td>Not capable</td>
</tr>
<tr>
<td><strong>Public/ Reserved data storage</strong></td>
<td>Public and reserved</td>
<td>Only public</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>Higher</td>
<td>low</td>
</tr>
</tbody>
</table>
RFID Applications

- Animal Identification
- Anti-theft Systems
- Asset Management
- Anesthetic Doses
- Baggage Handling
- Blood Banks
- Manufacturing
- Food safety
- Gasoline Dispensing
- Hotel and Resorts
- Stores Management
- Medical Surgeries
- Mother Baby Pairing
- Museums
- National Identification
- Real Time Location Tracking System (RLTS)
- Supply Chain Management & Retailing
- Vehicle Identification
Motivation

The number of RFID tags in use

- 6.3 million (2005)
- 80 billion (2010)
- 10 trillion (2015)

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Barriers to Use

- Lack of Comprehensive Standards
- Security/ Privacy Problem
- Cost
- Collision Problem
In RFID systems, when two or more devices transmit their signals simultaneously, the signals would collide. These collided signals are unrecognizable and cannot be identified by the reader. Therefore when the collision happens, objects cannot be recognized and the identification process has to be repeated again.

Collision Problem
Tag Anti-collision Algorithms

- Deterministic algorithms
  - Tree-ALOHA Based
    - FSAPB
    - EBFS
    - QT-ALOHA
    - QOT
    - BST
  - Tree Based
    - Query Tree
      - IPA
      - PROT
      - KOT
      - QTAA
      - QT
    - Binary Tree
      - BSB
      - EBS
      - ID-BTS
      - ABS
      - IBT
      - BBT
      - DBT
      - BS

- ALOHA-Based
  - VEDFSA
  - DJ
  - IFSA
  - EDFSA
  - BDE
  - LDFSA
  - AFSA
  - TSA
  - DSA
  - BFSA
  - SA
  - BA
Tag Estimation Methods

Static Estimation
- Lower bound tag estimate
- Zhen tag estimate
- Maximum Throughput tag estimate
- Collision Ratio tag estimate
- Idle Slot tag estimate
- Cubic Spline Based tag estimate

Dynamic Estimation
- Chebyshev’s Inequality tag estimate
- Maximum a Posteriori (MAP) Estimate
- Zero Estimate
- Fast Zero Estimate
- Bayesian Tag Estimate
- Birthday Paradox Tag Estimate

Harald Vogt, 2002
Bin Zhen et al, 2005
J. R. Cha and J. H. Kim, 2005
J. R. Cha and J. H. Kim, 2005
G. Khandelwal et al, 2007
M. Shakiba et al, 2012
W. T. Chen, 2009
Y. Cui and Y. Zhao, 2010
Y. Cui and Y. Zhao, 2010
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M. Shakiba et al, 2014
Tag Estimation Methods

- Tag Estimation Methods
- Capture Effects
- Anti-Collision Algorithms
- Tag-Tag Anti-Collision Algorithms

- Tag-Tag Anti Collision Algorithms Used Tag Estimation Methods Considering Capture Effects
- Tag Estimation Methods Considering Capture Effects
- Anti Collision Algorithms Considering Capture Effects
- Tag-Tag Anti Collision Algorithms Considering Capture Effects
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References:


