RFID Study Report

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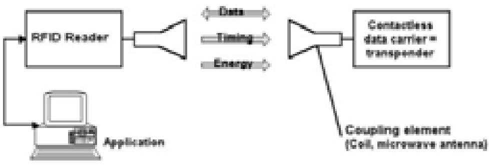
Existing RFID Applications

Introduction

- RFID system may include
  - Tags (passive, semi-active, active)
  - Readers
  - Data processing subsystems



http://RFID-Handbook.com

Tags

- Commercially available RFID tags

Enabling Ubiquitous Sensing with RFID, Roy Want, 2004 IEEE Computer pp 85

- RFID chips could be
  - Read only
  - Write-Once Read Many (WORM)
  - Read-Write
- Frequency
  - lower frequency means a lower read range, slower data read rate, but increased capabilities for reading near or through metal or liquid surfaces that distort radio waves.
  - LF : operate below 135 kHz, and have a read range of less than half of a meter
  - HF : operate at 13.56 MHz, and have a read range of one meter and transmit data faster than LF tags.
  - UHF : operate in a range between 860 - 940 MHz; read range is up to three meters away, and generally operate at greater speeds than HF tags.
  - 433.92MHz、2.45GHz and 5.8GHz are also available for used

Standards

- **ISO**
  - ISO 18000
    - Part 2, 125-135 kHz
    - Part 3, 13.56 MHz
    - Part 4, 2.45 GHz
    - Part 5, 5.8 GHz
    - Part 6, UHF (860-930 MHz, 433 MHz)
  - ISO 15418
    - MH10.8.2 Data Identifiers
    - EAN.UCC Application Identifiers
  - ISO 15434 - Syntax for High Capacity ADC Media
  - ISO 18047 - RFID Device Conformance Test Methods
  - ISO 18046 - RF Tag and Interrogator Performance Test Methods
  - ISO 15962 - Transfer Syntax

- EPC
  - EPC 1
    - **900 MHz Class 0 Radio Frequency (RF) Identification Tag Specification**
    - **13.56 MHz ISM Band Class 1 Radio Frequency (RF) Identification Tag Interface Specification**
    - **860MHz -- 930 MHz Class 1 Radio Frequency (RF) Identification Tag Radio Frequency & Logical Communication Interface Specification**
- EPCglobal : a joint venture between EAN/UCC and the MIT AutoID Center. The venture is charged with the commercialization of the Electronic Product Code and its support network
- The Electronic Product Code uses RFID tags, readers, Physical Markup Language (PML), and a database known as Savant for tracking items. The EPC Network could eventually allow manufacturers to uniquely identify every individual item they produce

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- EPC code
  - Extensible
  - 96 bits/ 64 bits

EPCglobal Taiwan, http://www.epcglobal.org.tw

- The next generation protocol only requires 13 bits for product id. The system must be collaborated with ECP network

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- Ubiquitous ID Center
  - The mission of the Ubiquitous ID Center is to establish and popularize the core technology for automatically identifying physical objects and locations and to establish the JISC standards for RFID in Japan
  - ucode: 128 bits long

  - Hitachi Ultra-small RFID Chip "μ-Chip", measuring 0.4mm square and 0.06mm thick

http://www.harmonious.jp/gl/service/demonstration/mu_chip.html

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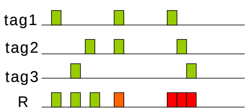
Research Issues

- Tag collision problem
- Reader collision problem
- Networked RFID
- RFID with sensing capability

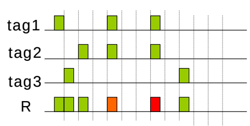
Tag Collision Protocol

- Tag transmission protocol mostly solve by TDMA methods
- Aloha

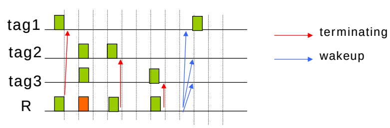


- Pure Aloha is not feasible for RFID
  - Time period during a frame is vulnerable to collision
  - Most RFID system has the inability to sense or detect the carrier
- Modification: Switch-off, Slow-down, or Carrier-sensed (super tag)

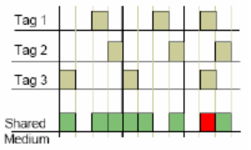
- Slotted Aloha



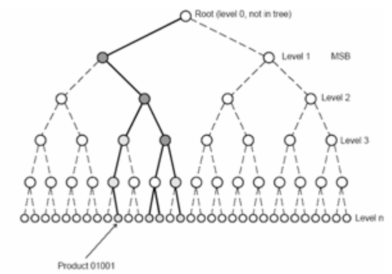
- Slotted Aloha with additional commands (terminating, wakeup)



- Frame Slotted Aloha
  - Each frame contain N slots
  - Every tag transmit once in every frame



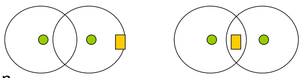
- Tree Algorithm
  - Each tag has globally unique identifier
  - If collision occurs, the reader successive bits of the ID field to make narrowed-down choice of the ID range. For example, tags will be divided into 2 groups: 0xxx, 1xxx



EPC 900 MHz Class 0 Radio Frequency (RF) Identification Tag Specification

Reader Collision Problem

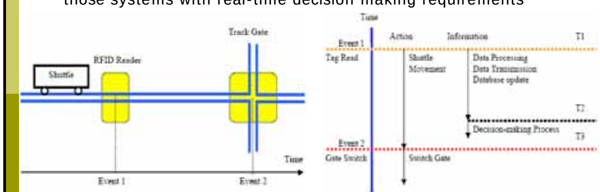
- [Engels, Sarma 02] Reader whose interrogation zones intersect or not intersect can interfere with one another's operation. Such interference is due to the use of radio frequencies for communication, and is similar to the interference experienced in cellular phone system. Such problem is described as a reader collision problem.



- TDMA solution
  - RTS/CTS
  - Variable power reader
- Distributed TDMA solution
  - [Waldrop, Engels, Sarma 03] Colorwave: An anti-collision algorithm for the reader collision problem

Networked RFID

- RFID application can applied in manufacturing automation systems, process control systems, advanced materials handling systems and supply chains. While the RFID technology could provide important identity and location information of items, it is predictable that RFID technology will eventually be integrated into those systems with real-time decision making requirements



http://www2.eng.cam.ac.uk/~ww250/index_files/nrtrfids.pdf

Networked RFID

- A networked RFID system generally comprises the following elements [McFarland 04]
  - A unique identification number which is assigned to a particular item
  - An identity tag that is attached to the item with a chip capable of storing - *at a minimum* - the unique identification number. The tag is capable of communicating this number electronically.
  - Networked RFID readers and data processing systems that are capable of collecting signals from multiple tags at high speed (100s per second) and of pre-processing this data in order to eliminate duplications, redundancies and misreads.
  - One or more networked databases that store the product information.
- MIT Auto ID lab defines the EPC Network try to be a Networked RFID system specification

RFID with Sensing Capability

- Power supply problems in traditional sensor network
  - Batteries
    - have life cycle, the mean time to replacement is one year or two.
    - The cost is still more than US $5/unit, with no clear commercial or technical solution that costs less than a dollar.
  - Ambient power scavenging
    - Reliance on ambient power constrains both where to place the sensors and when to use them.
    - Additional power-harvesting components increasing the cost as well

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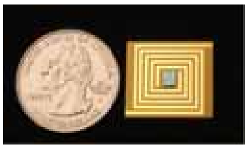
- The RFID reader extracts data from a register in an RFID tag can also be applied to collecting sensor-derived data.
- For passive tag, there are two challenges:
  - the sensor cannot use any power while the tag is not in communication with the reader
  - available energy is very small

Passive Tags with Sensor Capability

- Smart tag (KSW MicroTec): Temperature-threshold-monitoring RFID tag to monitoring food item.
- Aubum University: Bacterial sensor RFID tag

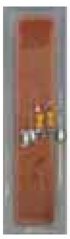


Enabling Ubiquitous Sensing with RFID, Roy Want, 2004 IEEE Computer, pp85-86

WISP

- The Wireless Identification and Sensing Platform (WISP) [Matt et. Al. 2005 IEEE pervasive computing]
  - Is part of the System for Human Activity Recognition and Prediction.
  - Aims to augment RFID tags with sensors so that tags can also send sensed data to the readers, even when tags are obscured by many material
  - RFID tags communicate to ambient readers over distances of up to 8 meters.
  - The tags can be read at nominal rates of up to 2,000 per second.
  - Each tags cost roughly $.50

WISP



- Application of WISP: elder care
  - Caregivers usually rate their elderly clients' ability to perform various activities
  - α-wisps tags are intended to measure the acceleration of the objects to which they are affixed. That WISP can collect elder's activities at home for caregivers to make sure their client's daily lives with sufficient competence.
  - Transmit a 1 along with an ID if the object is out of its rest configuration, 0 for in the rest configuration.
  - To sensing the vast majority of activities of daily living will probably require tagging about a thousand objects over the entire house

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A optimization problem of SRFID

- "A Genetic-based Application Oriented Approach to Optimize RFID-like Passive Sensor Devices for Homeland Security", Cesare Alippi, Giovanni Vanini, 2004 IEEE conference on Computational Intelligence for Homeland Security and Personal Safety
- Passive RFID tags with sensor ability (SRFID) deployed to monitor specific events (such as toxic gas)
- The SRFIDs and active devices (reader) are distributed over the area according to the required spatial resolution to constitute the local sensor network
- Reading distance maximization is strongly related to power/energy available in tag. Thus, the available energy issue is critical point in passive SRFID tag
- This paper is to proposed a design methodology to reduce the total energy required from a proper tag response.

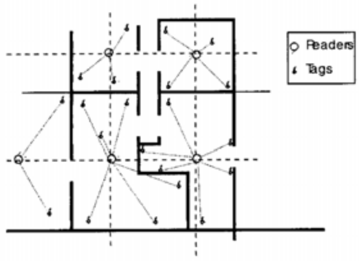

Figure 1: An active WSN with readers controlling passive local SRFID sensor networks

logical model of SRFID

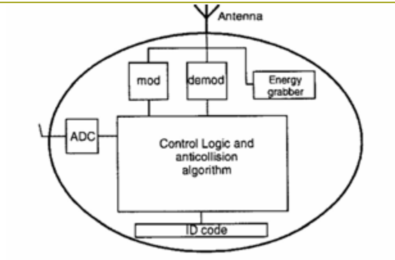

Figure 2: Logical schematization of a typical RFID tag with sensor acquisition capability.

Logical model of Reader

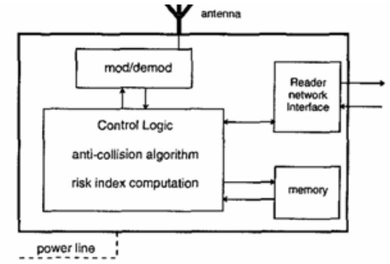

Figure 3: Logical schematization of the RFID reader.

- The reduction of data length of tag implies
  - The improvement of reading throughput
  - The improvement of transmitting distance
- The optimization problem would be
  - To minimize the number of bits to be transmitted as the objective function and
  - Subjected to the resulting accuracy constraint of the system output

- Notation
  - x_i: the input acquired by the i-th SRFID
  - $n_{max,i}$: the maximum resolution bits of i-th SRFID
  - $y=f(x_1, x_2 \ldots, x_N)$: the processing function of reader of N tags
  - $\Theta=\{n_1, n_2, \ldots, n_N\}$, $n_i \le n_{max,i}$: the number of bits used to represent the low-resolution inputs associated with vector $x(\Theta)=\{x_1(n_1), x_2(n_2), \ldots, x_N(n_N)\}$
  - $u(x, \Theta)$: generic loss function
  - $g(\Theta)$: auxiliary scalar function of Θ, $g(\Theta)$ could be

$g(\theta)=\sum_{i=1}^{N} n_i$ whole number of bits

$g(\theta)=\sum_{i=1}^{N} w_i n_i$ tags with different weights w_i

- The optimization problem is to identifying the optimal bit vector Θ_o granting that the accuracy loss $u(x, \Theta_o)$ induced at the receiver output is below a given tolerated accuracy loss γ

$$\begin{cases} \theta_0 = \arg\min_{\theta\in\Theta}(g(\theta)) \\ u(x,\theta_o) < \gamma \end{cases} \qquad \forall x \in X$$

- It is NP-hard problem
- The optimization phase can be tackled by mean of genetic algorithms, evolutionary computation, tabu search, simulated annealing...etc.

The experiment result

- Synthetic application: a toxic gas detection system
- Tag number N=10
- The reader collects data from each SRFID to provide overall index of risk y for the considered environment in [0:10] interval

$$\dot{y}=\begin{cases} mean(x_i) & & \text{if } \max(x_i)<6 & i=1,2,\ldots,10 \\ mean(x_j) & \forall j \mid 6\le x_j<8 & \text{if } 6\le \max(x_i)<8 & i=1,2,\ldots,10 \\ mean(x_k) & \forall k \mid x_k \ge 8 & \text{if } \max(x_i)\ge 8 & i=1,2,\ldots,10 \end{cases}$$

- Toleration of an error on risk index y is γ =0.5
- Each tag convert its input in 12 bits discrete signal subsequently stored in a data register

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- The calculation result was:

Table 1: Mean value and variance of the bits to be sent

	n_1	n_2	n_3	n_4	n_5	n_6	n_7	n_8	n_9	n_{10}
Mean	1.66	1.43	2.56	2.60	2.60	4.13	4.43	2.46	4.40	4.23
Variance	1.05	0.66	0.94	0.66	0.59	0.26	0.25	0.32	0.25	0.18

- Considered

$$b_t = b_{IDcode} + b_{signal} + b_{CRC}$$

b_{crc}=1 (parity check), b_{signal} was rounded to the vector [2233355355]. The variation of b_{IDcode} leaded to different throughput gains

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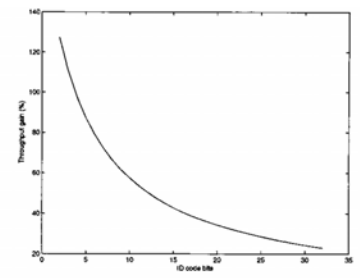

Figure 6: Trend of relative throughput gain w.r.t. the number of ID bits.

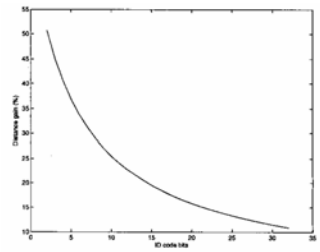

Figure 7: Trend of relative distance gain w.r.t. the number of ID bits

The relation model $1/r^2$ of receiving power and distance was considered

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- For 256 passive tags model which have IDcode length of 8, this paper claimed it can extend the reading distance to 13m compare to 10m of Trollay Scan(Pty) Ltd, 2004.

End