**TELKOMNIKA Indonesian Journal of Electrical Engineering**
Vol.12, No.6, June 2014, pp. 4557 ~ 4562
DOI: 10.11591/telkomnika.v12i6.5401


# Security Evaluation for RFID System: Security Evaluation Index Architecture and Evaluation Model

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***Abstract***
*With the rapid development and application of RFID system, people would pay more attention to the security of RFID, which is the essential issue and key technology in RFID system. This paper establishes the evaluation index architecture of RFID security, then according to these indexes for the evaluation of the RFID system security which based on fuzzy synthetic evaluation model, this paper proposes a AHP (The Analytic Hierarchy Process) for weighs, and then applies fuzzy comprehensive evaluation method for more accurate and effective evaluation results, which is used to evaluate the security of RFID system. Our security evaluation index architecture and evaluation model with RFID system is very practical and effective in the real life.*

***Keywords**: index system, evaluation model, fuzzy comprehensive evaluation*



## 1. Introduction

RFID (Radio frequency identification) technology, which uses spatial coupling of RF signal or transmission properties of radar, enabling the automatic object recognition, recognition without human intervention, works in a variety of harsh environments, and other advantages.

RFID includes three parts: RFID tags, RFID reader and RFID data processing system.

1) RFID tags, by coupling components and chips, which contains built-in antenna, and uses for communication with RF antenna of reader.

2) RFID reader, which reads or writes tag information of devices.

3) Data processing system for RFID, which is RFID devices for data transmission, processing and applications.

RFID security issues including some basic security features, such as confidentiality, integrity, availability, authentication, authorization and anonymity. RFID system of the security problem has caused particular concern of all aspects, comprehensive evaluation of the security of RFID systems is also the hot issues in this area, and this paper would a methodology to evaluate RFID system security as follows.

### 1.1. Evaluation Index Architecture Model

This paper will adopt a fuzzy comprehensive evaluation method for security evaluation of RFID system. The process of fuzzy comprehensive evaluation method is to start with qualitative fuzzy selection and then obtain results by operation through fuzzy transformation principle.

When evaluating security of RFID systems, as they involve a variety of different factors and properties of system, so the evaluation must take account of all its fields and decrease the impact of subjective factors. So this paper divide levels of the RFID system security, and each level would own some factors with corresponding weight, which evaluate the security of the entire RFID system comprehensively. It is difficult to compare the pros and cons of the order of impact factors by using single-level factors evaluation, which is difficult to identify uniform weights, so you can use the multi-level evaluation methodology instead.

*Received December 28, 2013; Revised February 25, 2014; Accepted March 11, 2014*

This security factors can be divided into two levels: the first level considers four indexes of RFID Security: physical security, communication security, data security, performance, and indexes subdivided into second level are indicated in Table 1.

Table 1. RFID System Evaluation Index Architecture

| | First Level（R） | Weight | | Second Level（C） | Weight |
|---|---|---|---|---|---|
| 1. | Physical Security | $U_1$ | 1. | Tags | $U_{11}$ |
| | | | 2. | Security of reader devices | $U_{12}$ |
| | | | 3. | Failure recovery | $U_{13}$ |
| 2. | Communication Security | $U_2$ | 1. | Interference between reader and writer device | $U_{21}$ |
| | | | 2. | Access control | $U_{22}$ |
| | | | 3. | Tags' encryption and decryption | $U_{23}$ |
| | | | 4. | Protocol security | $U_{24}$ |
| 3. | Data Security | $U_3$ | 1. | Data encryption | $U_{31}$ |
| | | | 2. | Data integrity | $U_{32}$ |
| 4. | Performance | $U_4$ | 1. | Tag capacity | $U_{41}$ |
| | | | 2. | Access time | $U_{42}$ |
| | | | 3. | Reader largest access speed | $U_{42}$ |
| | | | 4. | Reader largest access capacity | $U_{44}$ |

## 2. RFID System Security Evaluation Model Based on Fuzzy Comprehensive Evaluation

### 2.1. Evaluation Flow

The flow chart of this evaluation model is show in Figure 1.

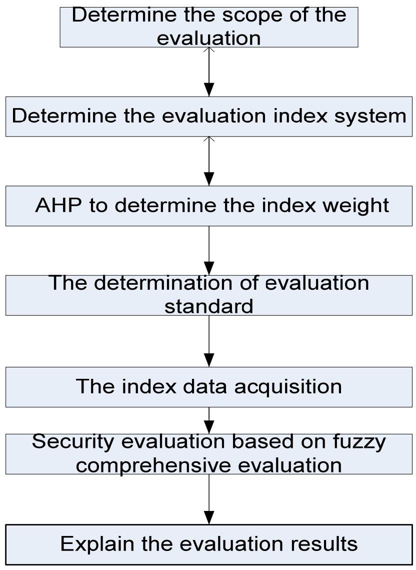


Figure 1. Evaluation Flow Chart

### 2.2. AHP for Weights

Determination of weight coefficients play an important role in RFID systems security evaluation model, occupies an important position, Weight coefficients of changes in the value to be evaluated will lead directly to changes in order of evaluation, which directly affect the evaluation results.

This paper uses hierarchy analysis process to determine weights. The AHP (The Analytic Hierarchy Process) is a United States University of Pittsburgh Professor T. L. Saaty proposed a combination of qualitative and quantitative analysis of multi-objective decision method. It has changed the previous optimization techniques can only address the issue of quantitative analysis of the traditional concepts, and headed into the long stay in many scientific studies on the qualitative analysis of level of territory, provides a simple method for quantitative analysis of non-quantitative event. In the analytic hierarchy process applied to the performance evaluation, its biggest advantage is the accurate determination of weights of indexes so that indicators could be reasonably reflect the relative importance and laid the foundations of scientific performance evaluation system. The flow chat of AHP method for weighting procedure is show in Figure 2:

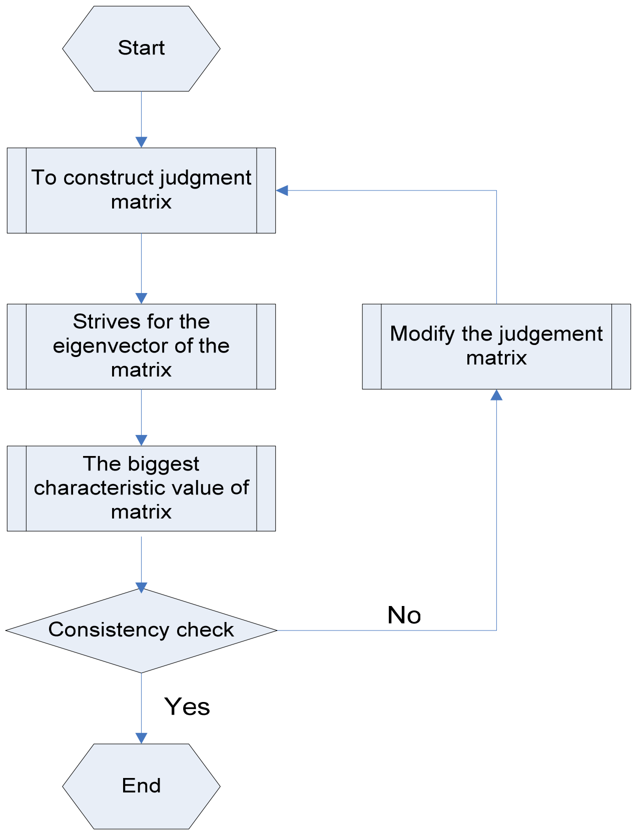


Figure 2. The Process of AHP Method to Determine the Weights

### 2.2.1. Construct Judgement Matrices

According to Table 1, it shows that in the hierarchical relationship of Upper and lower levels have been identified. It's assumed that R is one element of upper level, whose the effective value of lower level is C1, C2... Cm. So follow the R weights corresponding to the relative weight assigned to the C1,C2,...,Cm. Index system, C1,C2,...,Cm don't have fixed quantitative relationship, which need expert judgments for importance of Ci and Cj according to the 1-9-scale assignment of importance levels are shown in Table 2. First level index R judgement matrix in [1]:

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mm} \end{pmatrix} \quad (1)$$

Ri weights could be obtained:

$$W_i = W_i / \sum_{i=1}^{m} W_i \quad (2)$$

The approximation of weight vector is:

$$W_i = \sqrt[m]{r_{i1} * ri_2 * ... * r_{im}} \quad (3)$$

Table 2. The Scale Table

| Scale | Definition | Introduction |
|---|---|---|
| 1 | Equally important | Two elements are compared to equally important. |
| 3 | Slightly important | Two elements compare to each other. One element is slightly more important than the other |
| 5 | Obviously important | Two elements compare to each other. One element is obviously more important than the other |
| 7 | Much more important | Two elements compare to each other. One element is much more important than the other |
| 9 | Extremely important | Two elements compare to each other. One element is extremely more important than the other |
| 2,4,6,8 | Intermediate values | The effect of i-th factor relative to the i-th factors is between above two adjacent levels. |

The main problem of Computing is to solve the maximum eigenvalue of judgment matrix and its corresponding eigenvector. When relative weight vector is obtained, in order to ensure reasonable conclusion of AHP, it requires checking the consistency of judgment matrices. So by using consistency indicators $CI = \frac{\lambda_{max} - m}{m - 1}$ for consistency check, the bigger CI is, the more serious inconsistency judgment matrix is. If the check passed, the eigenvector is the weight vector; Otherwises, it needs to reconstruct judgment matrices [2, 3].

### 2.2.2. The Weights of the Second Level Index (Ci)

The weights are corresponding to the product of its level:

Ci=Wi*Wij (4)

### 2.2.3. The Weights of the Second Level Index Corresponding to the First Level

j indicators is established in level R, weights for various indexes could be obtained by using the above AHP method respectively:

$\omega_1 = \sum_{i=1}^{9} W_{i1}$ ( $W_{i1}$ is the weigths of first index I to the first level)

$$\omega_2 = \sum_{i=1}^{9} W_{i2,};......; \omega_i = \sum_{i=1}^{9} W_{ij} \quad (5)$$

### 2.3. Fuzzy Comprehensive Evaluation Method

The fuzzy comprehensive evaluation method [4, 5] is based on fuzzy mathematics theory and the principle of maximum membership degree [6, 7], which Considers the various factors associated with the evaluation to make a comprehensive evaluation. The evaluation methods will take into account all relevant factors.

### 2.3.1. Evaluation Elements Set

All the factors are divided into S subsets, which is $Y_i, Y_2, ......, Y_s$, satisfying the condition $Y_i, Y_2, ......, Y_s$, $Y_i \cap Y_s = F(i = j)$. Each set $Y_i, i = 1,2,......, s$ could be evaluated by the factor sets of its next level $X_{in}$, that is $Y_i = \{X_{i1}, X_{i2}, ..., X_{in}\}, i = 1,2,..., s$, where n is the number of $Y_i$.

#### 2.3.2. Establish Comments Set

The comment set of all the factors are established as $V_1, V_2, ..., V_m$ if there are m comments.

#### 2.3.3. Fuzzy Matrices

Each subset of evaluation factor $Y_i (i = 1,2,..., s)$ would be evaluated by single to obtain single factor evaluation matrices $R_i (r_{ij,k})_{nm}$ , where $i = 1,2,..., s;\ j = 1,2,..., n; k = 1,2,..., m$ . $r_{ij,k}$ is the degree of membership of single factor to comment $V_k$ . In a comprehensive evaluation, when making a comprehensive evaluation, based on actual single factor evaluation matrix could be obtained based on actual fields, here is Delphi method. The specific procedure is: on the basis of man-machine integration data acquisition, each expert score the factors of comments based on collected data, which scoring range is in the interval [0,1]. For example, each expert scores $X_{ij}$ factors, which should be satisfied $\sum V = 1$. The degree of membership is the corresponding score, and obtains single factor evaluation fuzzy matrices $R_i$.

#### 2.3.4. Establish Weight Set

$A_i = \{a_{i1}, a_{i2}, ..., a_{in}\}$ are the weights of each evaluation factor $Y_i (i = 1,2, . . . , s)$, where $\sum_{j=1}^{n} a_{ij} = 1$. Determination of weight coefficients is very important; it directly affects the final evaluation results. There are many common methods of determining weights, such as AHP, binary comparison function and son. But determining weights is an ever-more comprehensive process, so according to the specificity of information security, weight setting in practical applications can be carried out simultaneously with the evaluation division. This paper use AHP to determine weights.

#### 2.3.5. Fuzzy Comprehensive Evaluation

From above, the comprehensive evaluation vector of $Y_i (i = 1,2,..., s)$ is $B_i = A_i \bullet R_j = \{b_{i1}, b_{i2}, ..., b_{in}\}$ . Because many factors affect the evaluation results, in order to avoid losing valuable information and be truly unbiased, it should take into account a variety of factors influence, so $b_{ik} (k = 1,2,..., m\}$ should be computed by the weighted average method. So $b_{ik}$ of each $B_i (i = 1,2,..., s\}$ could be obtained as follows:

$$b_{ik} = \sum_{j=1}^{n} a_{ij} r_{ij,k,}, k = 1,2,..., m \quad (6)$$

#### 2.3.6. Multi-level Fuzzy Comprehensive Evaluation

$Y_i (i = 1,2,..., s)$ is regarded as a single factor and $B_i$ is regarded as the single factor evaluation matrices of $Y_i$, which are constructed the comprehensive evaluation matrix between Y and V.

$$B = \begin{pmatrix} B_1 \\ B_2 \\ \cdots \\ B_s \end{pmatrix} = \begin{pmatrix} b_{11}\ b_{12}\ \ldots b_{1m} \\ b_{21}\ b_{22}\ \ldots b_{2m} \\ \cdots\cdot \\ b_{s1}\ b_{s2}\ \ldots b_{sm} \end{pmatrix} \quad (7)$$

According to the weights of Yi in Y, $A = (a_1, a_2, ..., a_s\}$, where $\sum_{i=1}^{s} a_i = 1$. Finally, the final commet vector of Y is:

$$T = A \bullet B = (t_1, t_2, \dots, t_m) \quad (8)$$

## 3. Conclusion

Scientific and effective evaluation of security of RFID systems is one of the important measures to guarantee system security. This paper introduces the basic elements of RFID systems and general security requirements analysis of RFID systems. To evaluate RFID systems, it is importance of the establishment of the evaluation index system of systems security. The index system is basically built RFID system evaluation based on fuzzy comprehensive evaluation model, which is very helpful and effective in our pratical work. In practice more scientific, more efficient RFID system security assessment is further direction.

## References


[1] Schadschneider A, Klingsch W, Klüpfel H, et al. Encyclopedia of Complexity and System Science. Berlin Heidelberg, New York. 2009.

[2] Wu CG, Wang YM, Tang YM, et al. Variable fuzzy recognition model for the flood hazard evaluation based on set pair analysis. *J Northwest A&F Univ.* 2012; 40(1): 221-226.

[3] Zhang M, Yang YQ. Performance Analysis of Automobile Friction Clutch Based on Entropy Fuzzy Comprehensive Evaluation. *Advanced Materials Research*. 2012; 479: 2301-2304.

[4] Huang S, Xia H, Tan L. The Fuzzy Comprehensive Evaluation for Information Security. *Computer Technology and Development.* 2010; 1: 048.

[5] Anastassiou GA. Fuzzy mathematics: Approximation theory. *Springer*. 2010.

[6] Liu X, Pedrycz W. Axiomatic fuzzy set theory and its applications. *Springer.* 2009.

[7] Liu S, Proctor W, Cook D. Using an integrated fuzzy set and deliberative multi-criteria evaluation approach to facilitate decision-making in invasive species management. *Ecological Economics*. 2010; 69(12): 2374-2382.