Research on RFID Security Evaluation Method in smart meter

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Abstract: People pay more attention to the security of RFID of smart meter, this paper establishes the evaluation index framework of RFID security. Then according to these indexes for the evaluation of the RFID system security which is based on fuzzy synthetic evaluation model, all of this is to evaluate the security of RFID system.

1. Foreword

RFID (Radio Frequency Identification) is used for the spatial coupling of radio frequency signals or the transmission characteristics of radar reflections to realize automatic identification of objects. Its advantage is that it can identify the work without manual intervention and can work in various harsh environments.

The RFID system of a smart meter consists of three parts: the RFID tag embedded in the smart meter, the RFID reader and the RFID data processing system.

1. RFID tag, composed of coupling element and chip, the tag contains a built-in antenna for communication with the radio frequency antenna of the reader.
2. RFID reader, a device used to read or write tag information.
3. RFID data processing system, RFID equipment and application system for data transmission and processing.

The security issues of RFID systems include some basic security functions, such as confidentiality, integrity, validity, identity verification, authorization and anonymity. The security issues of RFID systems have attracted special attention from all aspects. The comprehensive assessment of RFID system security is also a hot issue in this field. This article will use the method described below to evaluate the security of RFID systems.

1.1. Evaluation index system model

We will use the fuzzy comprehensive evaluation method to evaluate the security of the RFID system. The process of fuzzy comprehensive evaluation method starts with qualitative fuzzy selection, and then calculates the result according to the principle of fuzzy transformation.

When evaluating the security of an RFID system, it is necessary to consider all aspects and reduce the influence of subjective factors in the evaluation process, because it involves multiple factors and attributes that have different effects on the system. Therefore, the author divides the security of the RFID
system into different levels, subdivides the factors of each level, and assigns corresponding weights and factors to comprehensively evaluate the security status of the entire RFID system. It is difficult to compare the order of influencing factors using single-level evaluation method, that is, it is difficult to determine uniform weight, and multi-level evaluation method can be used.

This article divides security factors into two levels. The first level considers four indicators of RFID security: physical security, communication security, data security, and performance indicators. The indicators subdivided into the second level are shown in Table 1.

| First level indicator(R) | Weights | Secondary indicators(C)                   | Weights |
|--------------------------|---------|------------------------------------------|---------|
| 1. Physical security     | $U_1$   | 1.1 label                                | $U_{11}$|
|                          |         | 1.2 Read and write device security       | $U_{12}$|
|                          |         | 1.3 Recovery                             | $U_{13}$|
| 2. Communication security| $U_2$   | 2.1 Interference between reading and writing devices | $U_{21}$|
|                          |         | 2.2 Access control                       | $U_{22}$|
|                          |         | 2.3 Label encryption and decryption      | $U_{23}$|
|                          |         | 2.4 Protocol security                    | $U_{24}$|
| 3. Data Security         | $U_3$   | 3.1 Data encryption                      | $U_{31}$|
|                          |         | 3.2 Data integrity                      | $U_{32}$|
| 4. Performance           | $U_4$   | 4.1 Label capacity                       | $U_{41}$|
|                          |         | 4.2 Access time                          | $U_{42}$|
|                          |         | 4.3 The maximum access speed of the reader | $U_{43}$|
|                          |         | 4.4 The maximum access capacity of the reader | $U_{44}$|

2. RFID system security evaluation model based on fuzzy comprehensive evaluation

2.1. Evaluation procedure
The evaluation process of the evaluation model established in this paper is as follows:

Determine the scope of the evaluation study

Determine the evaluation index system

Apply AHP to determine index weight

Determine evaluation criteria

Indicator data collection

Application of fuzzy comprehensive evaluation for safety assessment

Interpret assessment results

Figure 1. Evaluation flowchart
2.2. AHP method to determine the weight

The determination of the weight coefficient occupies an important position in the RFID system security evaluation model. The change of the weight coefficient value will directly lead to the change of the order of the evaluated objects and directly affect the evaluation effect.

This article uses the process of analyzing the hierarchy to determine the weight. AHP is a multi-objective decision analysis method that combines qualitative and quantitative analysis proposed by Professor T.L. Satie, University of Pittsburgh. It changes the traditional view that optimization technology can only handle quantitative analysis problems, and it is the first method to enter many scientific research fields that have been at the level of qualitative analysis for a long time, thus providing a simple method for non-qualitative analysis, Quantitative events. The biggest advantage of applying analytic hierarchy process to performance evaluation is to accurately determine the weight of performance indicators, which can reasonably reflect the relative importance of performance indicators and lay the foundation for the development of a fair and scientific performance evaluation system. The method of analytic hierarchy process to determine weight is as follows.

![AHP method to determine the weight process](image)

(1) **Construct a judgment matrix**

According to Table 1, the affiliation of the upper and lower layers has been determined. Assuming that the element \( R \) is at a higher level, according to the relative weight of \( R \), the lower elements dominated by specific influence values \( C_1, C_2, ..., C_n \) are allocated to \( C_1, C_2, ..., C_n \). In the indicator system, there is no clear quantitative relationship between \( C_i, C_2, ..., C_n \), so it is necessary to judge whether \( C_i \) or \( C_j \) is important according to the criterion \( R \), and calibrate according to 1-9. The importance value is shown in Table 2. First-level index \( R \) judgment matrix[1]:

\[
R = \begin{pmatrix}
    r_{11} & r_{12} & ... & r_{1m} \\
    r_{21} & r_{22} & ... & r_{2m} \\
    ... & ... & ... & ... \\
    r_{m1} & r_{m2} & ... & r_{mm}
\end{pmatrix}
\] (1)
Weight vector calculation:

\[ W_i = W_i / \sum_{j=1}^{m} W_j \]  

(2)

Approximation of weight vector:

\[ W_i = \sqrt[n]{r_{i1} \cdot r_{i2} \cdots r_{im}} \]  

(3)

Table 2. Quantity scale

| Scaling | Definition | Description |
|---------|------------|-------------|
| 1       | Equally important | Compare these two elements, they are equally important |
| 3       | Slightly important | Compare two elements, one element is more important than the other |
| 5       | Obviously important | Compare two elements, one element is obviously more important than the other |
| 7       | More important   | Compare two elements, one element is more important than the other |
| 9       | Very important   | Compare two elements, one element is much more important than the other |
| 2, 4, 6, 8 | Median | Indicates that the influence of the i-th factor relative to the j-th factor is between the above two adjacent levels |

The central problem of calculation is to solve the maximum eigenvalue of the judgment matrix and its corresponding eigenvector. After obtaining the relative weight vector, in order to ensure that the conclusion drawn by applying the analytic hierarchy process is reasonable, the consistency of the constructed judgment matrix must also be checked. Then, need to use consistency indicators \( C_i = \frac{\lambda_{\text{max}} - m}{m-1} \) for consistency testing. The larger the value of \( C_i \), the more serious the inconsistency of the judgment matrix. If the test passes, the feature vector is the weight vector. If the test passes, it needs to be rebuilt into a comparison matrix[2,3].

(2) Calculate the weight of the secondary index (\( C_i \))

The weight of each item is the corresponding product of each layer: \( C_i = W_i \cdot W_{ij} \).

(3) Calculate the weight of each index of the second level to the index of the first level

Assuming that there are \( j \) indexes in the \( R \) layer, the weight of each index can be calculated by the above AHP method as:

\[ \omega_i = \sum_{i=1}^{9} W_{ij} \]  

(W\(_{ij}\) is the weight of the first level of the first index \( i \) standard)

\[ \omega_2 = \sum_{i=1}^{9} W_{i2}, \ldots, \omega_j = \sum_{i=1}^{9} W_{ij} \]  

(5)

2.3. AHP method to determine the weight

The evaluation method we use is the fuzzy comprehensive evaluation method[4,5], which is a comprehensive evaluation based on the principle of fuzzy transformation and the principle of maximum membership in fuzzy mathematics[6,7], which takes into account various factors related to the evaluation object. The focus of this assessment method is to consider various relevant factors.

(1) Determine the evaluation element set

Divide all elements into \( s \) subsets, denoted as \( Y_1, Y_2, \ldots, Y_s \) , and \( Y_i, Y_2, \ldots, Y_s \) , \( Y_i \cap Y_j = F(i = j) \),
each subset $Y_i, i = 1, 2, ..., s$, it can also be evaluated by its sub-set $X_{in}$. It can be expressed as $Y_i = \{X_{i1}, X_{i2}, ..., X_{in}\}, i = 1, 2, ..., s$. Where $n$ represents the number of elements in $Y_i$.

(2) **Create comment set**

Establish a comment set of all evaluation elements. Suppose there are $m$ comments, $V_1, V_2, ..., V_m$.

(3) **Find the fuzzy matrix**

Single-element evaluation for each evaluation element subset $Y_i(i = 1, 2, ..., s)$, then get the single-element evaluation matrix $R_i$, can be determined according to the actual meaning, and determined by Delphi method. The specific process is: on the basis of human-computer combined data collection, each expert scores each element based on the collected data, and the scoring range is within the interval $[0, 1]$. For example, when each expert scores element $X_{ij}$, $\sum V = 1$ should be satisfied. Using this score as the corresponding degree of membership, the fuzzy matrix $R_i$ for single-element evaluation is obtained.

(4) **Establish a weight set**

The weight of each evaluation element in set $Y_i(i = 1, 2, ..., s)$ is $A_i = \{a_{i1}, a_{i2}, ..., a_{in}\}$, and $\sum_{j=1}^{n} a_{ij} = 1$. The determination of the weight coefficient is very important. It directly affects the final evaluation result. There are many methods to determine the weight, such as the analytic hierarchy process and the binary contrast function method. However, the determination of weight is a process of continuous improvement. Therefore, according to the particularity of information security, the weight can be set simultaneously with the division of evaluation factors in practical applications. This article uses the analytic hierarchy process to determine the weight.

(5) **Fuzzy comprehensive assessment**

Get the comprehensive evaluation vector of $Y_i(i = 1, 2, ..., s)$: $B_i = A_i \cdot R_i = \{b_{i1}, b_{i2}, ..., b_{in}\}$. The determination process of $b_{ik}(k = 1, 2, ..., m)$ is as follows: Since there are many factors that affect the evaluation results, in order to avoid losing valuable information and be true, objective and fair, the influence of various factors should be considered comprehensively, and the weighted average method should be adopted. That is, the following conditions should be met for each $b_{ik}$ in $B_i(i = 1, 2, ..., s)$:

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

(6) **Multi-level fuzzy comprehensive evaluation**

Treat $Y_i(i = 1, 2, ..., s)$ as a single element, take $B_i$ as the single-element evaluation vector of $Y_i$, form the fuzzy evaluation matrix from $Y$ to $V$:

$$B = \begin{pmatrix}
B_1 \\
B_2 \\
... \\
B_s
\end{pmatrix} = \begin{pmatrix}
b_{11} b_{12} ... b_{1m} \\
b_{21} b_{22} ... b_{2m} \\
... \\
b_{s1} b_{s2} ... b_{sm}
\end{pmatrix}$$
Calculate the weight according to the importance of \( Y_i \) in \( Y \),
\[
\mathbf{A} = (a_1, a_2, \ldots, a_s), \quad \sum_{i=1}^{s} a_i = 1
\]
(8)

Finally, the final comment vector of \( \mathbf{A} \) is as follows:
\[
T = \mathbf{A} \cdot \mathbf{B} = (t_1, t_2, \ldots, t_m)
\]
(9)

3. Conclusion
Scientific and effective evaluation of RFID system security is one of the important measures to ensure system security. This article first introduces the basic structure of RFID system, and then analyzes the general security requirements of RFID system. The importance of evaluating the security of the RFID system is pointed out, and the index system of the evaluation system is determined. Based on this index system, the RFID system safety evaluation model based on fuzzy comprehensive evaluation was established. How to conduct RFID system security assessment more scientifically and effectively in actual work is a further work direction.

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