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RFID Technology Based on Internet of Things in Public Library

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Abstract: *The goal of this article is to study the application of Internet of Things RFID technology in public libraries, and to find better algorithms to improve the efficiency of RFID technology in public libraries. The method is to find the problems that affect the efficiency of the RFID system according to the actual needs of the system in the public library, and try to optimize and improve the algorithm. This article first uses the principle of RFID technology as an entry point and introduces the principle of pure ALOHA algorithm in detail. Given its throughput rate curve with the amount of communication tags, this paper introduces the improved frame slot ALOHA algorithm based on the slot ALOHA algorithm. Then it introduces the tag quantity estimation mechanism, tag polling mechanism and privacy protection mechanism, analyzes several commonly used RFID tag quantity estimation mechanisms, and discusses the three RFID privacy protection mechanisms in detail and compares them with each other. Finally, the application of RFID technology in public libraries in China and the United States in the past decade has been investigated. It is found that the number of public libraries in both countries adopting RFID technology is in a rapid growth trend and the use rate of book tags and bookshelf tags is high. The experimental results show that compared with the pure ALOHA algorithm, the frame slot ALOHA algorithm has a significant increase in throughput. When the frame length is equal to the number of tags to be read, the throughput rate reaches the highest 36.78%. As the frame length is closer to the value of the tag to be read, the system efficiency is higher, so in practical applications, the dynamic frame slot ALOHA algorithm can be used, so that the frame length can be adjusted in real time according to the number of tags, which can effectively maintain the highest efficiency in real time.*

Keywords: *Internet of Things, RFID Research, ALOHA Research, Public Library*

1. Introduction

In the current ‘Internet of Things’ environment, a new generation of IT technology has been bred in all walks of life. As the core technology in the field of Internet of Things, RFID technology plays an increasingly important role in it. Currently, RFID technology is appearing more and more frequently in many Internet of Things applications such as electronic payment, RFID passports, logistics management, target tracking and monitoring. As the principles of RFID technology are gradually dissected and analyzed by scholars, a large number of cheap RFID components have emerged on the market. With more and more applications, more and more extensive, scholars have also invested a lot of energy in the security of RFID, so that they can be further guaranteed. In the future, RFID technology will become a vital role in the ‘Internet of Things’ environment, and its status will be unshakable.

The current applications of the Internet of Things are mainly RFID technology, Sensor technology, Artificial intelligence and Nanotechnology [1]. At present, the IoT technology closely related to the public libraries is RFID technology. Compared with other wireless nodes in the Internet of Things, RFID tags are extremely simple wireless devices. Due to the need to have cheap and lightweight features, the logic resources on the RDIF tags are very limited. When encountering conflicts in the transmission of tags on a wireless link, RFID tags cannot adjust their own wireless transmission methods to avoid them. Therefore, an RFID anti-collision algorithm is needed to solve the above problems. RFID anti-collision algorithms are currently divided into two camps: anti-collision algorithm based on binary tree and anti-collision algorithm based on ALOHA. Qingqing Yue combined a backward binary algorithm, introduced a counter to control the label status information, and proposed an improved binary anti-collision algorithm [2]; Aiming at the problem of multi-label collisions in traditional UHF radio frequency identification systems, Xiaoxia He proposed a parallel binary segmentation anti-collision algorithm based on lock bit [3]; Xinghe Xue combined a dynamic binary algorithm with a prefix and suffix response mode and a new collision bit decision rule to propose a new and improved binary algorithm [4]; Lei Mo proposed a two-slot dynamic binary search anti-collision algorithm based on the binary search algorithm [5]; Based on the analysis of the dynamic frame time slot ALOHA algorithm and the binary search tree algorithm, Xiaohong Zhang proposed a binary tree RFID anti-collision algorithm based on dynamic frame time slots [6]; Hanwu Wang proposed an improved adaptive multi-tree anti-collision algorithm. By calculating the collision factor to decide whether to use a binary tree or a quad tree, it can effectively reduce the total time slot of the system, reduce the communication load overhead, and improve the label recognition efficiency [7]. In the RFID system, in order to improve the efficiency of tag recognition, Yu Fu proposed a frame slot ALOHA anti-collision algorithm based on continuous slot prediction [8]; Fugui Chen uses some kind of approximate matrix instead of Hessian matrix, based on the dynamic frame time slot ALOHA algorithm, shortens the calculation time and improves the calculation accuracy [9]; Zhifeng Jiang et al. Proposed a hybrid RFID anti-collision algorithm based on CSMA / CD based on ALOHA algorithm [10]; Dan Wang et al. Proposed ALOHA algorithm based on distance prediction grouping [11]; Shaoke Zhou et al. Proposed a new dynamic frame slot ALOHA algorithm based on the dynamic factor mean estimation algorithm [12].

In view of the problem that the existing tag estimation method in the RFID system takes too long and the error is difficult to reduce, Zhaohua Long proposed a tag estimation method based on the number of non-empty time slots [13]; When the number of tags is large, the time efficiency problem is particularly important in the classification statistics. In order to solve this problem, Jiapeng Huang proposed a TAG method [14]; Combining the speed of coarse estimation, the accuracy of fine estimation and the stability of the performance of the secondary estimation algorithm, Jianli Ding proposed a method for estimating the number of RFID tags based on the secondary estimation of coarse and fine [15]; Yong Li proposed a method to determine the number of labels by searching the minimum vector modulus through genetic algorithm [16]; To solve the problem of large calculation amount of Chebyshev's inequality tag number estimation method, Xiaosi Cai proposed a coarse and fine secondary search RFID tag number dynamic estimation method [17].It is crucial for the RFID system to ensure the security and privacy of the data. No matter how advanced the algorithm is, and how powerful it is, the data is leaked and lost, which is difficult for users to accept. Qiang Zhang et al adopted a security protection mechanism based on physical methods [18-21]; Bing Zhang uses a protocol based on symmetric key encryption [22]; Yijie Zhu's mixed national secret SM2 and SM3 algorithm proposed a new RFID-SIM system security authentication protocol [23]; Ying Zheng uses a protocol based on Hash function [24]; Libo Liu analyzed and improved an RFID authentication protocol based on asymmetric keys and hash functions [25].

This article takes the principle of RFID technology as an entry point, details the principle of pure ALOHA algorithm, and gives its throughput rate curve with the amount of communication tags; This paper introduces the improved frame slot ALOHA algorithm based on the slot ALOHA algorithm used in this article. Compared with the pure ALOHA algorithm, its throughput rate has been significantly improved. When the frame length is equal to the number of tags to be read, the throughput rate reaches the highest 36.78%. Since the closer the frame length is to the value of the tag to be read, the higher the system efficiency. Therefore, in practice, the dynamic frame slot ALOHA algorithm is used to adjust the frame length according to the number of tags in real time, which can effectively maintain the highest efficiency in real time. Then it introduces the tag quantity estimation mechanism, tag polling mechanism and privacy protection mechanism, analyzes several commonly used RFID tag quantity estimation mechanisms, and discusses the three RFID privacy protection mechanisms in detail and compares them with each other.

2. RFID Technology Based on Internet of Things in Public Library

2.1 RFID Technology Overview

RFID, the full name is Radio Frequency Identification, is a radio-based information identification technology. Since the beginning of this century, RFID technology has become popular, the application fields are more and more extensive, and the technical level is getting higher and higher. Until now,

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RFID technology has been regarded as a benchmark in the field of Internet of Things, supporting the entire Internet of Things industry, RFID can be seen everywhere in various industries.

The RFID system is mainly composed of two parts: reader and tag. Readers actively identify tags through radio frequency signals and read related data and information in tags, which can greatly improve management efficiency in public libraries. RFID technology has made the application of the Internet of Things in public libraries a reality, and has achieved the efficiency, convenience, automation and intelligence of public libraries. A tag, also called an electronic tag, serves as a data carrier and transponder. The logic unit on the built-in chip realizes the storage of relevant electronic information data of the object to be identified. The built-in antenna interacts with the reader in the space electromagnetic field to allow reading. The reader serves as an intermediate bridge between the electronic tag and the management system. In order to realize the non-contact intelligent Internet of Things technology, the radio frequency signal interacts with the corresponding electronic tag to identify and read the label content on the corresponding object to be measured. Then the relevant data information is handed over to the system for unified management, distribution and scheduling, which realizes the intelligent 'Internet of Things' in the public library and provides a basic guarantee for the 'Internet of Everything' in other fields.

RFID technology can be traced back to the enemy identification system in World War II, which was mainly derived from the development of radar technology in the military field; In the 1950s, people began to explore a lot of RFID technology in the laboratory. The first model of a product came into being, but it still only stayed in the laboratory stage; In the 1960s and 1970s, RFID-related theoretical technologies became more and more mature, and began to slowly be applied in real life; The 80s and 90s were the golden era of RFID development, with further breakthroughs in technology, and a large number of products were used in various industries; Until the beginning of this century, RFID technology has been indispensable in people's lives as the pillar of the Internet of Things.

RFID is classified according to whether it carries its own power supply, and can be divided into passive RFID, active RFID and semi-active RFID. Passive RFID first appeared, the technology is the most mature and the most widely used. In passive RFID, the electronic tag receives the microwave radio frequency signal transmitted by the reader and obtains energy through the electromagnetic induction coil to temporarily supply power to itself, thereby completing this information exchange. Because it does not carry a power supply, the reader can recognize and complete data interaction at a distance of only about 5 meters, but its size is small and the price is low. Active RFID has a short rise time, but it plays an indispensable role in many areas, especially in highway electronic toll collection systems. Because active RFID carries its own power supply, the reader can identify and complete data interaction up to 30 times the distance of passive RFID, and the number of tags that the reader can read per second is 10 to 20 times that of passive RFID, but its price is relatively expensive and large. Semi-active RFID is a product of a new era that combines the advantages of active RFID and passive RFID, abandons the disadvantages, and comes into being. Under normal circumstances, semi-active RFID products are in a dormant state, and only the necessary parts of the tags to maintain data are powered, so the power consumption is small and can be maintained for a long time. The reader first activates the tag accurately in a small range with a low frequency signal of 125KHz to make it enter the working state, and then transmits information with it through the 2.4GHz microwave.

The reason why RFID technology can play such an important role is inseparable from its many advantages. From the aspect of its appearance, the carrier of RFID technology generally has the characteristics of waterproof, anti-magnetic and high temperature resistance in order to protect its own stability; In terms of its performance, RFID technology has inherent advantages in storing information, working efficiency, usage methods and security. The main advantage of RFID technology is its intelligence. It can store data, update backup information, and speed up work efficiency without the need for additional human, financial and material resources. In the absence of external damage, RFID equipment has a long service life and can be used repeatedly. The advent of RFID technology has completely changed the original processing of information, from complex and numerous operations to simple, fast and intelligent, greatly improving work efficiency. After the encryption and upgrading of the RFID equipment, the reliability of the current RFID equipment is quite high, and safety and efficiency are also the most concerned in today's society.

2.2 RFID Tag Identification Protocol

As with other communications, RFID systems also have problems with signal interference and collisions. In the RFID system, the main signal interference and conflict are: conflict interference

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between readers and conflict interference between tags. Therefore, if the RFID tag recognition rate is high, it is necessary to adopt relevant protocols to reduce conflict interference between readers and conflict interference between tags.

For conflict interference between readers, the three commonly used anti-collision interference protocols are: Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA) and Carrier Sense Multiple Access (CSMA). Time division multiple access is to separate the readers according to the time interval, to ensure that only one reader in the same period lies in the identification and data interaction of the tags, and the time management control between each reader allows each to work independently without affecting each other; Frequency division multiple access is to divide the communication channel of the readers according to the frequency, and the readers communicate with the tags through different channels. Through the channel management control between each reader, each reader can work independently without affecting each other; Carrier sense multiple access is to check whether the channel is idle before each reader interacts with the tag data. If it is not idle, wait, wait until it is idle, and then perform data interaction to ensure that each reader works in an orderly queue. It will not conflict with each other.

For conflict interference between tags, two currently used anti-collision interference protocols are: ALOHA-based anti-collision algorithm and binary tree-based anti-collision algorithm. The anti-collision algorithm based on ALOHA is a “random access” algorithm, that is, after the tag enters the reader read-write area, it randomly selects a time slot to send data to the reader. If a conflict occurs, the reader controls the tag to randomly wait for a period of time before sending data. Simply put, ALOHA uses a data rollback mechanism, and tags participate in the identification process in a probabilistic manner; The anti-collision algorithm based on the binary tree divides the conflicting tags into two subsets in a recursive manner, so that it is continuously divided until only one tag remains in the set.

2.3 RFID Tag Polling Mechanism

The RFID tag polling mechanism is actually an efficient polling protocol designed to collect a subset of tag information in the entire tag set, Often, in practical applications, it is not necessary to obtain all information related to the object to be identified in all the tags, but only need to determine whether related tags exist in the specified tag set. In this case, if the reader is to traverse all the tag information in the read tag set and then confirm whether a tag exists, it takes much longer than the acceptable range, so only the RFID tag polling mechanism is needed. There are currently three common tag polling mechanisms: BP (Basic Polling), CP (Code Polling) and TOP (Tag-Ordering Polling). BP is a simple polling mechanism. Each tag in the subset tags will receive an average of half the number of IDs sent from the reader, while the tags in the subset will receive all IDs sent from the reader; The polling mechanism adopted by CP reduces its energy consumption to half of BP by adding CRC code; TOP's polling mechanism keeps the tag in standby and energy-saving state most of the time, making the energy consumption lower than CP.

2.4 RFID Privacy Protection Mechanism

It is crucial for the RFID system to ensure the security and privacy of the data. No matter how advanced the algorithm is, and how powerful it is, the data is leaked and lost, which is difficult for users to accept. The main security risks of RFID are: eavesdropping, man-in-the-middle attacks, spoofing, replay, cloning, physical cracking, information tampering, denial of service attacks, RFID viruses, electronic destruction, shielding interference and violent removal. The main privacy issues of RFID are: leakage of private information and tracking of private information. Therefore, the corresponding RFID security and privacy protection methods are: inactivation, Faraday net cover, active interference, blocking tags, hash lock, hash chain, synchronization method, tree protocol, etc. If you need to implement an algorithm to protect privacy on the label, you must also consider the problem of less logic resources on the built-in chip on the label. Therefore, the hotspots of scholars in recent years are how to develop a lightweight algorithm on the built-in chip with extremely limited resources to perfect the privacy protection mechanism.

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3. Principle of RFID Technology Based on Internet of Things

3.1 Algorithm Principle

The ALOHA algorithm is a ‘random access’ algorithm, that is, after the tag enters the reader reading and writing area, it randomly selects a time slot to send data to the reader. The reader detects the received data to determine whether there is a conflict. The control tag randomly waits for a period of time before sending data.

The average data exchange volume within the communication time T:

$$G = \sum_{i=1}^{n} \frac{\tau_n}{T} r_n \tag{1}$$

Where n represents the number of tags to be read in the system, and r_n represents the number of packets sent by tag n in time T. The tags to be read are independent of each other, and the process of tags randomly sending data conforms to the Poisson distribution, where λ is the average number of tags that respond per second, and there is the following relationship:

$$\lambda = G/\tau \tag{2}$$

The probability that the number of correctly transmitted data in time T is k is:

$$p(k) = \frac{[G \cdot \frac{T}{\tau}]^k}{k!} \cdot e^{[-G \cdot \frac{T}{\tau}]} \tag{3}$$

The transmission time of each tag is τ. If the tag is successfully transmitted, it means that there is no data conflict with other tags. Therefore, the probability of no other tag responding within T = 2τ is

$$P_I = p(k=0)|_{T=2\tau} = e^{-\lambda \cdot 2\tau} = e^{-2G} \tag{4}$$

The throughput S of the ALOHA algorithm can be expressed as the average packet exchange G:

$$S = G \cdot P_I = G \cdot e^{-2G} \tag{5}$$

The frame time slot ALOHA algorithm is an improvement based on the time slot ALOHA algorithm. In the FSA algorithm, the specified frame length is set to N. First, the reader broadcasts the N value to surrounding tags to limit the time slots sent by the tags. The tag randomly selects an integer from 0 to N-1 and stores it in the slot counter as the number of slots for sending data. Each tag sends data in the corresponding time slot, and if no collision occurs, it is successfully identified; If a collision occurs, wait for the number of timeslots to be reloaded and identified at the beginning of the next frame.

Identify n tags to be read, and use the FSA algorithm to set the frame length to N. The tags to be read are independent of each other, and the probability of selecting each time slot is equal. The probability p of the response of a certain time slot i selected by the tag is:

$$p = 1/N \tag{6}$$

According to the binomial distribution theorem, the probability of r tags in time slot i is:

$$P(X=r) = C_n^r \cdot \left(\frac{1}{N}\right)^r \cdot \left(1 - \frac{1}{N}\right)^{n-r} \tag{7}$$

When r = 1, the probability of successful identification of the time slot is:

$$P_{succ} = P(X=1) = C_n^1 \cdot \left(\frac{1}{N}\right)^1 \cdot \left(1 - \frac{1}{N}\right)^{n-1} \tag{8}$$

When r = 0, the probability that the time slot is idle is:

$$P_{idle} = P(X=0) = \left(1 - \frac{1}{N}\right)^n \tag{9}$$

Each time slot has only three states: successful, idle, and collision. When r> 1, there are multiple tags in this time slot, and the collision probability is:

$$P_{coll} = 1 - n \cdot \frac{1}{N} \cdot \left(1 - \frac{1}{N}\right)^{n-1} - \left(1 - \frac{1}{N}\right)^n \tag{10}$$

The system throughput rate of the FSA algorithm is:

$$S = \frac{E(X=1)}{N} = \frac{n}{N} \cdot \left(1 - \frac{1}{N}\right)^{n-1} \tag{11}$$

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The above formula can be derived by derivation of N, when N = n, S gets the maximum value.

$$S = \lim_{n\to\infty} \frac{n}{N}\cdot\left(1-\frac{1}{N}\right)^{n-1} \overset{N=n}{\Longrightarrow} \lim_{n\to\infty}\left(1-\frac{1}{n}\right)^{n-1} \approx 0.3678 \tag{12}$$

3.2 Pure ALOHA Algorithm

The throughput rate of the pure ALOHA algorithm is shown in Table 1. From the table, it can be seen that the system efficiency of the algorithm is very low. When G is 0.5, S gets the maximum value, only 18.4%. When the communication volume is small, the channel is idle most of the time, and as the communication volume increases, the data conflict between the tags also increases significantly, resulting in a sharp decrease in throughput. Therefore, based on the pure ALOHA algorithm, an improved algorithm slot ALOHA algorithm is proposed. The throughput rate comparison between the slotted ALOHA algorithm and the pure ALOHA algorithm is shown in Figure 1. The throughput rate of the slotted ALOHA algorithm has been significantly improved. When G is 1, the maximum value of S is 36.78%.

Table 1: Throughput table of pure ALOHA algorithm

Average Packet Exchange	Throughput Rate
0.5	0.184
1	0.135
2	0.038
3	0.009
4	0.001

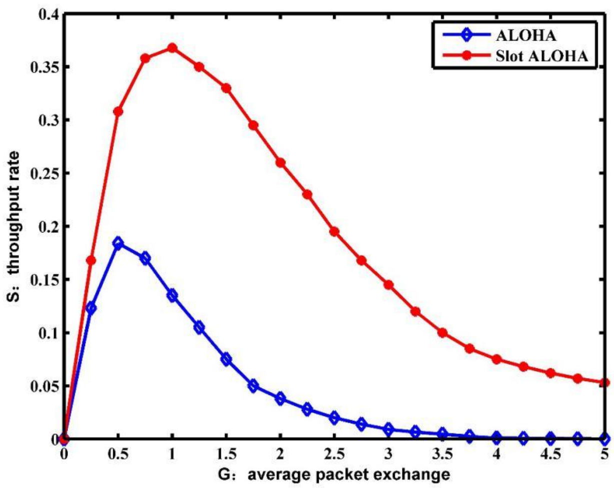

Figure 1: Throughput curve of pure ALOHA algorithm

3.3 Optimization Effect of Frame Slot ALOHA Algorithm

Frame slot ALOHA algorithm is an improvement based on slot ALOHA algorithm. Simulation analysis of the throughput rate of the frame slot ALOHA algorithm, as shown in Table 2 and Figure 2. The frame lengths are N = 32, N = 96, and N = 256. The number n of tags varies within the interval [0, 512]. It can be clearly seen from the figure that when the frame length and the number of tags to be read are equal (G = 1), the slot performance of the ALOHA algorithm is optimal, and the throughput rate reaches 36.78%, which is consistent with the result of Equation 12. The closer the frame length N is to the value of the number of tags to be read n, the higher the system efficiency. Therefore, the dynamic frame slot ALOHA algorithm is used to adjust the frame length according to the number of tags, which can effectively improve the efficiency dynamically.

Table 2: Throughput table of frame slot ALOHA algorithm

Throughput Rate	n=32	n=64	n=96	n=128	n=256
N=32	0.3678	0.2785	0.1489	0.0738	0.0053
N=96	0.2456	0.3486	0.3678	0.3536	0.1854
N=256	0.1124	0.1964	0.2567	0.3047	0.3678

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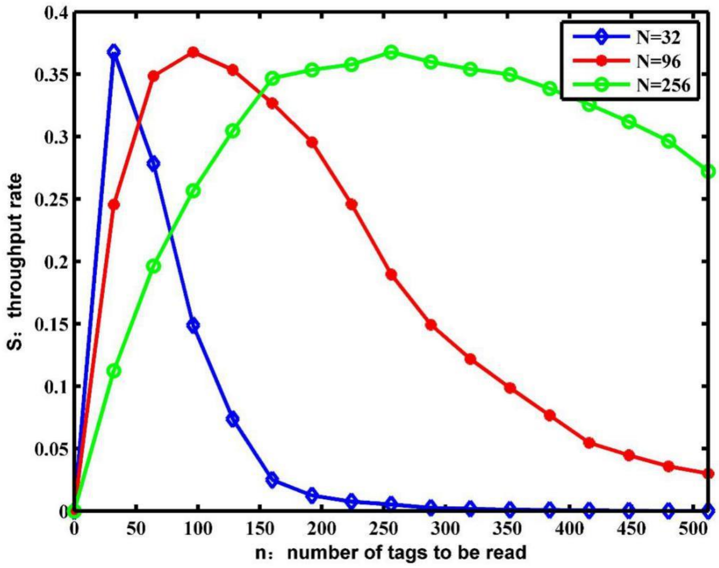

Figure 2: Throughput rate curve of frame slot ALOHA algorithm

3.4 RFID Tag Quantity Estimation

For the public libraries, the number of items requiring RFID tags in the library is considerable. If the system needs to identify and read all the RFID tags one by one in the library's data management and distribution, it takes time. Far beyond the acceptable range, this is obviously undesirable. Therefore, for the in-library system, it is usually only necessary to quickly obtain relevant statistical information within the scope. The number of RFID tags is one of the key information. How to quickly obtain it becomes the initial entry threshold in RFID technology. From the analysis of the algorithm in the previous section, the closer the frame length N and the number of tags to be read n are, the higher the system efficiency. The dynamic frame slot ALOHA algorithm is used to make the frame length adjusted in real time according to the number of tags to improve efficiency. The number of RFID tags must be known first. This shows the importance of the RFID tag quantity estimation mechanism.

This paper studies and discusses four common methods of label quantity estimation. (1) In a frame of interactive data, when the number of tags increases, the number of corresponding empty slots will decrease; and the number of conflicting slots will increase as the number of tags increases. Therefore, the number of empty slots and the number of conflicting slots have an obvious monotonous relationship with the number of tags, and the number of tags can be estimated based on this; (2) From the mathematical probability model of the binomial distribution, the expected values of empty slots and conflicting slots can be calculated, On this basis, a set of posterior probability models are used to estimate the number of RFID tags according to the decision, thereby maximizing their posterior probability; (3) A fast estimation method based on ball and probability models, each tag randomly selects a position reply, and the system estimates the number of RFID tags based on the position of the first observed event; (4) The estimation mechanism based on adaptive division uses geometric distribution rules to estimate the number of RFID tags. For these four RFID estimation methods, the following Table 3 is used for comparative analysis.

Table 3: Summary and comparison of the characteristics of label quantity estimation algorithms

Estimation algorithm	Compatibility with ALOHA	Estimated reference index	Probability model
Method 1	compatible	Number of empty slots and conflicting slots	Binomial distribution
Method 2	compatible	Number of three slots	Posterior probability model based on binomial distribution
Method 3	compatible	The location of the first tag reply	Binomial distribution
Method 4	Not compatible	The edge position where the conflicting time slot appears	Geometric distribution

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3.5 RFID Tag Polling

The RFID tag polling mechanism is actually an efficient polling protocol designed to collect a subset of tag information in the entire tag set, Often, in practical applications, it is not necessary to obtain all information related to the object to be identified in all the tags, but only need to determine whether related tags exist in the specified tag set. In this case, if the reader is to traverse all the tag information in the read tag set and then confirm whether a tag exists, it takes much longer than the acceptable range, so only the RFID tag polling mechanism is needed. There are currently three common tag polling mechanisms: BP (Basic Polling), CP (Code Polling) and TOP (Tag-Ordering Polling).

BP is a simple polling mechanism. Each tag in the subset tags will receive an average of half the number of IDs sent from the reader, while the tags in the subset will receive all IDs sent from the reader; The polling mechanism adopted by CP reduces its energy consumption to half of BP by adding CRC code; TOP's polling mechanism keeps the tag in standby and energy-saving state most of the time, making the energy consumption lower than CP.

3.6 RFID Privacy Protection Mechanism

It is crucial for the RFID system to ensure the security and privacy of the data. No matter how advanced the algorithm is, and how powerful it is, the data is leaked and lost, which is difficult for users to accept. This paper expounds the related research results from the aspects of security protection mechanism based on physical method, protocol based on symmetric key encryption and protocol based on hash function. The comparative analysis is shown in Table 4.

(1) Security protection mechanism based on physical methods. In the RFID system of public libraries, the RFID tags of books and documents record the contents of collections; Reader ID RFID tags record the personal information of readers and borrowers. If the privacy information in these RFID systems is leaked, it will be a great blow to the public library and will lose the trust of readers and borrowers. In order to protect the privacy in the RFID system, the simplest and most direct method is the physical method, such as: inactivation, Faraday net cover, active interference, blocking tags, etc.

(2) Protocol based on symmetric key encryption. Due to the limited logic and storage unit of the built-in chip of the RFID tag, it is difficult to implement complex encryption algorithms, usually a simple symmetric key encryption method is used, and any tag and reader in each area of each public library share a symmetric key. Without the key, the RFID tag information cannot be obtained, which plays a role in protecting privacy.

(3) Protocol based on Hash function. For the built-in chip of RFID tags with limited resources, the Hash function protocol will be very friendly, and it can build a privacy protection strength comparable to the symmetric key encryption method on a simple logic. Put a lock on the RFID tag to protect its internal privacy information from leaking.

Table 4: Comparison of three options

Methods	Effect	Resource
Physical method	The tag implementation logic is very simple and does not require the tag itself to achieve security and privacy protection	Very Low
Symmetric key encryption	The tag implementation logic is complicated, which can effectively implement encryption and decryption operations	High
Hash function	The tag implementation logic is simple, with forward security, and cannot implement encryption and decryption operations	Low

3.7 Research

In recent years, the Internet of Things technology has advanced by leaps and bounds, and the concept of ‘Internet of Everything’ has penetrated into all aspects of life. As the core technology in the field of Internet of Things, RFID plays an increasingly important role in it. According to incomplete statistics, the number of RFID applications in public libraries in China and the United States from 2006 to 2018 is shown in Figure 3. It can be seen from the figure that RFID technology was only applied in China in 2007. From 2007 to 2010 as the initial stage, RFID technology has developed slowly, and there are relatively few public libraries that use RFID technology. It has entered a rapid growth stage since 2010. The American technology RFID technology started earlier and has been in a stage of rapid

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growth.

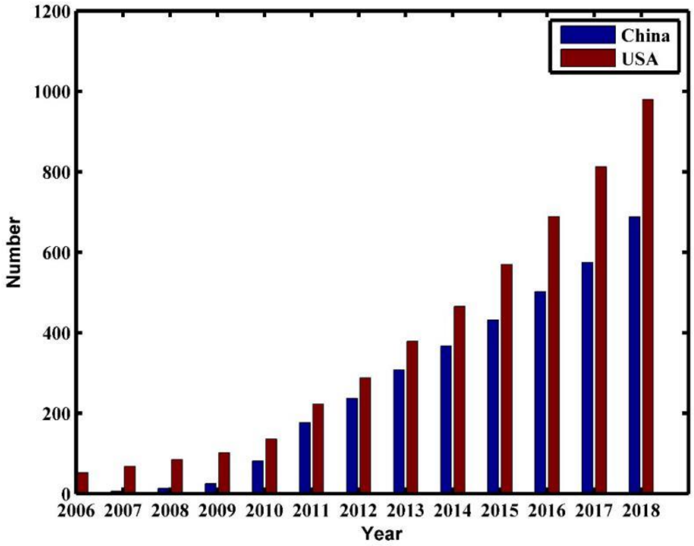

Figure 3: Trend of library RFID technology usage

At the same time, we also conducted a survey on the status quo of the use of labels in public libraries in China and the United States, as shown in Figure 4. It can be seen that the utilization rate of book tags and bookshelf tags in both countries is relatively high, while the utilization rate of literature tags is low.

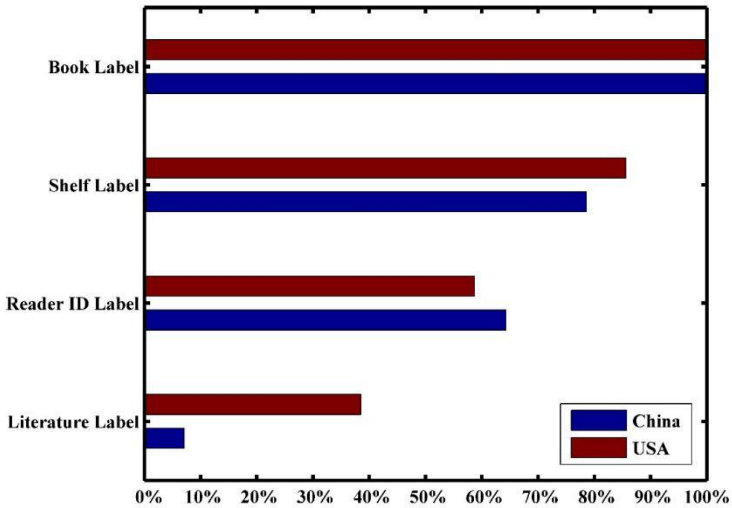

Figure 4: Statistics on the use of various tags in libraries

4. Conclusions

(1) This article analyzes the use of Internet of Things RFID technology in the public libraries, the principle and structure of RFID technology are introduced in detail. It mainly discusses RFID anti-collision algorithm, tag quantity estimation mechanism, tag polling mechanism and security and privacy protection mechanism. Investigating the number of RFID applications in public libraries and the status of the use of tags in public libraries from 2006 to 2018 in China and the United States. From the survey results, RFID technology is slowly replacing the original old technology, becoming an indispensable intelligent technology in public libraries.

(2) As with other communications, RFID systems also have problems with signal interference and

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collisions. In the RFID system, the main signal interference and conflict are: conflict interference between readers and conflict interference between tags. Therefore, if the RFID tag recognition rate is high, it is necessary to adopt relevant protocols to reduce conflict interference between readers and conflict interference between tags. From the point of view of reducing conflict interference between tags, the two commonly used anti-collision interference protocols are: anti-collision algorithm based on ALOHA and anti-collision algorithm based on binary tree. In this paper, the improved frame slot ALOHA algorithm based on the slot ALOHA algorithm, compared with the pure ALOHA algorithm, its throughput has been significantly improved. When the frame length is equal to the number of tags to be read, the throughput rate reaches 36.78%. Since the closer the frame length is to the value of the tag to be read, the higher the system efficiency. Therefore, in practice, the dynamic frame slot ALOHA algorithm is used to adjust the frame length according to the number of tags in real time, which can effectively maintain the highest efficiency in real time.

(3) The timeliness of the identification and reading from the RFID tags is poor and the dynamic frame slot ALOHA algorithm needs to know the number of RFID tags so that the frame length can be adjusted in real time according to the number of tags. The importance of the RFID tag number estimation mechanism is discussed in two aspects. Focus on introducing several commonly used RFID tag quantity estimation mechanisms, and compare and analyze four common tag quantity estimation methods in detail, each with advantages and disadvantages.

(4) It is essential for the RFID system to ensure the security and privacy of the data. No matter how advanced the algorithm is, and how powerful it is, the data is leaked and lost, which is difficult for users to accept. Therefore, this article discusses three RFID privacy protection mechanisms in public libraries in detail and compares them with each other.

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