RFID Reader Deployment Strategy using Genetic Algorithm

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***Abstract*—Recently, auto Identification system develop strongly and apply a lot of fieds. The almost system in there is Radio Frequency Identification (RFID) system. According to the chip and wireless technological fast-growing, system RFID becomes more and more improve every aspect. However, putting reader anywhere to carry out better combined operations is the trouble problem. When readers using the same frequency are not arranged suitably, the same query signal of numbers of readers in interference area causes concidence data on server or is distorted or causes collision between tag – tag, tag – reader and reader – reader. This paper propose one idea to sovle the above problem: Moving RFID readers on a lot of tracks to find better location that communicate between tag and reader.**

***Index Terms*—RFID Visual, Gennetic Algorithm, Optimal Deployment.**

I. Introduction

Radio Frequency Identification (RFID) is an automatic identification method. A device using the Radio Frequency Identification technology [6] can read some information of chip without touching them. A RFID system have 2 elements: RFID tag, RFID reader. There are generally two types of RFID tags: active RFID tags, which contain a battery and can transmit signals autonomously, and passive RFID tags, which have no battery and require an external source to rouse signal transmission. This systems provide increased productivity, efficiency, convenience and many advantages over bar codes for numerous applications, especially global supply chain management.

Despite all the advantages RFID technology offers there are serious concerns about security, privacy and system deployment. So, it is important problem that how do we do to have a good RFID system operation, this effects some elements, such as the reader collision, the power of signal, the interference of SNR (Signal-to-Noise ratio), the direction of the antenna, system throughput and hit-query ratio.

In this paper, we use the virtual reader model, approximate curve Bezier technology, genetic argorithm and the adaptive power control strategy to demonstrate the new reader deployment strategy.

In there, we must solve the three problem:

– Building some tracks using aproximate curve technology bezier [7] that control points are coodinates of tag.

– Finding out better arranged readers coordinate using the genetic algorithm [8].

– Reader collision: Signal of one reader can effect other at interference area. We use Time Division Multiple Access Technology (TDMA) [5] to deal this problem.

Our paper is organized as follows: Section 1 is the introduction, Section2 presents related work, Section 3 presents proposed RFID reader deployment. Section 4 presents effect analyze and we conclude this paper in section 5.

II. Related Work

In terms of the RFID system deployment mechanism, the RFID system deployment can be categorized into two types: the dense reader deployment mechanism and deployment mechanism by analyze the locations of RFID tags and size of deployment area in advance.

The example of RFID system deployment: Byung-Jun Jang [1] using the link budget concept to calculate forward-link and reverse-link interrogation ranges, design hardware considerations at the reader: phase diversity and quadrature signal combining, phase noise with range correlation effect, and transmitter leakage reduction methods and present deployment issues including reader-to-reader interference in dense reader environments. Kin and Mun [2] introduces the ETSI 302 208 and EPC Class 1 Generation 2 Protocol and their impact on RFID reader deployment, explains the concept of RFID reader synchronization and how it adheres to strict regulations, RFID reader placement and ways of fine-tuning RFID reader positioning. M. V. Bueno-Delgado, J. Vales-Alonso, C. Angerer, M. Rupp [3] description of the dense reader collision environments and perform the different

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mechanisms for common reference scenarios, in order to provide comparative results of the efficiency in the allocation of resources.

In our application, we used genetic algorithm to locate readers, the bezier approximate curve for building track of readers and applied TDMA algorithm to decreasing collisions.

III. PROPOSED RFID READER DEPLOYMENT MECHANISM

In this paper, a new approach for the reader deployment is being proposed. It can be described as follows:

- *Dividing the big current area into some smaller area*
- Building approximate curve Bezier for sequence of the smaller areas
- Defining perfect reader deployment coordination by applying Genetic Algorithm
- Using Time Division Multiple Access Technology (TDMA) to decrease collision

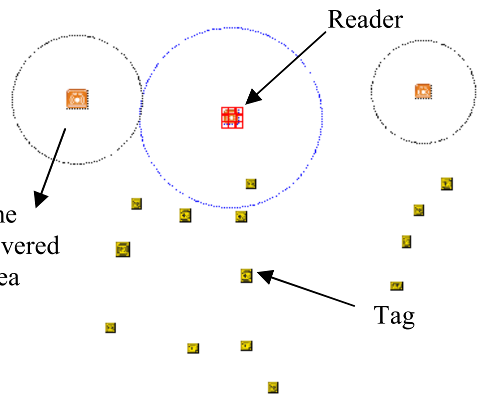


Fig. 1. Space contain tag

Let's assumes that we have the tag manager area as Figure 1. To find a perfect reader deployment coodination, we perform sequence of steps as follows:

A. Dividing the big current area into some smaller area, in there, total of this equals a number of readers.

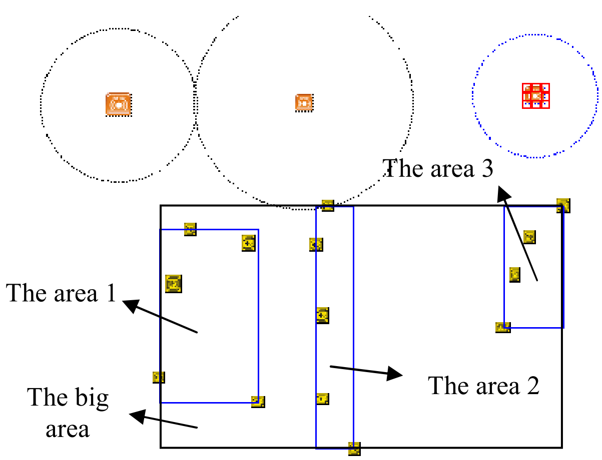


Fig. 2. Dividing the big area into some smaller area

We are going meet trouble when we build the approximate curve Bezier for the big area, such as equation exponent of the approximate curve Bezier is high because amount of the control points (coordination of tags) are large, if tags are put dense on some specific areas, we will get more redundancy points created by building the approximate curve Bezier All of these reduce the speed of information process. So, we have to divide the big area into some smaller area. Specific as follows:

Algorithm 1:

–Step 1: In the big current area, we definte top left coordination of tag as (x_1,y_1) and bottom right coordination of tag as (x_2,y_2).

–Step 2: if $(x_2 - x_1) > (y_2 - y_1)$, we should divide the big current area into some the smaller areas as x-axis direction, otherwise, we divide it into some the smaller areas as y-axis direction

–Step 3: we calculate top left coordination of tag and bottom right coordination of tag for sequence of the smaller areas => we have divided the big area into the smaller areas completely.

For example, as figure 2

B. Building approximate curve Bezier for sequence of the smaller areas

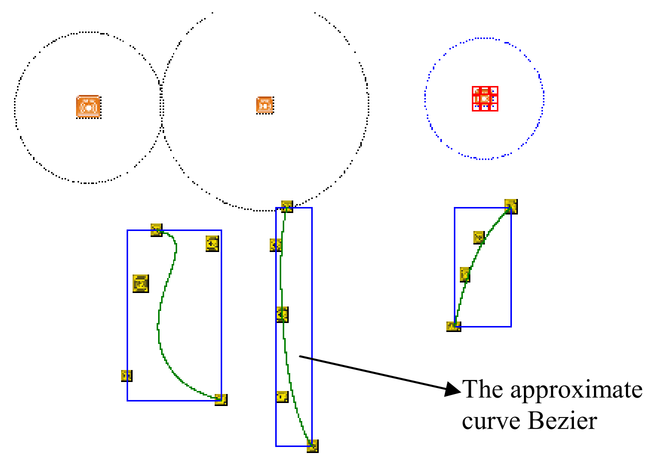


Fig. 3. Building the approximate curve Bezier for sequence of the smaller areas

In the smaller areas, we apply approximate curve Bezier for sequence of the smaller areas, control points of this is coordination of tag in these areas (as Figure 3).

A recursive definition for the Bézier curve of degree n expresses it as a line interpolation between two Bézier curves of degree $n - 1$.

Let $B_{P0P1\ldots Pn}$ denote the Bézier curve determined by the points $P_0, P_1, \ldots, P_n$. Then

$B_{P_0}(t) = P_0$ to start, and

$B(t) = B_{P0P1\ldots Pn}(t) = (1\text{-}t)\, B_{P0P1\ldots Pn\text{-}1}(t) + tB_{P0P1\ldots Pn}(t)$

The formula can be expressed explicitly as follows:

$$\begin{aligned}\mathbf{B}(t) &= \sum_{i=0}^{n} \binom{n}{i} (1-t)^{n-i} t^i \mathbf{P}_i \\ &= (1-t)^n \mathbf{P}_0 + \binom{n}{1} (1-t)^{n-1} t \mathbf{P}_1 + \cdots \\ &\cdots + \binom{n}{n-1} (1-t) t^{n-1} \mathbf{P}_{n-1} + t^n \mathbf{P}_n, \quad t \in [0,1],\end{aligned} \tag{1}$$

where $\binom{n}{i}$ is thebinomial coefficient.

For example, for $n = 5$:

$$B(t) = (1-t)^5P_0 + 5t(1-t)^4P_1 + 10t^2(1-t)^3P_2 + 10t^3(1-t)^2P_3 + 5t^4(1-t)p_4 + t^5P_5,\ t \in [0,1] \quad (2)$$

Based on the approximate curves Beizier in the smaller areas, we get the point collections that are nearest the tags.

C. Defining perfect reader deployment coordination by applying Genetic Algorithm

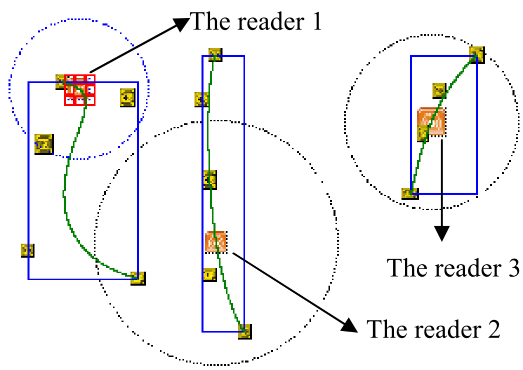


Fig. 4. Placement of appropriate for reader

We get the coordination collection after completing buiding the approximate curves Bezier, is called the Bezier coordination collection. Every points belong to the Bezier coordination can be used to try to put readers where combination of them is the best. Nowadays, we have many the searching algorithms in the artificial intelligence to solve the above problem, such as, tabu search, DFS search, Rabin-karp algorithm, AVL searching tree, Hill Climbing search, etc… In this paper, we select one of them is the Genetic Algorithm to find better locations that put readers (as Figure 4), because in this case, it is easily deployed and result in faster than other.

1. The genetic algorithm

A genetic algorithm (GA) is a search heuristic that mimics the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization and search problems. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover.

In this algorithm, a population of strings (called chromosomes or the genotype of the genome), which encode candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem, evolves toward better solutions. The evolution usually starts from a population of randomly generated individuals and happens in generations. In each generation, the fitness of every individual in the population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), and modified (recombined and possibly randomly mutated) to form a new population. The new population is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached.

A typical GA requires:

- A genetic representation of the solution domain,
- A fitness function to evaluate the solution domain.

GA find application in bioinformatics, phylogenetics, computational science, engineering, economics, chemistry, manufacturing, mathematics, physics and other fields.

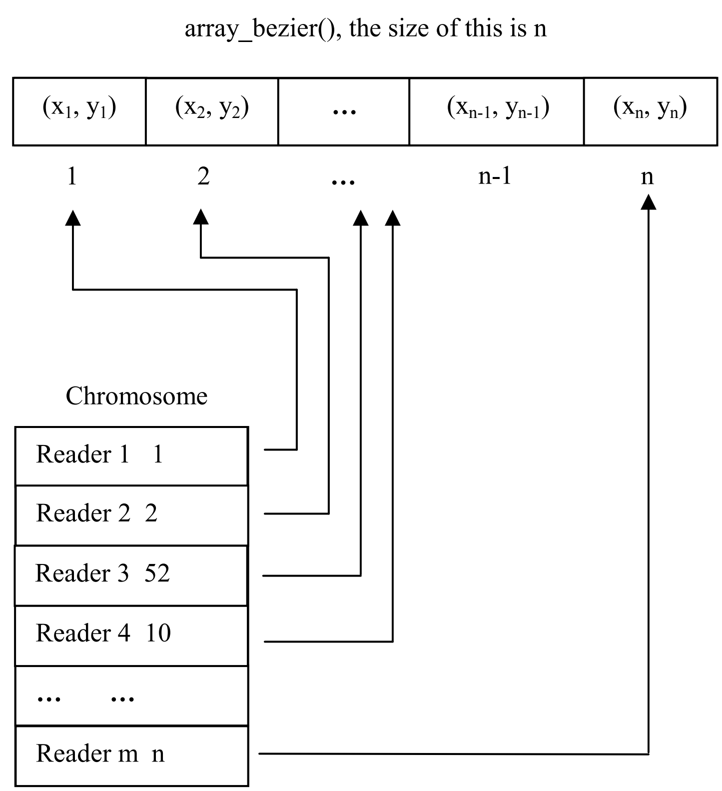
2. Chromosome defintion for this problem

And now, we begin to definite the data struture for this problem as follows:

Denoting Gen structure: We use a array that contains all of the points of the Bezier coordinations collection, is called array_bezier(), the size of this array equals total of points of the Bezier coordinations collection, every element of this array make the order number started from left to right, it holds two fields: x and y (as Figure 5).

We create the two column table to hold information of readers as follows:

- Column 1: To hold Identification of readers.
- Column 2: To hold one any the order number of array array_bezier that a reader points to it.



Fig, 5. Chromosome structure

For example, we have 10 readers in RFID system, so, chromosome is:

READER ID	POINTER
Reader 1	10
Reader 2	50
Reader 3	100
Reader 4	3
Reader 5	150
Reader 6	30
Reader 7	78
Reader 8	96
Reader 9	129
Reader 10	143

Table 1: Example of chromosome

Every table have the structure as Figure 5 is a chromosome that contain a result of problem. In this table, it allows two or more reader that points to the same the order number of array_bezier().

3. Fitness function of a chromosome

A fitness function is a particular type of objective function that is used to summarise, as a single figure of merit, how close a given design solution is to achieving the set aims.

In particular, in the fields of genetic programming and genetic algorithms, each design solution is represented as a string of numbers (referred to as a chromosome). After each round of testing, or simulation, the idea is to delete the 'n' worst design solutions, and to breed 'n' new ones from the best design solutions. Each design solution, therefore, needs to be awarded a figure of merit, to indicate how close it came to meeting the overall specification, and this is generated by applying the fitness function to the test, or simulation, results obtained from that solution.

Moreover, the fitness function must not only correlate closely with the designer's goal, it must also be computed quickly. Speed of execution is very important, as a typical genetic algorithm must be iterated many times in order to produce a usable result for a non-trivial problem.

Fitness approximation may be appropriate, especially in the following cases:

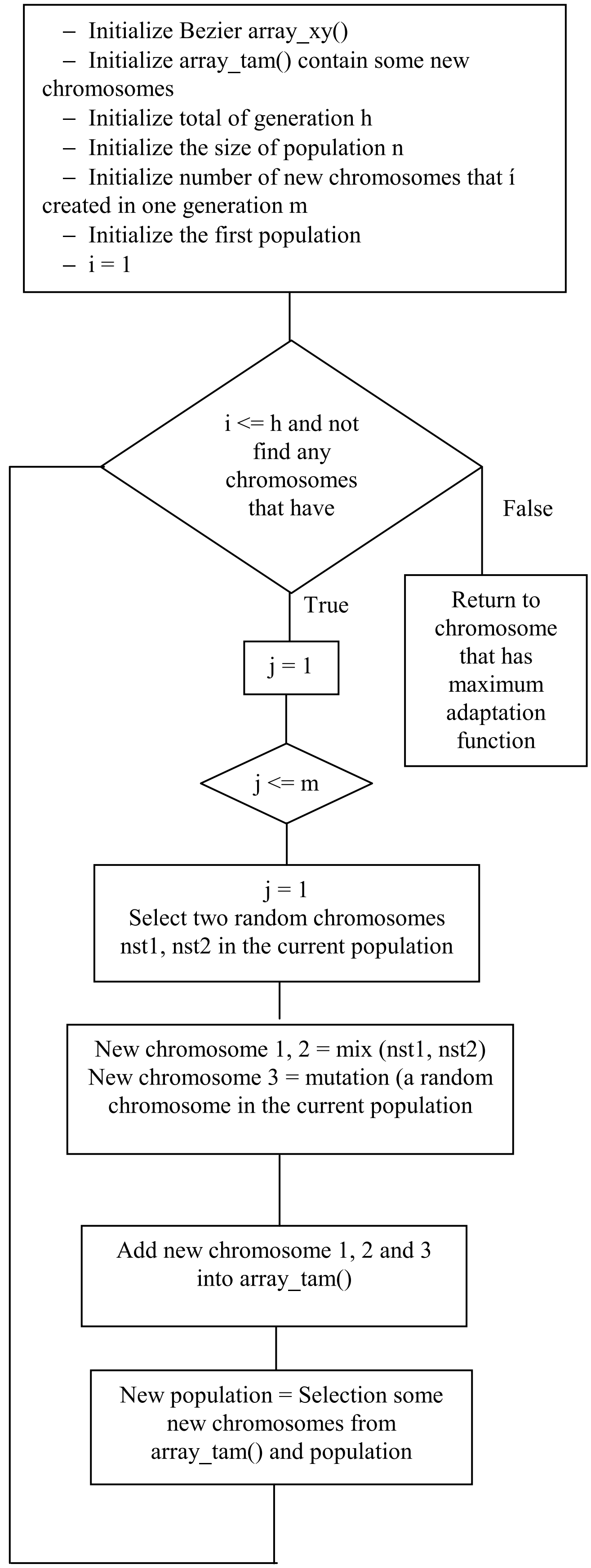
- Fitness computation time of a single solution is extremely high
- Precise model for fitness computation is missing
- The fitness function is uncertain or noisy.

In this case, fitness function is a real number, less than or equal to 1 and calculated as follows:

Fitness function = total of tag that RFID system detect /total of tag that really exist in big area.

4. The genetic algorithm defintion for putting readers on the approximate curves Bezier

Algorithm 2: Finding the perfect reader location



5. Solving some problem related algorithm

– Solving the degradation problem in population:

+ This take of place as follows: Adaptation of next generation higher than previous generation. We do not happen this.

+ Solution: At every evolutionary time, we always keep one or more good chromosome.

– Solving early convergence:

+ After some generation, population happen saturation phenomena, because chromosomes adaptation function is proximate together, leading to less evolutionary.

+ Solution: At every generation, we only save one chromosome that represent for some chromosome having the same adaption function. Random selection progress will keep some chromosomes having higher adaptation function.

– Increasing speed of evoltionary of poplation: when we carry out some operation of the genetic algorithm, such as: mix chromosome, mutation, it will appear some new chromosomes. These new chromosomes will be save in population but they do not replace parents of them in population. In next generation, we select some of them to create a new population base on probability. With variable size of population, it boosts evolutionary significantly.

D. Time Division Multiple Access Technology (TDMA) to decrease collision

The deployment of multiple readers in close proximity brings two new problems in multireader deployments are the reader-tag collision problem and the reader-reader collision problem which are jointly referred to as the reader collision problem:

- The reader-tag collision problem arises when one reader's signal drowns out the relatively weak response signal of a tag to another reader in the vicinity. This happens due to the large interfering range compared to the reading range in RFID systems. We illustrate these problems through examples in figure 6 This can be solved by having the readers programmed to read at fractionally different times. This technique (called time division multiple access - TDMA) can still result in the same tag being read twice.

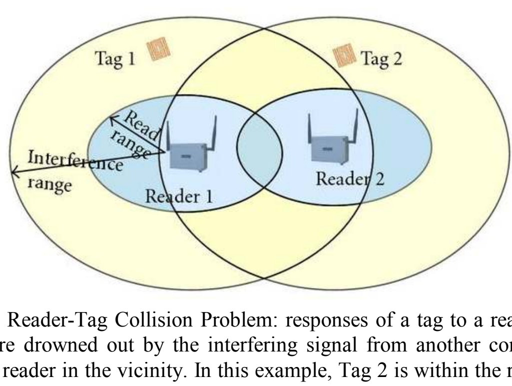


Fig. 6. Reader-Tag Collision Problem: responses of a tag to a reader when queried are drowned out by the interfering signal from another concurrently operating reader in the vicinity. In this example, Tag 2 is within the read range of Reader 2. Reader 2 is also in the interfering range of Reader 1. After Reader 2 queries Tag 2 for its ID, the response of Tag 2 at Reader 2 is interfered with by the signal from Reader 1 which was querying Tag 1 at the same time.

- The reader-reader collision problem arises where tags in the read range of multiple readers (referred to as overlapped tags) may not be reliably read. In this case, both the reception as well as response of a tag are affected due to the greater strength of the interfering signal in the reader's read range. We illustrate these problems through examples in figure 7. The only solution is to program the RFID system to make sure that a given tag (with its unique ID number) is read only once in a session.

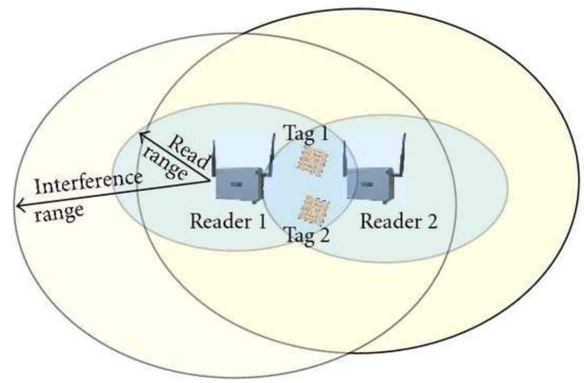


Fig. 7. Reader-Reader Collision Problem: tags fall within the read range of multiple readers (called overlapped tags), and the query-response sequence with one reader is interfered with by the simultaneous query-response sequence with other readers. In this example, Tag 1 and Tag 2 are overlapped tags within the read range of both Reader's 1 and 2. When both readers operate at the same time, each interferes with the query-response sequence of the other with any of the overlapped tags. This type of interference is stronger (as compared to that of Figure 1) as the affected tag is also within the read range of the interfering reader and affects both the reception as well as response of signals to/from the tag.

Time division multiple access (TDMA) is a channel access method for shared medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots. The users transmit in rapid succession, one after the other, each using its own time slot. This allows multiple stations to share the same transmission medium (e.g. radio frequency channel) while using only a part of its channel capacity. TDMA is used in the digital 2G cellular systems such as Global System for Mobile Communications (GSM), IS-136, Personal Digital Cellular (PDC) and iDEN, and in the Digital Enhanced Cordless Telecommunications (DECT) standard for portable phones. It is also used extensively in satellite systems, combat-net radio systems, and PON networks for upstream traffic from premises to the operator. For usage of Dynamic TDMA packet mode communication, see figure 8.

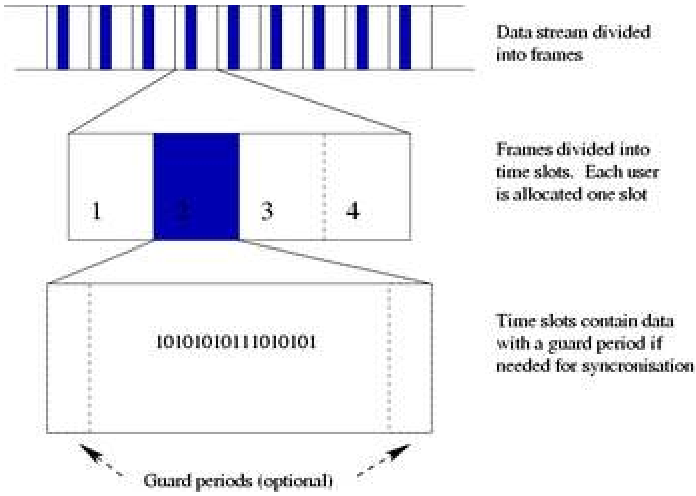


Fig. 8. TDMA

TDMA frame structure showing a data stream divided into frames and those frames divided into time slots.

In this paper, algorithm is displayed as follows:

Algorithm 3:

– Step 1: Call a() is array that contains ID of tag, these ID are read by reader and transfer them to server system.

– Step 2: Initialize cycle of readers equal 1s.

– Step 3: Adjusting the read cycle of Readers

+ Step 3.1: Finding ID that iterates many time in a()

+ Step 3.2: To define ID of readers that read above tag, these readers are reasons that cause collisions and the same ID of tag.

+ Step 3.3: Based on list of the detected readers, we fix the cycle of them as follow: If it appears two readers that have the same cycle, we will fix cycle of them to they are not equal each other.

+ Step 3.4: We mark ID of this tag is deal completely.

– Iterating Step 3.1 until we can not find any the same ID.

Above algorithm make to decrease collisions and the same raw. Thus, system run easyly and exactly

IV. Effect Analyze

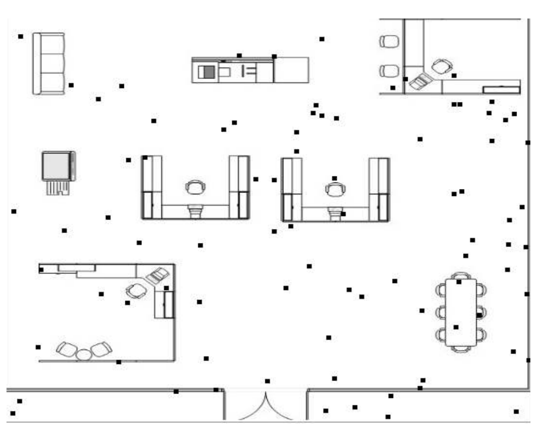


Fig. 9. The test model

A test model is designed to check feasible feature of this method as Figure 9. Result of the proposed algorithm approximate result of paper [3] as follows:

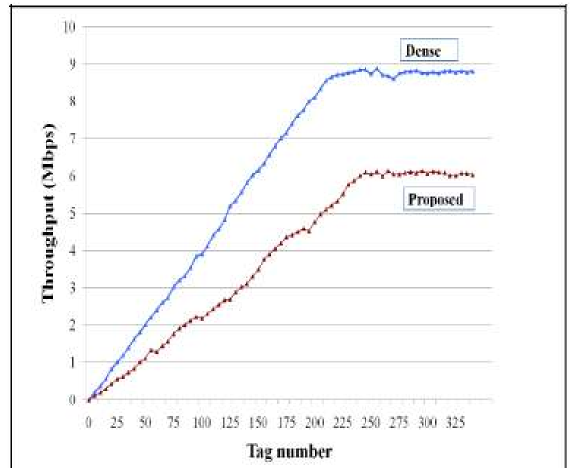


Fig. 10. System throughput

Figure 10 shows the comparison between dense mechanism and proposed mechanism. Before dense mechanism beginning to deploy RFID readers in best locations, dense mechanism needs large deployment time and has high probability of reader-to-reader collisions. this mechanism analyzes the locations of RFID tags and size of deployment area in advance. Consequently, dense mechanism has more maximum system throughput than other mechanisms.Otherwise the proposed mechanism has less deployment time and light reader-to-reader collisions.

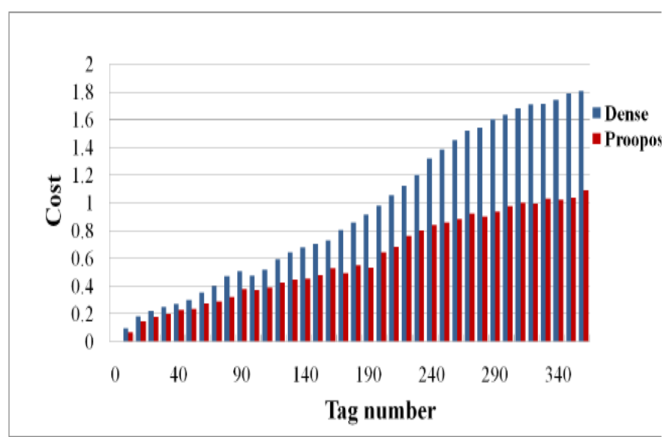


Fig. 11. Deployment cost

Figure 11 shows the dense mechanism has high deployment cost compared with the proposed mechanism.

This study defines the cost function as follows:

Cost (Tag number) = (Number of Reader/Number of $Reader_{max}$*) + (Deployment Time/Deployment* $Time_{max}$*) +(SNR/*$R_{requined}$*)*

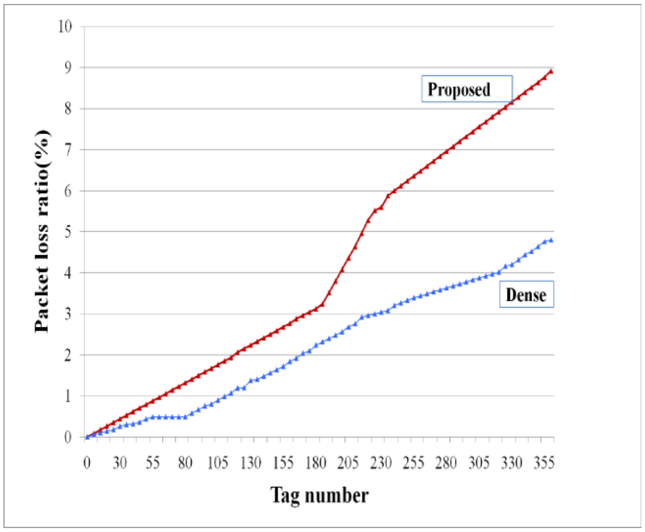


Fig. 12. Hit-miss ratio

Figure 12 illustrates the dense mechanism has low hit miss ratio due to intensive deployment way. The proposed mechanism has increased 4% of hit miss ratio comparing with dense mechanism.

Therefore, there is a comparison table of effect Analysis table:

Technical / parameters	throughput	Cost	hit miss ratio	RFID collisions	Deployment Time
dense mechanism	High	low	High	low	low
proposed mechanism	low	High	low	High	High

Table 2: Comparison of effect Analysis

Table 2 illustrates total view of comparison. Resulty, this method fit readers that have small signal power, and combine Time Division Multiple Access Technology to adjust the read speed of readers, we can reduce collisions.

V. Conclusion

This study employs a virtual reader model and perfect position detection method to deploy readers. It sutable reader that have small signal power, and we base on Time Division Multiple Access Technology to fix read speed of reader, thus, we decrease collision. Experimental results indicate that the proposed system is more efficient than current systems when used in large deployments with numerous tags. Reader collision probability is also improved. Eventually, the proposed RFID reader deployment mechanism in this study can significantly reduce the time and cost of RFID deployment.

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