

# Optimal Deployment Strategy of RFID Networks Using Tabu Search Mechanism

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**Abstract**— This work proposes a novel reader deployment mechanism for RFID applications used in daily life activities. Two aspects of the proposed mechanism are discussed: optimizing RFID reader deployment and adjusting reading speed to minimize reader collision. Tabu search strategy is used to find the better locations of deploying readers. Reader deployment performance is analyzed in terms of deployment cost, reader collision, system throughput and hit-miss ratio. Compared to traditional dense mechanisms, the proposed mechanism has a 36% lower deployment cost and a 34% lower average collision rate with only minor sacrifice of system throughput or hit-miss ratio.

**Keywords**—RFID, Virtual Reader, Adaptive Power Control, Tabu Search, Optimal Deployment

## I. INTRODUCTION

RFID is widely used in the modern life. RFID reader deployment is an important issue on RFID applications [1]. There are many concerns in deploying RFID readers, such as the reader collision, the power of signal, the interference of SNR, the direction of the antenna, system throughput and hit-query ratio. The virtual reader model and the adaptive power control strategy are developed to adjust readers' coverage in this study. Based on the Tabu search scheme, this study proposes a novel deployment mechanism to achieve optimal deployment with the least number of readers in RFID service networks.

## II. PROBLEM DEFINITION

RFID technology applies Radio Frequency (RF) transmitting/receiving signals in the air, which communicate each other via radio signals. RFID readers query tags ID and then obtain ID information from tag memory. However, with the same frequency signal sent simultaneously on the overlapping interrogation zones by different readers or tags will leads to some interference. The space is referred to as the interrogation zone. The interference refers to the collision of different radio signals with the same frequency in RFID system will lead to distorted signals received [2]. The RFID collision problems include tag-to-tag, tag-to-reader, and reader-to-reader collision [3].

This study mainly provides RFID readers deployment mechanism, which uses mobile RFID readers to find out the better locations in pipelines, that is able to read more tags and decreases the interference by other readers. Figure 1 illustrates the proposed application environment. This environment is divided into multiple regions and every region contains immovable RFID tags and information gateway. The information gateway stores the unique ID data of RFID tags in the connection table. This study can utilize this table to calculate the Query-hitT ratio (QT) in one of the regions. So if any new RFID tag will join into the regions, it must notify the information gateway to record its unique ID data. Every region can be monitored by multiple RFID readers. If RFID tags have been read by readers, the information gateway would receive RFID reading events, which mark "read" tag in its connection table. Every RFID reader can arbitrarily move to search better location by means of intelligent RFID deployment agent. This scenario can be suitable for fixed RFID tag applications, such as goods management, personal monitoring and object tracking.

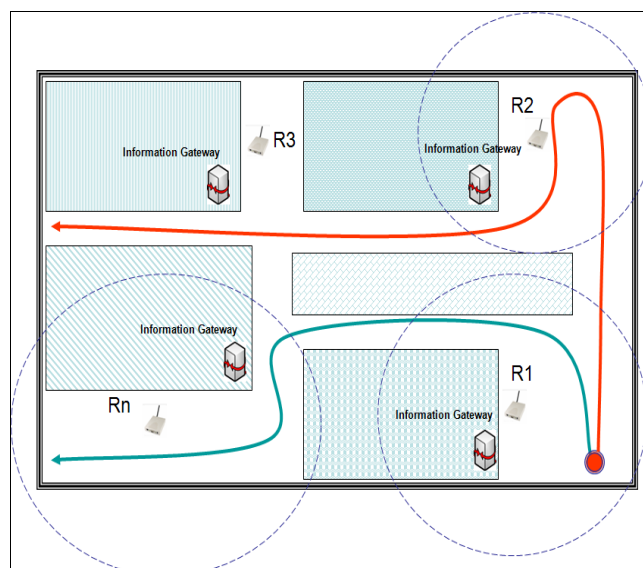


Figure 1. RFID Service Scenario

### III. SYSTEM ARCHITECTURE

Figure 2 illustrates the proposed deployment agent for RFID applications, which mainly can be divided into two parts: superior mechanism in RFID reader deployment and reading speed adjustment for anti-collision.

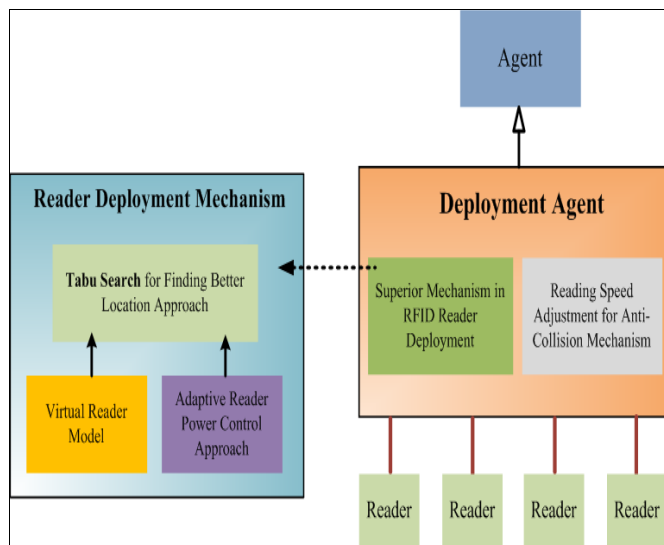


Figure 2. System Architecture

The first mechanism utilizes the virtual reader model to estimate the backscatter power and the Tabu search to find the better locations of deploying readers. In the procedure of Tabu search [4], it dynamically uses the adaptive power control approach to correct power coverage of readers, so that the interference of reader-to-reader collisions can be avoided and QT value can be enhanced.

However, some of RFID tags can't be read in this proposed mechanism. In other words, that is incapable for covering all of Tags. To solve the above problem, first of all, this study calculates if there is more space for deployment, and then determines that how many readers can be raised. Secondly, this study increases power coverage of readers which locating at the neighbor for the unread tags if there still has some tags can't be covered. In the mean time, the experimental result reports the RFID collision occurred. To avoid the problem, this study adjusts reading speed to decrease the reader collision, and renovates the definition of QT calculating function.

By both of deployment mechanisms, this study can utilize lowest RFID readers to reach the better readers deployment in RFID applications. The operating mechanism is shown in Figure 3.

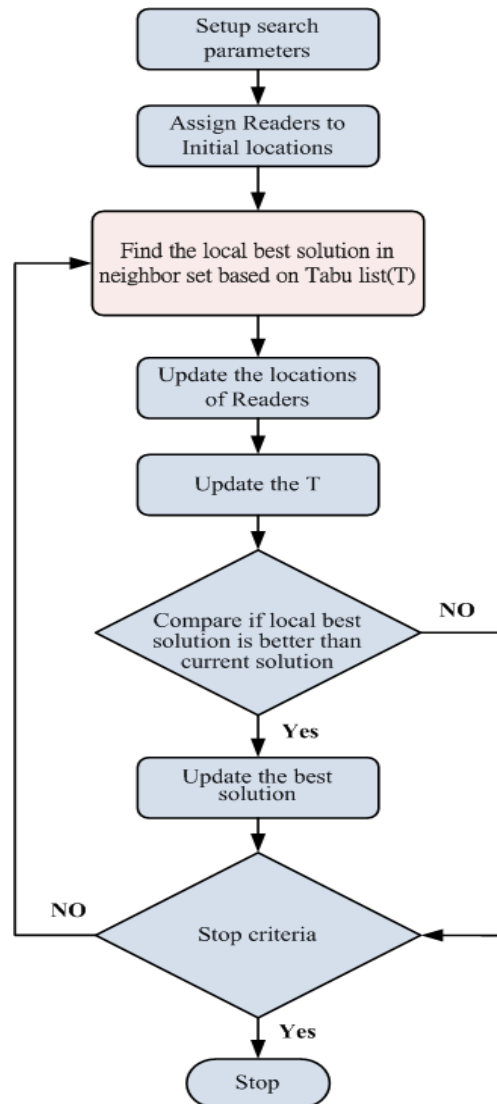


Figure 3. Operating Mechanism

### IV. PERFORMANCE ANALYSIS

To investigate the feasibility of the proposed mechanism, a tested scenario shown in Figure 4 is designed.

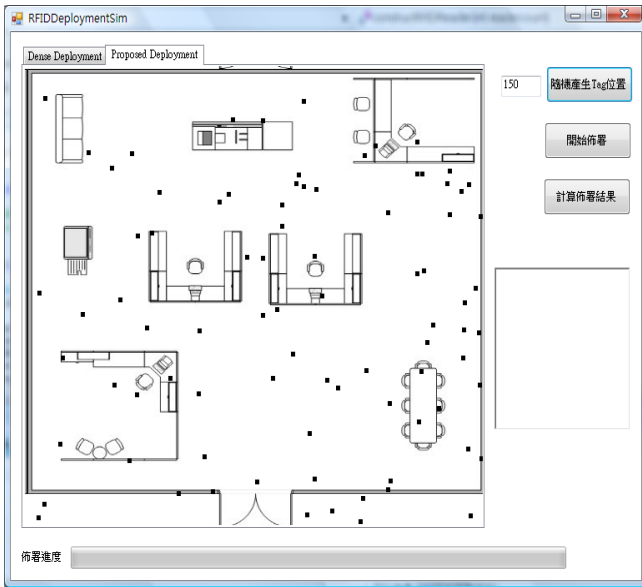


Figure 4. Testbed for RFID Reader Deployment

Figure 5 shows the comparison between dense mechanism and proposed mechanism. Before dense mechanism beginning to deploy RFID readers in best locations, 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. But dense mechanism needs large deployment time and has high probability of reader-to-reader collisions. On the other hand, the proposed mechanism uses moving readers to find better locations rely on deployment agent, but the proposed mechanism has low system throughput compared with dense mechanism. Furthermore, the proposed mechanism has less deployment time and light reader-to-reader collisions.

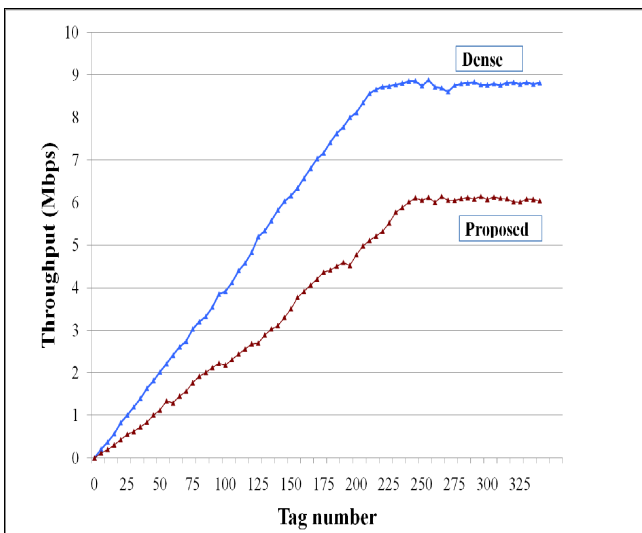


Figure 5. System Throughput

Figure 6 illustrates the dense mechanism has high deployment cost compared with the proposed mechanism. This study defines the cost function as follows:

$$\text{Cost (Tag number)} = (\text{Number of Reader/Number of Reader}_{\max}) + (\text{Deployment Time/Deployment Time}_{\max}) + (\text{SNR/R}_{\text{required}})$$

The different categories of effecting factors are fairly transformed into general decimal point, and can be summed to be the total deployment cost. As figure 6 shows the deployment cost approximately lies in between 0 and 2. This study verifies that the proposed mechanism has less deployment cost related to the dense mechanism.

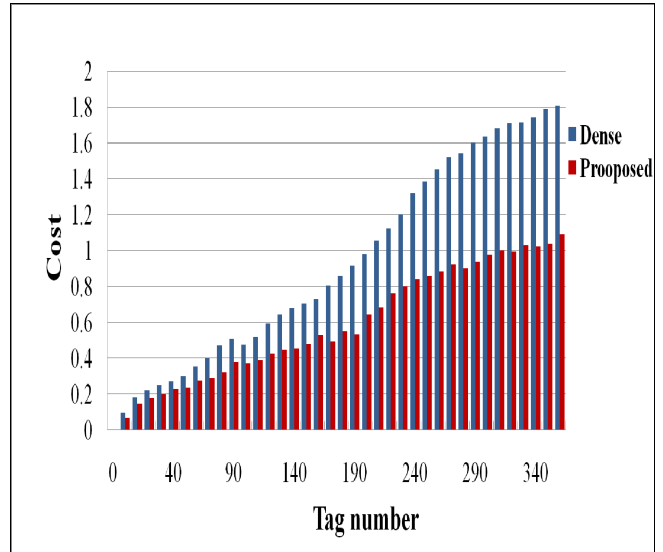


Figure 6. Deployment Cost

Figure 7 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.

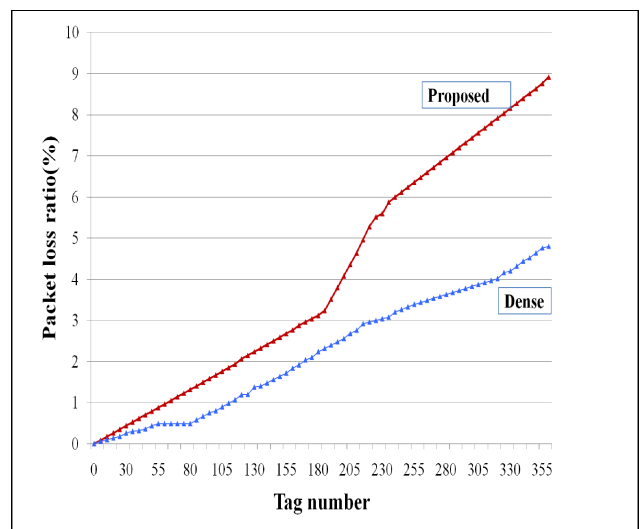


Figure 7. Hit-miss Ratio

**Table 1. Comparison of Performance Analysis**

Parameter Mechanism	Throughput	Cost	Hit miss ratio	RFID Collision	Deployment time
Dense					
Proposed					

Table 1 illustrates total view of comparison, dense mechanism has advantages of high system throughput and low hit miss ratio due to accurate planning of deployment. The proposed mechanism has advantages of less deployment cost, deployment time, and probability of reader-to-reader collisions, because this mechanism utilizes low RFID readers to reach the goal of better deployment depending on deployment agent, and adjusts the reading speed of RFID readers to decrease the probability of reader-to-reader collisions.

### V. CONCLUSION

This study employs a virtual reader model and Tabu search mechanism to optimize the deployment of RFID readers. The adaptive reader power control approach is used to solve the uncovered tags situation. Reader collision is avoided by adjusting reading speed. For benchmarking, the RFID reader deployment obtained by the proposed mechanism compared

with an intensive deployment obtained using traditional methods. 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.

### ACKNOWLEDGMENT

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