Multi-level optimal deployment of RFID readers by using particle swarm optimization

Abdelkader Raghib, Badr Abou El Majd

Department of Mathematics and computer science FSAC – Hassan II University, Km 8 Route d'El Jadida, Maarif, 20100 Casablanca Morocco
raghib.abdelkader@hotmail.com, b.abouelmajd@fsac.ac.ma

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1 Introduction

Radio Frequency Identification (RFID) is an automated data collection technology using radio-frequency waves to transfer data between a reader and a tag in order to identify track and do management of material flow. The following figure shows the basic components of RFID systems.

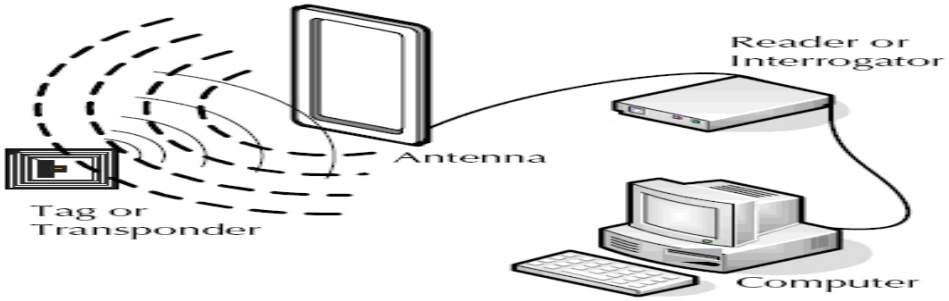

Fig. 1, Basic components of a typical RFID system.

An electronic tag, attached to an item, is scanned by a reader that can be mobile (hand-held), and can also be at a fixed point such as an entrance/exit, or as a point of sale. The success in the identification of items depends on the communication process between the reader and the tag. This process depends on correlated factors: the position and orientation of RFID tags, the interference from the environment, the type of material to identify and infrastructure limitations. One factor that is under control is the location and orientation of RFID reader.

Generally, due to the limited read range of readers, multiple readers are required to detect and monitor the tags in RFID networks. Therefore, there is a need to determine the optimal quantity and positions of RFID readers in the area of interest without losing efficiency in the communication process. This problem has studied by many researchers in order to cover all tags in the entire region with a few number of readers. Unlike the approaches developed in [1,2], which consist to place the readers only in candidate fixed positions, we propose an efficient approach, based on PSO with several attractive features: determining the minimum number of readers, finding their optimal positions without fixed them, and guarantying a full coverage of all the tags.

2 The proposed approach :

In order to find an optimal deployment of the RFID readers, the PSO algorithm [3] has adopted for this investigation due to its simplicity, efficiency, robustness, flexibility, ease of application and implementation. This advantage makes PSO algorithm more robust than many search algorithms, and has been successfully applied in many areas and solved a variety of optimization problems in a faster and cheaper way [4-8].

In this work, we developed and compared three methods: the first one starts by deploying randomly a reader, and then updates its position in order to determine the best location required to cover the maximum of tags. At each update, the best position is searched until we reach the full coverage, or we increment the number of readers when a search timeout occurs. In the second one, we save all the previous best positions when a search timeout occurs, and we start to update only the new reader until we find a full coverage. It's faster in term of CPU time but less accurate than the first one. The third method, illustrated by the figure 2, addresses the previous limitation by combining the first and the second method to yield even higher accuracy and efficiency. A key step in this algorithm is checking the best location of the readers in the proximity of the best previous positions when the search timeout occurs.

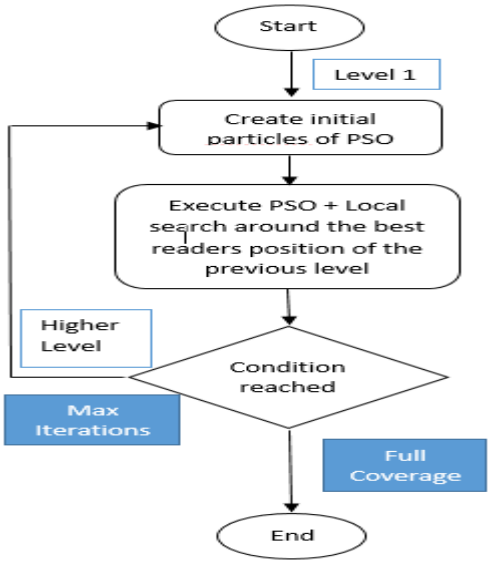

Fig. 2, Flowchart of the third method.

The simulation results demonstrate the efficiency of the proposed approach by determining a minimal number of readers, finding their optimal positions and guaranteeing a full coverage of all tags.

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