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# Optimization of the RFID network in IoT through Hybrid Genetic Algorithmz

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***Abstract***-- Several cutting-edge technologies, like as Radio Frequency Identification (RFID) optimization and sensors, are enabling the Internet of Things (IoT). Using a unique code connected with tags, this radio frequency identification technology allows the sensor to read from a distance without requiring sight contact. Optimal tag coverage, cost efficiency, and quality of service needs are all important considerations when deploying RFID networks. We investigated optimization approaches for RFID in Internet of Things (IoT) devices in this paper. RFID optimization saves processing time, hardware costs, and improves efficiency. Random search strategies based on Artificial Intelligence (AI) are more suited than deterministic methods that are difficult to solve in polynomial time. In this paper, we present a hybrid algorithm that combines PSO and GA features to improve the efficiency of an IoT network system.
***Keywords*-- RFID, antennas, optimization, particle swarm optimization, genetic algorithm, Internet of Things, artificial intelligence.**

## I. INTRODUCTION

Internet of Things (IoT) includes a collection of smart and networked devices serving a large domain of our daily needs, including accommodation, transportation, logistics, smart environment, entertainment, food, medical devices, and clothing [1-3]. The purpose of IoT devices is to implement autonomous, robust, and secure data exchange between devices and applications [2]. Radio Frequency Identification (RFID) is one of the most widely used technology in the domain of IoT [1]. Every year about 10 billion new Radio Frequency Identification (RFID) tags are deployed, and the number is growing faster ever since RFID's significant role in the Internet of Things (IoT) [4,5]. RFID technology does not require line of sight or contact between readers and tags, enabling access to real-time information about locations of various devices [6].

The tagging and tracking of IoT device deployment is usually done through RFID technology [7]. RFID uses radio-frequency waves to transfer data between a reader and a movable item to identify and categorize track with the technology called automatic identification and data capture (AIDC) technology [4,8]. The other AIDC techniques are bar code and Optical Character Reader (OCR) [9]. RFID is fast and does not require physical sight or contact between reader/scanner and the tagged item with the help of a unique system associated with tags. RFID operates using low-cost components such as recording metadata and controlling individual targets. RFID-based systems are quite widely used for tagging and keeping track of IoT deployment [7]. There are several critical challenges in the deployment of RFID networks, including optimal tag coverage, cost efficiency, and quality of service requirements [10]. This paper studies optimization techniques for RFID in the Internet of Things (IoT) devices.

## II. RADIO FREQUENCY IDENTIFICATION (RFID)

RFID technology is classified as a wireless automatic identification AIDC technology [8]. There are three critical components in an RFID system, namely, the tags, the reader, and the server [9]. RFID systems include a microchip tag that allows personal data to be sent to an RFID reader, which, in turn, emits radio waves to retrieve the data [11]. The reader can identify, track, and monitor objects attached to tags. RFID technology has several advantages as compared to the traditional bar code techniques, including non-contact, automatic, and unique identification [9,3]. The major challenge in IoT software is its capability of processing massive amounts of data in real-time applications such as smart health care, smart vehicles, smart condos, smart home, smart cities, etc. [12,9]. In this paper, we propose a hybrid algorithm combining features of Particle Swarm Optimization (PSO) and Genetic algorithm (GA) to improve the efficiency of the network system of IoT. Optimization in RFID reader helps to reduce the cost of hardware. Many research works are being carried via Ant Colony Optimization, Differential Evolution, Particle Swarm Optimization, and Genetic Algorithm.

These tags are microprocessor chips with integrated circuits and memory [13]. Each tag has a unique code for its identification called a tag's ID. RFID tags are classified into two types, namely passive tags and active tags. Passive tags do not require powers and draw from the interrogator field and are smaller in size and cheaper. Passive tags can detect objects in the distance up to eight meters in the UHF band. Active tags are larger than passive tags and hence have high storage capacities [14]. These are used for the specific application and have their power source to initiate the communication between RFID readers. The usually read range is 300 feet, typically these can be re-written by RF Interrogators [15,13,16].

The RFID reader is used to read or write the data to the RFID tags. These are remote power tags establishing a bidirectional link. Inventory tags filter results in communicating with networked servers are capable of reading 100-300 tags per second [13]. The RFID reader is usually fixed at the entrance or exit. These are external powered equipment used in the RFID system for creating and accepting radio signals. The antenna is used for reading tags and has its magnetic field of reading tags within these magnetic fields. A Reader can operate on multiple frequencies and depend on the vendor antenna signal directly reflecting your tag information. WSN is used to observe the physical parameters like temperature, pressure & humidity, etc. Data is then transformed from sensor nodes to the base station [14,16].

## III. SWARM INTELLIGENCE AND OPTIMIZATION TECHNIQUES

Artificial Intelligence (AI) based random search techniques are better suited as compared to deterministic methods which are difficult to be solved in polynomial time [11]. Swarm Intelligence is the discipline that deals with natural and artificial systems composed of many individuals (multiple agents) that coordinate using decentralized control self-organization. A Swarm has been defined as a set of (mobile) agents which are liable to communicate directly or indirectly (by acting on their local environment) with each other and which collectively carry out a distributed problem-solving [17]. Swarm intelligence is based on the collective intelligence of groups of agents in a decentralized environment. This behavior is characterized by self-organization, control, and indirect interaction in the context of task allocation. For instance, ants demonstrate swarm behavior where first some ants randomly search for food, and once they find food, they lay pheromone along the path so that other ants can follow them [17].

RFID readers and tags need to communicate with each other to transfer collected data and process upon it further. RFID tag realizes the long-range communication when it starts operating on received weak electromagnetic waves. The optimization technique is used to improve the process to a more functional and effective one, thus improving the overall system design and decision process. It is the most cost-effective technique or highest achievable performance under the given limitations. The word optimum reveals the process maximum or minimum of certain factors in a method or function. An optimal solution is achieved through the best and efficient optimizer. RFID tag output voltage of the circuit is maximized. The reader is placed sufficiently far from the RFID tag, and the plane wave is incident to the RFID tags. When the input impedance of the back-scattering antenna is changed, the RFID tag is maximized, and the RFID antenna circuit in the plane wave is incident on the double antenna under the situation [18].

### *A. Ant Colony Optimization*

Ant Colony Optimization (ACO) algorithms are used to solve most optimization problems and are explored almost into all fields of computer and sciences as well [19]. ACO algorithms are inspired by the behavior of real ant colonies [20]. These algorithms can find the solution by generating artifi-

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cial ants. This technique well explains discrete optimization problems. ACO is a meta-heuristic technique presenting good performance and robust enough to be applied across a range of combinatorial optimization problems. Building routing paths is done in ACO algorithms through a set of artificial ants that work cooperatively using indirect communication of information following a stochastic local search strategy [19,20]. We apply this ACO algorithm to find the best location for the communication of the RFID readers. The study of ACO reveals that this algorithm is used to find the best location for RFID readers [21].

*B. Particle Swarm Optimization*

Particle Swarm Optimization (PSO) is a popular swarm intelligence algorithm that is influenced by the models of swarming and flocking [10]. Particle swarm optimization is a population-based stochastic optimization technique that provides a population-based search procedure. It gives the best solution from the problem by taking particles and moving them around in the search space. The study intended to graphically simulate the choreography of a bird block and found its use as an optimizer. As described in Figure 1, the system is initialized with a population of random solutions and searches for optima by updating generations without crossover and mutation.

The particles fly through the problem space by following the current optimum particles. Particle swarm optimization uses a computational method that optimizes a problem by iterating trying to improve a candidate solution, about a given measure of quality. Since it has fewer parameters to tune, easier searching is possible in a vast problem space with faster convergence. The basic principle behind this is to let particle swarm move towards the best position in search space, remembering each particle`s best-known position and global (swarm`s) best-known position [22,23].

*C. Genetic Algorithms*

Genetic Algorithm (GA) is an optimization technique based on the principle of genetics [3]. GA is one of the most used heuristic algorithms that use a population-based approach to solve a wide range of problems, including multi-objective optimization problems [6]. This is inspired by the natural evolutionary process of chromosomes selection, developed by John Holland [24]. The problem is solved in a genetic algorithm by randomly generating a population of chromosomes, followed by assessing the fitness of each chromosome [25]. As shown in Figure 2, the next step is to randomly mate and mutate the bits to generate new chromosomes and also to remove some of the less-fit members from the population [25]. The last step involves the evaluation of the new chromosomes and also including them in the population [25].GA search global optimizer searches the solution space in a parallel manner and does not depend on the initial set of conditions. GA generates the initial population randomly, and the fitness values of all chromosomes are natural and usually evaluated by calculating the objective function in a decoded form (phenotype).

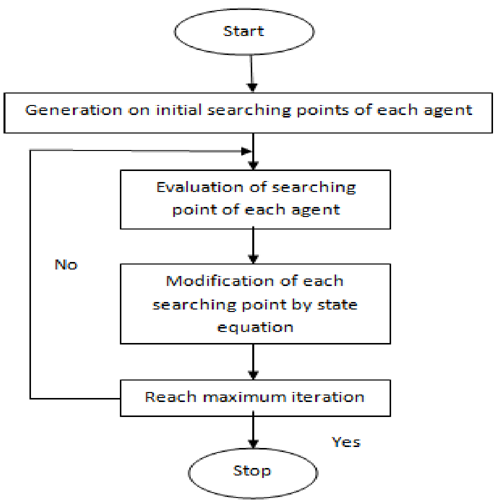


FIG.1 PARTICLE SWARM OPTIMIZATION FLOWCHART.

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From the present population, the process of defined G-operations selects a particular group of chromosomes (parents) to generate the offspring [3]. This process ensures that the fitness of newly created offspring is evaluated similarly to their parents. The chromosomes in the current population are replaced by their offspring based on a certain replacement strategy, and this GA cycle is repeated until the desired termination criterion is achieved. Therefore, a highly evolved solution of the population is obtained from the best chromosomes achieved in the final population. The various techniques that are adopted in GA include encoding, fitness evaluation, parent selection, genetic operation, and replacement. The study reveals that GA is the most appropriate technique for the optimization of RFID readers. The optimizer of GA is non-bias to the solution space. GA has three primary operations, which are selections, crossover, and mutation.
GA can avoid being trapped in situations like traditional methods as it searches from a population of points, which is from a single point. The population is generated randomly first, then the fitness values of all the chromosomes are evaluated. The evaluation is done by calculating the objective function in a decoded form (phenotype). A particular group of chromosomes (parents) are selected from the population to generate the offspring by the defined genetic operations. Similarly, the fitness of the offspring is evaluated to their parents. This GA cycle is repeated until the desired termination criterion is reached. At the end of the process, the best chromosomes in the final population can become a highly evolved solution of the population [26].
GA is based on the mechanisms of natural selection with several advantages, including solving complex problems efficiently. The chromosome in a GA is a permutation of genes. The parameters for a GA include the number of iterations, the size of the population, as well as the crossover and mutation probability. The status of a chromosome in a genetic algorithm is determined through a function. GA uses an objective function, a mathematical approach to evaluate the status of each chromosome. This objective function can be the best minimization that takes chromosome as input to produce a list of numbers. Now we use this so as a measure to the performance of the chromosome. The fitness function is necessary to map the objective value to a fitness value. This function, also known as the fitness function, uses a set of numbers as input to examine the performance of the chromosome. A higher value of fitness means that the solution has a higher chance of being selected into the next generation.
$f_j = f_{best} - (j-1).d$

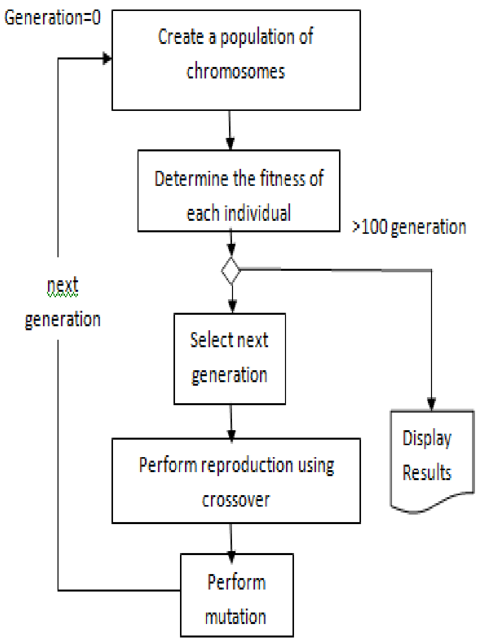

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FIG. 2. GENETIC ALGORITHM FLOWCHART.

## IV. HYBRID PSO-GA ALGORITHM

Hybrid PSO-GA algorithm reduces the processing time, cost of hardware, and improve the efficiency in RFID optimization. We include the process of PSO as the initial step of GA to manipulate the chromosomes.

TABLE 1. COMPARATIVE ANALYSIS OF PSO, GA, AND HYBRID PSO-GA ALGORITHMS.

| Measure/Algorithm | ACO | PSO | GA | Hybrid PSO-GA |
|---|---|---|---|---|
| Effisciency | Low | High | Medium | Higher |
| Robustness and Flexibility | Low | High | Medium | Higher |
| Size | Low | High | Medium | Higher |
| Cost | Low | High | Medium | Higher |
| Fitness | 26.6 | 33.4 | 32.7 | 33.9 |

The selection of individuals is made the creation of new individuals for reproduction, followed by Crossover for recombination. The hybrid PSO-GA system includes three steps. In the PSO enhancement step, individuals of the same generation are enhanced. We can calculate the fitness value of individuals belonging to the same population so that we can mark the most successful first half population. We use PSO to enhance individuals instead of reproducing the individuals of GA's directly.

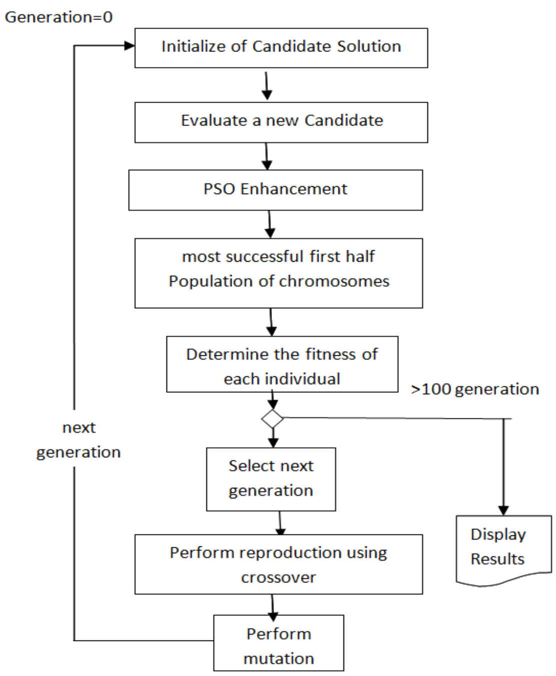


FIG. 3. HYBRID PSO-GA ALGORITHM.

Crossover is used to select parents for the crossing operation. We also used the selection scheme roulette wheel. This produced successful individuals among parents of the crossing operation, which are selected from the only people who improved. The flowchart depicted in Figure 3 illustrates the Hybrid PSO-GA algorithm.

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This algorithm initially starts with PSO, and then the output is fed to GA to manipulate the process. The first step in this process is to initialize the candidate solution and then evaluate a new candidate. Subsequently, we enhanced the best solution with the PSO algorithm. Then, the most successful first half population is fed to GA, which now determines the fitness of each individual. If the result is achieved, then the results are displayed. Otherwise, the next generation is selected. Reproduction is then performed using the crossover to produce successful individuals among parents of the crossing operation from the new population. Finally, the mutation is performed to produce new genetic material by achieving the global convergence of the algorithm. The results, as shown in Table 1, demonstrate a comparative analysis of PSO, GA, and Hybrid PSO-GA algorithms. This table indicates how the hybrid optimization technique improves the overall performance once the data is read completely. Table 1 gives the complete result of comparison calculating the fitness value. The results of the fitness tests are drawn from algorithmic calculations.

## V. CONCLUSION

RFID technology is used in most of the smart applications of IoT. The major challenge is the IoT software and its capabilities to process the data while communicating between the reader and its objects attached with RFID tags. There are several other key challenges in the deployment of RFID networks, including optimal tag coverage, cost efficiency, and quality of service requirements. In this chapter, we studied the optimization techniques for RFID in the Internet of Things (IoT) devices. We also studied optimization techniques for RFID in the Internet of Things (IoT) devices in this chapter. Optimization in RFID reduces the processing time, cost of hardware, and improve efficiency. Artificial Intelligence (AI) based random search techniques, including Genetic Algorithms (GA) and Particle Swarm Optimization (PSO), is better suited as compared to deterministic methods that are difficult to be solved in polynomial time. In this paper, we proposed a hybrid algorithm combining features of PSO and GA to improve the efficiency of the network system of IoT. This study revealed that the global performance of the proposed hybrid algorithm is efficient and can be used as a universal algorithm to solve several kinds of optimization problems. Future work will also focus on the optimization of the RFID network in IoT for adjustable network coverage in RFID readers.

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