PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA

MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

MOHAMED BOUDIAF UNIVERSITY - M'SILA

FACULTY OF MATHEMATICS AND COMPUTER SCIENCE

DEPARTEMENT OF COMPUTER SCIENCE

N° :……………………………………….

جامعة محمد بوضياف - المسيلة
Université Mohamed Boudiaf - M'sila

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OPTION : ………………………………

Thesis submitted for obtaining

From the Academic Master's degree

By: AMIRA MOHAMMEDI

RAYANE HAMMMAMOUCHE

Titled

RFID NETWORK PLANING

Defended before the jury composed of:

First and last name Teacher	M'sila University	President
…………………………….	M'sila University	Rapporteur
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Academic year: 2021 / 2022

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ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful, And prayers and peace be upon the holy Prophet Mohammed.

Firstly, we would like to thank God for giving us the power to complete this work, and because it illuminated our path until we achieved the goal that we aspired to.

I would like to express my special appreciation and thanks to my advisor professor Dr.Sayad Lamri for his support And for guiding us in this work over and over. it was pleasure to work with you ,a lot of thanks because you offer to us the opportunity to completing this work.

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MOHAMMEDI AMIRA,HAMMAMOUCHE RAYANE

DEDCATION

I would like to dedicate this thesis to Our parents ,who gave the little they had to ensure we would have the opportunity of an education ,their effort have allowed us to have a key to unlock mysteries of our world ,and beyond .

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Table of Abbreviation

WIP:	work in progress
RFID:	Radio frequency identification
SCM:	supply chain management
RNP:	RFID network planning
IOT:	internet of thing
RF:	Radio frequency
PC:	portable computer
NLIP :	non-linear integer programming
MC-BFO:	multi-colony bacteria foraging optimization
CA-RNP:	curling algorithm for RNP
HPSO-RNP :	Hybrid Particle swarm optimization for RFID network planning

***INT*:**	the interference
CMOABC:	a cooperative multi-objective artificial colony algorithm
EPC	Electronic Product Code
P_r:	received power
COV:	Covrage
P(T , R) :	the boolean model
RAT:	the interference rate of the tag
LB:	load balance
POW:	Power
HTML:	hyper text
PSO:	particle swarm optimization
TS:	set of tags
RS:	set of readers

GENERAL INTRODUCTION

RFID is outstanding technology developed by Dr. Bill Hardgrave the founder of the RFID Research Center at the University of Arkansas. The center had a strong collaboration with Wal-Mart; the first company to implement RFID in a large scale. He suggested that RFID will be used in the next generation.

Fortunately, his vision become true in various retails located in the USA and some European countries.

Actually, RFID system is very appropriate for various applications including: the manufacturing industry such as for tracking work in progress (WIP), automotive related systems, supply chain management (SCM) and can, also, be used in various processes such as shipping and receiving, warehousing …etc. From here, we can conclude that the word of DR. Bill Hardgrave is true.

Challenges of large scale RFID deployment:

The use of this technology by lot of companies ,in large scale ,makes some troubles like cost of RFID technology. Also, we can see that the number of equipment (reader, tag, middleware and other) is relatively huge which means that the complexity of the RFID system is increasing because of the significant needs for deploying a huge number of RFID readers without issues.

Additionally, the detection range of RFID system is limited for the actual time. Hence, we can observe that readers are needed in order to cover a large area. There are also some challenges that need to be considered such as optimizing: tag coverage, readers collision avoidance, cost efficiency and good load balance. These challenges formed a new branch of knowledge named RFID Network Planning (RNP).

A good RNP solution will optimize the RFID system and minimize the system interference to other RF systems in the surroundings.

In this work, a K-Means algorithm was chosen for solving this problem. This work focuses on the problem described above.

Thesis Organization:

Our work has been organized as follows:

Chapter01:

We give an overview of the RFID system and the different applications of this technology, and also the use of this technology in Algeria.

Chapter02:

In this chapter, some related works will be explained and discussed.

Chapter03:

In chapter03, we formulate the problem of RFID network planning and give the details of the used algorithm to solve it (K-Means).

Chapter04:

We talk about the tools that will be used to implement the K-Means algorithm and the implantation of this algorithm and we conclude this chapter with a discussion of the problem

CHAPTER 1:

RFID NETWORK

1.1. Introduction :

Before 1948, people used to access to their own building, room, vehicle using a car key, validate a ticket and so on. In the early 1940 to the bigning-1970, the first contactless technology was invented by Charles Walton (1) . Since that, the RFID system has been successful integrated in many areas such as logistics, automotive, surveillance, automation systems, and in general real time object identification (1). Typically, RFID technologies generally refer to transfer data from a device tag, called an RFID tag or label, through a reader attached to an object for the purpose of identifying and tracking the object (2). The purpose of this chapter aims at introducing the RFID technology and its history, In the second section, we discuss the different types of identifiers or Tags and readers. Then , we describes the operation of an RFID system. After that, we give a list of some famous applications that have been developed in the RFID context. Also, We identify the current limitations and challenge still facing RFID system. Finally, we conclude this chapter with a conclusion.

1.2. History of RFID:

The RFID system was firstly discovered during the second World War II where the military researchers effectively proven that the radar could identify the aircraft based on the radar redefect wave (2) . Overall, its development historic can be summarized in the below table:

Year	Description
1940s (RFID Invented)	•Radar is refined. • Harry Stockman publishes "Communication by Means of Reflected Power."
1950s (Time of Research and Development)	• Technologies related to RFID were explored in laboratories. • Designs developed for long range transponder systems for aircraft.
1960s (Applications Abound)	•During the 1960s inventors began applying radio frequency technology to devices aimed at markets beyond the military.

	• Companies Sensormatic, Checkpoint and Knogo develop theft prevention production for public consumption using Electronic Article Surveillance. •EAS is an affordable and relatively simple technology. "1 bit tags" meant that systems could only detect the presence of absence of the tag. • EAS represents the first and to date, most popular use of RFID technology
1970s (Hard at Work)	•Academic institutions, government laboratories companies and independent researchers are all working to develop RFID technology. • Work done at this time was aimed toward electronic toll collection, animal and vehicle tracking, and factory automation.
1980s (Commercial Expansion)	•RFID technology is fully implemented. Europe and the U.S.apply RFID to transportation systems, animal tracking, and business applications.
1990s (RFID Becomes Commonplace)	•RFID uses are so widespread that standards begin to emerge. •RFID is widely used by consumers and companies globally.
2000s (RFID Enhancements)	• Improved technology leads to miniaturization. • Cost of RFID continues to fall. •Private authentication develops as key concern in library implementation
2010s (New generation RFID system)	-integrated in different industry 4.0 context - IoT system - Unmanned Aircraft System

	- Healthcare - Agriculture

Table1. 1: radar historic development

1.3. RFID system:

An RFID system uses remote radio communication innovation to identify labeled objects or individuals. There are three essential components of an RFID system, as shown in :

Figure1. 1:RFID system

1. A tag (in some cases called a transponder), which is consisting of a semi-conductor chip, a contact or contactless wire, and in some cases coupled with a battery.
2. An investigator (some of the time called a reader or a read/write gadget), which is consisting of a RF receiver, and a control hardware module.
3. A controller connected with PC or a workstation where the data sorted in a database and software controller (middleware).

1.3.1. The tags

RFID cards are equipped with a chip that allows the desired data to be stored. This chip is connected to an antenna for transmitting and receiving data from the RFID reader (3).

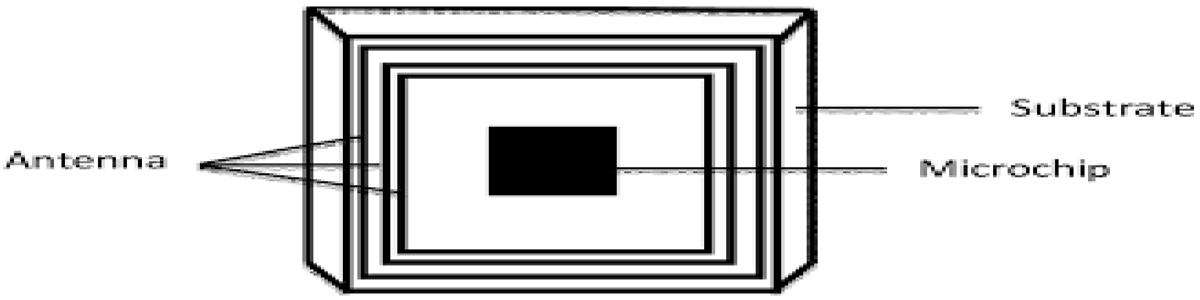

Figure1. 2:RFID tag

RFID tags can be in three basic types; passive, active, and semi-passive.

1.3.1.1. Active tags:

Active radio distinguishing proof may be a frame of distinguishing proof innovation characterized by the use of dynamic labels moreover called dynamic tags. Tags are little objects that can be stuck on objects or embedded into the same objects, they contain:

- an electronic chip.
- an antenna.

Thus, we are talking about active RFID when they contain an on-board control source, such as a battery.

These sorts of labels regularly have bigger recollections, up to 128 Kbytes. In any case, they are much bigger and more complex than their detached partners as well, making them more costly to deliver. The batteries in dynamic labels can final from two to seven a long time.

1.3.1.1.1. Benefits:

Unlike the inactive name framework, dynamic names are prepared with a clean vitality that permits them to transmit a flag autonomously. The most advantage lies within the long separate to which they can communicate the information without an RFID reader being nearby.

1.3.1.1.2. Disadvantages:

- The fundamental drawbacks of dynamic RFID are:
- the privacy of the data transmitted;
- the taken a toll of labels;
- the profoundly disputable wellbeing affects due to the emanation of attractive waves;
- the restricted working time of the name.

1.3.1.2. The passive tags:

Not at all like dynamic labels, inactive labels don't hold a battery: they draw their vitality through the electromagnetic flag of the readers which empowers the tag to enact and, in this way, permits it to transmit data.

Detached labels utilize distinctive radio recurrence groups depending on:

- their capacity to transmit information at changing distances
- the diverse substances that the information must pass through (discuss, water, metal...)

Just like the active RFID system, passive RFID has a wide range of applications, such as:

- animal identification,
- the traceability of waste,
- the tracking of postal packages,

- supply chain,
- stock management, etc.

1.3.1.2.1. Benefits and Disadvantages:

The advantage of detached RFID over dynamic RFID lies more within the fetched of labels that are less costly than dynamic tags.

This framework is exceptionally valuable for products in huge volume when the products can be perused from a brief separate (checkout at supermarkets).

Also, the perusing remove is be that as it may a genuine brake to this framework since the reader must be within the field of the tag in arrange to recuperate the information

1.3.1.3. RFID semi-active:

These semi-active labels, also called semi-passive labels, take after the working of dynamic labels as they are too fueled by an on-board control source.

The contrast between these two sorts of names is based on the battery control supply: it powers the RFID chip not persistently but at normal and programmable time interims and does not send any flag.

1.3.1.3.1. Benefits:

Radio-identification has numerous points of interest in itself. Employing a semi-active distinguishing proof medium has, in turn, certain focal points over dynamic or detached tags:

- More execution compared to the detached RFID system
- more reasonable compared to dynamic names

1.3.1.3.2. Disadvantages:

The most impediment of semi-active RFID compared to dynamic RFID is basically its reliability. Depending on the utilize of labels, semi-active RFID will in this manner not be suitable and you'll fundamentally ought to favor dynamic labels to guarantee way better traceability.

1.3.2. The readers:

An RFID reader may be a gadget used to inquiry the RFID Tag. The reader plays the part of transmitter and collector. The Player has a receiver wire, in transmission, that transmits information by radio waves whereas the Tag reacts by returning its information. The Player employ his radio wire, in gathering, to gather the information gotten from the Tag. He then transmits this information to a computer for handling, RFID communication is based on the principle of master-slave relationship (Fig1.2-3.).

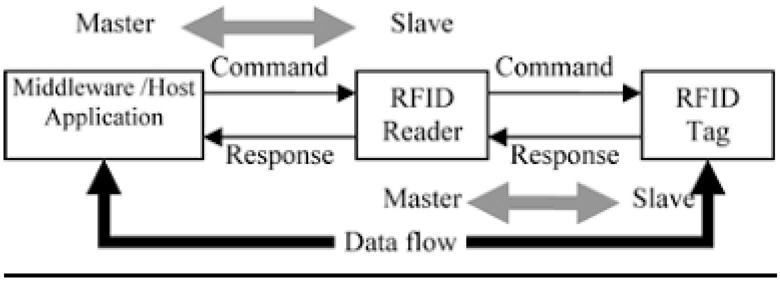

Figure1. 3:master slave relationship in RFID communication

Where the reader, himself controlled by a software of the desired RFID application, plays the role of master and the tag that of slave (4).

The information contained in the Tag is then read (read only) and in the case of more complex systems, the reader can also rewrite new data in the Tag (read/write). So, the reader's work depends on the tag mode. This communication between the reader and the label listed in four stages:

A. The drive transmits the energy needed to activate the tag.

B. It spear during a request asked the closed label.

C. Listens to responses and eliminates duplicates or collisions between responses.

D. Finally, it transmits the results obtained to the applications concerned

Figure1. 4:RFID Reader

1.4. Operation of RFID systems:

The RFID system operates as follows:

The RFID name (or transponder or tag) is itself prepared with a chip associated to a receiver wire, The radio wire permits the chip to transmit data (serial number, weight...) that can be studied through a handset reader.

Once the data has been transmitted to the RFID reader prepared with a coordinates or outside radio wire, the reader as it were must change over the radio waves into information and these can be perused by an RFID software.

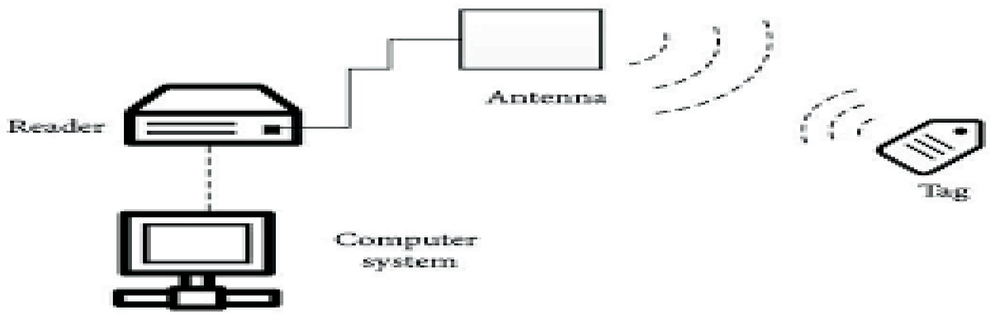

Figure1. 5: Operation of RFID system

1.5. Application of RFID Technology:

Today, the use of RFID systems is expanding rapidly. We can find this technology in various everyday RFID applications.

RFID applications are based on different standards depending on functionality required by business processes and certain local constraints. RFID meets a large number of needs. It is developing well in intra-company and in the logistics (4).

1.5.1. RFID in Supply Chain Management and Logistics:

Supply chain management and logistics is the foremost rich field as distant as the applications of RFID are concerned. Let’s consider all the components of supply chain administration one by one.

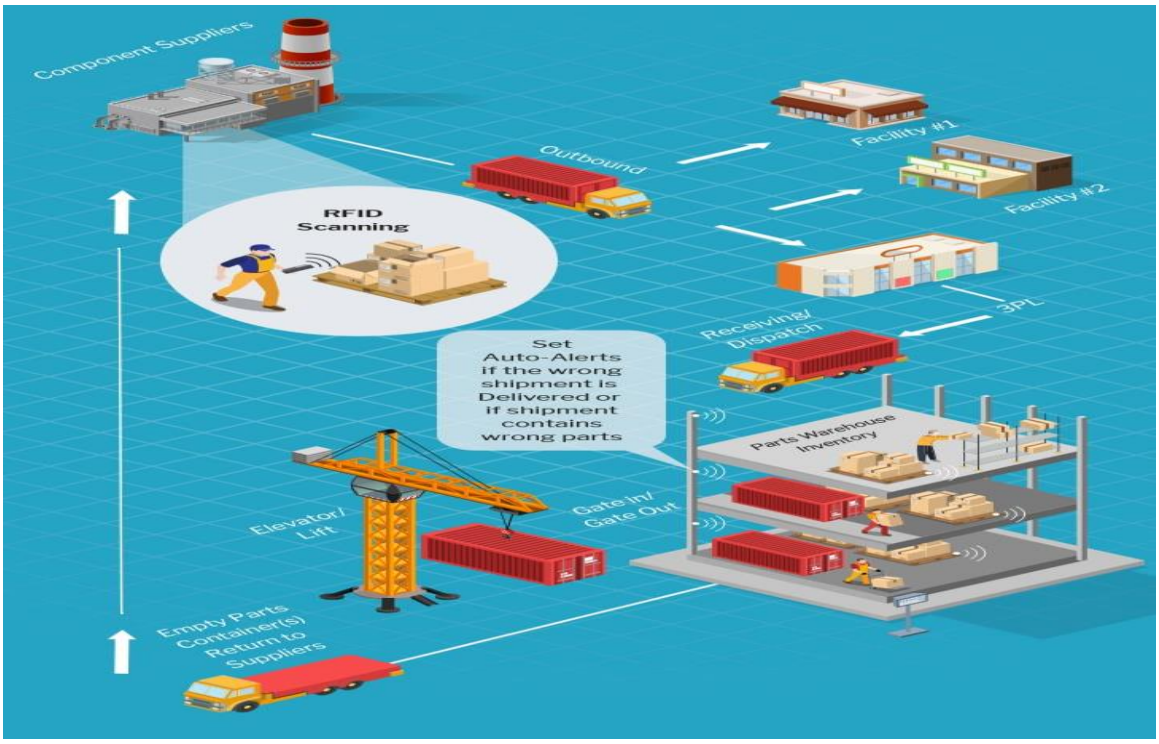

Figure1. 6:RFID in Supply Chain Management and Logistics

1.5.1.1. Inventory Management:

These properties of RFID help to speed up the inventory management process and reduces human errors, thus rendering highly accurate inventory records.

1.5.1.2 Warehouse Management :

Warehouses are simply a storage area where products received from the suppliers are sorted. Recently, RFID has emerged as a technology that supports warehouse management systems for simpler supply chain and greater product intelligibility.

1.5.2. Application in animal tracking :

Another well-known application of RFID is in creature following. Utilizing RFID labels to track creatures isn't a modern application, but it has advantage from the utilization of identifying of missed cattle to the following of its developments and behavior. The RFID labels are indeed utilized to control out breaks of creature illnesses. Nowadays innovation has trans shaped into human implantation of RFID labels. RFID based wristbands and dress inserted with RFID labels are utilized to track detainees

1.5.3. Application in health care industry:

The RFID tags are also used in the health care industry; an RFID tag is used to store the patient's medical history. RFID tag is scanned each time to know the developments and changes of the patient's health condition and medication. RFID tags are often used for medical transactions.
RFID tags can also be used in airline industry to track the baggage of the passengers (5)

1.5.4. Application in Passports :

A number of countries, including Japan, the United States, Norway, and Spain incorporate RFID tags into passports to store information (such as a photograph) about the passport holder and to track visitors entering and exiting the country.

1.6. The RFID exploitation legislation in Algeria:

The misuse of RFID innovation in Algeria is subject to official declare n°= 12-367. The operation of RFID frameworks must not cause obstructions with radio communication. The purport, showcasing, fabricating and RFID gadgets are subject to authorization by the National Organization for Frequencies and Specialists telecommunications capabilities. The control must be rise to or less than 100mw for 18000-1, 18000-6, 18000-7 benchmarks. (6)

1.7. Advantages and disadvantages of RFID technology:

1.7.1. Benefits of RFID technology:

RFID is one of the automatic identification techniques (or Auto-ID- Automatic Identification) the most used in several fields. This RFID technology presents several advantages such as:

1.7.1.1. Greater capacity for content:

In a radio recurrence name a capacity of 1000 characters is effectively storable on 1mm2, and can reach without specific trouble 10000 characters. In a logistic name on a bed, the diverse units contained and their amounts respective may be recorded and perused

1.7.1.2. The marking speed:

Standardized tag in a calculated setting most regularly requires printing paper. The taking care of and arrangement of names remains a manual or mechanical. Radio recurrence names can be included within the holder handling or bundling from the beginning. Information on objects contained or transported are composed in a division of a moment at the time of constitution of the coordination or transport unit, without extra dealing with

1.7.1.3. Security of access to content:

Like every computerized medium, the radio recurrence name can be watchword ensured write or perused. Information can be scrambled. In a single label, one portion of the data may be open get to, and the other secured. This staff made the RF name, a device adjusted to the battle against burglary and counterfeiting.

1.7.1.4. Others benefit:

- Labels RFID can have a life expectancy of almost ten a long time with the data can be adjusted more than one million times within the course of these a long time
- Expansive information capacity of RFID labels (a few kilobytes), in differentiate to bar codes with exceptionally restricted capacity (approximately ten numbers or letters)
- Detached labels that can be embedded in a human body to recognize (n° identification) of people

1.7.2. Limitations of RFID technology:

1.7.2.1. Costs of RFID Tags:

In spite of the fact that inactive labels are less costly than bar code frameworks, labels assets are costly since of their complexity. Dynamic Labels have a stack that increases the fetched of Tag. RFID Frameworks are exceptionally costly. They require equipment, RFID software, engineering and administration. The key to compelling frameworks is administration

1.7.2.2. Disturbance by the physical environment:

The reading of radio frequency tags is disturbed by the presence, for example, metals in their immediate environment. Solutions should be considered cases to minimize these disturbances, as was done for example for the identification of gas cylinders (4)

1.7.2.3. Lack of universal standards and standards:

At present, there are no real conventional standards worldwide for RFID. There are defined frequency bands and RF guidelines, but standards and operating rules are different from each country to other (6).

1.7.2.4. Sensitivity to parasitic electromagnetic waves:

RFID reading systems are in some circumstances sensitive to electromagnetic interference from electromagnetic waves emitted by computer equipment (computer screens) or lighting systems more generally by electrical equipment. electrical equipment. Their use must therefore be tested taking into account the environment.

1.8. Conclusion:

To summarize, we can say that RFID technology has enabled the possibility to read information without contact with the object or visibility, to update the information contained, to withstand high temperatures, ensure a mass reading, all this whose barcode is unable. This chapter has given us an idea of this technology, which presents the identification system; thus, we will move on to the next chapter whose title is RFID related work.

CHAPTER 2:

RELATED WORK

2.1.Introduction:

Radio frequency identification (RFID) is widly used in many applications such as production, logistics, supply chain management, etc. and due to the limited communication between readers and tags, RNP has been the most challenging problem that has to meet many requirements. However, RNP must optimize a set of objectives (coverage, load balance, economic efficiency and interference between readers, etc.). Recently, many algorithms have been proposed to solve this problem that we will study and discuss in this chapter. We will, also, discuss some papers addressing the RNP problem.

2.2.Related work:

In (7)a novel multi-swarm optimizer, called PS^2O ,which extend the single population PSO to interacting multi-swarm model by constructing hierarchical interaction topologies and enhanced dynamical update equation ,is proposed for solving the network planning problem and also for the planning the position of readers in the RFID network .

In (8), a novel approach is proposed for solving the RNP problem and to evaluate the network performance based on k-coverage model. which is formulated as a multi-dimensional constrained optimization problem.

In (9), they introduced a new and generic RFID network planning (RNP) model, a new non-linear integer programming (NLIP) to measure the detection reliability of the RFID network.

In (10), they proposed a kinematics-based algorithm, named as curling algorithm for RNP (CA-RNP).we treat each readers as a curling ,which can sliding in the working space and it will be stop with the friction of the tags ,and they designed the reader movement operator and reader collision operator to search the best places for readers in the working space

In (11), a novel optimization algorithm called multi-colony bacteria foraging optimization (MC-BFO) for solve RFID network planning, which integrates the cell-to-cell communication strategies of multi-colony bacterial community with the chemo taxis behavior of single cell.

In (12), they proposed a probabilistic-based multi-objective optimization model to solve RFID planification, a firefly algorithm is designed to solve also this problem but in other way (multi-problem)

In (13), they investigated the RFID reader planning problem for the surveillance of predictable mobile objects. They divided the time duration of surveillance into multiple time slots, and investigate the identification of objects in individual time slots. Different from existing approaches that aim to reduce the overlap of interrogation regions of readers, our approach directly computes the identification of objects under a given planning of readers.

In (14),a hybrid algorithm with k-means and clustering and virtual force is used to solve a RFID planning problem , it name is HPSO-RNP that it can initialize the readers in the network using k-means and then optimizing them automatically.

In (15),they proposed a cooperative multi-objective artificial colony algorithm called CMOABC to find all the Pareto optimal solutions and to achieve the optimal planning solutions by simultaneously optimizing four conflicting objectives in MORNP. The experiment presents an exhaustive comparison of the proposed CMOABC and two successful multi-objective techniques.

2.3.**Summary:**

The paper	Title	Year	Algorithm	Simulation
Paper01	”RFID network planning using a multiswarm optimizer”	2010	PS^2O	PS^2O finds the superior result, comparing to the other algorithm(MCPSO,EGA,SA-ES)
Paper02	“A fuzzy k-coverage approach for RFID network planning using plant growth simulation algorithm”	2013	k-coverage model with PGSA algorithm	The testing results show that the proposed approach using PGSA outperforms the compared algorithms in terms of optimization precision
Paper03	Uncertainty-aware RFID network planning for	2016	Non-linear integer programming model and	The results indicate that the genetic algorithm with GRASP outperforms other algorithms in terms of

	target detection and target location		POPA algorithm to solve the model	solution quality and computational robustness.
Paper04	An efficient and fast kinematics-based algorithm for RFID network planning	2017	Curling algorithm for RNP(CA-RNP)	Eight RNP instances are used to verify the performance of CA-RNP. The experimental results show that CA-RNP outperforms GA and PSO, and can find good solutions in a short time.
Paper 05	Multi-colony bacteria foraging optimization with cell-to-cell communication for RFID network planning	2009	A noval optimization algorithm, namely the multi-colony bacteria foraging optimization (MC-BFO)	The simulation studies show that the MC-BFO obtains superior solutions for RNP problem than both PSO and GA in terms of optimization accuracy and computation robustness. Moreover, it remains to be see how practically useful that the MC-BFO is for engineering optimization problems. These depend on extensive evaluation on many benchmark functions and real-world problems.
Paper06	Decomposition-based multi-objective firefly algorithm for RFID network	2017	Firefly algorithm	Numerical simulations are introduced to demonstrate and validate our proposed method. Comparing with existing methods, such as

	planning with uncertainty			Non-dominated Sorting Genetic Algorithm-II and Multi-objective Particle Swarm Optimization approaches
Paper07	RFID Reader Planning for the Surveillance of Predictable Mobile Objects	2017	Reader planning approaches	Genetic algorithm and particle swarm optimization are used to get the optimal result based on the evaluation metric and the reader planning strategies. We perform extensive simulations for validating the proposed approaches. The results show that our approach can achieve a good accuracy in the surveillance
Paper08	A hybrid particle swarm optimization algorithm for RFID network planning	2021	HPSO-RNP	the results validate that the performance of the proposed method is superior for planning RFID networks in terms of the number of readers, interference, power and load balance
Paper09	Cooperative artificial bee colony algorithm for multi-objective RFID network planning	2014	CMOABC	Simulation results show that CMOABC proves to be superior for planning RFID networks compared to NSGA-II and MOABC in terms of optimization accuracy and computation robustness.

Table2. 1 summary of related work

2.4. Conclusion:

Since RFID system plays important role in the real world, we provided the reader a potential review comparison of important exiting works, thus made us to adopt the appropriate algorithm that will be studied for our study cases.

CHAPTER 3:

RFID NETWORK PLANNING

3.1.Introduction :

RFID technology is widely used for identification and tracking application, a typical RFID system is consisting of three components: tags, readers, and computer system linked to readers. the communication range of an RFID system is limited.

Several readers must be installed in the network. It can also cause reader conflicts, rendering the tag information unreadable. As a result, we must determine the total number of readers and the locations in which they should be placed in order to cover tags efficiently. This problem is increasingly being viewed as a network planning problem, specifically the RFID

network planning (RNP) problem. It is an NP-hard problem. a problem with multiple targets(coverage, interference between them) readers, power, and load balance) as well as numerous constraints (the readers; coordinates and power radius)

3.2. Problem formulation:

In the previous chapter, we have seen the related work, In this section, we will explain the mathematical model used to optimize some important requirements (coverage, interference between readers, power , and load balance)

Firstly, a RFID system consists of tags and readers and middleware like we have seen in chapter 2. Readers and tags transmit the energy through electromagnetic waves and then read the tag information to complete the data transmission. In the following, we will mathematically describe the problem formulation as proposed in (16).

3.2.1. Tag:

For the tags , there are many types (passive tags ,semi-passive tags ,and active tags).and every tag is identified by a unique electronic identification code .at present time a passive labels(tags) are mainly used in practical application because of the advantages compared to the others .the main point of the tags is to respond to the request of readers and send it to the Electronic Product Code(EPC) identifier.

3.2.2. Readers:

The reader is used for read information of the tags using the antenna ,it based on the friis transmission equation

We can calculate the received power by reader from passive tags as follow:

$P_{\mathrm{r}} = P_{\mathrm{t}} G_{\mathrm{r}}{}^{2} G_{\mathrm{t}} (\frac{\lambda}{4\pi d})^{4} T^{2}$ (1)

Equation3. 2: power

where P_T is the transmitted power of the reader's antenna, G_T and G_R are the gains of a reader's and a tag's antenna, respectively, d is the distance between the reader and the tag, k is the wavelength, and T is the backscatter trans- mission.

3.3.RFID system evaluation index:

As we seen above the RFID system consists of readers and tags , and the communication between them is so limited, multiple readers must be deployed in the network .it can also cause conflicts between readers ,making the tag information unreadable .for that reason we need to determine the total number of readers and location where they should be placed to cover tags efficiently

For the function we have four function :

3.3.1. Coverage:

If tags detected by readers we called it cover points , from this point the coverage is important.

The overall coverage is defined as follows:

$$\mathrm{COV} = \sum_{t=0}^{t=N_{\mathrm{t}}} \frac{p(t,r)}{N}{}_{\mathrm{t}} \times 100\% \qquad (3)$$

Equation3. 4: The overall coverage

The Boolean model is built as follows:

$$\mathrm{P(t\ ,\ r)} = \begin{cases} 1\ d(t,r) <= Radius \\ 0\ d(t,r) > Radius \end{cases} \qquad (5)$$

Equation3. 6: The boolean model

In this case, RS is represented as the set of readers and TS is denoted as the set of tags. Here N_t is the number oftags, $d(t,r)$ is the Euclidean distance between a tag t and areader r. Radius is used to represent the power radius of readers. If there is a reader r [RS and $d(t,$

$r) \setminus = R$, the tag t is covered. The algorithm is expected to deploy readers to increase coverage using fewer readers

3.3.2. Interference :

We have two mode :

One is the interference between readers. If the transmit signal of a reader is very strong, it will affect the communication between the other reader and tags.

Another interference is caused by the overlapping workscope of readers. If a tag is in the range of several readerssimultaneously.

$$INT = \sum_{t=0}^{t=N_t} rat(t)/N_t \qquad (7)$$

Equation3. 8:interference

$$\text{Rat(t)}= \begin{cases} \frac{num(t)-1}{N}\text{t} & num(t) \geq 1 \\ 0 & num(t) < 1 \end{cases} \qquad (9)$$

Equation3. 10: Rat

Where num(t) is the total number of readers that cover tag t and N_t is the number of tags .rat(t) represents the interference rate of the tag. when num(t)<1 and rat(t) is 0,no reader can detect tag t and there is no interference

3.3.3. Power:

In the RFID model, we can measure the power of the system by counting the total radius of readers. In order to save energy and reduce cost, it should be reduced as much as possible. To ensure the communication quality between readers and tags the power is the objective with the lower priority in RFID network planning. The total power of all readers in the RFID network is defined as follows:

$$\text{POW}=\sum_{r\in RS} Radius_{\text{r}} \qquad (11)$$

Equation3. 12: Radius

where Radiu s_r is the power radius of reader r.

3.3.4. Load balance:

$$LB=\prod_{r=1}^{m} 1/N_r \qquad (13)$$

Equation3. 14: Load balance

Where N_r is the number of tags covered by reader r.

3.4.The Algorithm:

After we have seen the problem, we proposed to use a k-means clustering algorithm.

Firstly, the number of reader is determined automatically and then the k-means do the next step which is initialization.

After that , the new reader is kept putting into the working space until tags are covered within an assumed.

It can be summarized as follows:

1. The K-means algorithm is used to search the number of readers automatically and initialize the location of readers.

2.Achieve the optimal planning solutions by hierarchically optimizing four conflicting objectives in MORNP.

3.4.1. Initialization of individual particles:

As we seen in the paper ,they use the k-means for initialization

3.4.1.1. k-means:

Input:

k:number of readers in RFID network.

t_i:position of tags, where $t_i \in TS$;

r_j:random initial position of k readers, where $r_j \in RS$;

r_{orij}:location information of k readers. where $r_{orij} \in RS$;

Output:

RS^k:deployment of k readers.

mark←1;

while(mark=1)**do**

for each tag $t_i \in RS^k$ **do**

calculate distance $d_j(t_i,r_j)$;

end for;

obtain the closest cluster min_j,which is min($d_j(t_i,r_j),r_j \in RS$);

divide the tag t_i into cluster RS_{min_j};

end for;

update the location of readers;

for each cluster TS_j **do**

$r_{orij} \leftarrow r_j$;

calculate the mean of all points in cluster TS_j and take it as center;

$r_j \leftarrow (x_j,y_j)$;

end for

for each cluster TS_j;

if ($r_{orij}==r_j$)**then**

mark←0;

break;

end if;

end for;

end while;

3.4.1.2. HPSO-RNP:

Input:

N_t:number of tags in the network;

gen: number of times for operating HPSO-RNP operator;

output:

K^t:number of readers in the network;

r_j'':location of readers in the network , $r_j'' \in RS$;

initialization: initialize the locations of readers r_j with k-means;

selection Mechanism: calculate the number of readers in the network;

(k',r_j')←**selection Mechanism**(k,r_j);

t←0;

while(t<gen)**do**

Evaluation: evaluate the performance of RFID system in a hierarchical manner

According to eqs .(2) (7);

Updates: update the best individual using PSO;

pBest ←**Updates(**pop);

gBest←the best pBest;

Adjustments: adjust by virtual force the process of PSO optimization;

r_j''← **Adjustments** (gBest);

t←t+1;

end while

3.5. Conclusion:

In this chapter we study the hybrid algorithm PSO, which has been proposed to solve RFID planification problems in terms of number of readers in the RFID system, the power, interference and load balance. Thus, it leads to deploy the RFID technology in realistic condition.

CHAPTER 4:

IMPLEMENTATION

4.1.Introduction :

In this chapter, we will detail the tools that we used to implement our algorithm (HPSO), secondly, we will see the implementation of our work ,and finally we will finish this chapter with a short discussion and result to our work.

4.2.Tools:

To date, they are many platforms provided for RFID developing system, in this work we use a set of well-known tools to asses our adopted algorithm performance, as listed below:

4.2.1. Python:

Python is an open source, cross-platform, object-oriented programming language. Thanks to specialized libraries, Python is used for many situations such as software development, data analysis, or infrastructure management. It is therefore not, like the HTML language for example, only dedicated to web programming.

Interpreted programming language, Python allows the execution of code on any computer. Usable by both beginner and expert programmers, Python allows you to create programs in a quick and easy way.

Figure 4. 1:python

4.2.2. Pycharm:

Pycharm is an Integrated Development Environment (IDE) used for programming in Python. It provides code analysis, a graphical debugger, an integrated unit tester, integration with version control systems (VCSes), and supports web development with Django. PyCharm is developed by the Czech company JetBrains. It is cross-platform working on Windows, Mac OS X and Linux. PyCharm has a Professional Edition, released under a proprietary license and a Community Edition released under the Apache License. PyCharm Community Edition is less extensive than the Professional Edition.

Figure 4. 2:pycherm

4.3.Proposed approach :

4.3.1. Approach:

4.3.1.1. k-means:

Now ,Let's talk a little bit about our approach (k-means),is used to search the number of reader automatically and initialize the location of reader .So , firstly we initialize the number of reader randomly in the work space ,then we use the k-means algorithm.it take each reader as central point of the cluster .then the coordination of the readers are generated randomly in work space .then we calculate the Euclidian distance between each tag and readers, After that, we dived the tag into nearest cluster ,the coordination of the center recalculated according to the eq(1) and (2),when the center of cluster is change we repeat the above process for classification until it no changes.

$$x_i=\frac{1}{N_{tj}}\sum_{i=1}^{N_{tj}} x_{ij}$$

(1)

$$y_j=\frac{1}{N_{tj}}\sum_{i=1}^{N_{tj}} y_{ij}$$

Equation4. 2:the ecludian distance

where (xj, yj) represents the coordinates of jth cluster center, Ntj represents the number of tags in the jth cluster, and (xij, yij) represents the coordinates of the ith point in the jth cluster. We represent the center of cluster as rj, j [1…k. A set of tags divided into the cluster rj is represented as TSj.

4.3.1.2. Hpso algorithm:

Our main algorithm is began with selection of the number of reader ,then the individuals are initialized using the k-means algorithm .moreover ,we introduce the virtual force during the optimization process of PSO to adjust the location of readers .the evaluation measures of particles mainly include coverage, interference, total power, and load balancing. The individual is updated with a hierarchical mechanism based on the priority of the objective function. In large-scale label coverage problems, Euclidean distance measurement is somewhat inaccurate on account of the different radius of reader

4.3.2. implementation:

4.3.2.1. k-means algorithm:

In our implementation we define four function :

1. get-data: which is define the number of tags.
2. calc-dists :this function calculate the distance between each tag and readers.
3. get-clusters :divide the tag into two cluster.
4. Calc-centers :this function take the reader into the center of cluster

In the main program we use those four function to classify the tags into two clusters, firstly we chose the number of reader ,then the program calculate the distance between each tag and readers ,after that it divided the tag into the closest cluster and take the reader as center for each cluster ,the program repeat the calculation above using while until non changes .

4.4.Resultats and discussions:

4.4.1. Resultats:

4.4.1.1. k-means:

We execute the program and every time we change the number of tags ,we beginning with 100 tags, and the result shown in the picturs bellow:

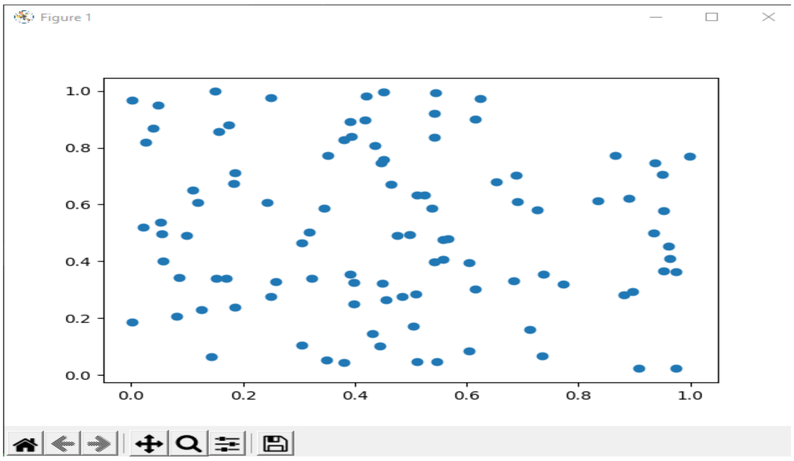

Figure 4. 3: Result 1 K-Means

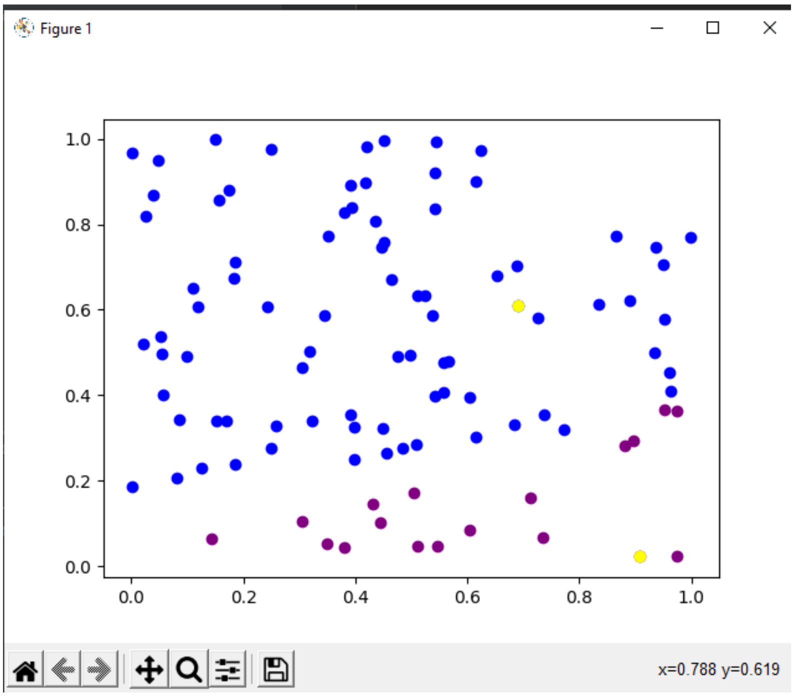

Figure 4. 4: Result 2 K-Means

4.4.2. Discussions:

Similarly, Fig.6 is the solution when the tags in the network are clustered. The results show that our algorithm has greater advantages over the previous. The coverage, anti-interference degree, total power, and load balancing have been greatly improved.

As the number of tags increases, the algorithm PSO for RNP still has some disadvantages. For example, the convergence speed of PSO is too slow, which is easy to fall into local optima and the communication quality cannot be guaranteed. Therefore, we introduce virtual force duringthe optimization process of PSO.

In order to illustrate the effectiveness of virtual force, we conduct a comparative experiment. Figure 7a is the solution before adding virtual force. Figure 7b is the solution of our algorithm. The coverage remains 1, and interference is reduced from 0.0011 to 0.0003. The result shows that the virtual force is effective for PSO optimization, which can avoid interference without affecting coverage.

4.5.Conclusion:

In this chapter, we described the tools that has been used to implement our approach. Therefore, we explained how to perform our algorithm for RFID planification scenario.

GENERAL CONCLUSION

Nowadays, the RFID system is used in different large-scale applications and domains. So, in our thesis, we have discussed and studied the RNP problem. Then a K-Means algorithm has been used and implemented to this issue.

We began with an introduction to RFID system to show the functionality of this system and to see the component of this system (tags and readers), but also its applications. We have seen also the legislation of these RFID systems in Algeria.

After that, we have seen some related work to compare the algorithm and choosing the perfect one to solve this Problem.

Finally, we have seen the designed platform that we used to carry out our adopted algorithm.

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ABSTRACT:

Radio frequency identification (RFID) technology is a kind of wireless technology that has been successfully employed in various fields, such as object and tracking applications. Nevertheless, one of the main challenges that still remains unsolved in RFID is the network planning(RNP) problem. To overcome this issue, in this work, we proposed a hybrid particle swarm optimization (HPSO) with k-means clustering and virtual forces. Firstly, HPSO-RNP reads automatically the number of readers and then initializes their coordination using the k-means algorithm. Lastly, the algorithm (virtual forces) is integrated into the random movement to adjust the location of readers during the search process of PSO. To compare HPSO-RNP with the existing method, extensive experiments are conducted on eight RNP benchmark datasets and the results validate that the performance of the proposed method is superior for planning RFID networks in terms of the number of readers, interference, power and load balance.

keywords: particle swarm optimization ,Radio frequency identification ,RFID network planning , K-means algorithm , Virtual force.

RESUME:

La technologie d'identification par radiofréquence (RFID) est une sorte de technologie sans fil qui a été employée avec succès dans divers domaines, tels que les objets et les applications de suivi. Néanmoins, l'un des principaux défis qui reste à résoudre dans la RFID est la planification du réseau (RNP) problème. Pour surmonter ce problème, dans ce travail, nous avons proposé une optimisation d'essaim de particules hybrides (HPSO) avec k-means clustering et des forces virtuelles. Premièrement, HPSO-RNP lit automatiquement le nombre de lecteurs, puis initialise leur coordination à l'aide de l'algorithme k-means. Enfin, l'algorithme (forces virtuelles) est intégré dans le mouvement aléatoire pour ajuster l'emplacement des lecteurs pendant le processus de recherche de PSO. Pour comparer HPSO-RNP avec la méthode existante, des expériences approfondies sont menées sur huit ensembles de données de référence RNP et les résultats valident que la performance de la méthode proposée est supérieure pour la planification des réseaux RFID en termes de nombre de lecteurs, interférence, puissance et équilibre de charge.

keywords : particle swarm optimization ,Radio frequency identification ,RFID network planning, K-means algorithm , Virtual force

ملـــــــخـــص:

تكنولوجيا تحديد الترددات الراديوية (RFID) هي نوع من التكنولوجيا اللاسلكية التي تم استخدامها بنجاح في مجالات مختلفة، مثل تطبيقات الكائنات والتتبع. ومع ذلك، فإن أحد التحديات الرئيسية التي لا تزال دون حل في RFID هو مشكلة تخطيط الشبكة (RNP). للتغلب على هذه المشكلة، في هذا العمل، اقترحنا تحسين سرب الجسيمات الهجين (HPSO) مع تجميع k-mean وقوى افتراضية. أولاً، يقرأ HPSO-RNP تلقائيًا عدد القراء ثم يبدأ تنسيقهم باستخدام خوارزمية k-mean. أخيرًا، يتم دمج الخوارزمية (القوى الافتراضية) في الحركة العشوائية لضبط موقع القراء أثناء عملية البحث في PSO. لمقارنة HPSO-RNP بالطريقة الحالية، يتم إجراء تجارب مكثفة على ثماني مجموعات بيانات مرجعية من RNP وتثبت النتائج أن أداء الطريقة المقترحة أفضل لتخطيط شبكات RFID من حيث عدد القراء والتداخل والطاقة وتوازن الحمل.

الكلمات المفتاحية :سرب الجسيمات الهجين(PSO)،تحديد الترددات اللاسلكيةRFID،تخطيط شبكة (RFID)،خوارزمية K-Means،خوارزمية القوى افتراضية .