Using Genetic Algorithms for the Classification of Employees in the Context of a Transformation to the e-Administration

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ABSTRACT
This article presents a general vision to perform a transformation of an ordinary service to an e-service as part of the modernization of a public Administration. Human resources have been opted to play an essential role in this transformation. This work is summed up in a method that helps choosing employees (functionaries) most willing to be adapted to the changes induced by the establishment of an e-service. The genetic algorithms have been chosen to be applied, on the base of criteria retained in the evaluation of employees, in order to create mutations between generations to reach a better generation.

General Terms
Classification, genetic algorithms, e-Governance.

Keywords
Service, e-service, public administration, e-Administration, genetic algorithms, e-Governance, e-Transformation.

1. INTRODUCTION
Electronic administration (e-Government) refers to the use of information technology and communication (ICT) by public administrations in order to make them more accessible to their users, and to improve their internal functioning to better satisfy citizens [1] [2].

Under the governmental plan, several initiatives have been implemented to make easier access to the public administration by using the online service on the Internet [3] [4].

To accomplish this task, transformations that administrators must integrate in the new form of their missions must be taken into account [5] [6].

So the e-Transformation of services of a public administration to a total or partial use of ICT must take into account several factors including the predisposition and involvement of employees to the e-Governance [7] [8] [9].

To retain the best employees, they should be subjected to a way of valuation (tests, questionnaires ...) in order to identify and valorize their skills, which will allow us to define several classes of employees:

- Employee apt
  - Interested.
  - Not interested.
  - Refractory.
- Employee not apt
  - Interested.
  - Not interested.
  - Refractory.

Many methods can be applied in this domain; in this article, the application of genetic algorithms is proposed to determine the classification of employees of a public administration according to the above classes [10].

This method will allow us, in its finality, to identify the best employees who will accompany this change, and the way forward to convert the others to be integrated into the e-Governance while eliminating those whose integration is impossible [11] [12].

To achieve this classification, each employee must be valued according to several criteria; these employees are classified into the following categories [13]:

- Common skills.
- Computer skills
- Abilities and personal qualities.

2. EVALUATION OF AN EMPLOYEE
2.1 Objectives of the evaluation
- Identify and recognize the potential and skills of each employee.
- Providing a forum for exchange between employees so that everyone can share their concerns about living and work organization.
- To ensure that each employee has the resources and support needed to accomplish his tasks.
- To ensure that the work team remains polyvalent and complementary in terms of expertise and mandates, so that everyone realizes and the organism performs its mission to the public.

2.2 Criteria to evaluate
The present article takes into account a study carried out on 40 employees by only evaluating their computer skills based on classification and the following criteria:

- **Subcategory 1 : Level of mastery in computer tools**
  - Criterion 1.1: a level of knowledge in the functioning of a computer.

  - Criterion 1.2: the basic office software level of mastery (word processing and spreadsheet).
  - Criterion 1.3: a level of mastery in the use of Internet and internal or external e-mail.

- **Subcategory 2 : Level of mastery in management software as part of an information system**
  - Criterion 2.1: a level of knowledge in the functioning principle of an information system.
  - Criterion 2.2: a software frequency of use, using an information system of the employee's activity field.
  - Criterion 2.3: mastering, configuring and detecting failures of an information system in the employee activity domain.
  - Criterion 2.4: to be able to participate in software development.
  - Criterion 2.5: to audit and integrate appropriate solutions in order to optimize the information system.
- **Subcategory 3 : Server of administration**
  - Criterion 3.1: to know the basic functioning of an operating system.
  - Criterion 3.2: to know how to manage user profiles and their rights.
  - Criterion 3.3: to be able to install and configure the client applications on terminals.
  - Criterion 3.4: to know how to manage the backup and restoration of a database.
  - Criterion 3.5: to implement the techniques and methods of the system operation.
  - Criterion 3.6: to be able to analyze and resolve system problems.
  - Criterion 3.7: ensuring the security and the data integrity.
- **Subcategory 4 : Networks and telecommunications**
  - Criterion 4.1: to have basic knowledge in networking and communications systems.
  - Criterion 4.2: to implement the constructive architecture, client-server.
  - Criterion 4.3: to know how to install networking devices including terminals.
  - Criterion 4.4: to know how to configure the devices and interfaces' network and ensure equipment maintenance.
  - Criterion 4.5: to master the interconnection of LAN/WAN.
- **Subcategory 5 : Programming and development**
  - Criterion 5.1: to be able to write tender specifications.
  - Criterion 5.2: to be able to elaborate an analysis.
  - Criterion 5.3: to be able to develop a desktop application.
  - Criterion 5.4: to be able to develop a client/server application.
  - Criterion 5.5: to be able to develop a web application.
  - Criterion 5.6: to be able to make tests of software quality.

3. APPLICATION OF GENETIC ALGORITHMS TO ADMINISTRATORS

3.1 Definition

Genetic algorithms belong to the family of evolutionary algorithms. Evolutionary algorithms are a family of meta-heuristics (optimization algorithm aimed at resolving difficult optimization problems) stochastic inspired by the theory of evolution [14].

The goal of evolutionary algorithms is to obtain an approximate solution for an optimization problem, when there is no exact method (or the solution is unknown) to solve within a reasonable time. An evolutionary algorithm does not permit to find an exact analytical solution, but to find satisfying solutions to best meet the different criteria [15].

3.2 Mode of Functioning

A genetic algorithm looks for one or many extreme of a function defined on a data space, based on the following five elements [16] [17] [18] [19]:

- Generating individuals from the initial population and encoding them.

  In this study, these are employees of an administration.

- Evaluation of the optimizing function (fitness) or evaluation of the individual function.

  In this case, employees are identified according to the considered criteria.

- A mechanism to determine which individuals are more likely to approach the solution (selection).

  In this case, pre-disposed employees are found for the changes.

- Genetic operators (mutation, crossover...) in order to diversify the population.

  This represents a way to identify employees who can be adapted quickly to the changes.

- Generating a new population and verification of stopping criteria (size of the new population, number of generations…).

  What corresponds to the population of employees which may be assigned to the e-Governance.

3.3 Generation of Individuals

In this study basis, 40 employees were considered from an administration. This administration wants to introduce online services (transition to the e-Governance).

To achieve this integration of the e-Governance, genetic algorithms are applied to extract from the 40 employees, people who can be the most adapted to this changing. The others may attend training to join the best employees or they will be assigned to more appropriate positions [20].

Employees correspond to the "solutions" of this study. These solutions must be "coded" so that the treatment could be done by the genetic algorithm. This coded representation of a solution is called a chromosome, and it's composed of genes. Each gene represents a subcategory [21].

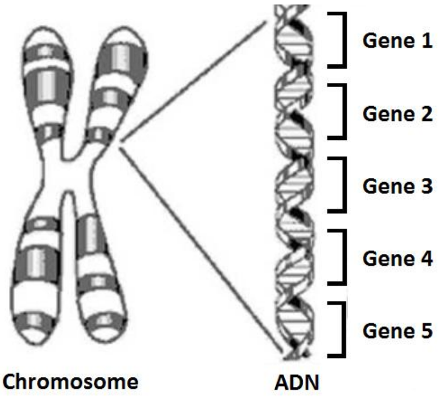


Fig 1: Composition of the chromosome

Coding this chromosome can be done through one of the following methods:

- Binary coding.
- Real coding.
- Gray's coding.

For this study, each criterion is scored from 0 to 3. These numbers will be coded by binary code (two bits) according to the following table:

Table 1. Coding notes in binary and there appreciation

Score	Binary coding	Appreciation levels
0	00	Null
1	01	To improve
2	10	Satisfying
3	11	Excellent

Stopping criteria: up to five generations by considering the initial population as the first one [22].

3.4 Evaluation of Individuals

Each chromosome provides a potential solution to the problem. However, these solutions don't have the same degree of pertinence. It is to the function of performance (fitness) to measure the efficiency in order to allow the genetic algorithm to evolve the population in a beneficial sense for the research of the best solution. In other words, the performance function must be able to assign a positive indicator to each person representing its relevance to the problem trying to solve. [23]

The adaptation function will be calculated as follows:

$$F(I_i) = \sum_{j=0}^{m} \alpha_j * N_{SC(j)}(I_i) \quad (1)$$

$$N_{SC(j)}(I_i) = (\sum_{q=0}^{p} N_{Cri(q)}(I_i)) / p \quad (2)$$

$$F(I_i) = \sum_{j=0}^{m} \alpha_j * (\sum_{q=0}^{p} N_{Cri(q)}(I_i)) / p \quad (3)$$

Equation (1) represents an adaptation function of an individual.

$\mathbf{N_{SC(j)}(I_i)}$**:** represents a subcategory's score of an individual.

$\mathbf{N_{Cri(q)}(I_i)}$**:** represents a criterion's note of a subcategory.

$\boldsymbol{\alpha_j}$**:** represents a weight attributed to a subcategory depending on its degree of importance relative to the position of the individual.

p: represents the number of criteria for a well-defined subcategory.

m: represents the number of subcategories for a well-defined category.

By applying to the chromosome, the obtained result is:

Table 2. Parameters of the function of adaptation

Gene	Subcategory	$N_{SC(j)}$	Weight
Gene 1	Mastery level in computer tools	$N_{SC(1)}$	α_1
Gene 2	Mastery level of management software as part of an information system	$N_{SC(2)}$	α_2
Gene 3	Server of administration	$N_{SC(3)}$	α_3
Gene 4	Networks and telecommunications	$N_{SC(4)}$	α_4
Gene 5	Programming and development	$N_{SC(5)}$	α_5

3.5 The selection of individuals

The selection is the most important step as it allows individuals of a population to survive, to reproduce or to die. In general, the probability of survival of an individual is directly related to his relative efficiency and his ability to fulfill certain criteria within the population [24] [25].

There are several methods for reproduction:

- The method of "biased lottery" (Roulette Wheel).
- The elitist method.
- The tournament selection.
- The stochastic universal selection.
- Selection by rank.

In this study, the following two methods are chose:

- The elitist method.
- The tournament selection.

3.6 Genetic Operators

3.6.1 Crossing

It consists in combining any two individuals (called parents) to highlight two other individuals (called children).

Types of crossing:

- Crossing at one point.
- Crossing multipoint.
- Uniform Crossing.

In this analysis, the multi-crossing is used.

3.6.2 Mutation

A mutation consist, simply, in the inversion of a bit (or more bits, but considering the probability of mutation it is extremely rare) located in a particular locus and also randomly determined.

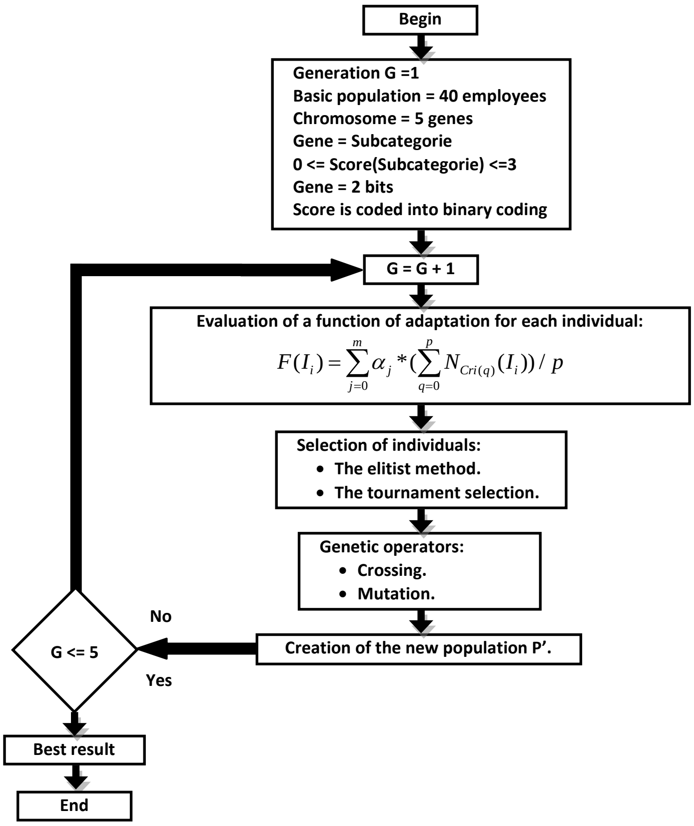


Fig 2: Flowchart of the genetic algorithm [26][27]

Figure 2 represents the entire genetic process (identification of parameters of the initial population, transition to the next generation, application of the evaluation function, selection of individuals, apply to individuals the crossover and mutation operators, creation of a new generation) followed from the initial population until obtaining a best one [28].

3.7 Example of application

Thereafter, this article will give details of the genetic process that was specified in Figure 2. There are four analysis phases which each one has five-steps [29] [30]:

- **Step 1:** coding and generation of the population.
- **Step 2:** calculus of the adaptation function.
- **Step 3:** selection.
- **Step 4:** crossover and mutation.
- **Step 5:** determination of the new population.
- **Step 5:** determination of the new population.

3.7.1 Analysis I:

- **Step 1:** generation of the 1st population composed of 40 employees where each one is represented by a chromosome of five genes. A gene is equivalent to a subcategory coded in binary under two bits.
- **Step 2:** calculus of the adaptation function according to the following formula: $F(I_i) = \alpha_1 * N_{SC(1)} + \alpha_2 * N_{SC(2)} + \alpha_3 * N_{SC(3)} + \alpha_4 * N_{SC(4)} + \alpha_5 * N_{SC(5)}$.

Table 3. Generation and calculation of the function of adaptation of the 1st population

Individual	$N_{SC(1)}$	$N_{SC(2)}$	$N_{SC(3)}$	$N_{SC(4)}$	$N_{SC(5)}$	Code					$F(I_i)$
						Sc1	*Sc2*	*Sc3*	*Sc4*	*Sc5*	
I_1	2	2	1	1	1	10	10	01	01	01	7
I_2	3	1	1	2	0	11	01	01	10	00	7
I_3	1	2	1	1	1	01	10	01	01	01	6
I_4	2	1	3	1	0	10	01	11	01	00	7
I_5	2	1	2	1	2	10	01	10	01	10	8
I_6	1	2	1	1	2	01	10	01	01	10	7
I_7	0	1	0	1	0	00	01	00	01	00	2
I_8	0	0	0	0	0	00	00	00	00	00	0
I_9	2	2	1	1	2	10	10	01	01	10	8
I_{10}	3	1	2	0	1	11	01	10	00	01	7
I_{11}	1	2	0	1	1	01	10	00	01	01	5
I_{12}	3	2	2	2	1	11	10	10	10	01	10
I_{13}	2	1	2	0	1	10	01	10	00	01	6
I_{14}	1	1	1	1	1	01	01	01	01	01	5
I_{15}	0	1	0	1	0	00	01	00	01	00	2
I_{16}	3	1	2	1	1	11	01	10	01	01	8
I_{17}	2	1	0	1	1	10	01	00	01	01	5
I_{18}	1	2	2	1	1	01	10	10	01	01	7
I_{19}	1	1	2	0	0	01	01	10	00	00	4
I_{20}	1	2	1	0	1	01	10	01	00	01	5
I_{21}	1	1	2	2	0	01	01	10	10	00	6
I_{22}	1	0	2	1	1	01	00	10	01	01	5
I_{23}	2	0	0	0	1	10	00	00	00	01	3
I_{24}	2	2	2	1	1	10	10	10	01	01	8
I_{25}	3	2	2	1	2	11	10	10	01	10	10
I_{26}	3	0	1	2	2	11	00	01	10	10	8
I_{27}	2	1	1	1	3	10	01	01	01	11	8
I_{28}	1	1	1	1	1	01	01	01	01	01	5
I_{29}	1	0	2	1	0	01	00	10	01	00	4
I_{30}	3	2	1	1	2	11	10	01	01	10	9
I_{31}	2	2	2	1	0	10	10	10	01	00	7
I_{32}	1	1	2	1	2	01	01	10	01	10	7
I_{33}	3	0	2	1	1	11	00	10	01	01	7
I_{34}	2	0	1	1	2	10	00	01	01	10	6
I_{35}	1	1	1	1	0	01	01	01	01	00	4
I_{36}	2	1	1	1	2	10	01	01	01	10	7
I_{37}	2	2	1	2	0	10	10	01	10	00	7
I_{38}	2	1	1	0	2	10	01	01	00	10	6
I_{39}	1	0	1	1	2	01	00	01	01	10	5
I_{40}	1	0	2	1	0	01	00	10	01	00	4

The present article considers that all the subcategories have the same weight and the same importance. Which translates in the previous table by a coefficient $\alpha_i = 1$. Similarly, the article is only interested in identifying a classification of employees to those able to integrate e-Governance services and those who are not able.

Thereafter, it will consider α_i according to their impact on the job profile. For this, an α_i may have a linguistic value of type: very important, average importance, few important, not important ... In which it will apply the principles of fuzzy logic.

- **Step 3:** the first step is making an elitist selection to identify the best employees for e-Governance. It comes to a direct selection that allows them to move to the next generation (new population P_1) without following a genetic process that involves mutations and crossovers. To do so, the elements whose fitness>6 will be taken. These constitute the class of «Employee apt». In this case, 20 employees will be selected directly and the rest will constitute the class «Employee not apt». The latter will go to the crossover and mutation step.

- **Step 4:**
  - Crossing multipoint: genes 2 and 3 of the chromosome are permuted (xx **xx xx** xx xx).
  - Mutation: the 2nd bit of gene 4 is inverted (xx xx xx **x**x xx).
- **Step 5:** a new population P_1 is present, of 40 employees, consisted by the union of the class «Employee apt» and the result from the first step of crossover and mutation. However, as the stopping condition is not yet satisfied, the process will reiterate by a new analysis.

3.7.2 Analysis II:

- **Step 1:** the new population P_1 resulting from the first analysis will be coded.
- **Step 2:** the function of adaptation according to the following formula: $F(I_i) = 1*N_{SC(1)} + 1*N_{SC(2)} + 1*N_{SC(3)} + 1*N_{SC(4)} + 1*N_{SC(5)}$ will be calculated.
- **Step 3:** it redoes an elitist selection to keep employees whose fitness>6. Next, it applies tournament selection with five participants and it keep the two finalists.
- **Step 4:**
  - Crossing multipoint: genes 1, 2 and 3 of the chromosome are permuted (**xx xx xx** xx xx).
  - Mutation: the 2nd bit of gene 2 is inverted (xx **x**x xx xx xx).
- **Step 5:** a new population P_2 is present and it is composed of 12 employees but as the stopping condition is not satisfied, it recommences a new analysis.

3.7.3 Analysis III:

- **Step 1:** the new population P_2 resulting from the second analysis will be coded.
- **Step 2:** the adaptation function according to the following formula: $F(I_i) = 1*N_{SC(1)} + 1*N_{SC(2)} + 1*N_{SC(3)} + 1*N_{SC(4)} + 1*N_{SC(5)}$ will be calculated.
- **Step 3:** it redoes an elitist selection in order to take away the best elements. To do this, it takes the elements whose fitness>=10. These latter go directly to the new population. As result of this selection, three employees will be selected and the rest will go to step crossover and mutation.
- **Step 4:**
  - Crossing multipoint: genes 3, 4 and 5 of the chromosome are permuted (xx xx **xx xx xx**).
  - Mutation: the 2nd bit of gene 2 is inverted (xx **x**x xx xx xx).
- **Step 5:** a new population P_3 is present and it is composed of 12 employees but as the stopping condition is not satisfied, it recommences a new analysis.

3.7.4 Analysis IV:

- **Step 1:** the new population P_3 resulting from the third analysis will be coded.
- **Step 2:** the adaptation function according to the following formula: $F(I_i) = 1*N_{SC(1)} + 1*N_{SC(2)} + 1*N_{SC(3)} + 1*N_{SC(4)} + 1*N_{SC(5)}$ will be calculated.
- **Step 3:** it redoes again a tournament selection with three participants and it keeps the two finalists. It will retain eight employees from twelve.
- **Step 4:**
  - Crossing multipoint: gene 1 of the chromosome is permuted (**xx** xx xx xx xx).
  - Mutation: the 2nd bit of gene 4 is inverted (xx xx xx **x**x xx).
- **Step 5:** a new population P_4 is present and it is composed of eight employees. The stopping condition is satisfied and the result of this study is the following.

Table 4. Final generation

Individual	Code					$N_{SC(1)}$	$N_{SC(2)}$	$N_{SC(3)}$	$N_{SC(4)}$	$N_{SC(5)}$	F (i)
	Sc1	*Sc2*	*Sc3*	*Sc4*	*Sc5*						
I_5	11	10	10	11	01	3	2	2	3	1	11
I_9	10	10	01	00	01	2	2	1	0	1	6
I_{12}	11	10	10	11	10	3	2	2	3	2	12
I_{18}	10	11	10	11	01	2	3	2	3	1	11
I_{24}	11	10	10	11	01	3	2	2	3	1	11
I_{27}	11	10	10	11	10	3	2	2	3	2	12
I_{34}	10	11	01	01	10	2	3	1	1	2	9
I_{38}	10	10	10	00	10	2	2	2	0	2	8

4. Interpretation of the study case

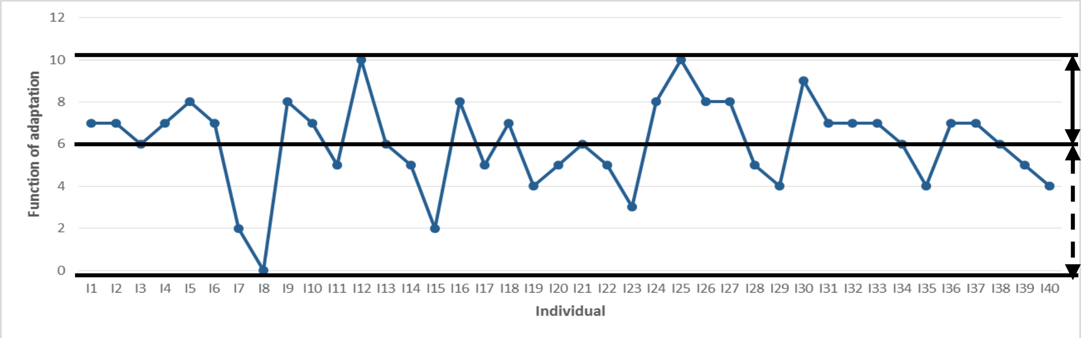
The application of the proposed method on a sample of 40 employees has resulted following different generations (selection, crossover, mutation ...) to bring out that only 8 of them are able to integrate digital literacy in their professional practice.

The next charts will show the progression of these generations by giving all the analysis in detail. The Figure 3 represent the result after applying an elitist selection to the initial population. Therefore, 20 employees will be among the 1st population and the rest will accomplish all the genetic process.

A result of the first analysis will be confronted to an elitist selection, as shown in Figure 4, where 11 employees will be out of this population and 29 employees will be applied by tournament selection, as shown in Figure 5.

In the Figure 6, there is the 2nd population applied by an elitist selection. After this application, 3 employees will be taken to the 3rd population and the other employees will go to crossover and mutation step.

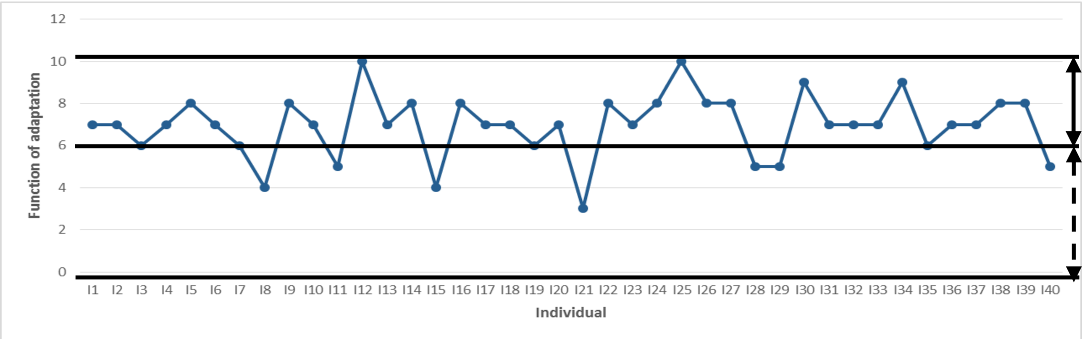
After applying a tournament selection to the 3rd population, there are 8 employees more appropriate to this study case. These employees will go to crossover and mutation step once again and the result is presented in Figure 8.



⟷ Number = 20 employees. “Employee Apt”: Taken to the 2nd generation.

⇠ ⇢ Number = 20 employees. They will go to crossover and mutation step.

Fig 3: The result after applying an elitist selection to the initial population



⟷ Number = 29 employees. “Employee Apt”: They will be applied by tournament selection.

⇠ ⇢ Number = 11 employees. “Employee not Apt”.

Fig 4: The result after applying an elitist selection to the 1st population

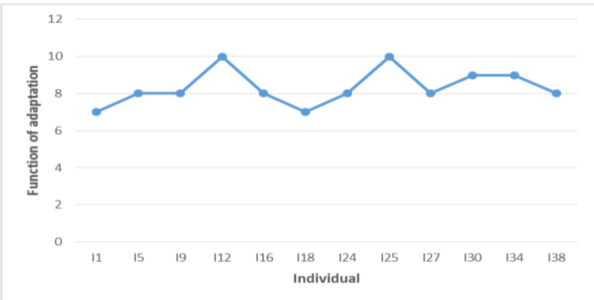
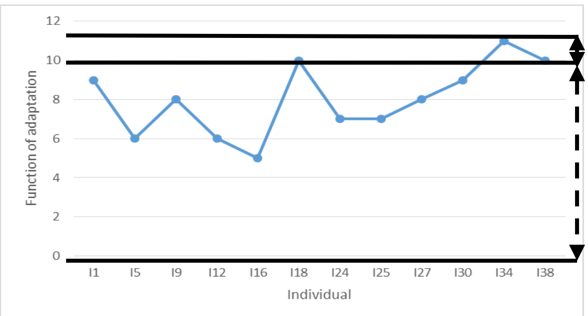


Fig 5: The result after applying a tournament selection to the 1st population



⟷ Number = 3 employees. “Employee Apt”: Taken to

⇠ ⇢ Number = 9 employees. They will go to crossover

Fig 6: The result after applying an elitist selection to the 2nd population

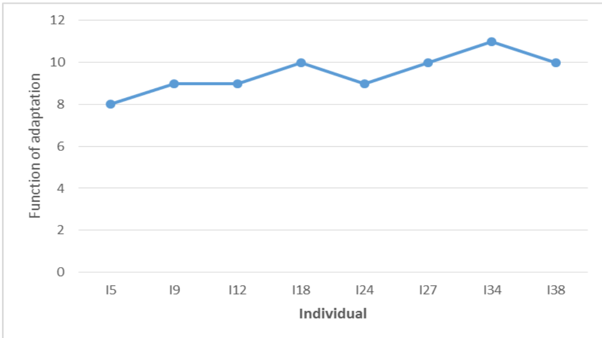


Fig 7: The result after applying a tournament selection to the 3rd population

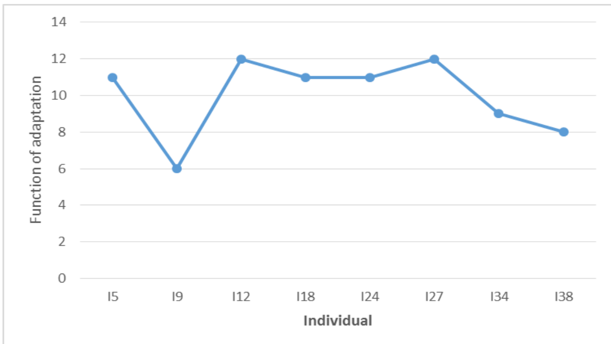


Fig 8: The final population

At the end of the genetic process, the eight most appropriate employees will be gotten and adapted by the change that will be operated through the transformation services towards the e-Governance. As an extension of this study, specified treatments will apply to the categories of criteria mentioned in the introduction.

This analytical approach allowed to classify employees in this study to eight employees that forms the «Employee apt» class and that initially were among the most «Interested». Among the rest of employees, someone can integrate the e-Governance only after a preparation following a specific training, while others cannot.

5. CONCLUSION

In this article, the major interest is in the selection of employees, pre-disposed to changes and who can easily integrate tools and services of the e-Governance into their missions. For this, the principles of genetic algorithm have been chosen to be applied to a restricted population (40 employees) and with only five subcategories. The basic idea of this work resides in an application field of genetic algorithms around the retraining of employees and especially officials in the transformation of administrative services around the implementation of solutions oriented to the e-Governance. To find the most able employees to cope with the change, three intermediate generations were through before arriving at the best generation. These intermediate generations are composed of individuals having more adapted profiles.

This work is part of a most complex approach that aims to expand the study to a more representative population (hundreds) taking into account all of the above categories criteria. It may also apply the fuzzy logic to quantify degrees of importance of the different subcategories and the different categories with respect to the employee profile. The expected objective is the establishment of a tool, following a diagnosis, which allows to classify employees and to take a decision for any assignment or for any training to follow. This process can be used also to evaluate employees in their career plans.

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