Predict energy charging points to electric vehicles in a Smart City using a novel metaheuristic

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ABSTRACT

The purpose of this research is to understand from a Multivariable optimization associated with the path of a group of vehicles integrated in an Ecological Community and determine the optimal route involve speed, storage and travel resources including time of charge for determining the cost benefit have partnered with a travel plan associated with the charge point in a Smart City, which has as principal basis the orography restriction related with the energy consume, although this problem has been studied on several occasions by the literature failed to establish by supporting ubiquitous computing for interacting with the various values associated with the achievement of the group of vehicles and their cost-benefit of each member of the community and comparing their individual trips for the group and determine the quantity of energy which requires each one. There are several factors that can influence in the achievement of a group trip, for our research we propose to use Bat Algorithm on, which has proven to be efficient for the convergence of several issues (artificial bats) when they have such restrictions and obstacles should use this energy to avoid in our case, a gain resource as food which in our case is represented as the use of food optimally for the duration of a long trip with the uncertainty of not knowing when you have a resupply of energy considering a Considering a useful life of between 8 and 10 hours depending of the use and load in weight of the electric vehicle.

Keywords: Vehicle Routing Problem, Bat Algorithm and Electrical vehicles.

INTRODUCTION

With the increase of the electric vehicles in the Smart City it is of utmost importance to realize an Intelligent Models that determine the proper location of loaders for this type of vehicles in the city. Modern versions of Electrical Vehicles (EV) have the same function, but are conditioned to adapt to different orography and the duration of the battery that must condition to its continuous use. These can serve a variety of different purposes, and can be adapted to the needs of most travelers one way or another.

Figure 1.- An Standard Electrical Vehicle associated with users in a Smart City.

The ways in which this space can be used depend on the type of journey that is planned, with whom and for how long; in this research we try to optimize a standard model which requires minimum eight hours of duration as in Figure 1. With the search to optimize the efficiency of an electric car it is important to determine its operation, since it uses an electric motor, which propels the car, thanks to the current generated by a battery, most of these batteries are of the Ion-Lithium type , due to its high energy capacity and the lack of memory effect in them (effect in which when recharging a battery, it loses a certain part of its capacity to store energy), its capacity depends on several factors, however most of the companies have units ranging from 100 km to 200 km range, Tesla, one of the companies with the most fame in this branch has developed vehicles that exceed these reaches reaching up to 400km range, however these are also part of the more expensive, so it could be said that they are focused on a certain market with greater purchasing power, these measurements are given by the same manufacturing companies of said products, the 100 km range are actually a good performance, since in static state only consume the energy of the lights and other complementary systems such as heating, so for example a car of 160km range, could travel 4 hours at 40km / h , although this time may decrease due to different conditions such as the external climate and the topography of the streets, however in the latter case, the cars are designed to recover the energy of a slope by lowering it, since it would be necessary to reduce the speed to down, the brakes are designed to take advantage of that braking as kinetic and calorific energy and turn it back into electric thanks that the electric motor works at the same time as a generator. The most obvious use of charger on Electrical Vehicles is the duration time and a relevant aspect is the storage space related with this kind of vehicles. This is useful when moving around the city or even for shorter distances as they are as a storage model and can optimize the time of duration of each charge in addition with the space associated with each element of the charge. These can be equipped with storage racks or cabinet space that will help you organize all the equipment and supplies needed for a day of rest and associated with a long distance journey. When buying a trailer in particular should have a list of what items to fit inside it, if this will be the main purpose of its use. Furthermore, the trailer is enough as living space. Despite that connects to car or other vehicle, which can be disengaged in campgrounds or elsewhere whether towns or in the countryside. In addition, it can be used as a living room and bedrooms, with the addition of some furniture or other sleeping materials. It is very useful for long-term travel when road, and saves the cost of accommodation along the route, making it one of the most popular uses. Routing problems vehicle (Vehicle Routing Problem - VRP) are actually a broad range of variants and customizations problems. From those that is simplest to some that remain today research as in (Dariusz Barbucha, 2013). They generally were trying to figure out the routes of a transportation fleet to service a customer. This type of problem belongs to the combinatorial optimization problems. In the scientific literature, Dantzig and Ramser were the first authors in 1959, when they studied the actual application in the distribution of gasoline for fuel stations.

The objective function depends on the type and characteristics of the problem, in our case locations to charge Electrical vehicles. The most common is to try: minimize the total cost of ownership, minimize total transportation time, minimize the total distance traveled, minimize waiting time to charge this kind

of vehicles, maximize profit, maximize customer service, minimize the waiting time of electric vehicles to perform energy loading in the designated locations, balance of the resource utilization.

PROJECT DEVELOPMENT

To do this research project was developed by dividing into three sections which are modules of application development, implementation of the server and the intelligent module associated with Bat Algorithm and Data Mining. Android is the operating system that is growing in to Streak 5 from Dell, for this reason we select this mobile dispositive along with other manufacturers are propelling the Latin American landing on Android with inexpensive equipment, and on the other hand, some complain about the fragmentation of the platform due to the different versions. Android is free software, so any developer can download the SDK (development kit) that contains your API (Andreu R. Alejandro, 2011). This research tries to improve users of Electrical Vehicles used charge to this kind of vehicles where 1500 people and their electrical vehicles conforms this Ecological Community. There are different ways for an electric motor to work in the most efficient way, taking advantage of the maximum possible energy, many of these are already designed from the beginning, a car has to basically overcome the inertia, air resistance and friction. The power of the engine has to overcome all these forces, which in sum can be extended by: the design of the car (Aerodynamics), the weight of the car. Because of this Most manufacturers use a special alloy of super light aluminum that allows to reduce the weight of the car, and this and other developments such as the regenerative brake mentioned above are the techniques that are being used from production to optimize the vehicle. Within the possibilities of the consumer, there are also various ways to make the most of the load, some companies recommend turning on the air conditioning, while the car is charging to reach a desirable temperature when entering, and keep it as much as possible off during travel and that this limits the scope a lot by using part of the energy.
An option that some cars already implement would be to place solar panels, these obviously do not yield energy for the power of displacement, and however, they are a good way to recharge systems with less need of energy such as air conditioning and electronic control systems of the automobile.

Components of the application

Bat Algorithm

Bats are fascinating animals and their advanced capabilities of echolocation have attracted attention of researchers from different fields, we propose Artificial bat algorithms as in Figure 2. Echolocation works as a type of sonar: bats, mainly micro-bats, emit a loud and short pulse of sound, wait it hits into an object and, after a fraction of time, the echo returns back to their ears (D. R. Griffin, 1960). Thus, bats can compute how far they are from an object (W. Metzner, 1991). In addition, this amazing orientation mechanism makes bats being able to distinguish the difference between an obstacle and a prey, allowing them to hunt even in complete darkness (H.-U. Schnitzler. et al., 2001). Based on the behavior of the bats, Yang (X.-S. Yang., 2011) has developed a new and interesting meta-heuristic optimization technique called Bat Algorithm. Such technique has been developed to behave as a band of bats tracking prey/foods using their capability of echolocation. In order to model this algorithm, Yang (X.-S. Yang., 2011) has idealized some rules, as follows:
1) All bats use echolocation to sense distance, and they also “know” the difference between food/prey and background barriers in some magical way;
2) A bat bi fly randomly with velocity vi at position xi with a fixed frequency $f$min, varying wavelength λ and loudness $A0$ to search for prey. They can automatically adjust the wavelength (or frequency) of their emitted pulses and adjust the rate of pulse emission $r \in [0, 1]$, depending on the proximity of their target;
3) Although the loudness can vary in many ways, Yang (X.-S. Yang., 2011) assume that the loudness varies from a large (positive) $A0$ to a minimum constant value $Amin$.

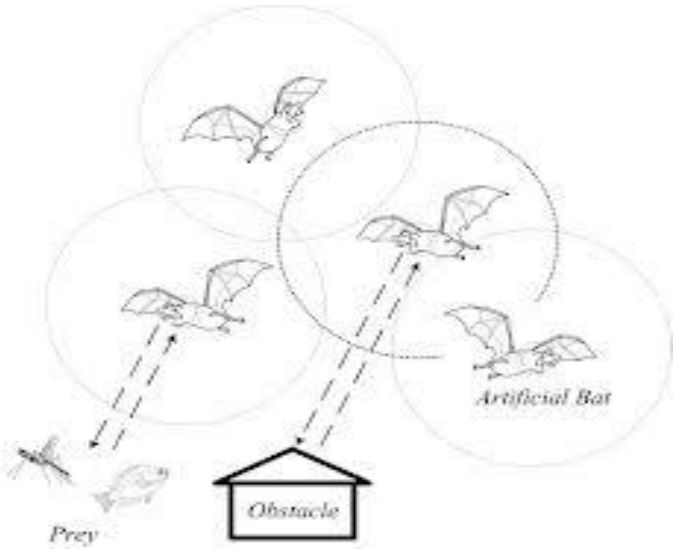

Figure 2.- Representation of Artificial bats proposed in Bath Algorithm featured obstacles and food (prey).

Algorithm 1 presents the Bat Algorithm adapted from (X.-S. Yang., 2011):

Algorithm 1. – BAT ALGORITHM

Objective function $f(x)$, $x = (x1, ..., xn)$.
Initialize the bat population xi *and* vi, $i = 1, 2, ...,m$.
Define pulse frequency fi *at* xi, $\forall i = 1, 2, \ldots, m$.
Initialize pulse rates ri *and the loudness* Ai, $i = 1, 2, \ldots, m$.
1. *While* $t < T$
2. *For each bat* bi, *do*
3. *Generate new solutions through Equations (1), (2) and (3).*
4. *If* $rand > ri$, *then*
5. *Select a solution among the best solutions.*
6. *Generate a local solution around the best solution.*
7. *If* $rand < Ai$ *and* $f(xi) < f(\hat{}x)$, *then*
8. *Accept the new solutions.*
9. *Increase* ri *and reduce* Ai.
10. *Rank the bats and find the current best* $\hat{}x$.

Firstly, the initial position xi, velocity vi and frequency fi are initialized for each bat bi. For each time step t, being T the maximum number of iterations, the movement of the virtual bats is given by updating their velocity and position using Equations 1, 2 and 3, as follows:

$$fi = f\min + (f\min - f\max)\beta, \quad (1)$$

$$vji(t) = vji(t-1) + [\hat{}xj - xji(t-1)]fi, \quad (2)$$

$$xji(t) = xji(t-1) + vji(t), \quad (3)$$

where β denotes a randomly generated number within the interval [0, 1]. Recall that $xji(t)$ denotes the value of decision variable j for bat i at time step t. The result of fi (Equation 1) is used to control the pace and range of the movement of the bats. The variable $\hat{}xj$ represents the current global best location (solution) for decision variable j, which is achieved comparing all the solutions provided by the m bats. In order to improve the variability of the possible solutions, Yang (X.-S. Yang., 2011) has proposed to employ random walks. Primarily, one solution is selected among the current best solutions, and then the random walk is applied in order to generate a new solution for each bat that accepts the condition in Line 5 of Algorithm 1:

$$xnew = xold + \epsilon A(t), \quad (4)$$

in which $A(t)$ stands for the average loudness of all the bats at time t, and $\epsilon \in [-1, 1]$ attempts to the direction and strength of the random walk. For each iteration of the algorithm, the loudness Ai and the emission pulse rate ri are updated, as follows:

$Ai(t + 1) = \alpha Ai(t)$ (5) and

$ri(t + 1) = ri(0)[1 - exp(-\gamma t)]$, (6)

where α and γ are ad-hoc constants. At the first step of the algorithm, the emission rate $ri(0)$ and the loudness $Ai(0)$ are often randomly chosen. Generally, $Ai(0) \in [1, 2]$ and $ri(0) \in [0, 1]$ (X.-S. Yang., 2011). Bat Algorithm is very different from PSO Algorithm because specify better casual minor variations when is affected by exogenous events (X.-S. Yang., 2011). In addition, we compare the results of another novel research as Wolf Search Algorithm (Glass, Steve et al., 2010) and ideas form a proposal of Okapi Algorithm which try to understand the mimetically concept in addition of velocity and support at the rest of its herd.

IMPLEMENTATION OF AN INTELIGENT APLICATION

When designing an interface for mobile devices has to take into account that the space is very small screen, plus there are many resolutions and screen sizes so it is necessary to design an interface that suits most devices. This module explains how to work with different layout provided by the Android API. The programming interface is through XML. Obtaining the geographical position of a device can be made by different suppliers; the most commonly used in this project through GPS and using access points (Wi-Fi) nearby, and perform the same action but differ in some as accuracy, speed and resource consumption. Data Server Communication is the module most important because it allows communication with the server, allowing you to send the GPS position obtained by receiving the processed image and map of our location, thus showing the outcome of your application that is the indicator of insecurity. To communicate to a server requires a HTTP client which can send parameters and to establish a connection using TCP / IP, client for HTTP, can access to any server or service as this is able to get response from the server and interpreted by a stream of data. The Android SDK has two classes with which we can achieve this, HttpClient and HttpPost. With the class HttpClient is done to connect to a remote server, it needs HttpPost class will have the URI or URL of the remote server. This method receives a URL as a parameter and using classes HttpPost HttpClient and the result is obtained and received from the server, in this specific case is only text, which can be JSON or XML format. Here, the server responds with a JSON object which would give the indicator is then used to create the map, as is shown in the Figure 3.

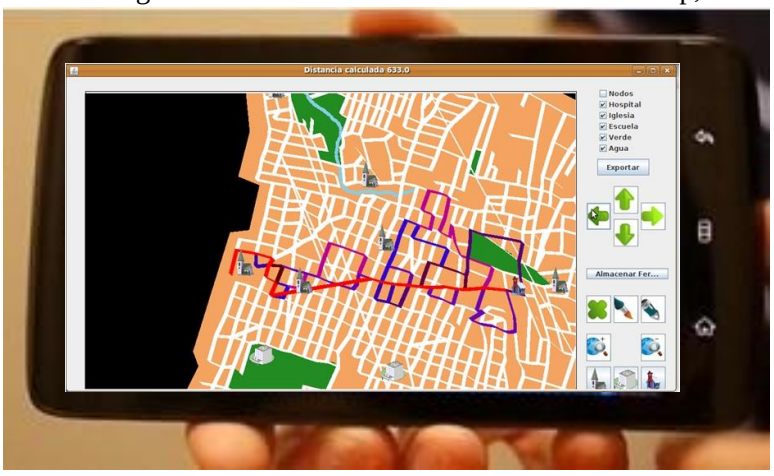

Figure 3. Intelligent Tool recommends a group travel associated with limited resources and optimize energy (electrical charge), time and comfort.

For the construction of the polygon that indicates the rate of incidents in a certain radius of the current position is not possible to create it using the GPS coordinates that yields, as these are specified in

"degrees" and requires the unit to convert to meters. For this you need to know how an arc equals the terrestrial sphere, which depends on the place on earth where it is located and the address where you are, the simplest case is to measure an arc in Equator, considering that the earth is 3670 km radius, the perimeter of serious Equator radio 2, which would be equal to 40.024 miles (Liu Mingxi et al., 2019). With this you can get a relationship that would be as follows. If 360 degrees is 40.024 miles then a degree is 111,000.18 miles, this relationship can add and subtract yards to the position, as shown in the figure 4, this process related a specific point to charge Electrical vehicles of interest in our case to model a smart city and describe the distance and time to charge in an available point of charge, the information is display on the mobile device recommend inclusively waiting times associated with vehicle loading.

Figure 4. Acquisition of polygon map related with the position of the Android application.

The largest distances between the extreme points in a Smart City from north to south are about 50 km, assuming that on average people do not travel more than 30 km to reach their destinations it would be possible to make at least 4 trips. It is necessary that there are different places where the user can recharge the battery, for this we locate the main areas within the city where various factors converge such as: Transit, Places of interest, and urban development, it is easy to identify these places with indicators by of the INEGI (Jeong Seungmin et al., 2019), and of the same visible development within the city, since all the indicators indicate the areas where there is already infrastructure that would allow to place said posts, in fact we can take advantage of the distribution of the gas stations in the city to position the loaders as is proposed in (Liu Chensheng et al, 2019), this distribution can be seen in Figure 5.

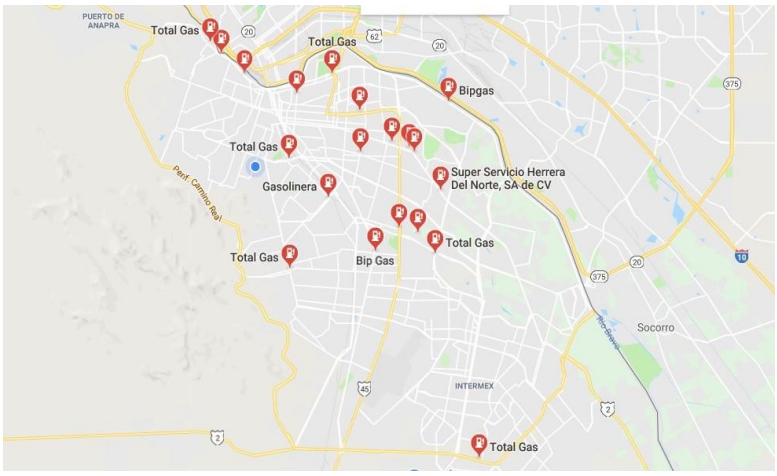

Figure 5. Taken from Google's satellite service related with Juarez City

For the preparation of graphics, we propose use a class supported with Bat Algorithm supported which facilitates to manipulation of data to express visually using different types of graphs, as in the figure 6 in where each number of iteration is proposed to relate with a generation. To the 11th Iteration a specific behavior is described to the most possible places where is possible advance the most of vehicles in this Ecological Community.

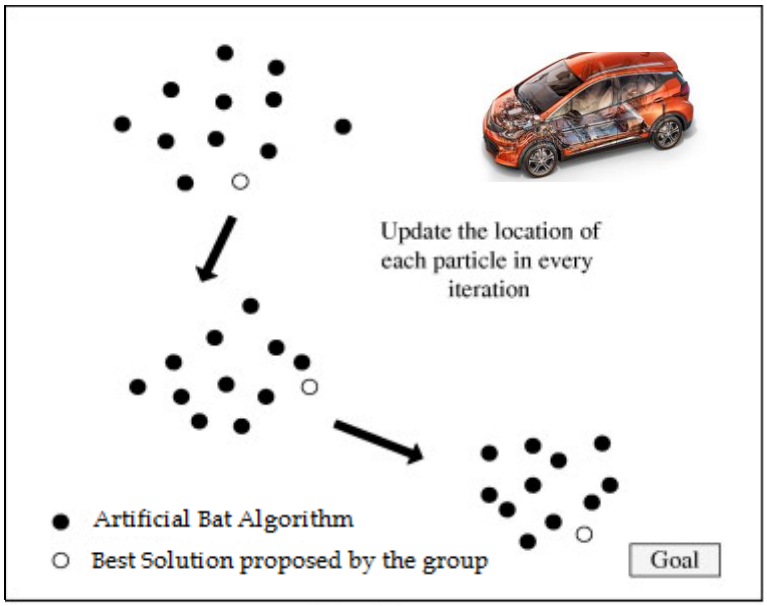

Fig. 6. Statistics Graphics related with the solution proposed by Bat Algorithm.

To implement the application is installed in operating system devices with Android 2.2 or higher, which tests the system in different areas of the three different parks and natural reserve in Chihuahua based on the previously research related with Cultural Algorithms on Urban Transport (Cruz, Laura; Ochoa, Alberto et al., 2010), by answering a questionnaire of seven questions to all users related with this Ecological Community have elapsed since installing the application, the questions are to raise awareness of the performance, functionality and usability of the system, the demonstrate use of this application is shown in figure 5. To understand in an adequate way, the functionality of this Intelligent Tool, we

proposed evaluate our hybrid approach and compare with only data mining analysis and random select activities to protect in the city, we analyze this information based on the unit named “époques” used in Bat Algorithm Algorithms, which is a variable time to determine if exist a change in the proposed solution according at different situation of different routes with better use of restricted resources.

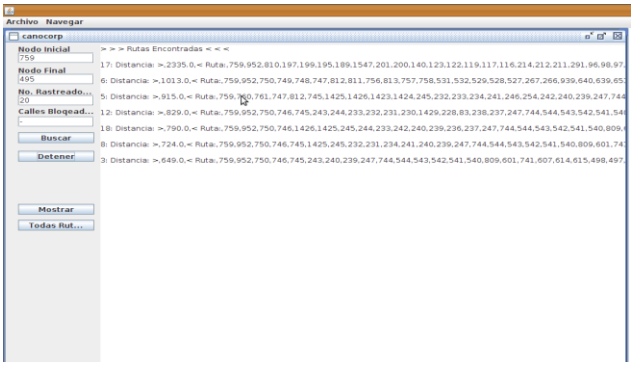

Fig. 7. Hybrid Intelligent Application based on Bat Algorithm and Data Mining.

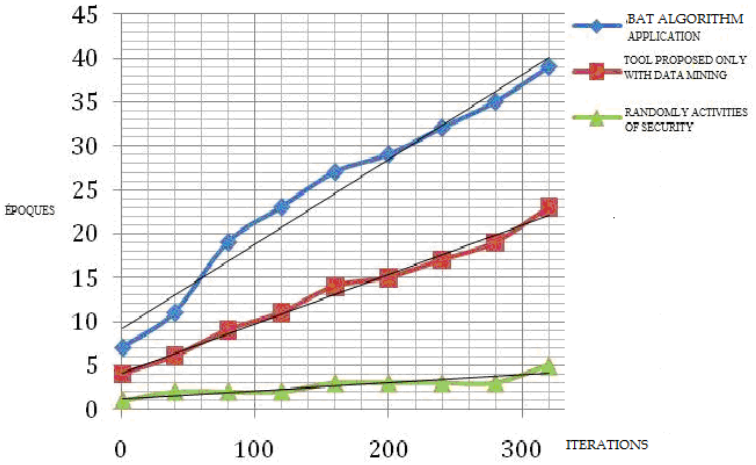

Fig. 8. Solutions proposed to group travel problem: (blue) hybrid approach; (red) only using data mining analysis and (green) using randomly actions to improve the safety of the users.

We consider different scenarios to analyze during different time, as is possible see in the Figure 6, and apply a questionnaire to a sample of users to decide search a specific number of places to travel, when the users receive information of another past travels (Data Mining Analysis) try to improve their space of solution but when we send solutions amalgam our proposal with a Bat Algorithm and Data Mining was possible determine solutions to improve the resources of the group, the use of our proposal solution improve in 91.72% against a randomly action and 14.56% against only use Data Mining analysis the possibilities of recommend arrive in a specific time to use less energy, these messages permits in the future decrease the possibility of deplete the supply of food and spend time rerouted in an orography terrain with more obstacles and uncertainty of the weather conditions and the use of limited resources.

Proposed Solution

The objective would be to place stations at points near these locations; taking advantage of the well-known market distribution of gas stations as is shown in Figure 5. The issue is that these chargers require more time to complete the charge, even though they are the fastest system, they take about 30 min, to recharge 80% of the battery, these systems have a small transformer and work with an approximate power of 440 volts. There is not a big problem in terms of the placement of these, that is, they could be located

as gas pumps up to 8 points with recharging on both sides. Some companies offer their customers snacks at the store while they wait, this is an option placing up to 6 charging points in the city and with the possible option of combining the service to make the wait something useful, however, waiting be a determinant in customer satisfaction

CONCLUSION AND FUTURE RESEARCH

With the use of this innovative application combine Bat Algorithm and Data Mining based on a mobile dispositive is possible determine the places where is possible improve a group travel in Chihuahua's natural parks by an alert sent to a mobile device with GPS, providing statistical information through a Web server that returns the level of insecurity in the area consulted (Mencía Carlos et al., 2019), a specific factor decisive in this part of Mexico. The future research will be to improve the visual representation of group travel to a social networking to this we proposed an Intelligent Dyoram –An Intelligent display in 3D used on Social Networking- with real on time information of each one of their members and establishment a travel including save money and time and enjoy with the rest of Ecological Community. The most important contribution is prevent spend time and money in this kind of travels because drive in a unsafe place at night on a wrong time and suffer an assault, our future research is adequate the information to actualize from the central server of security of the State government, to the users, considering that the number of people travel at this parks during this last year was of 57000 people, because the Ecotourism is very high as recreational activity, this innovative application is possible to use in another smart cities in Paris, Milano, Cardiff, Barcelona, Guadalajara, Vancouver or Singapore City – This society has 147000 electrical vehicles and realize an accumulate of 2975000 travels during one year- with similar conditions of travel by their respective Ecological Communities, this Intelligent Tool will be used by different kind of people whom requires travel together. In addition, this application will be used as Recommender System when travel to another smart cities or places in different societies (Souffriau, Wouter et al., 2009) and explain different scenarios according time, limited resources and location. Another field topic will be benefited with more adequate organization is Logistics of product or service as in (Ochoa, Alberto et al., 2010) which describes the use of Cultural Algorithms to improve a Logistics networking associated with the deliveries of a bottle product.

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