Use the Firefly Algorithm to Find the Profits of the Airlines at Baghdad International Airport

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Abstract

In this paper, queueing system with losses (M\M\m\-\m) is investigated depending on First in First out (FIFO) technique. The main task is to find the earnings of three airline companies in international airport of Baghdad, by establishing the best number of service centers. The researcher was present on daily basis to collect data related to travelers arrival and departure time from centers of services. The researcher calculated arrival averages and service (μ **,** λ**)** by using (Professional EasyFit5.6). Also, he observed distribution of service centers for all previously mentioned companies. The aim of researcher is to determine arrivals time of airline companies, service centers which are Poisson distributed and how service time (Exponential distribution) is distributed. Then, it is necessary to find the best service center depending on earnings indication of suggested model for each company, using Firefly Algorithm (FA) and writing the program by (Matlab R2015a) to show the results. And finally, the results are compared with Particle swarm Algorithm (PSO), (FA) algorithm is proved to be better as compared to (PSO).

Keywords: Queuing System, Firefly Algorithm.

1. Introduction

Many problems have emerged in the population systems which cause many obstructions to service performance in service centers, so the queueing system model is chosen to solve some of the problems that are caused by waiting rows for service centers and due to knowledge developments and performance improvement to solve some these problems, a developed algorithm is chosen to improve the performance of such systems. Firefly Algorithm is considered one of the high efficiency, new algorithms that solves complex problems especially the problem of waiting queues. This algorithm is considered one of the algorithms, which is inspired from the nature. The Firefly insect which is found in the tropical places especially at night has a lightening body flying in flocks as they are attracted to each other because of their light. There is 2000 type of these insects around the world. Most of them are lightening in a short terminal rhythmical way as a way of courting or warning signs. The scientist (Xin She Yang) has suggested this algorithm on (2008). It contributes in solving many problems like improving problems and complex problems that are difficult to be solved by traditional ways.

2. Queuing models

1. Queueing system model from one service center description one waiting queue and of a particular service center to form simple model. When the service provider is a serving the customers' needs slowly, the waiting queue becomes longer, as shown in figure 1:

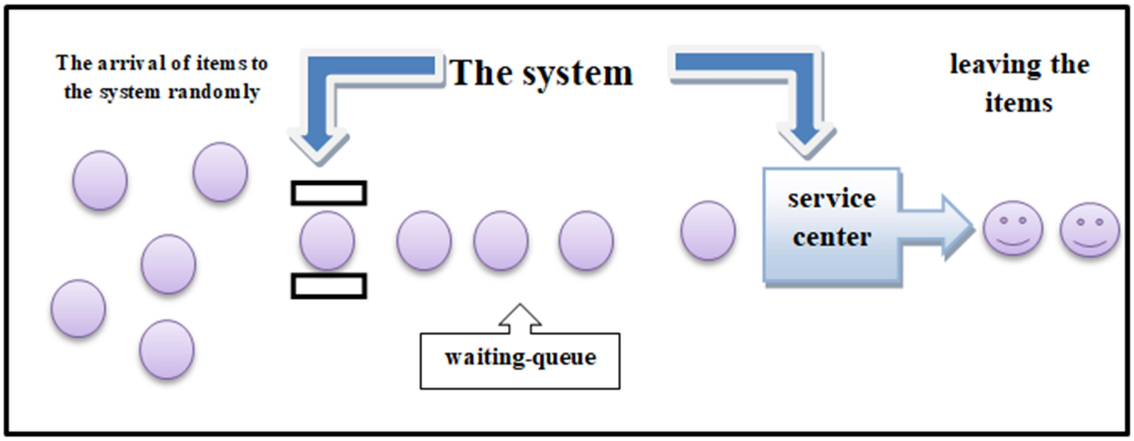

Figure 1. Model of one center

2. It is a multi service centers model, in other words, it is a system where there are a number of service centers like petrol station etc.

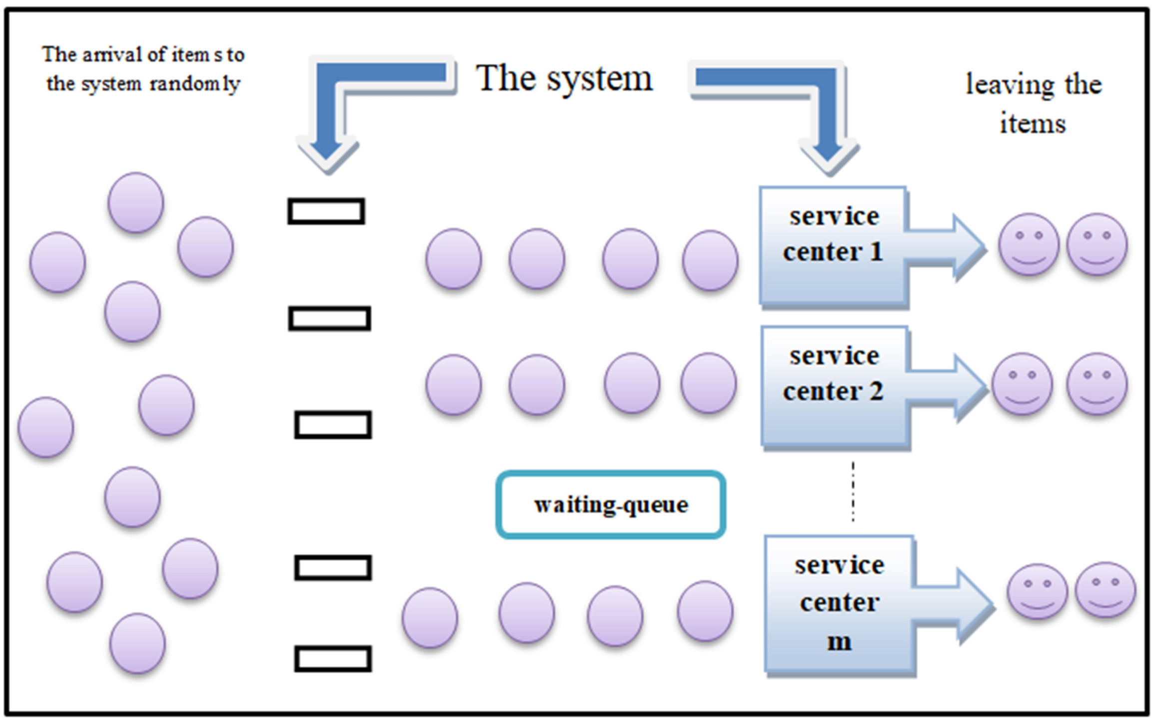

Figure 2. A sample of a number of service centers

3. The M/M/m/-m queueing system with losses:

Exponential service time m is to be analyzed from the parallel, identical servers. In this system, they get to the customer in the case where at least there is one service provider, When another new customer comes to the long waiting queue, he leaves the system without getting the required service so the system loses its customers, Also, the probability of the static-state for the system is empty, as shown in the following equation:

$$p_0 = \frac{1}{\sum_{k=0}^{m} \frac{\rho^k}{k!}}, \dots \dots (1)$$

$$\rho = \frac{\lambda}{\mu}, \dots\dots (2)$$

λ : The mean arrival rate (per unit of time).
μ : the parameter of the service time.
ρ : Traffic intensity.
m : Number of service centers.
the probability of the activities stability k in the system:

$$p_k = \frac{\frac{\rho^k}{k!}}{\sum_{k=0}^{m} \frac{\rho^k}{k!}} \quad , \dots\dots \quad (3)$$

The probability of static case in which the system loses l its customers:

$$p_l = p_k = \frac{\frac{\rho^m}{m!}}{\sum_{k=0}^{m} \frac{\rho^k}{k!}} \quad , \dots\dots \quad (4)$$

The average of service providing centers in the system Which are:

$$\bar{k} = \rho(1 - p_l) \quad , \dots\dots \quad (5)$$

4. Firefly's Algorithm

Firefly's Behavior in Nature[18]:

Firefly insect or what is lightening mosquitoes is one of the insects which has bright light resulted from the chemical processes (biological luminescence). The prominent feature of this insect is to be lightening. The light forms a beautiful scene in the sky of summer especially in the tropical areas. There is 2000 type of these fireflies in the world and most of them produce a lightening sparks in a short rhythmical way.

The produced light of the firefly might be one of courtship ways, techniques of attracting the prey, or a warning sign from danger for the other fireflies. Also it could be a sign to remind predatory animals that they taste bitter. Some of the tropical fireflies can synchronize their lightening sparks among the flock so they form a biological trend. This algorithm is inspired from this nature of fireflies. They move to a more charming and brighter places through the light produced from them. Each firefly changes its position frequently according to illumination intensity.

These fireflies are found in hard, rough places of high temperature, so they travel at night to get food, and see each other among the high trees which hide the light of moon and stars in the clear summer nights. These fireflies have this phenomenon due to the following reasons:

- To illuminate the dark thick forests at night and see what is around.
- Fireflies of the same type know each other by the degree of light strength and if it is connected or disconnected as separated sparks.
- To attract its preys of other small insects, slugs, snails, and earthworms. These insects charmed with the light of the fireflies so they come near and get catch.
- The males of fireflies use this light to attract the females for mating process. For each male, there is a lightening sign known for his female relating to his type. As soon as the females of firefly see the lightening sign, they react in a lightening sign also to indicate their willing to mate with that male. Some of them would not like to mate from a male so they give no reaction lightening sign.
- Some of fireflies' females send a false lightening sign to males relating to some other type of males of fireflies and when they come near for mating, they got eaten by the females.
- Some fireflies use this light to frighten the other pedantry animals that eat them.

Figure 3. Bright fireflies sweeping garden in China

Firefly's Algorithm [17]:

Nature is considered the main source of inspiration for many researchers for its ability to emulate the best components in nature. Therefore, the algorithm inspired from nature is considered one of the most important and modern algorithms in contrary with traditional algorithms. These algorithms are divided into three divisions (the cleverness of the particle, improving algorithms, and bacterial feeding algorithm). The technique of the particle cleverness takes a group or flock of fireflies, birds, or ants, and it inspire an algorithm from them to find the possible solutions for the world real problems. This algorithm gave satisfactory solutions therefore we will tackle firefly algorithm in our study as it is the modern one. It is considered one of the modern algorithms presented by (Xin- She Yang) on (2008). It was classified as one of the random algorithms because it adopts randomness in searching for possible solutions. Due to the light resulting from the firefly, the algorithm depends on the change of illumination intensity and attractiveness. This means that we always can depend on the attractiveness by determining illumination intensity which in its turn determines the mark of the goal in case of improvement problems. Attractiveness (I) for the firefly for the position X is in direct proportion with the function of the target.

($I(x) \alpha f(x)$) means that it is visible for other fireflies. The intensity of illumination is reversible with distance noticing the absorption of light by the effective mean around the fireflies. So, we let the attractiveness differ according to the degree of light absorption ($I(r)= I(s)\backslash r^2$).

The algorithm of fireflies depends on three main bases:

a- Fireflies are of two sexes (male and female) and they move around the other fireflies to search for another more lightening and charming firefly. The male firefly, usually, sends a lightening sign to attract the female. Females respond in a continual sparks of light.

b- The distance between female firefly and male firefly is considered an important factor. The more distance increases, the more the attractiveness diminishes, so they began to search for a firefly of more charm and attractive lightening. If not, they will search randomly.

c- The lightening of the firefly is determined by the function of the target because the problems of glorification are directly proportional with the value of the targeted function.

Each firefly has its own attractiveness β, while r represents the distance among the fireflies.

$$\beta(r) = \beta_0 e^{-\gamma r^m} \quad , \quad m \geq 1 \quad , \ldots \ldots \quad (6)$$

β : is attractiveness.

γ : is absorption coefficient.

r : represents the distance among the fireflies.

β_0 represents the greatest attractiveness when r=0 and γ is absorption coefficient which controls the diminishing of illumination intensity. Light absorption ranges between (0.1,10) in usual cases.

$$\beta(r) = \beta_0 e^{-\gamma r^2} \quad , \quad \dots\dots \quad (7)$$

The distance between the firefly i and the firefly j gives the following equation:

$$r_{ij} = \|x_i - x_j\| = \sqrt{\sum_{k=1}^{d} \left(x_{i,k} - x_{j,k}\right)^2} \quad , \dots\dots (8)$$

x_i : to i-th firefly .
$x_{i,k}$, $x_{j,k}$: is k-th which is composed of the special format .
d : indicates the number of dimensions .

$$x_i = x_i + \beta_0 e^{-\gamma r_{ij}^2}\left(x_j - x_i\right) + \alpha\left(rand - \frac{1}{2}\right) \quad , \dots\dots \ (9)$$

The first parts refers to the current position of the firefly I and the second part refers to the attractiveness of the firefly and the last part works for random movement if there is no illumination for the firefly. Rand is the random number which is made of uniform distribution in the range (0,1) in its greatest state $\beta_0 = 1, \alpha \in (0,1)$.

5. Fireflies algorithm in symbols:

1. Preparation of algorithm information
- the number of fireflies (n).
- defining the symbols β_0,γ,α.
- generating the greatest number of generations (repetitions)
- defining the mark of goal (x) f where $x=(x_1,x_2,\dots,x_d)$
- generating the primary population of fireflies x_i where (i=1,2,…,n).
- generating n of primary solutions .
- illumination intensity of the firefly (i) in x_i is determined by the value of goal mark f (x_i)

2. While k <MaxGen//(k = 1 : MaxGen)

For i = 1:n//all n fireflies
For j = 1:n
If (I_j> I_i) move firefly i towards firefly j in
d-dimension according to Eq. (8); End if
Obtain attractiveness, which varies with
distance r according to Eq. (7)
Find new solutions and update light intensity
End for j
End for i
Rank the fireflies and find the current best
End while

3. Finding the firefly which carries the greatest intensity of light and generating a primary generation of fireflies as in the following equation:

$$\mathrm{X(i) = LB + rand(UB - LB)}, \dots\dots (10)$$

UB, LB are the less or greatest point to i-th firefly.

After evaluating the primary generation, firefly algorithm enters the main cycle which represents the maximum number of firefly generations (repetitions). For each generation, fireflies of strong illumination intensity are selected (solution with the best value of the goal mark). The best probable solution is selected.

Firefly algorithm emulates an operating strategy which is parallel to n of fireflies' population to generate n of solutions.

3- Random control [17]:

The additional improvement to the algorithm is the change of randomness coefficient a where we make it diminish to approach typicality, for example:

$$\alpha = \alpha_\infty + (\alpha_0 - \alpha_\infty)e^{-t}, \ldots \ldots (11)$$

The false time of emulation between $t \in [0, t_{max})$ و t_{max} is the greatest number for generation and a_0 is the lowest randomness coefficient and α_∞ is the final value.

Also we can use a similar geometric progression which is the table of engineering forces:

$\alpha = \alpha_0\theta^t$, … … (12)

θ belongs to (0,1) which are random constants.

So we can consider $\theta = 0.95 \sim 0.99$ and $\alpha_0 = 1$

The following model shows the performance of firefly algorithm:

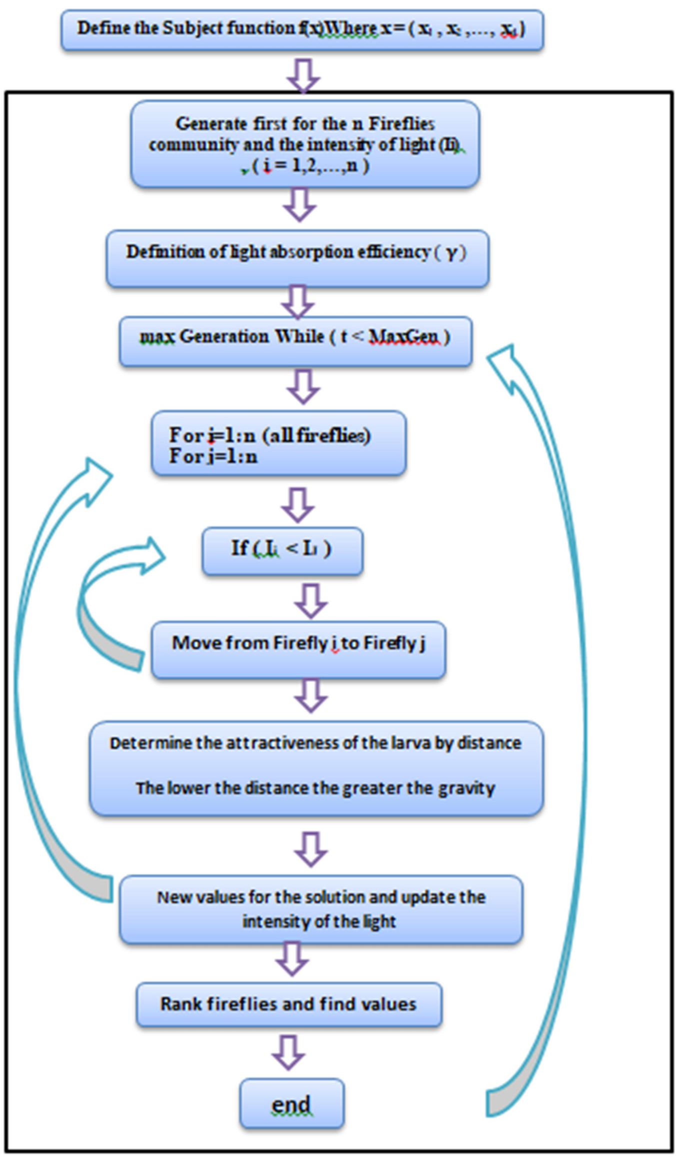

Figure 4. The diagram of the process of applying the algorithm of fireflies

The typical solution for waiting – queue by the firefly algorithm[1]:

To formulate the problems of improvement, we need to determine the features which formulate decision variables. Many of the systems' features may formulate the components of different types of improvement problems, like: diminishing to the least level of cost concerning the production by changing service average, increasing production, and lessening the average of responding time. We may look to the problem of improving the controlling costs like the number of service providers, service average, and the capacity of waiting list and the maximum waiting time.

In the case of (M\M\m\-\m) of queue systems with loss, we aim for a number of service providers which increase the total profits. Here, we get the geometric function:

$$\text{Max} \longrightarrow f(m) = r\left(\frac{\lambda}{\mu}1 - \frac{\left(\frac{\lambda}{\mu}\right)^m}{m!\,\sum_{k=0}^{m}\frac{\left(\frac{\lambda}{\mu}\right)^k}{k!}}\right) - cm\,, \dots\dots \quad (13)$$

As such:

r : represents the cost relating to the system's function.

C : represents the cost of service provider consumption.

λ : arrival average

μ : represents service average

m : represents number of service providing centers

6. Data collecting method:

Data were collected by the researcher through calculating the travellers' movement in Baghdad International Airport during official time for Iraqi Airways. it is considered the major national transporter for passengers so the service center would be multi service center due to the congestion of booking flights while other companies have a limited specified time and days for that. We will summarize the work of each company and give three results for three service centers with noticing the difference of profits for these different companies. The following equations give the results of service and arrival for passengers:

a. Iraqi Airways

It is considered the official transporter in Baghdad International Airport. It is one of the greatest airways in Iraq. Target places of air fights are as the following in the table for the year 2017:

Table 1. The target destinations of Iraqi Airways from and into Baghdad 2017

Erbil	Istanbul	Moscow
Sulaimany	Ankara	London
Al Basra	Antalya	Stockholm
Al Najaf	Tehran	Berlin
Baghdad	Mashhad	Frankfort
Al Kuwait	Esfahan	Dusseldorf
Jeddah	Delhi	Manchester
Dubai	Mumbai	Wein
Amman	Kwanza	Copenhagen
Beirut	Kuala lumpur	

The number of arrivals' averages is found by the use of the equation (13). After that , we enter the result in a program of data analysis (standard easy fit 5.6) to get the suitable distribution for these data. Also, we can find the averages of service by the use of equation (14). So, distributions were Bowsons' while service is exponential function to emulate (FA) algorithm by using the program (MATLAB R2015a) to find the profits of the company. This is done by finding the best service center and comparing the result with the algorithm (PSO) using the equation (12). The results are as in the following table:

Table 2. The results of FA and PSO optimization for m∈(1, 50)

#	service center	**λ**	**μ**	The optimum value of m	f (m) (FA)	f (m) (PSO)
1	m1	6.8056	0.11442	1	117.9582	114.9582
2	m2	7.559	0.10461	2	143.5177	138.5177
3	m3	7.0104	0.11299	1	123.0889	116.0888

The larval algorithm proved superior to the estimate of the gain when the number of fireflies was 40 and the frequencies 50 were the level of randomization (0.1), gravity (0.1) and absorption (1).

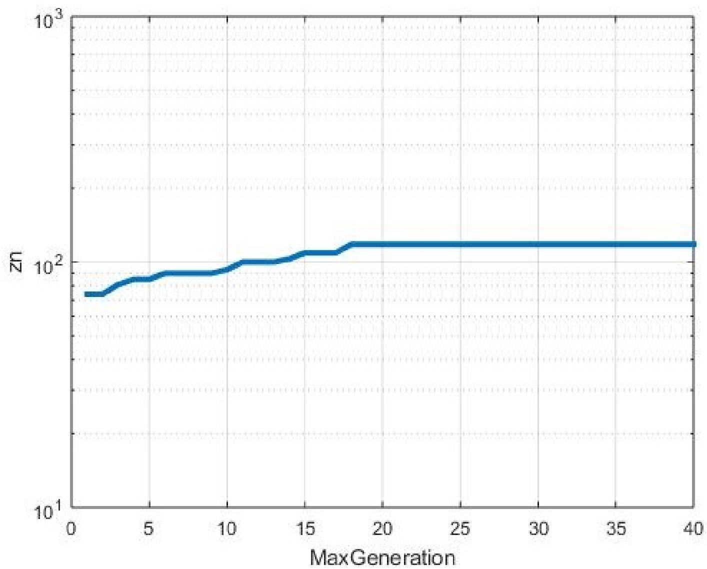

Figure 4. The relationship of the objective function with iterations; (case: λ = 6.8056 , μ =0.11442)

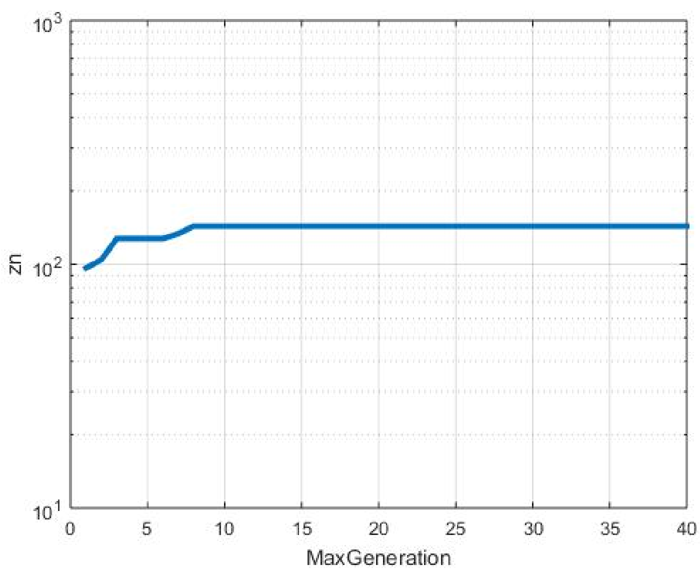

Figure 5. The relationship of the objective function with iterations; (case: λ = 7.559 , μ =0.10461)

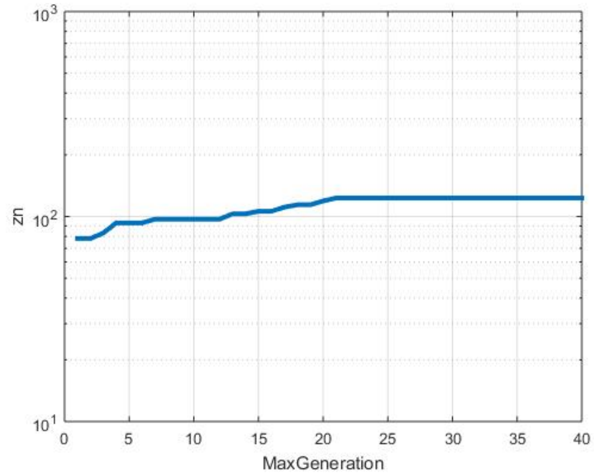

Figure 6. The relationship of the objective function with iterations;
(case: λ = 7.0104 , μ =0.11299)

b. Egyptian Airlines

"Egyptian Airlines" is considered from the pioneering companies in the world. When it was established on May (1932), it was considered the seventh aviation company globally. It started the operation of its commercial activities with airplanes of "Spartan Cruiser" type which work between Cairo and Alexandria. During the second world war , 12 airplanes of Day Havilland type were added to the company.

Table 3. The results of FA and PSO optimization for m ∈(1, 50)

#	service center	λ	μ	The optimum value of m	f (m) (FA)	f (m) (PSO)
1	m1	19.938	0.0459	2	867.7582	864.7582
2	m2	21.849	0.04147	1	1052.7	1050.72558
3	m3	20.451	0.04247	1	962.0798	958.07982

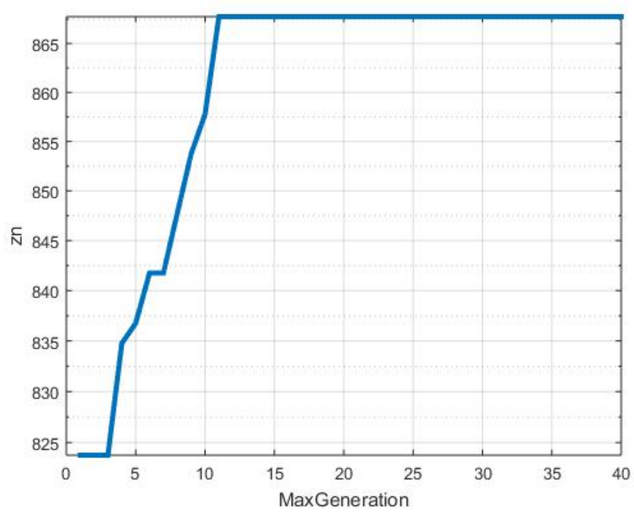

Figure 7. The relationship of the objective function with iterations;
(case: λ = 19.938, μ =0.0459)

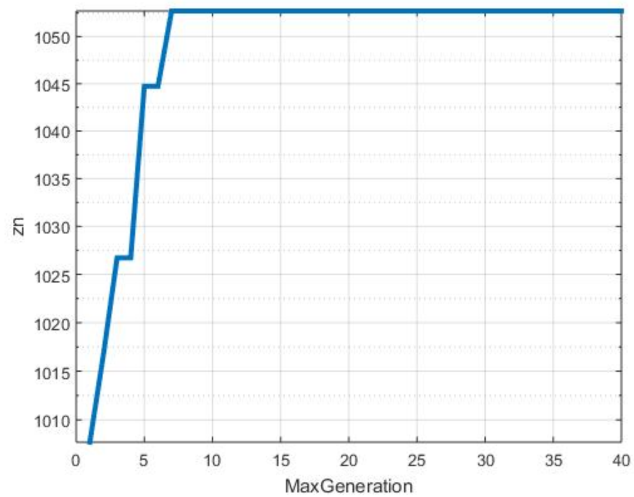

Figure 8. The relationship of the objective function with iterations; (case: λ = 21.849, μ =0.04147)

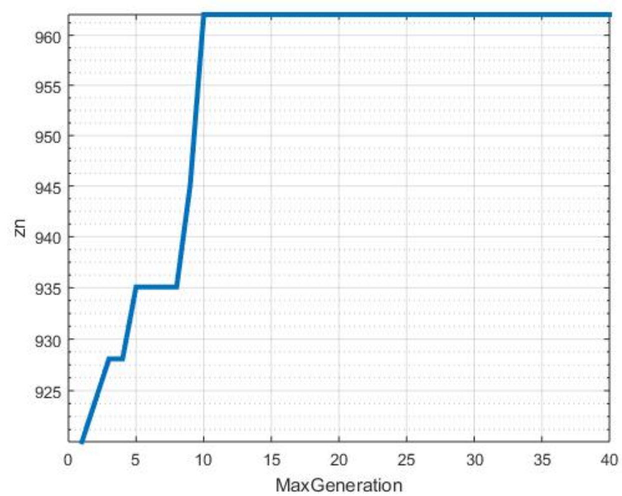

Figure 9. The relationship of the objective function with iterations; (case: λ = 20.451, μ =0.04247)

c. Turkish Airline

It is a national aviation company, which has its main center in Istanbul. It takes Ataturk airport as a center for its activities. It offers its services to more than 290 distention in Europe, Asia, Africa, and north America. It is a member in world star allay.

Table 4. The results of FA and PSO optimization for m∈ (1, 50)

#	service center	**λ**	**μ**	The optimum value of m	f (m) (FA)	f (m) (PSO)
1	m1	29.451	0.03087	5	1900.06608	1898.0661
2	m2	24.059	0.0372	2	1292.49462	1286.4946
3	m3	18.349	0.04681	2	782.97778	773.9778

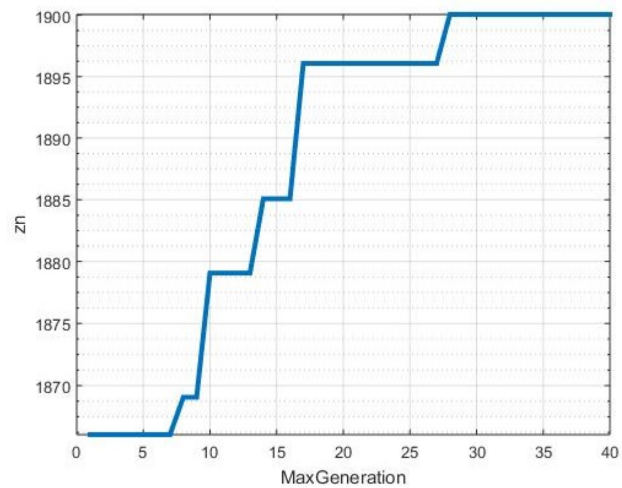

Figure 10. The relationship of the objective function with iterations; (case: λ = 29.451, μ =0.03087)

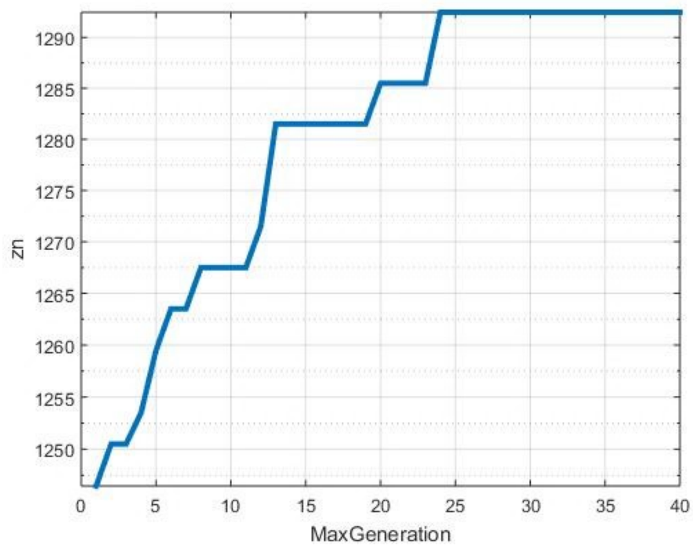

Figure 11. The relationship of the objective function with iterations; (case: λ = 24.059, μ =0.0372)

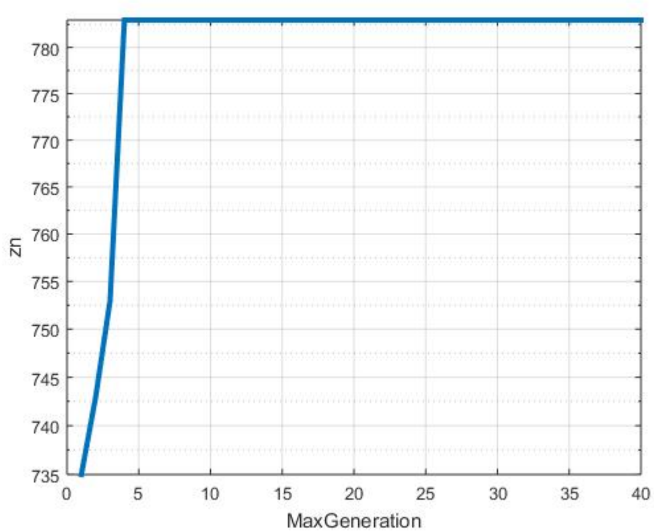

Figure 12. The relationship of the objective function with iterations; (case: λ = 18.349, μ =0.04681)

The comparison of companies with each other was the results of the algorithm as in the table (5)

Table 5. The results of FA and PSO optimization for m∈(1, 50)

#	Service center	λ	μ	The optimum value of m	f (m) (FA)	f (m) (PSO)
1	Iraqi Airways	7.125	0.1105	1	127.9593	122.9593
2	Turkish Airlines	20.704	0.04346	1	951.7842	947.7842
3	Egyptian Airlines	24.22	0.03885	1	1245.8	1238.8468

As the figure 13 shows, the results of companies where Iraqi Airways emerged less than Turkish Airlines and Egyptian Airlines.

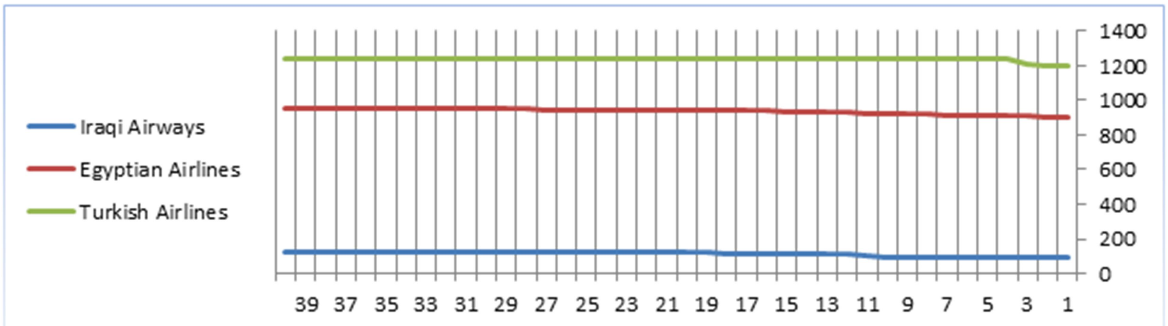

Figure 13. The result of the subject function and frequency of the three companies

7. Conclusions and recommendations

The results of the FA and PSO show that the FA was the best improvement results of the PSO where it was:

1. in the first service center was the result of profit (FA) Iraqi Airways (117.9582) and (PSO) (114.9582) and second service center (143.5177) for (FA) and (138.5177) for (PSO) and third service center (123.0889) for (FA) and (116.0889) for (PSO).
2. in the first service center was the result of profit (FA) Egyptian Airlines (867.7582) and (PSO) (864.7582) and second service center (1052.7) for (FA) and (1050.72558) for (PSO) and third service center (962.0789) for FA and (958.07982) for (PSO).
3. Turkish Airlines in the first service center was the result of profit (FA) (1900.06608) and (PSO) (1898.0661) and second service center (1292.49462) for (FA) and (1286.4946) for (PSO) and third service center (782.97778) for (FA) and (773.9778) for (PSO) .
4. The results of the with some of the were the three companies Iraqi airlines result of (FA) (127.9593), (PSO) (122.9593) and was the Egyptian Airlines result of (FA) (951.7842) and (PSO) (947.7842) and (FA) Turkish Airlines(1245.8) and (PSO) are (1238.8468) there is a big difference between corporate profits where profits are less Because of the few Iraqi Airways passenger traffic the result may change if there is a strong movement for travelers as well as the reason for this change is to travel seasons.

References

Brest, J., Fister, I., & Yang, X.-S. (2014). "On the Randomized Firefly Algorithm". Cuckoo Search and Firefly Algorithm. 27 Studies in Computational Intelligence 516. DOI: 10.1007/978-3-319-02141-6_2.

Belkacem, R. E. M., Benzid, R., & Bouguechal, N. (2017) . "Multilevel inverter with optimal THD through the firefly algorithm". Archives of Electrical Engineering; Vol. 66(1), Received: (28.05.2016) , revised: (09.09.2016): pp. 141-154.

Chandrasekaran, M., & Udaiyakumar, K. C. (2014). "Application of Firefly Algorithm in Job Shop Scheduling Problem for Minimization of Makespan" . K.C. Udaiyakumar and M. Chandrasekaran / Procedia Engineering 97: pp. 1798-1807.

Filipowicz, B., & Kwiecień, J. (2012). "Firefly algorithm in optimization of queueing systems". Bulletin Of The Polish Academy Of Sciences Technical Sciences; Vol. 60, No. 2: pp. 363-368.

Horng, M.-F., Nguyen, T.-T., Lin, Y.-C., Le, Q.-D., Shieh, C.-S., & Sai, V.-O. (2015). "Parallel Firefly Algorithm for Localization Algorithm in Wireless Sensor Network". International Conference on Robot, Vision and Signal Processing; DOI 10.1109/RVSP: pp. 300-305.

Köse, C., & Yelghi, A. (2018). "A modified firefly algorithm for global minimum optimization". Applied Soft Computing, 62: pp. 29–44.

Kora, P., Krishna, K. & Sri Rama. (2016). "Hybrid firefly and Particle Swarm Optimization algorithm for the detection of Bundle Branch Block". International Journal of the Cardiovascular Academy 2: pp. 44–48.

Li, M., Liu, J., Zhang, Y., Zeng, B., & Zhou, H. (2015). " The modified firefly algorithm considering fireflies' visual range and its application in assembly seque nces planning" . International Journal of Advanced Manufacturing Technology; DOI 10.1007/s00170-015-7457-8.

Lobato, F. S., & Steffen, Jr. V. (2013). "Multi-Objective Optimization Firefly Algorithm Applied to (Bio)Chemical Engineering System Design". American Journal of Applied Mathematics and Statistics; Vol. 1, No. 6, Received (April 13, 2013), Revised (May 06, 2013), Accepted (November 19, 2013), pp. 110-116.

Neely, M. J. (2010). "Stochastic Network Optimization with Application to Communication and Queueing Systems", Synthesis Lectures on Communication Networks, University of Southern California .

Oniszczuk, W. (2010). Loss tandem networks with blocking – a semi- Markow approach, Bulletin of The Polish Academy Of Sciences Technical Sciences, No.58 (4), pp 673–681.

Shamsuddin, S. M. & Rini, D. P., & Yuhaniz, S. S. (2011). "Particle Swarm Optimization: Technique, System and Challenges" , International Journal of Computer Applications (0975 – 8887) Volume 14– No.1, pp. 19-27.

Shukla, R. & Singh, D. (2017). Selection of parameters for advanced machining processes using firefly algorithm. Engineering Science and Technology, an International Journal: pp. 212–221.

Singh, G. P. (2016). Pricing Financial Option as a Multi-Objective Optimization Problem Using Firefly Algorithms. A Thesis submitted to the Faculty of Graduate Studies of The University of Manitoba in partial ful_llment of the requirements of the degree of Master of Science.

Wilder, C. R. (2010). "The Queuing Theory of Two-Populations with Lane Switching" . Stuart School Of Business Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Management Science in the Graduate College of the Illinois Institute of Technology , pp. 286.

Yang , X. S. (2008). " Nature-Inspired Metaheuristic Algorithms " . Frome: Luniver Press ; ISBN 1-905986-10-6.

Yang , X. S. (2010). " Swarm Intelligence Based Algorithms: A Critical Analysis" , a critical analysis, Evolutionary Intelligence, vol. 7, no. 1, pp. 17-28.