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Congestion Control and Routing Improvement in Wireless Sensor Network Using Genetic Algorithm

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التحكم في الازدحام وتحسين التوجيه في شبكة المستشعرات اللاسلكية باستخدام الخوارزمية الجينية

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Abstract

At present, wireless sensor networks (WSNs) are applied as a paradigm in environments where the use of conventional sensor networks is impossible. Many characteristics of WSNs make it suitable to apply, such as low power consumption, mobility of sensors, and the ability to deploy on a large scale but, when the size of these wireless networks increases, some challenges need appropriate solutions, and one of these challenges is the congestion. Congestion occurs when the network is more than the available capacity at any network point. The cause of congestion can also be attributed to the nature of wireless sensors and the nature of the data transmitted through these sensors. For this purpose, it is necessary to analyze the layers of these networks specifically (transport layer) properly and provide appropriate mechanisms for communicating information through the sensor network for each layer. The discovery of congestion is significant for the effective utilization of network resources to balance traffic load balancing. In this paper, we propose the use of the genetic algorithm for routing knowledge of congestion control and interference in WSNs where we defined two objective functions which are reduced packet transmission delay and the expected transmission number to reach the destination. The results of the simulation show that the response time of the two-objective genetic algorithm is shorter than the basic genetic algorithm.

الخلاصة:

في الوقت الحاضر ، يتم تطبيق شبكات الاستشعار اللاسلكية **(WSNs)** كنموذج في البيئات التي يكون فيها استخدام شبكات الاستشعار التقليدية أمرًا مستحيلًا. العديد من خصائص الشبكات اللاسلكية تجعلها مناسبة للتطبيق ، مثل انخفاض استهلاك الطاقة ، وحركة المستشعرات ، والقدرة على النشر على نطاق واسع ، ولكن عندما يزداد حجم هذه الشبكات اللاسلكية ، فإن بعض التحديات تحتاج إلى حلول مناسبة ، وأحد هذه التحديات التحديات هي الازدحام. يحدث الازدحام عندما تكون الشبكة أكبر من السعة المتاحة في أي نقطة شبكة. يمكن أن يُعزى سبب الازدحام أيضًا إلى طبيعة أجهزة الاستشعار اللاسلكية وطبيعة البيانات المرسلة عبر هذه المستشعرات. لهذا الغرض ، من الضروري تحليل طبقات هذه الشبكات على وجه التحديد (طبقة النقل) بشكل صحيح وتوفير الآليات المناسبة لتوصيل المعلومات من خلال شبكة الاستشعار لكل طبقة. يعد اكتشاف الازدحام أمرًا مهمًا للاستخدام الفعال لموارد الشبكة لموازنة موازنة حمل حركة المرور. في هذا البحث ، نقترح استخدام الخوارزمية الجينية لتوجيه معرفة التحكم في الازدحام والتداخل في الشبكات اللاسلكية **WSN** حيث حددنا وظيفتين موضوعيتين وهما تقليل تأخير إرسال الحزمة ورقم الإرسال المتوقع للوصول إلى الوجهة. تظهر نتائج المحاكاة أن زمن استجابة الخوارزمية الجينية ثنائية الهدف أقصر من الخوارزمية الجينية الأساسية.

Keywords:

Overcrowding Control, Routing Improvement, Network, Genetic Algorithm, Effective Utilization of Resources, Load Balancing

الكلمات المفتاحية

التحكم في الازدحام ، تحسين التوجيه ، الشبكة ، الخوارزمية الجينية ، الاستخدام الفعال للموارد ، موازنة الحمل

Introduction

In wireless sensor networks, many demand for real - time service has created many challenges to provide services quality. The design of routing protocols that can provide multi - objective goals is computationally hard and confusing. The K - connectivity topology control can withstand the performance of multicast networks. The proposed algorithms are mainly focused on maintaining a k - connectivity connection between both nodes. However, in implementing the network operation, k - connectivity execution algorithms reduce network performance and the topology requires fault tolerance and interference [1].

In this paper, a multi - objective optimization problem which has objective functions that contradict each other, makes a set of responses generated, rather than a solution number. In this way, none of the answers will be better than the other and all the answers are identical. One of the main purposes for a multi -objective optimization is that we obtain a set of responses that are distributed optimally. To preserve the diversity of numbers not only requires a specific distance between these, but requires a good alliance between the series that are not dominated. The proposed algorithms are used to solve these problems; these algorithms are defined in the form of algorithms that are intended to provide a set of optimal solutions. Then, the final solution is found using choosing the best decision among the existing solutions [9]. In many ways that have been proposed so far, topology control problem has been associated with the problem of fault tolerant. For example, in [2] and [3] using fault tolerant, the method is first proposed to control the topology and then a method is presented to delay transmission delay. By making changes in the structure of this algorithm, it can be applied to interference.

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In wireless sensor networks, the phenomenon of congestion is one of the challenges in these networks, in which we try to overcome the above challenges and congestion control. In wireless sensor networks, the detection of congestion is very important for effective utilization of network resources in order to balance traffic load. in the proposed scheme, the congestion detection process is based on monitoring the status of the sensor node and the wireless channel, as nodes monitor the energy consumption and congestion status, in parallel with the congestion state of the sensor node and the connection between nodes according to buffer occupation and channel use, respectively, on minimizing the transmission delay rate using genetic algorithm.

In this paper, using genetic optimization algorithm, we propose a better condition in topology control considering congestion and load balancing in wireless sensor networks compared to previous algorithms. In the proposed method, we use two objective functions of congestion and load traffic load balancing in choosing the topology that has not been used so far and by defining these constraints, the data packets generated by nodes will be able to reach the destination node. In other words, the most appropriate and appropriate topology is the least amount of traffic in terms of congestion and load balancing.

Related Work

A routing algorithm was proposed by [4]. In this method, integer model was used to maximize the traffic transmitted in the form of success of all resources. This method gives rise to a 58 % improvement over the previous method, but it tends to show too much interference in the dynamic environment [4].

In [2] proposed an optimization algorithm for WMN networks using the NSGA-2 algorithm, which had three objectives: minimizing packet losses, end-to-end latency, and power consumption. The NSGA-2 algorithm finds multiple paths that meet the needs of Qos and also supports multimedia data transmission. Balancing between nodes makes categorized sensor networks vulnerable to communication errors and deficiencies and reduces network reliability.

In this paper, [8] investigated the problem of broadcast scheduling in wireless networks that focus on packet latency. This was done with the aim of minimizing the number of packages. In this paper, a packet encryption and playback algorithm based on maximum weight band is presented in which the receiver can receive all the packets receiving the buffer coding and decoding of the packet. This innovative algorithm works on weighted graph vertices according to the color mark. The simulation results show that the computational time algorithm significantly reduces but does not cover the fault tolerance.

In [6] have introduced a new error-free routing protocol that guarantees service quality. This protocol ensures latency, vibration, and reliability in wireless multimedia sensor networks. In this protocol, each sensor node knows the geographical location of neighboring nodes and wells and uses this information in routing. This protocol tries to reduce the end-to-end latency of packets by trying to reduce the number of steps the packet takes to the destination. Reliability in this protocol is guaranteed by sending two copies of the package

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to the well at the same time. Vibration is an important parameter for real-time multimedia streams; this parameter must be considered by the routing protocol in order to prevent confusion and error in the information received at the destination. The simulation results prove the efficiency of this protocol in ensuring latency, vibration and reliability, efficiently in terms of power consumption, in wireless multimedia sensor networks, but it cannot simultaneously improve these parameters. Reduce interference.

In [7] presented a fault-aware topology in the case network. These terrestrial sector protocols are designed to receive short safety packages with sensitive delays, while the high vehicle dynamics and internal network segmentation are frequently considered, which is not yet available in the literature. The advantage of the protocol is that it makes better use of network throughput by avoiding the exchange of unnecessary information between vehicles. The protocol handles applications easily, in this way it is possible to increase interference in further delays and network static mode.

In [12] have proposed a destination-aware, dense, and adaptive protocol. Each node finds more than one path between itself and the destination. Each intermediate node sends packets according to path conditions. If a congested route is detected, a warning packet will be sent to the source to redirect to a less loaded route. If all nodes in the inter-vehicle case networks perform the same routing strategy, the overall network load between all interconnected routes will be balanced. The proposed scheme applies the least traffic in the network and has the best performance in loading with high traffic.

In [13] have developed a decentralized route planning algorithm based on a hierarchical routing scheme to reduce the complexities associated with route planning schemes. The issue of route planning is area route selection and intra-regional routing. In choosing the route of the zones, the average transit time of the zones is minimized so that the zones can be effectively induced in dense conditions. In intra-regional route planning, the optimization model is used to minimize the average intra-regional transit time. The advantage of the proposed algorithm is its low complexity, and its weakness is more network interference.

In [14] have proposed a new routing protocol for intercity case networks in urban scenarios. Stable CDS-based Routing Protocol extracts general topology information to increase and improve the quality of service in low-level non-secure applications to modulate network congestion. This protocol is developed to find the most stable paths between source and destination. The SCRP protocol begins with building a strong framework on road sections and connecting them through nodes as bridges at intersections. It then assigns these weights to different sections of the road based on information collected through the Road Assessment Packet, a method that does not cover interference in static paths.

The authors have introduced a mimetic algorithm based on differential evolution in [15]. An imitation algorithm is a population-based algorithm used for complex and large optimization problems. The main idea of this algorithm is to use a local search method within the structure of the genetic algorithm to improve the efficiency of the search intensification process.

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In this algorithm, it is assumed that the sensor nodes are static and have no movement. Nodes are organized in clusters where each cluster has one cluster head. The head node collects the data from the nodes inside the cluster and sends them to the central station after aggregating the data. This algorithm also assumes that cluster head nodes have more energy than other nodes.

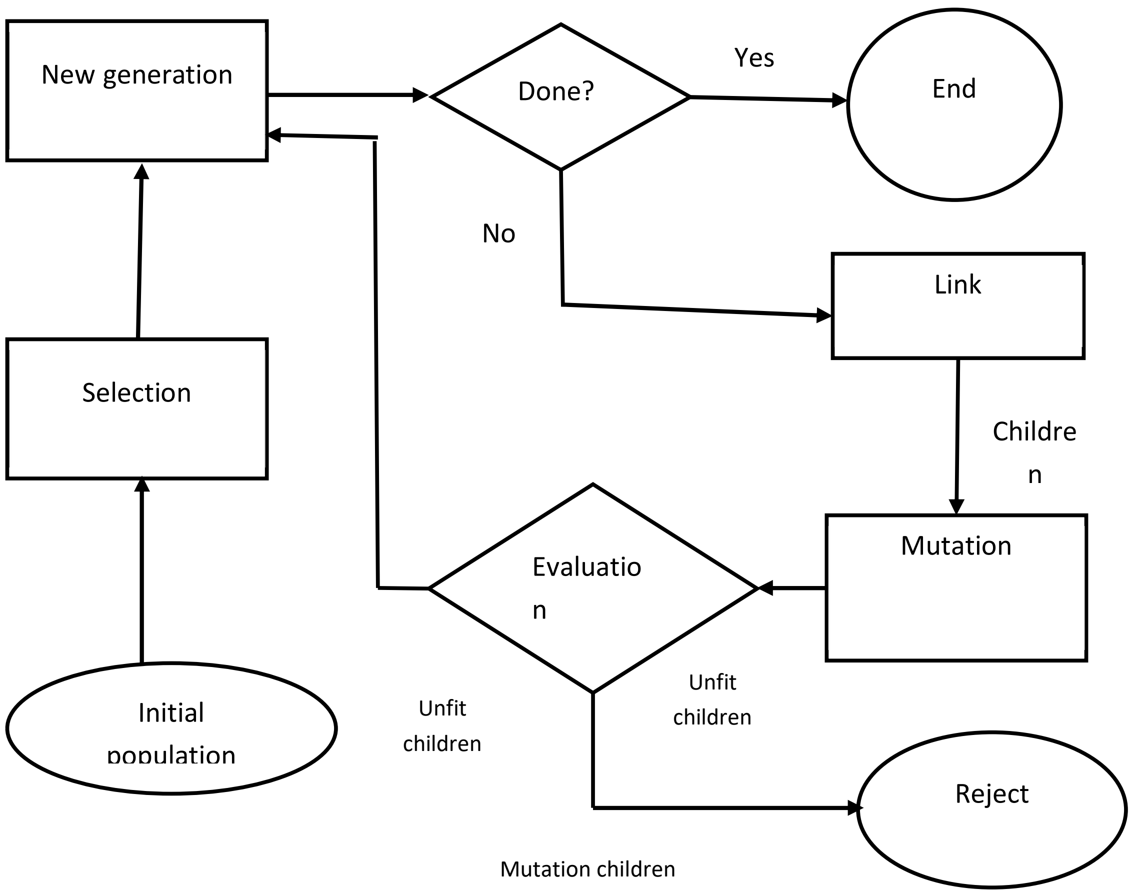

Figure 1: The Genetic Algorithm Framework [16]

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Proposed Method: Congestion Control by Using Genetic Algorithms

The genetic algorithm has a number of parameters that have a particular problem and must be checked to obtain the best performance of the algorithm. These parameters are the size of the population, which is the intersection and crossover probabilities and the type of crossover. The genetic algorithm, during the optimization process, captures the random action, whereas the initial quality of the randomly generated random population affects the final performance.

Genetic algorithm is a specific type of evolutionary algorithms that use biology techniques such as inheritance and mutation. In the genetic algorithm, a chromosome is a set of indices, which define a proposed solution for the problem that the genetic algorithm tries to solve.

The genetic algorithm starts with the production of an elementary random population. After the initial population production, a percentage of chromosomes are selected as the parent from the current population. The parent chromosomes are combined to form the child's two chromosomes by exchanging data between each other. Also, in order to make more efficient children more efficient than the mutation method. After this step, the new generation will be evaluated using fitness function. From the population of the best children and the population of the older generation, the new generation.

- **Create an initial population**

In the proposed method, the initial population is considered to be 20 chromosomes and randomly using the uniform distribution function.

- **Calculation of fitness functions (objective)**

Using the target functions of the routing problem, the suitability of each chromosome is calculated.

- **Transfer delay function**

This function is intended to minimize the delay in transferring packets from the source node to the destination node. Based on this, the objective function can be calculated as the following relation [10].

$$f_1 = \min \sum_{(i,j)\in E} D_{i,j} X_{i,j}$$

$D_{i,j}$ is the measure of the delay of each node.

- **Expected Transmission Count (ETC)**

The purpose of this function is to select paths that have the minimum number of transmissions expected. ETX A link is the number of data transmissions required to send a packet per link. The ETX parameter for

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path p, which includes links (edges) $v_1, v_2, \ldots, v_n$ with the fd_{vi} transfer rate for edge v_i, is calculated as follows: [11]

$$etx_{vi} = \frac{1}{(fd_{vi} \times rd_{vi})}$$

The probability that a packet of data will reach the recipient successfully is the probability of forward delivery and the inverse delivery ratio when the packet is successfully received. ETX of a path is the total ETX of each link in that path and is calculated using the following equation [11]:

$$ETX(P) = \sum_{i=1}^{n} etx_{vi}$$

The objective function to minimize the expected number of transmissions (ETX) is calculated using the following equation: [11]

$$f_2 = \min \sum_{(i,j)\in E} T_{i,j} X_{i,j}$$

When it sends the requested nodes, it not only appends its address, but also adds the criteria of the link that received the request. This criterion is also in response to the path returned to the sender. When it receives the requested node, which has already sent it, it will be redirected if the path criterion is better than the criteria previously sent with this request ID. This increases the likelihood that the exporter will find the best benchmark. The entries in the link cache are weighted by the criteria in the path responses. In general, the quality standard offered is ETX. This criterion selects the route with the least amount of sending expected to reach the destination (including resending). The purpose of designing this criterion is to find a path with a high throughput, despite the packets. In general, the overall fitness function in the proposed method can be defined as the following equation.

$$f_{/Total} = f_1 \times f_2$$

The pseudocode of the proposed method is shown in Figure 2. In a multi-objective problem, different approaches to elitism can be considered. In one approach, only one response, as the best chromosome of each generation, can be passed on to the next generation, which will not actually create much opportunity to combine with other chromosomes and produce diverse responses. Another approach can transfer all the superior answers to the next generation, which in turn reduces the number of new answers that are produced in the process of evolution and practically slows down the process of achieving optimal answers. Slows down. The appropriate approach is the procedure between the two, which leads to the transfer of the superior α chromosome to the next generation. The parameter α represents the Selection Pressure of the elite operator.

Picture (1) shows the genetic algorithm used in the proposed method. The initial population is delivered to the genetic algorithm as random initial solutions to get started. Each chromosome somehow indicates how the sensor nodes are connected to the threads. The length of each chromosome is equal to

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the number of sensor nodes in the current stage. For example, if the value of the i-th gene of a type II chromosome is equal to j, the Ni node is assigned to the g_j thread. For each sensor node, a unique number (starting from one) is considered as the identification number. Thus, on the response chromosome, the index of each gene refers to the number one sensor node. The value of each gene also refers to the number of the nodule for the sensor node. The amount of gene that represents the cluster node is equal to the gene index.

```
Set t = 0, N = Population Size.
Select ETX and MD values from OLSR routing table.
Generate initial population routes using priority based encoding.
Pt = Calculate the objective functions for the initial population.
Repeat.
Qt = Generate offspring from Pt according to recombination and mutation operator.
Rt = Qt ∪ Pt.
F = Do Fast non dominated Sorting (Rt), Obtaining different non dominated fronts (F1, F2, . . ., Fn).
Dynamic crowding distance assignment (Fi).
Apply the selection of routes based on the binary tournament selection.
t = t + 1.
Until t < MaxGen
```

Figure 2: Pseudo-code of the proposed method

The work in the genetic algorithm in the proposed method is done with two methods of mutation and integration

A common way to display chromosomes in a genetic algorithm is to use a binary string. Each specified variable is displayed in binary and then chromosomes are created by putting the variables together. In the appropriate function, a value is considered for each code. During the process, eligible parents are selected to give birth to new children by combining gene mutations. This process is repeated several times to create the next generation. This population is then examined, and if the convergence criteria are met, the process ends.

The pseudocode of the proposed method is shown in Figure (2). In a multi-objective problem, different approaches to elitism can be considered. In one approach, only one response, as the best chromosome of each generation, can be passed on to the next generation, which will not actually create much opportunity to combine with other chromosomes and produce diverse responses. Another approach can transfer all the superior answers to the next generation, which in turn reduces the number of new answers that are produced in the process of evolution and practically slows down the process of achieving optimal answers. Slows down. The

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Simulations and comparison of the proposed method

Matlab software has been used to simulate and evaluate the proposed algorithm. Considering that the proposed method uses a heuristic algorithm, the results are evaluated in terms of convergence, which will be presented below.

For the convergence test, the proposed method as well as the genetic algorithm for the three paths, which were composed of 5, 10 and 20, respectively, were implemented, and Figures 3, 4 and 5 show how to converge to the final solution, respectively. In the above diagrams, the horizontal axis shows the order of repetition of the algorithm and the vertical axis shows the best suitability of each iteration**.**

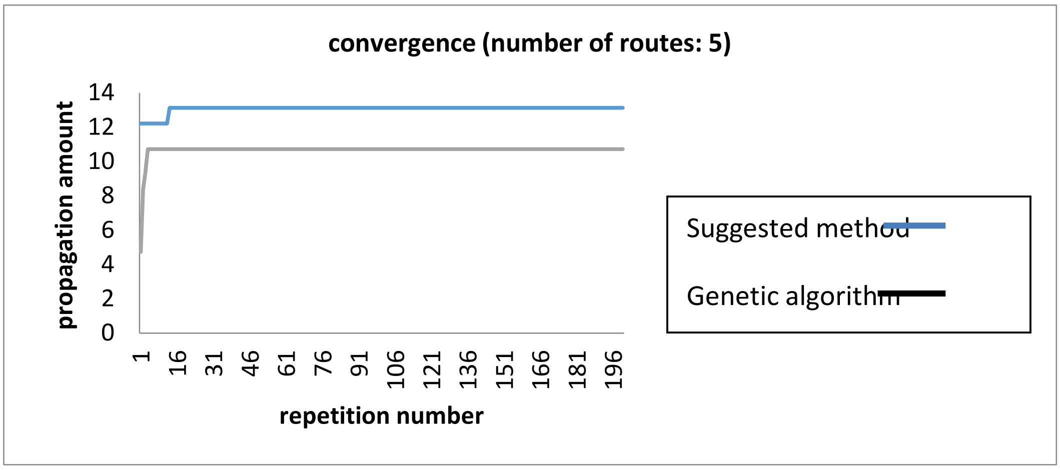

Figure 3: Convergence of the proposed algorithm (number of routes: 5)

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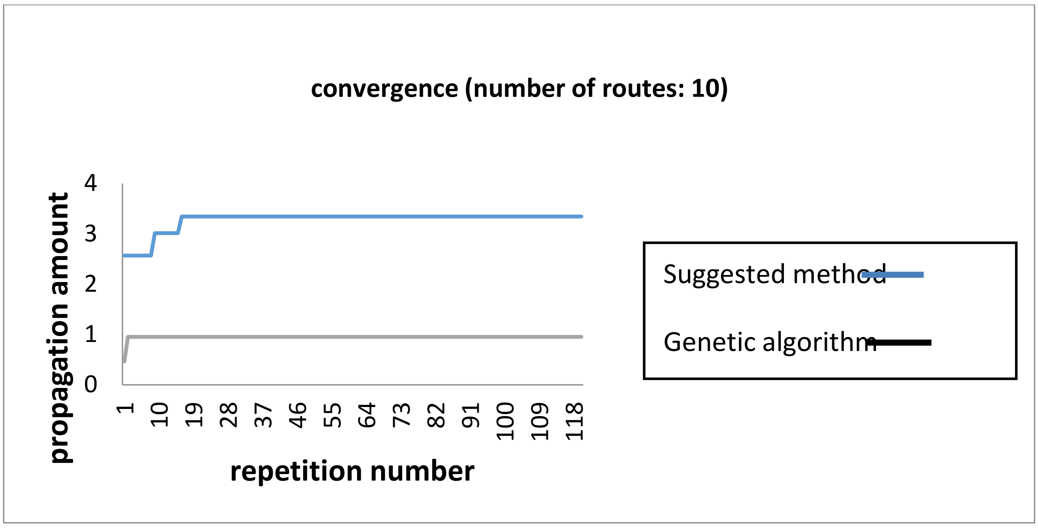

Figure 4: Convergence of the proposed algorithm (number of routes: 10)

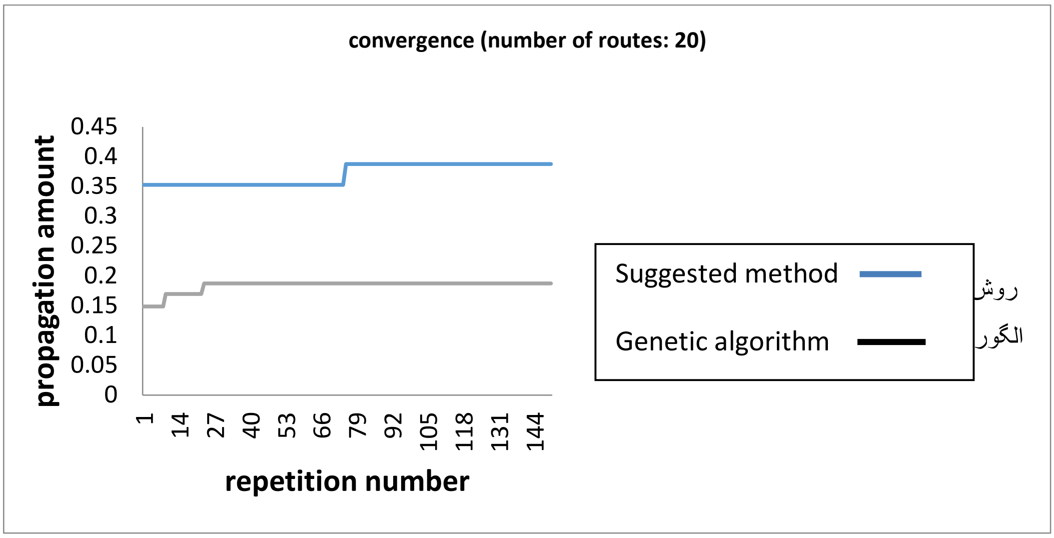

Figure 5: Convergence of the proposed algorithm (number of routes: 20)

Examining the results of this experiment, it is clear that the proposed method for combining the paths of wireless sensor networks has a good degree of convergence and finds the near-optimal path. Also, the results show that the quality of the composite path created by the proposed method is better than the basic genetic algorithm. The main reason for this experiment is to evaluate and compare the quality of the paths created by the proposed method and the two-objective genetic algorithm. To perform this test for 20 different applications with the number of routes 5, 10 and 20, the above methods have been implemented and the average throughput obtained from their implementation is shown in Table 1. Carefully in the results of Table 2, it can be seen that the quality of the paths produced by the proposed method of the two-objective genetic algorithm is better according to the path quality criteria.

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Table1: Operational power of two genetic algorithms

Group number	*MNSGA-2*	*GA*
20	0.3	0.5
40	0.7	0.8
60	0.8	0.9
80	1.5	1.7

Table 2: Comparison of the equality of the composite routed produced

method	n = 5	n = 10	n = 20
Two-objective genetic algorithm	98562/10	67522/1	28952/0
Suggested method	68594/15	89854/4	42658/0

Conclusion

In this study, a new framework for routing with awareness of congestion control and interference in wireless sensor networks was presented. The attempt of the proposed method was to find an optimal path combination that has a good level of competence. Also, the proposed algorithm was implemented with the main source parameters and related diagrams were observed. Using a two-objective genetic algorithm reduces the time required for routing to some extent, although it does not give us a definitive answer and will give a near-optimal answer. To show the performance of each algorithm, it is necessary to compare it with previous algorithms. Therefore, the results were compared with a two-objective genetic algorithm. Comparing the two algorithms, we concluded that the response time of the two-objective genetic algorithm is shorter than that of the basic genetic algorithm. Therefore, the convergence of the two-objective genetic algorithm is good and it can be concluded that the answer obtained from the proposed algorithm can be close to the optimal answer.

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