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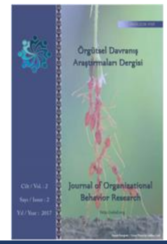

Improving the reduction of energy consumption and increasing the balance in the Internet of Things using the ant colony algorithm

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ABSTRACT

Today, the use of wireless sensor network is increasing. This is because the network is made up of nodes that can be used anywhere. That is, they can be used in industry, military, medicine and other fields. The physical nodes that are scattered in the sensor network have several parts: the communication part, the power supply part, etc. In terms of power supply, the nodes supply their power consumption from the battery, so they have limited energy. For this reason, and because these nodes are not available, all researchers have turned to research into routing and clustering protocols that reduce energy consumption and provide better coverage. There is a lot of research in the field of routing in this field, which is sometimes done by using meta-heuristic algorithms or combining these algorithms with others. But the complexity of algorithms is different in all areas. In this article, a combined method is used Reduce energy consumption and increase load balance of this network by using the ant colony algorithm.

Keywords: *Wireless sensor network, routing, ant colony algorithms, coverage.*

INTRODUCTION

1-Introduction

With the advent of the Internet of Things and the equipping of devices with sensors, there was a significant difference in life. In fact, the interaction between the physical world and the digital world is made possible through the Internet of Things. With the advent of the use of the Internet of Things in smart homes, energy consumption has also become very important in this area. The Internet of Things refers to a set of devices that operate in a field and communicate with each other over the Internet. According to the global concept, all objects around the world have small computer capabilities and intelligence and can exchange information with each other. The Internet of Things includes various components called architecture, sensor, coding, transmission, data processing, network, and so on. The most challenging topics in the Internet of Things, which has a large number of devices connected to the Internet. In the IoT, there are a number of sensors in different parts of the house that communicate with each other through the base station [1]. The Internet of Things (IoT) is the new revolution of the Internet. This allows objects to be recognizable, to obtain information, to send information about themselves, and to be able to access information collected by other objects. The Internet of Things allows people and objects to communicate with anything, anytime, anywhere. This means addressing elements such as convergence, content, collections, communication and connectivity [2]. In addition to all the benefits of the IoT, it has several challenges: Establishing security is perhaps the biggest challenge in the IoT. - The concept of privacy has always been used in conjunction with security, but in this discussion it is appropriate to pay special attention to it; Because in the Internet of Things more private information is placed on the network than the current situation. -

Increasing demand for network-connected equipment will increase competition in this area. - energy consumption - The load balance Load balances are divided into static and dynamic categories based on network topology and available resource information. Static algorithms are not dependent on the current state of the system and require intermittent knowledge of the system, such as resource work, connection time, and processing power. System nodes, memory, etc. These algorithms use pulling methods, such as the rotation algorithm. This method is simple and uses less resources, but the disadvantage of this method is that it can not detect connected servers. Algorithms are not suitable for distributed systems where system modes change dynamically. In contrast, algorithms are dynamic algorithms that use unpredictable methods based on the current state of the system and methods and algorithms. In this algorithm, tasks can be moved dynamically from a crowded node to a more secluded node and the system mode can be changed intermittently. This method is more suitable for most systems and is more efficient [3]. Due to the challenges in this field, this article focuses on reducing energy consumption and balancing the load in this network. To do this, two proposed methods of clustering and meta-heuristic algorithms have been used. In the proposed method, in addition to clustering, ant colony is also used. This has the advantage that because it uses the shortest path to send and receive information, it creates less energy consumption and more balance in the network. In this regard, in this study, we face the following questions: 1. Can using ant colony improve energy consumption in the Internet of Things? 2. Can using ant colony increase the lifespan of the network? 3- Can using ant colony improve the load balance in the network? In the second part, an attempt is made to acquaint the reader with the literature of the subject and also some of the existing methods in this field of research are presented. In this chapter, the most important and most practical algorithms developed in this regard are discussed. The third part is dedicated to presenting the proposed method and the fourth part contains the results of the practical implementation of the proposed approach. The collected results are presented. The fifth section provides an overview of the leading dissertation and the proposed approach, as well as suggestions for improving system performance for future work.

2- Related works:

In 2013, Qiu et al. [4] proposed an advanced GEAR network protocol that not only reduced network stress but also improved network energy utilization. The authors used a multi-layered strategy to organize nodes in an efficient and effective manner. One of the works done in this field is HVAC technology. Smart grid is one of the most important applications of the Internet of Things (IoT) paradigm. In this context, this paper refers to the management of energy consumption of heat, ventilation and air conditioning (HVAC) in smart retail with variable energy prices. Thus, first, an energy scheduling method is proposed in which the cost of energy consumption for a certain time interval, according to the energy price and a set of convenience constraints, so that the range of temperature according to the user settings Given for a room. Then, an energy scheduler is provided in which the user can relax the temperature constraints to save more energy. In addition, thanks to the IoT parameter, the user can interact remotely with the HVAC control system. In particular, the user can remotely determine the comfort temperature, while energy and heat consumption information is sent over the Internet and displayed on the user's device. The proposed algorithms are implemented indirectly [5]. [20] An energy-saving architecture is proposed for the IoT that includes three layers: measurement and control, information processing, and presentation. Architectural design allows the system to predict the sleep distance of sensors based on their remaining battery life, previous use history, and the quality of information required for a particular application. The predicted value can be used to increase the utilization of cloud resources by reusing dedicated resources when the relevant sensory nodes are dormant. This mechanism allows the use of energy saving in all IoT resources. Experimental results show a significant amount of energy savings for sensor nodes and improved use of cloud resources [6].

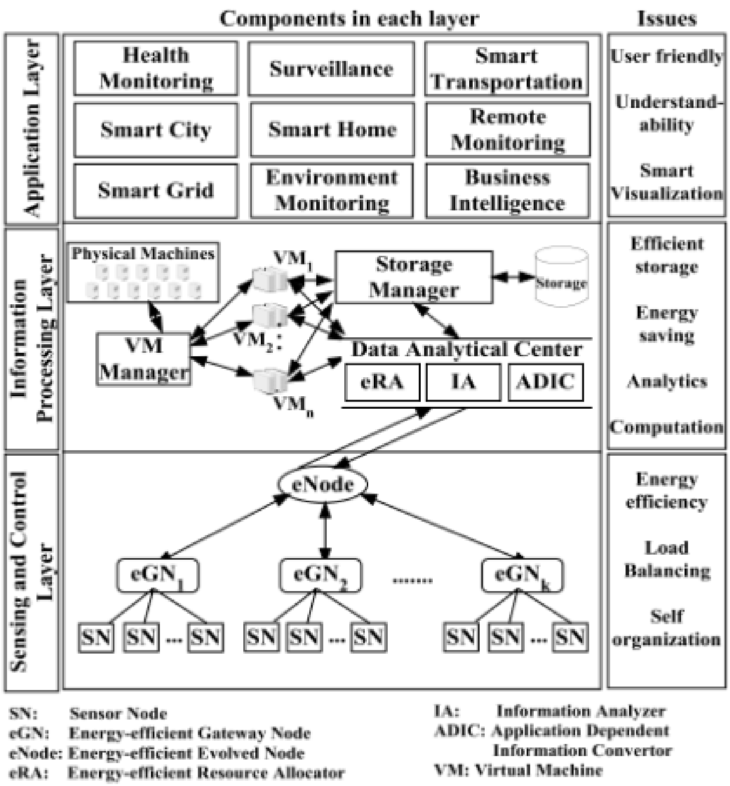

Figure1- An energy-saving architecture[6]

In 2014, an algorithm was introduced for the relationship between sources and load balance in the computing unit, which placed the two in two separate units, and each node was equipped with a load balancing unit and source discovery. By exchanging the message, the load balancing unit shifted the source status information, and based on this, more precise decisions were made by the source discovery unit. In this method, load balancing was a method of extracting processor behavior and could be used in several ways. This model can reduce the connection between units and has high scalability. In this method, the response time is short and the source discovery time increases[7]. In [8] an algorithm was developed using two phases, in the first phase the cpu performance and the memory required for each task and the available memory for each virtual machine were measured, and in the second phase the available resources were compared with the available resources. And if the required resources were available, he would have allocated them, otherwise he would have rejected the request. In 2014, classifications based on various parameters were presented to analyze these techniques. These parameters include comparison of models and future chats and tasks, etc. were analyzed for use in a dynamic grid environment. Finally, a new load balancing algorithm was proposed to complete the chat research and the grid field was performed [9]. In 2015, an analysis for two grid and cloud environments was presented based on five parameters: ACO ant colony optimization and GA genetic algorithm PSO particle swarm optimization Champions League algorithm or LCA and BAT algorithm. This algorithm was mostly used in the field of metaheuristic algorithms [10].

3-proposed method:

The proposed new algorithm is similar to the cluster-based routing algorithm in the Internet of Things in terms of reducing energy consumption. This proposed algorithm actually presents a clustering method based on point and region coverage. The whole proposed method has two important parts:

• Cluster formation

•data transfer The base station is a node (usually off-grid) assumed to have no limit on energy and processing resources. The performance of the proposed algorithm, like the LEACH algorithm, is divided into several cycles. Each cycle begins with the installation phase (cluster formation) in which the clusters are organized. Following each installation step, the data transfer step begins, during which data is sent from normal nodes to headers. Each header integrates or combines the data received from the member nodes and sends it to the base station in the form of a data packet. The base station also generates a table for multiple access with time division (TDMA) for each cluster, which affects the headers. The TDMA table is used to schedule node node data transmissions [11]. The proposed algorithm performs its work in two basic stages, which are:

• Clustering stage

• Data transfer stage

3.1 Local information collection:

An average number of nodes are randomly distributed near the targets to be activated according to specific schedules for performing tasks and identifying predefined targets and sending the information to the CPU node. In the figure below, you can see the dot coverage. In this figure, the black dots represent the points of interest for refinement and the red dots represent the refined points and the blue circles represent the sensed area of each node. We denote the radius of this region by rs and the relation radius by rc and the number of nodes by N. In this type of coverage, two important definitions can be expressed [12]: If the Euclidean distance between si and pj is less than rs, then pj is covered by si. If the Euclidean distance between node si and sj is less than rc, then sj is adjacent to node si. According to the above definition, the range of each node can be defined as follows:

$$C(s1) = \{p1, p2, p3, p4, p5, p6\}$$
$$C(s2) = \{p4, p5, p6, p7, p8, p9, p10\} \quad (1$$
$$C(s3) = \{p3, p5, p7, p11, p12, p13\}$$

According to the above definition, we obtain a range called o, which includes the following definition [12]:

$$O(si) = C(si) \cap (C(s1) \cup C(s2) \cup \ldots\ldots \cup C(si-1) \cup C(si+1) \ldots\ldots \cup C(sn)) \quad (2$$

Initially, each node recipient will calculate their coverage area using the following formula [12]:

$$CIP(si) = \frac{|C(Si)| - |O(Si)|}{|\bigcup_{i=1}^{n} C(Si)|} \quad 3)$$

3.2 compute remaining energy:

It will calculate the average remaining energy of its neighbors according to the following formula[12]:

$$\text{Eave(si)}=\frac{1}{|ND(Si)|}\sum_{j=1}^{|ND(Si)|} Ecur(Sj) \qquad (4$$

At this point, the neighbors are identified one step away from each node. Neighbors with a distance step denoted by NB (s¬i) are called nodes that have the following condition:

$$\text{NB(si)}= \{sj|\ d(si,sj)\leq rc\} \qquad (5$$

In other words, neighbors with one step distance are nodes whose distance from the corresponding node is less than or equal to their coverage distance and the number of nodes with one step distance is expressed by ND (si).

Nodes whose distance is greater than the value expressed in the above formula are called neighbors with two steps and their number is expressed by ND2 (si). After identifying and completing this step, the nodes send the message 2_Node_Msgs so that the neighbors can identify their distance difference with two steps [12].

$$\text{Eave(si)}=\frac{1}{|ND2(Si)|}\sum_{j=1}^{|ND2(Si)|} Ecur(Sj) \qquad (6$$

After collecting information about neighbors, this information is stored in a table called NT. At the end of this phase, after collecting information about the neighbors, ninety heads should be determined. To do this, the nodes wait for the head-msg message to be received according to the following time. If during this time they receive the head-msg message from another node, it means that the node is happy, and if they did not receive the head-msg message, each node sends the head-msg message to the other nodes and the node is selected as happy. It may have more residual energy. Each node must calculate the waiting time for the eclipse message to be propagated according to the following formula [13]:

$$\text{ti}=\begin{cases}\left[\alpha\frac{Eave(Si)}{Eave(Si)}+(1-\alpha)CI\right]T2Vr1 & Ecur(Si)\geq Eave(Si)\\ T2Vr1 & Ecur(Si)<Eave(Si)\end{cases} \qquad (7$$

3.3 Cluster formation:

At this point, if the Ti node has not received a message to select the eclipse through the other nodes, then it will send a message claiming eclipse to the other nodes, but if this message is received, then the node that sent this message It makes me happy. The point here is that this message must be sent at Ti time, otherwise the nodes will enter the competition to be selected as the header, which must be considered the following parameters, which in Time T2 is done: • A node with the maximum energy level; Because the overhead node of the cluster is higher than the other nodes, the node must be selected as a block with sufficient energy, otherwise the nodes of that cluster will be disconnected from the base station due to the death of the node. • The nearest node to the base station; The closer the eclipse node is to the base station, the less energy it needs to send data packets. • The nearest node to the center of gravity of the cluster; In fact, it is a node from which the average distance of other nodes in the cluster is the minimum. In fact, the centrality of the cluster reduces the energy consumption to establish intracranial connections (between the nodes of the cluster and the cluster). At the end of this phase, the eclipse is selected and the total time is t2. 3.4 Cluster selection: After the above step, each node selects the nearest header and sends the join_msg message. In this message, there are id nodes along with the remaining amount of node energy. Each node prepares a list for its cluster members called a schedule so that each member of the cluster can be in a temporary sleep mode to reduce their energy consumption when they are not being used to transmit information.

3.5 Intra-cluster communication:

Inside each cluster, the nodes collect information and transmit it directly to their head.

3.6 Extra-cluster communication:

In extra-cluster communications, the connection between the central station and the node is eloquent. If this distance is in one step, this information will be sent directly, but if the distance from head cluster to the central station is more than one step, then first according to the ant colony, the best head cluster route to the central station is found and then the information is sent along this route.

4-evaluate:

MATLAB environment is used for simulation. In MATLAB environment and using coding, the method mentioned in the pre-section is implemented and analyzed. In this method, there is no need to use a pre-prepared database. For simulation, a ground with dimensions of 250 by 250 is used, in which we set the position of the base station equal to 250 and 100. Consider the number of nodes in this environment to be 100. Other simulation parameters can be seen in Table 1:

Table 1-Simulation parameters

Parameter	value
ground environment simulation	250 * 250
base stations	250 and 100
Node count	100
packet sizes	500

At the beginning of the work, we scatter 100 nodes on a 250 x 250 field. This scattering is random. You will see this in Figure 2:

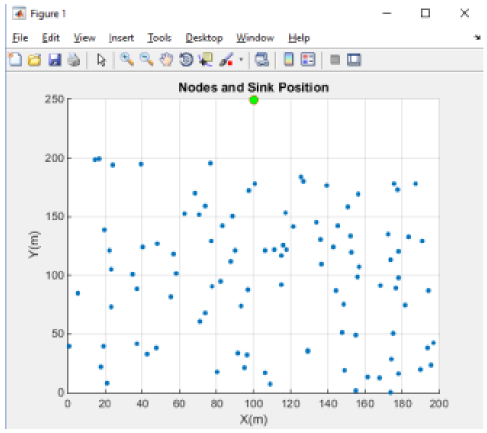

Figure2- scattering nodes

In this environment, to send information, each node is first checked whether the node is dead or not? This is measured using the s (i) .Ecur parameter, and if the node is alive, it sends a message to its neighbors and measures its distance to the other node, using the s (i) parameter. At this stage, the nodes are clustered.

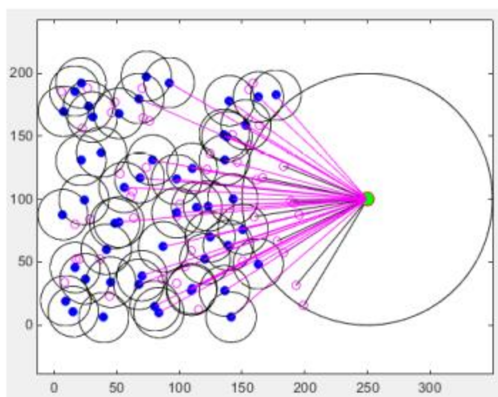

Figure3- clustering nodes

In Figure 3, the black circles represent the clusters and the blue circles represent the head of the cluster. To select a node as a header, the node must meet the following three conditions: 1. The energy level of the node is more than the other nodes. 2. It is located in the center of the cluster. 3. This node should be closer to the base station.

Now, to send information, each node sends its information to head cluster, and if the distance of head cluster to the base station is one step, this sending is direct, otherwise, an ant colony is used for sending. Figure 3 shows the pink lines sending directly. Figure 4 shows how to send directly or based on ant colony:

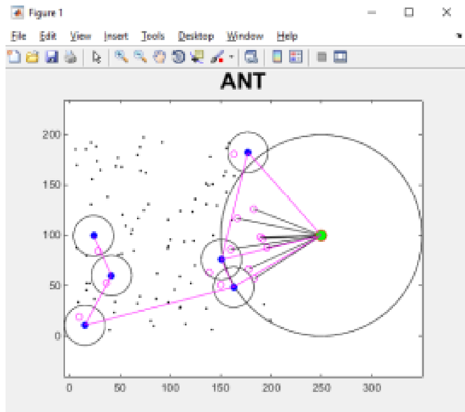

Figure4- ant colony routing

In Figure 5, you will see the best cost rate, and as you can see, this rate decreases with increasing repetition, which indicates finding the best route.

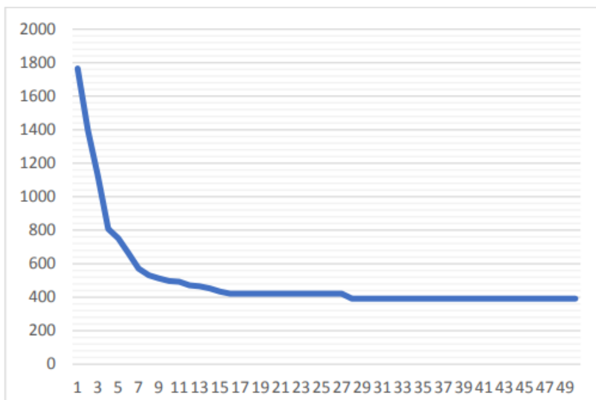

Figure5- cost chart

We will compare the proposed method with the other two methods. These two methods are:

1. Clustering and genetics
2. LEACH algorithm

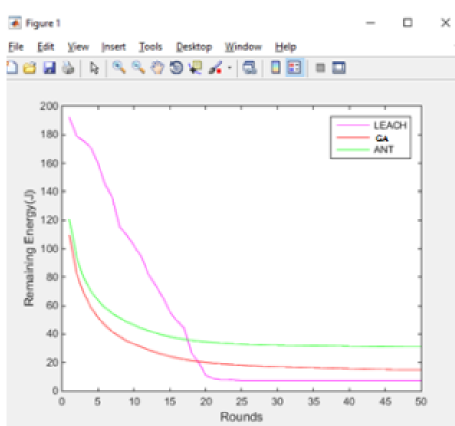

Figure 6- remaining energy

The second comparison is in the number of live nodes in the network.

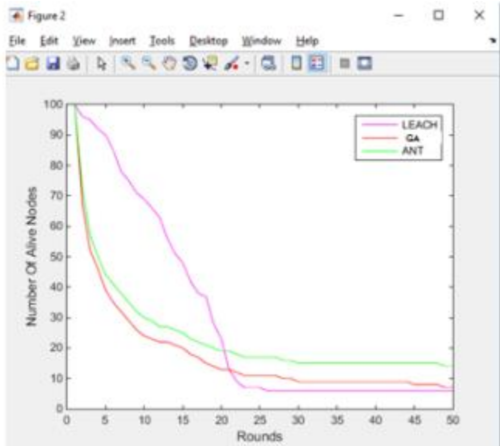

Figure9- live nodes

As you can see from the figures above, in all cases the number of live nodes remaining in the network and the amount of energy remaining in the nodes in the proposed method is better than other methods.

5-conclusion

The proposed method to reduce energy consumption and increase load balance in the Internet of Things has been proposed. In this method, because communication is not always done from one route and we are always looking for a short route, it does not impose traffic on the route and allows communication in this network to take place from different directions. Therefore, this method does not waste the energy of the nodes in the path. Because the short path is chosen and as a result the amount of energy loss will be less. Because the energy loss is lower, the nodes in the path can survive longer. This will extend the life of the existing network.

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