Genetic Algorithm for Effective Optimization of Delay Performance in Wireless Sensor Networks

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Abstract

Wireless sensor networks (WSNs) play an important role in many real-world applications like surveillance. Wireless networks are also used to have data transfer. In such cases, there are problems with resourcece-constraintnednetworks. The problems include a delay in communication and reduction in Quality of Service (QoS). Topology control can solve this problem to some extent. However, the delay performance and QoS need to be improved further to support intended operations in wireless networks. When relay node concept is considered, it is possible to optimize performance in such networks. In this paper, we proposed a Genetic Algorithm (GA) based relay configuration for optimizing delay performance in WSN. Relay nodes compute optimal positions using the proposed algorithm so as to improve QoS and reduce delay as much as possible. We implemented the algorithm using NS2 simulations. The results revealed that the proposed approach is able to improve QoS, reduce delay besides improving network performance in terms of throughput, network capacity, and energy efficiency.

1 - Introduction

Wireless Sensor Network (WSN) is a network with a collection of sensor nodes that involve in data gathering and data transmission. The nodes in the network are resource constrained and they are vulnerable to various attacks. In this paper, we focus on the performance of the network in reducing delay and improving QoS in data transmission. The nodes in WSN can be configured in such a way that a node can act as a relay node. Thus the node can move to an optimal place which improves QoS and reduces delay in data transmission.This concept is known as relay configuration. Before looking at more details on this, a typical WSN is shown in Figure 1.
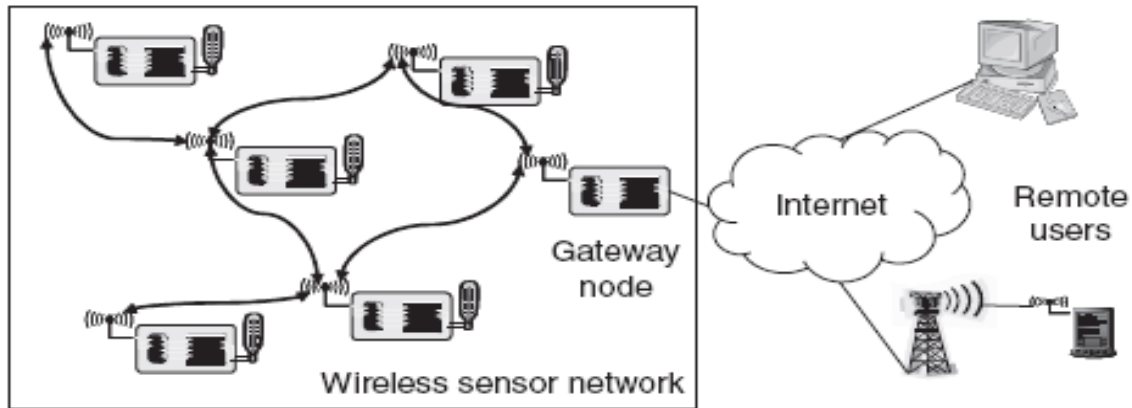
Figure 1: A typical WSN [20]

As shown in Figure 1, it clear that WSN is deployed in target places and it can sense data and transfer it to sink node. The sink node can be accessed by intended users through the internet. In such scenarios, it is essential to ensure that the data transmission is not delayed and there is sufficient Quality of Service (QoS) in rendering required information. In the literature, many solutions came into existence [4]-[7]. However, it is relatively new to think about relay nodes and configuring them. The delay performance of wireless network one of the main factors that effected on network performance [9], [16], [17]. Therefore, it a hot area for researching. The researchers improve the delay performance based on many aspects. In [1], [2] improve the delay performance of the wireless network based on scheduling schemes of the network. [3] Combine both network protocols and network operations to optimize the delay. The control topology leads to control on the interference of network the result of that [5] use the control topology to enhance the delay. Meanwhile [8] depend on control topology and energy performance. [6] Optimize permeates of power, broadcast, interference, antenna, and reliability in order to enhance the delay. The mobility of network is a certain issue to enhance delay of the network [14],[15]. In this paper propose method based on Genetic Algorithm and relay configuration to enhance the delay performance of the wireless network.

In this paper we employed the idea of GA for best configuration of relay node. The relay node is the node which moves to an optimal position in order to transfer data faster and with efficiency. The node which relays data runs the proposed algorithm in order to have best possible decisions in terms of moving and rendering services. It finds the best place to move using GA and transfers data to reduce delay and improve QoS. The remainder of the paper is structured as follows. Section 2 provides a review of various methods available for dealing with delay optimization in wireless networks. Section 3 presents the proposed approach in delay optimization. Section 4 presents simulation results while section 5 provides conclusions and recommendations for future work.

2- GA Based Relay Configuration for Performance Optimization

This section provides the proposed relay configuration concept based on GA. GA is an evolutionary approach that has very important utility in real-world applications. In this paper, we used GA to optimize delay performance in wireless network and improve QoS. GA contains operators like crossover and mutation and work in evolutionary fashion until objective function is met. Thus it is found suitable for the delay optimization problem considered in this paper. When the nodes in the network in a typical WSN suffer from two problems such as increased delay and reduced QoS, it is essential to have a suitable solution. In this paper, we studied the relay configuration of nodes in the network in order to achieve delay performance optimization. One of the nodes acts as a relay node and moves to a different place in order to have efficient data transfer and reduce delay in communication.
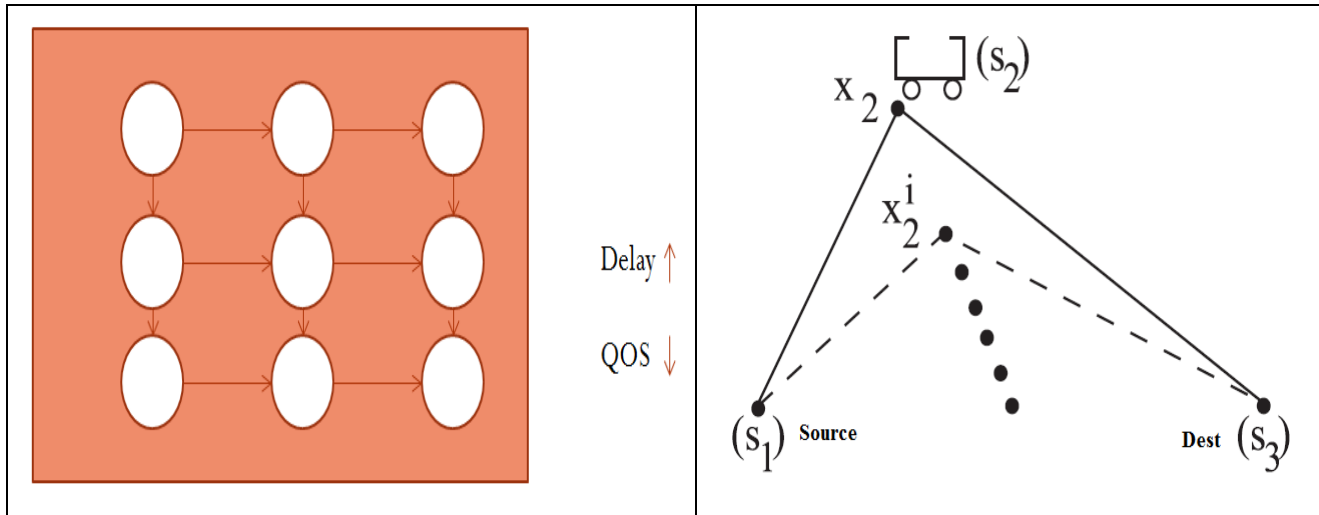
Figure 2: Shows problem (left) and solution in the form of GA based relay configuration

As shown in Figure 2, it is evident that there is delay problem with the existing network (left). Moreover, it is causing reduced QoS. In Figure 2 (right) relay configuration concept is presented. According to the proposed GA configuration of relay node, the node x2 moves to different location in order to transmit data. This is computed using an evolutionary approach (GA) based relay configuration. We proposed an algorithm to this effect and the algorithm takes care of optimization of delay performance and improves QoS in the network. The following Equations (1) and (2) are the underlying mechanisms in the relay configuration.

$$c(\langle E, U\rangle) = \sum_{(s_i, s_j)} am_i + b\|\mu_i - \mu_j\|2\, m_i + k\|o_i - \mu_i\| \qquad (1)$$

$$c_i(U) = k\|\mu_i - o_i\| + am + b\|\mu_{i+1} - \mu_i\|2m \qquad (2)$$

These equations provide cost-related configurations that are used to make well-informed decisions. The proposed algorithm makes use of them effectively. More details on these concepts are available in [18].

```
Algorithm: Relay Configuration
01   Initialize benefitThreshold
02   Initialize interferenceLimit
03   delayThreshold=expertGivenThreshold
04   RELAYBENIFITS=null;
05   d=0
06   Interference=0
07   direction=null
08   valid = false
09   Find d
10   Find interference
11   Define objective function
12   Do while valid = false and d<delayThreshold and interference < interferenceLimit and consider objective
     function
13       Consider moving right
14       Compute configuration benefit RELAYBENIFITS
15       IF RELAYBENIFITS > benefitThreshold
16         valid = true
17         direction = right
18       END IF
19       Make decision to move left
20       Compute RELAYBENIFITS
21       IF RELAYBENIFITS > benefitThreshold
22         valid = true
23         direction = left
24       END IF
25       Use direction to move
26       Perform crossover or mutation
27   End While
28   Relay data (on reaching objective function)
```

Algorithm 1: Genetic Algorithm Based Relay configuration

The algorithm considers both delay and interference with the network and performs optimization. The algorithm is executed by the relay node which uses GA based approach in order to optimize relay configuration thus reduce delay and improve QoS. The algorithm is implemented using NS2 simulations. The work of the paper is divided into WSN construction, controlling topology, GA based relay configuration and achieving delay performance. WSN is created using NS2 simulation. The network is a collection of nodes that are configured to gather data and transfer data. The basic WSN network is built in order to demonstrate proof of the concept in this paper. The network is used to show delay optimization, QoS enhancement and other performance metrics like throughput.

Topology control is involved in the form of adjusting nodes in order to reduce interference and improve delay performance. This can lead to QoS in wireless network. The proposed algorithm analyzes delay and takes necessary steps to reduce delay. Especially it considers relay nodes moving places for better data transfer. The evolutionary GA based approach for relay configuration is employed as it can make use of operators of GA for best possible solution. Delay and interference thresholds are used to make good decisions while computing benefits of moving places with respect to delay node. The relay configuration is computed effectively by considering position of the node, source, and destination based on the data to be transferred. Node movement is determined using the proposed algorithm for gaining maximum benefits. The mobility cost and data transfer cost are considered while making decisions.

3 - Simulation Results

A simulation study with NS2 is made to demonstrate the concept of relay configuration using GA with underlying operators. The proposed algorithm is implanted using simulations. The observations are made in terms of delay, throughput, and network capacity and so on. The simulation environment used in this paper is shown in Table 1.

Table 1: Simulation environment

S.No	Parameter Type	Parameter Value
1	Channel Type	Wireless Channel
2	Radio-Propagation	Propagation/TwoRayGround
3	Network Interface	WirelessPhy
4	Interface Queue Type	DropTail
5	Antenna Model	OmniAntenna
6	Interface Queue Length	50
7	Routing Protocol	AODV
8	CTSThreshold	2000
9	RTSThreshold	5000
10	basicRate	1MB
11	dataRate	5MB

The simulation environment considered many parameters. They include channel type, radio-propagation, network interface, interface queue type, antenna model, routing protocol and so on. The routing protocol used for simulations is AODV. GA based relay configuration algorithm is employed to improve delay performance while transferring data.
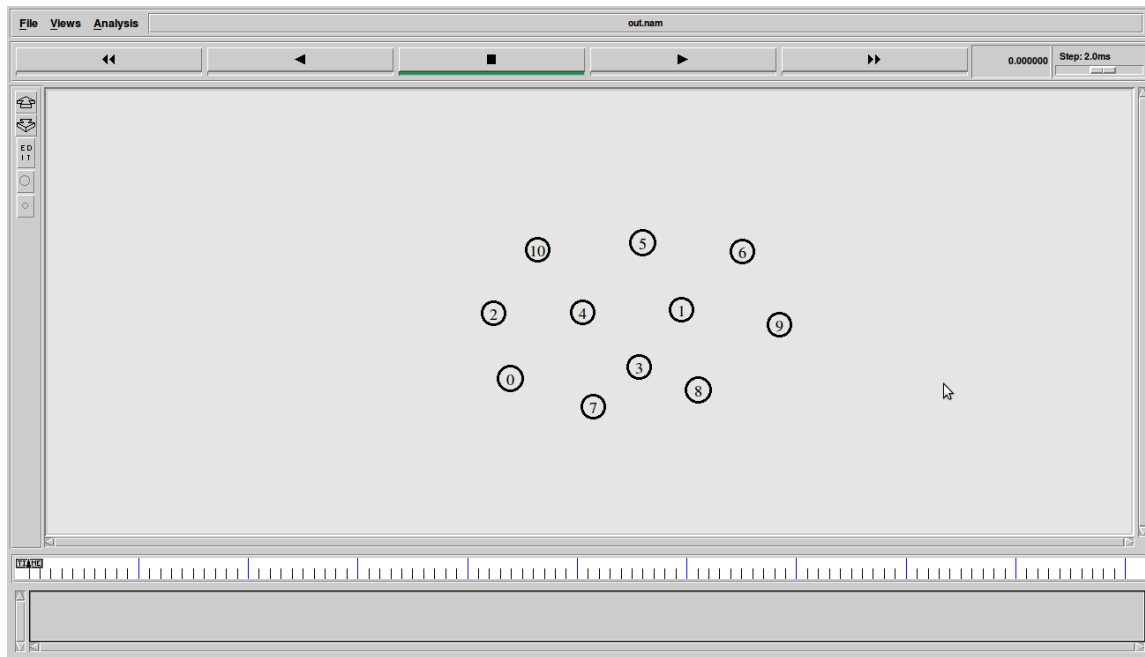
Figure 3: A typical WSN

As presented in Figure 3, it is evident that the wireless network is constructed with many nodes. The nodes are placed in the network with standard settings as presented in Table 1. The simulation is aimed at showing relay node positioning and its configuration using GA based algorithm.
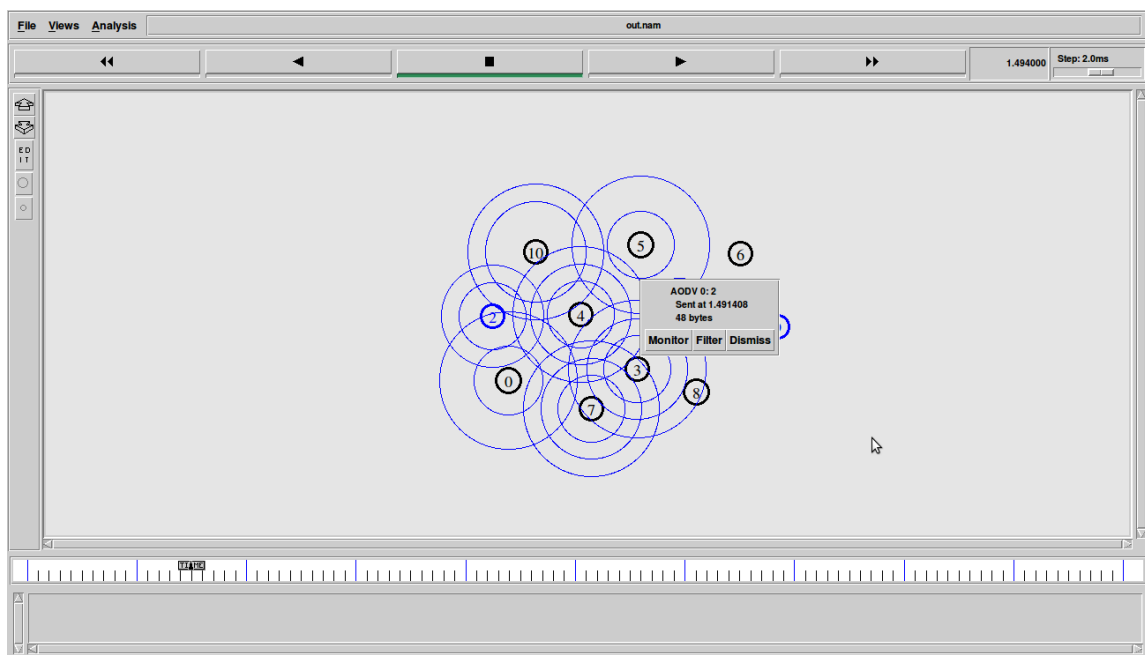

Figure 3: Wireless network with AODV protocol propagation

As presented in Figure 4, it is evident that the proposed in wireless network that is AODV started with intended functionality. The protocol propagation is shown that reflects initial operations such as protocol handshaking.
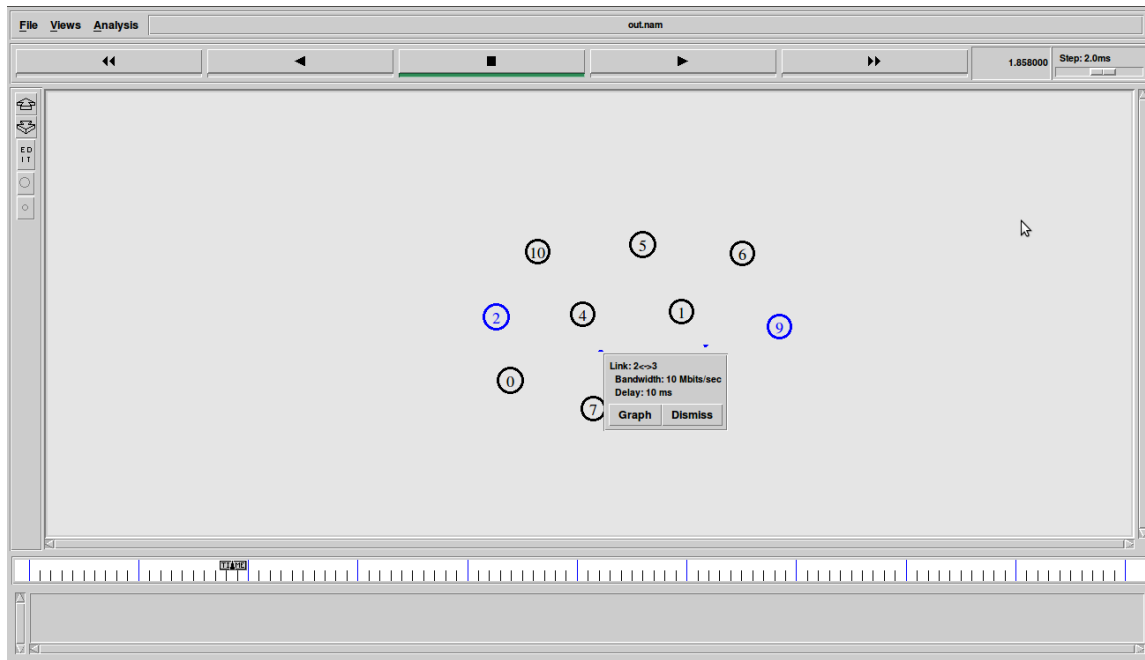
Figure 5: Shows packet interval, bandwidth, and link between nodes

As presented in Figure 5, it is evident that the proposed protocol shown the communication scenario between nodes. The details shown in the simulation include bandwidth, packet interval, and delay performance.
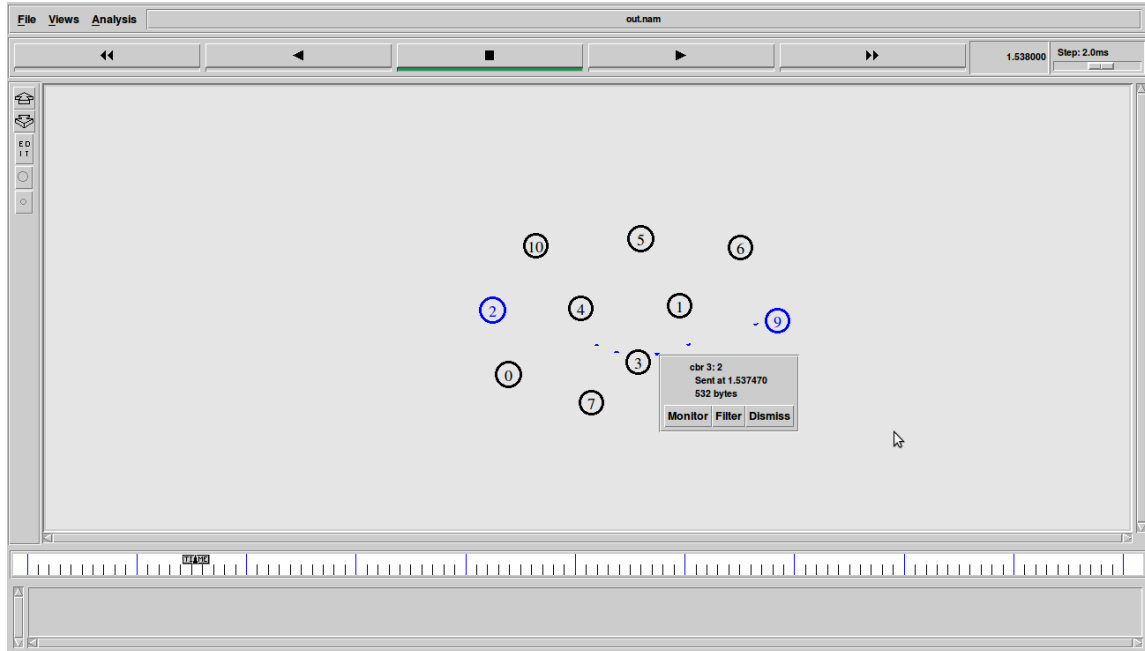

Figure 6: Shows packet transmission between source and destination nodes

As presented in Figure 6, it is evident that the simulation shows flow of packets between pre-defined source and destination. The CBR model of packets is flown between source and destination.
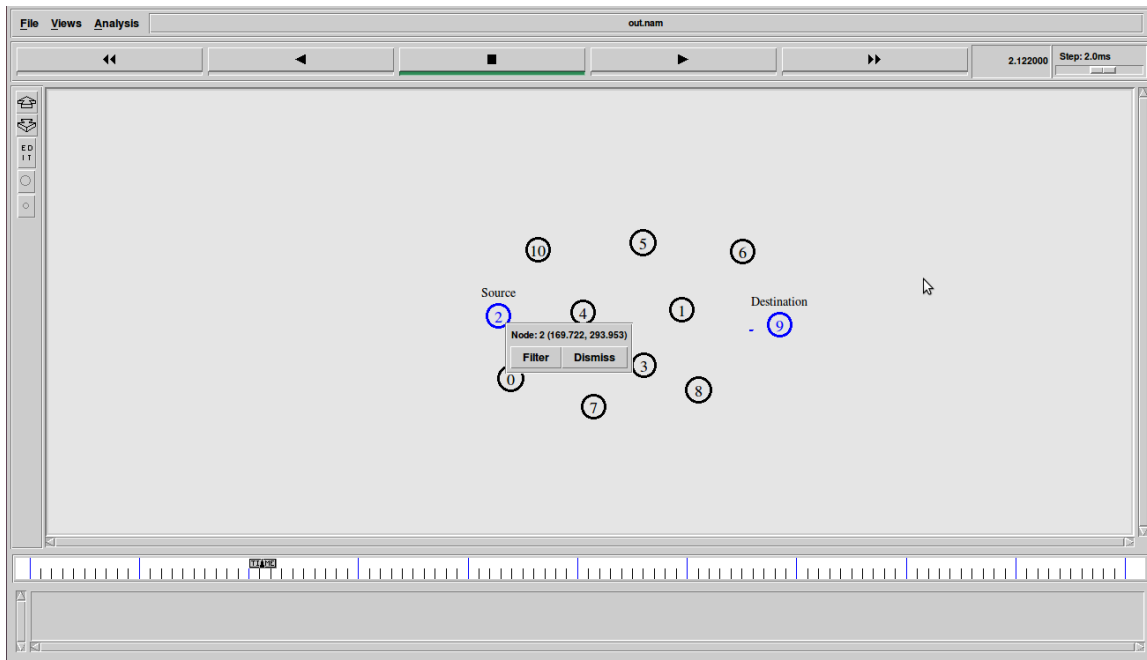
Figure 7: Demonstrates node movement and relay

As presented in Figure 7, it is evident that the relay node is moving to different location to have an optimized data transfer. The efficiency of GA based evolutionary algorithm is evident in the simulation as the relay node is able to compute optimal movement for better data transfer performance.
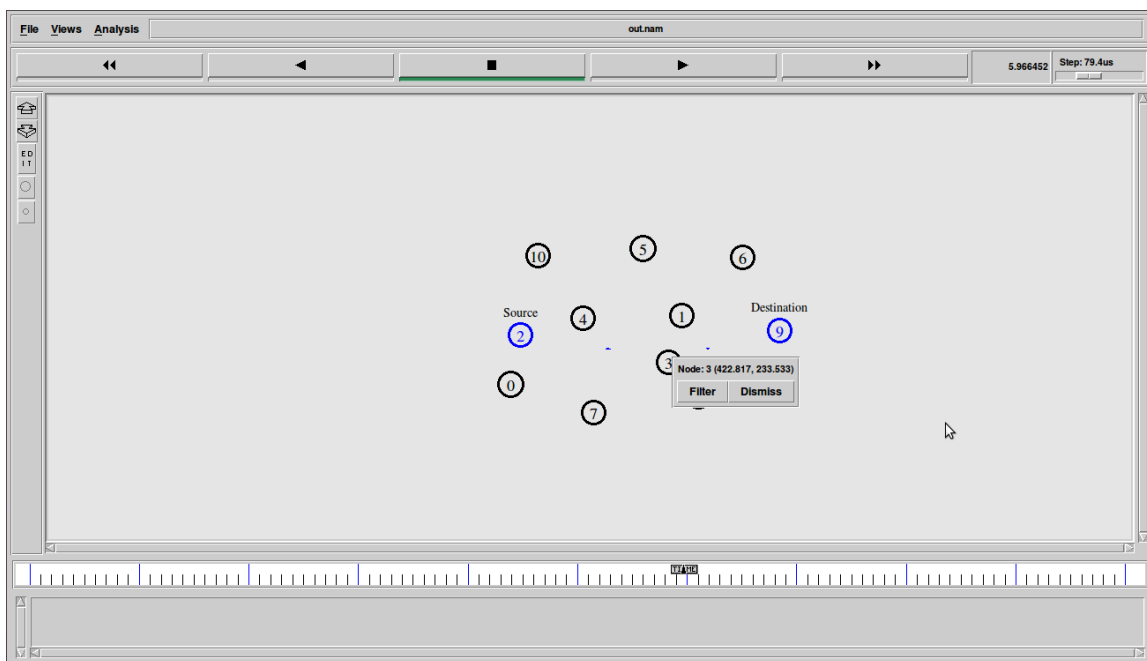

Figure 8: Shown Node 3 moving with relay configuration in place

As presented in Figure 8, the simulation shows the movement of an intermediate node according to the GA based relay configuration algorithm before sending data to destination.
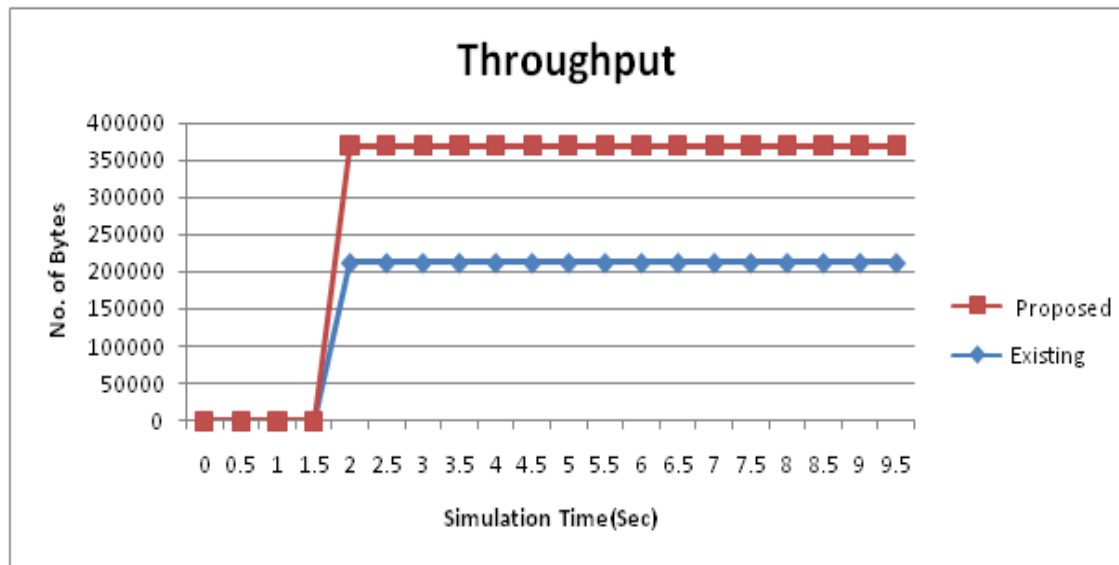
Figure 9: Throughput performance

As presented in Figure 9, it is clear that simulation time and throughput are plotted in horizontal and vertical axes respectively. The results show that the trouped performance of the proposed system is better than that of existing. The rationale behind this is the utility of proposed GA based relay algorithm for reducing delay.
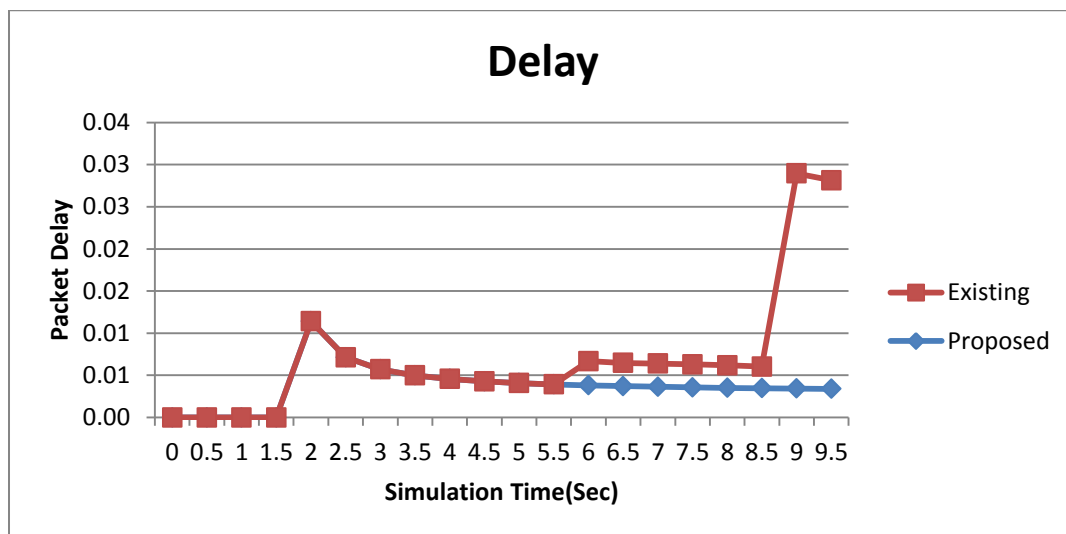

Figure 10: Delay performance comparison

As presented in Figure 10, it is clear that the performance of the proposed approach is better as it shows less delay. As simulation time goes on the delay is decreased in the proposed system. The existing system shows the same trend but its performance is less than that of the proposed system.
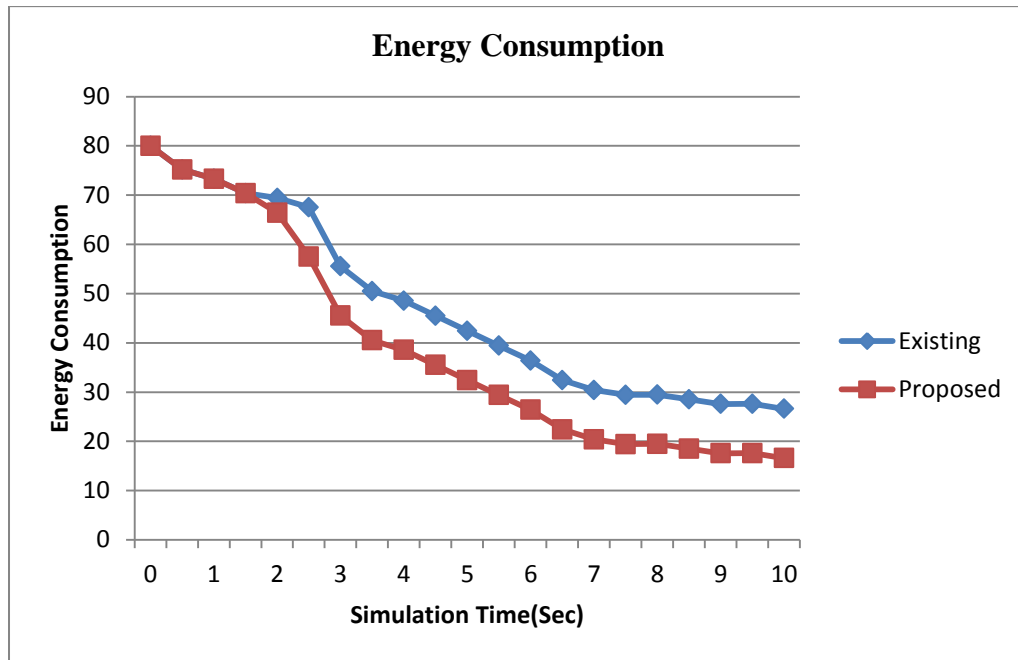
Figure 11: Energy consumption

As presented in Figure 11, it is clear that the energy consumption of the proposed system is reduced. As simulation time is increased, the energy consumption showed improved performance. In other words, it can be said that the residual energy is more in the proposed system.

4 - Conclusions and FUTURE WORK

Wireless sensor networks provide means of collecting data from remote places. Even in hostile environments, it is possible to obtain surveillance information. Interference and delay are the two problems of WSN focused in this paper. When these two parameters are considered, it is essential to have an approach that can handle topology and node mobility. To ensure delay performance in such networks, it is required to have an efficient approach. In this paper, we employed GA based mobile relay configuration algorithm to optimize delay performance. The approach considers one of the noses as relay node which is responsible to move to a different place if needed in order to relay data. Thus it can improve performance in data transmission. The proposed algorithm in this paper makes use of GA operators and objective function in order to have an evolutionary mechanism to determine the movement of relay node for optimized performance. We implemented the algorithm using N2 simulations. The results showed that the proposed approach is able to provide better performance in terms of network capacity, delay performance, energy efficiency and throughput.

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الخلاصه

شبكات الاستشعار اللاسلكية (WSNs) تلعب دورا هاما في العديد من التطبيقات في العالم الحقيقي مثل المراقبة .وتستخدم الشبكات اللاسلكية أيضا لنقل البيانات .في مثل هذه الحالات، هناك مشاكل مع شبكات محدودة الموارد .وتشمل هذه المشاكل التأخير في الاتصال وتقليل جودة الخدمة .(QoS) توبولوجيا السيطرة يمكن أن تحل هذه المشكلة إلى حد ما .التأخير في الاداء و QoS يحتاج إلى مزيد من التحسين لدعم العمليات المقصودة في الشبكات اللاسلكية .وعند النظر في مفهوم عقدة التأخير من الممكن تحسين الأداء في مثل هذه الشبكات .في هذه الورقة اقترحنا تكوين التاخير قائم على الخوارزمية الجينية (GA) لتحسين أداء التأخير في WSN. وتحسب عقد التتابع المواضع المثلى باستخدام الخوارزمية المقترحة من أجل تحسين نوعية الخدمة وتقليل التأخير قدر الإمكان .نفذنا الخوارزمية باستخدام المحاكاة NS2. وكشفت النتائج أن النهج المقترح قادر على تحسين جودة الخدمة، والحد من التأخير إلى جانب تحسين أداء الشبكة من حيث الإنتاجية، وقدرة الشبكة وكفاءة الطاقة.

الكلمات الدالة: شبكة الاستشعار اللاسلكية، الخوارزمية ألجينية تكوين التتابع، تأخير تحسين الأداء.