

Mitigate Congestion of Wireless Sensor Network using Genetic Algorithm

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Abstract

Wireless Sensor Networks (WSN) are used in many application areas such as industrial and civilian. Sensors will be shared by multiple applications to collect several types of data. Not all data be equivalence in the important, some data may be more important than other so loss this data may cause problems. Packet losses and retransmissions resulting from congestion and cause loss important data and decrease the lifetime of sensor nodes. This problem need for control to reduce the loss data, energy consuming and etc.

The main aim of this paper is to discuss how can use genetic algorithm (GA) to optimize the parameters that can affect on congestion in WSN and then evaluate the performance of network used AODV, DSDV, DSR and NOAH routing protocols by using NS-2 simulator.

Keywords: WSN, GA, protocols, AODV, DSDV, DSR, NOAH.

الخلاصة

تستخدم المتحسسات اللاسلكية اليوم في عدة تطبيقات مثل التطبيقات الصناعية و المدنية وغيرها. يشارك المتحسس بعدة تطبيقات لتجميع عدة أنواع من البيانات. ليس كل أنواع البيانات بنفس الأهمية بعض البيانات تكون أكثر أهمية من الأخرى لذلك فقدان هذه البيانات يسبب مشاكل. فقدان البيانات وإعادة الإرسال ناتج عن الازدحام ويسبب فقدان بيانات مهمة وتقليل عمر عقدة المتحسس. هذه المشكلة تحتاج إلى سيطرة لتقليل فقدان البيانات، استهلاك الطاقة وغيرها.

الهدف الرئيسي لهذا البحث هو كيف يمكن تكيف عمل الخوارزمية الجينية للحصول على أفضل قيم للمعاملات التي تؤثر في الازدحام في الشبكات المتحسسات اللاسلكية ومن ثم تقييم عمل ألبكة للبروتوكولات AODV, DSDV, DSR و NOAH باستخدام محاكي الشبكات NS-2.

الكلمات المفتاحية: WSN, GA, البروتوكولات, AODV, DSDV, DSR, NOAH.

1. Introduction

In computer networking there is a great importance of wireless networking because it has no difficult installation, no more costs. In the field of wireless networking there is another form of networking which is called as wireless sensor network (Kazem Sohraby *et al* 2010).

Wireless Sensor Networks (WSNs) are a self-organizing set of peer sensor that work together to achieve some application-specific task. its constitutes a wireless ad-hoc network which have to work flexibly with each other to achieve an assigned goal. WSN consist of spatially distributed autonomous devices using sensors to cooperatively monitor environmental conditions such as seismic temperature, humidity, acoustic and radar, low sampling rate magnetic, thermal and other at different locations. currently Wireless sensor networks are used in many civilian application areas, such as healthcare applications, home automation, and traffic control. On the basis of such sensing ability, combined with wireless connection and computation technology, they are expected to be deployed in a broad range of applications due to the sensor nodes characteristics of low-cost, low-power and easily-manufactured. However, the limited computing resources, severe energy constraints of the sensor nodes, and the application-specific characteristics, present major challenges to meet such an expectation One of the key challenges which needs to be addressed is the application-specific characteristic of wireless sensor networks (Akyildiz 2002).

Congestion is much important problem occurs when the load on the network-the number of packets sent to the network-is greater than the capacity of the network cause high-rate input traffic, the queue (buffer) that holds the packets to be transmitted overflows and

packets is dropped. Congestion control refers to the mechanisms and techniques to control the congestion and stay the load lower than the capacity (Antonis Antoniou 2007).

In this thesis, we focus on Genetic Algorithms(GA) for Mitigate congestion in wireless sensor networks. Genetic algorithms provide a natural tool to solve several problems .

2. Overview of Wireless Sensor Networks

The use of wireless communication technologies has become public. Wireless Sensor Networks (WSNs) have developed as the next phase of wireless technology.

A typical sensor network is formed by a large amount of nodes. Usually there is no pre-determined topology for a sensor network. (I.F. Akyildiz et al. 2002). The main components of sensors consist of a sensing unit, a processing unit, a transceiver, and a power unit as shown in Figure (1.1). (Muhammad Ullah *et al.* 2009).

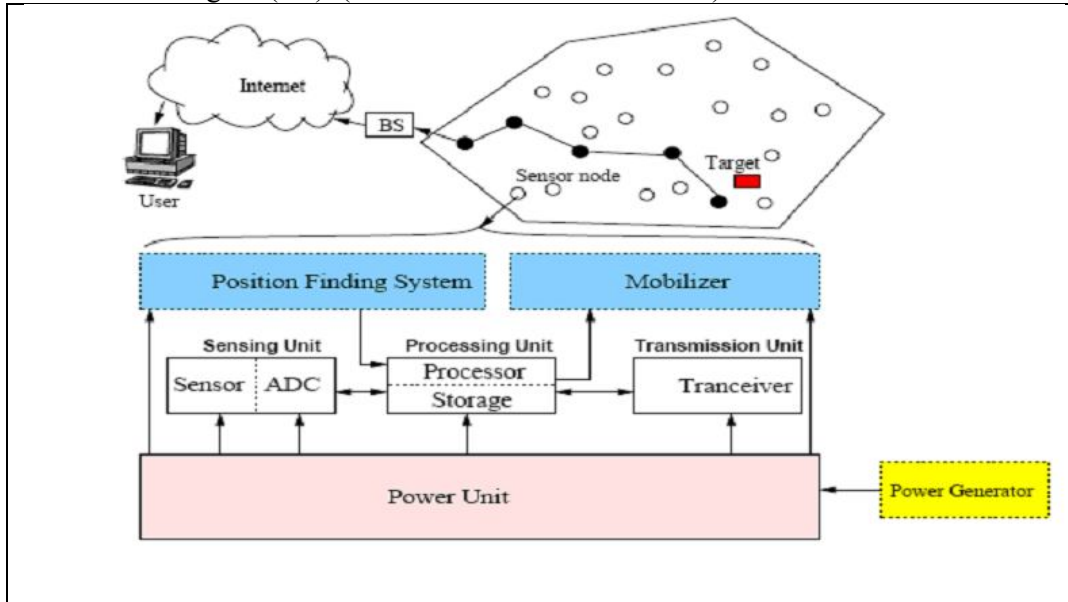


Fig (1.1): Typical Sensing Node

Congestion is occurs when the load on the network (the number of packets sent to the network) is greater than the capacity of the network cause high-rate input traffic, the queue (buffer) that holds the packets to be transmitted overflows and packets is dropped, This leads to both waste of communication and energy resources of the sensor nodes and also obstructs the event detection dependability because of packet losses.

Congestion control refers to the mechanisms and techniques to control the congestion and stay the load lower than the capacity. Congestion control is necessary in avoiding congestion (Yunli Xiong ,2005).

3. Routing Protocol Description

3.1 Ad-Hoc On-Demand Distance Vector routing protocol (AODV)

AODV is essentially a combination of both DSR and DSDV. It borrows the basic on-demand mechanism of Route Discovery and Route Maintenance from DSR, plus the use of hop-by-hop routing, sequence numbers, and periodic beacons from DSDV. It uses destination sequence numbers to ensure loop freedom at all times and by avoiding the Bellman-Ford count-to-infinity problem offers quick convergence when the ad hoc network topology changes. In this research paper we attempt to present an overview of two main categories of mobile ad-hoc routing protocols and performance comparison of both the protocols by simulation of three routing protocols(DSR, DSDV and AODV)focusing on the differences in their dynamic behavior that can lead to performance differences(Vijendra Rai 2010).

3.2 Dynamic Source Routing protocol (DSR)

Dynamic Source Routing (DSR) also belongs to the class of reactive protocols and allows nodes to dynamically discover a route across multiple network hops to any destination. Source routing means that each packet in its header carries the complete ordered list of nodes through which the packet must pass. DSR uses no periodic routing messages (e.g. no router advertisements), thereby reducing network bandwidth overhead, conserving battery power and avoiding large routing updates throughout the ad-hoc network. Instead DSR relies on support from the MAC layer (the MAC layer should inform the routing protocol about link failures). The two basic modes of operation in DSR are route discovery and route maintenance (N. Sengottaiyan *et al.* 2009).

3.3 Destination-Sequenced Distance-Vector Routing protocol (DSDV)

DSDV is a distance-vector protocol with extensions to make it suitable to MANET. Every node maintains a routing table with one route entry for each destination in which the shortest path route (based on number of hops) is recorded. To avoid routing loops, a destination sequence number is used. A node increments its sequence number whenever a change occurs in its neighborhood. This number is used to select among alternative routes for the same destination. Nodes always select the route with the greatest number, thus selecting the most recent information (Haider Ayad 2013).

3.4 No-Adhoc routing protocol (NOAH)

NOAH is a wireless routing agent that (in contrast to DSDV, DSR,...) only supports direct communication between wireless nodes or between base stations and mobile nodes in case Mobile IP is used. This allows to simulate scenarios where multi-hop wireless routing is undesired (does not want to route the packets through multiple hops). NOAH does not send any routing related packets. It is suitable for simulation scenario where routing overhead is not desired.

NOAH is a routing agent which does no routing, packets are received by it and it does not attempt forward them on.

Using NOAH permits a cleaner analysis of the MAC protocols without the presence of anomalies from route discovery delays or broadcast storms (J. Widmer 2004).

4. Introduction to Genetic Algorithm (GA)

GA is a search heuristic that is used to produce useful solutions to both constrained as well as unconstrained optimization and search problems. It can be used to solve variety of optimization problems that are not appropriate for standard optimization algorithms, including problems in which the objective function is discontinuous, non-differentiable, stochastic or nonlinear. It generates solutions by use techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover and produce a high quality solution. (Pratibha Bajpai *et al.*, 2010). The GA used in a many large number of application such as scientific and engineering problems and models, including: Optimization, Automatic Programming, Machine learning, Economic models, Immune system models, Ecological models, Interactions between evolution and learning, Models of social systems.

Genetic algorithms are implemented using computer simulations. It can be adapted to used it to optimize the parameters that need to operate the WSN and can help in make better operate of WSN to by select the suitable parameters. A brief description of GA requirements will now be considered (Goldberg *et al* 1989).

GA operate on population of individual. The initial population is collection of chromosomes generated randomly. Produce initial population has effect on converge of solution depending on how much the generated chromosome are closest to the solution (Ayon Chakraborty, 2011). The simplest form of genetic algorithm involves four basic categories of operators: Encoding, selection, crossover and mutation (Goldberg *et al* 1989).

5. Performance Metrics Analysis and Comparison

There are number of performance metrics that can be used to compare routing protocols. This performance metric determines the completeness and correctness of the routing protocol. We have used the important and popular metrics for analyzing the performance of mentioned routing protocols:

- **Throughput:** This represents the number of packets received within a given time interval.
- **End to End delays:** It represents the delay encountered between the sending and receiving of the packets.
- **Jitter:** It represents any unwanted variation in one or more signals generated during the packet transfer. The term jitter is often used as a measure of the variability over time of the packet latency across a network. However, jitter is the variation of the packet arrival time (Ahmed Jawad 2012).
- **Dropped packets:** It is the number of packets that sent by the source node and fail to reach to the destination node (Aliff Umair et al. 2006).
- **Total collision:** is number of collision between nodes in networks (Aliff Umair *et al.* 2006).

6. Design and Implementation of The Proposal System

The system consist of two stages. The first stage is optimize parameters by using GA. GA has many operators which are Encoding , selection, crossover and mutation. These operator work in population of chromosomes. Data of WSN represented by mean of chromosomes which contain genetic information of GA. Chromosome is collection of genes. Each chromosome represent particular operator (no. of node, rate, simulation area) of WSN. The GA strategy as follow.

1. Generate initial population randomly using random generation. After determine number of individuals in population and number of genes in each individual use Rand() function to generate random values of individuals.
2. Integer encoding is used to encoding chromosomes which represent parameter of WSN, these integer values represent the genes of the chromosomes.
3. Roulette-Wheel Selection used in selection parents from population. In roulette wheel selection, individuals are given a probability of being selected directly, proportionate to their fitness. Two individuals are chosen randomly based on these probabilities and produce offspring.

Mask crossover is used to perform crossover between individuals. Binary mask is selected randomly and number of its genes equal to numbers of genes of parents. At each iteration of GA, the genes of mask shift to right at position determine from cut point of crossover to ensure the high diversity of individuals. If the gene of mask is 0 no exchange between parents is done else exchange is done between genes of parents.

4. Mask mutation is done on genes of individuals. Mask is select randomly and its number of genes equal to number of genes in new individual generated from crossover. If gene of mask is 0 no mutation is done. If gene of mask is 1 the mutation is done. Genes of mask also shift to right depending on point selected randomly to sure diversity and reach to optimal population.

5. Fitness function must be devised for each problem to be solved. Given a particular chromosome, the fitness function returns a single numerical fitness which is supposed to be proportional to the ability of the individual which represents the chromosome.

After normal termination of GA operator new individual represent the optimal parameter of WSN. Normalize the value of individuals to convert them to more proper values depending on parameters needed from genetic algorithm to generate it.

These steps are repeated as number of parameters needed from GA to produce it. At the end of the first stage , parameters of WSN (number of nodes, simulation area and rate of transition) are use in stage two. In stage two simulation of WSN is done using parameters, some of these parameters gets from GA. NS-2 simulator program consist from the following:

1. Create scheduler (event scheduler): generate object from simulator class which simulation done from it.
2. Set parameters of WSN such as WirelessChannel, radio-propagation model, WirelessPhy, Mac, interface queue type, link layer type, antenna model, max packet in ifq, number of nodes, routing protocol and environment dimensions.
3. Create network topology.
4. Create connection between nodes.
5. Create traffic.
6. Schedule events.
7. Start the simulation.
8. A stop procedure to exit the simulator.

Figure (1.1) show integrate environments of GA and NS-2 Simulator.

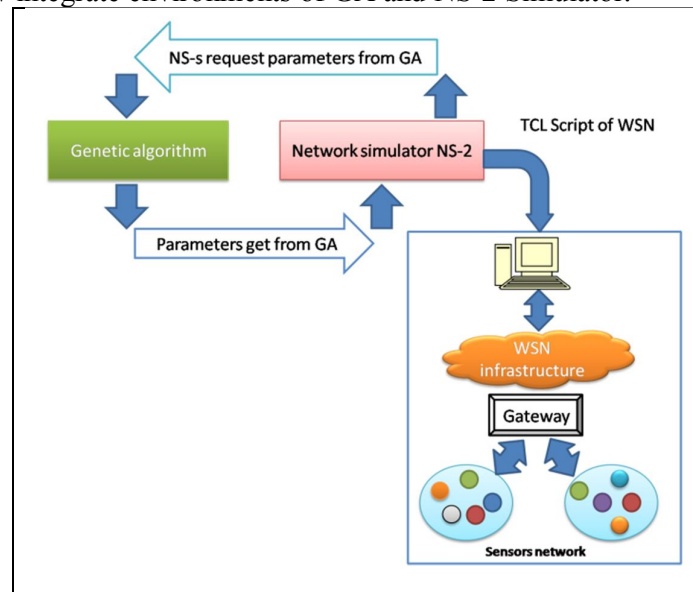


Figure (1.2): Architecture of the Environment that Integrates GA and NS-2 simulator.

7.Simulation Setup and Performance Evaluation

The network simulator NS-2 version 2.34 was used in this thesis to simulate the WSN to evaluate the performance of it with four routing protocols (AODV, DSDV, DSR, NOAH) . The simulation environment was executed with these parameters for 10 times and computes the performance metrics for each routing protocol (40 times for four routing protocols used for each parameter ,160 times for four varying parameters values , three values for parameter when not use GA and one when use GA "). A long and complex process of dealing with large number of files and rich data resulted was performed in order to get the average results .Three different scenarios used which are:

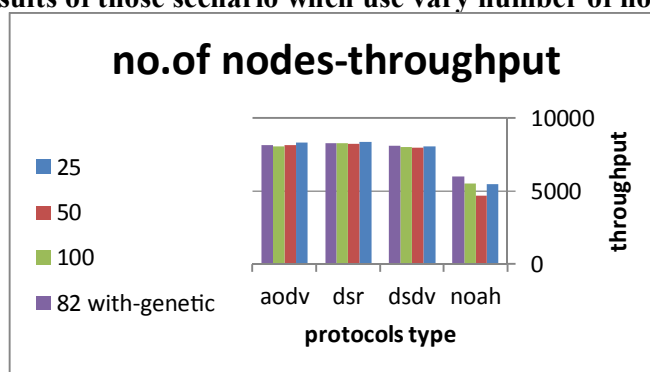
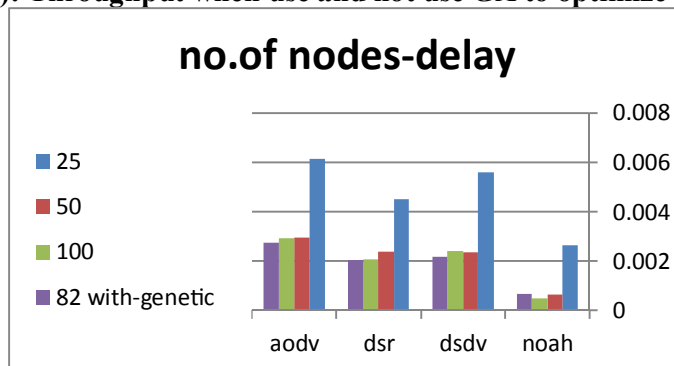
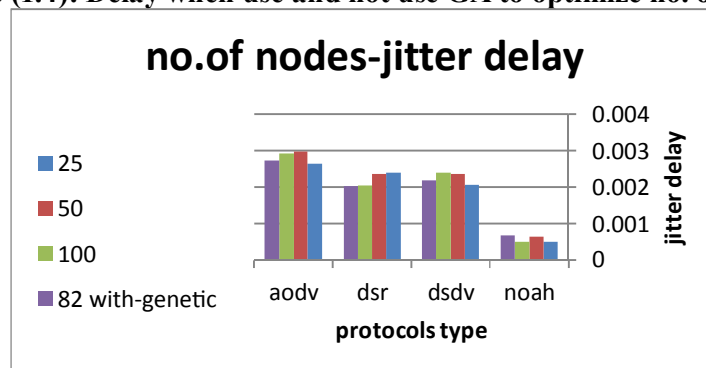
1. Number of nodes: in this simulation number of nodes are varies to check protocols behavior with changing number of nodes by measure performance metrics of WSN. Then use GA to optimize number of nodes to get better then re-simulate the WSN with these parameters generated from GA and finally draw these results graphically.

Table(1.1) show parameters of these scenario.

Table (1.3): WSN Parameters of No. of Nodes Scenario.

Parameter	Value
The simulator	NS 2.34
MAC	802.11
No. of nodes	25,50,100 82(by GA)
Routing model	NOAH,AODV,DSR,DSDV
Simulation time	100
Traffic generator	CBR
Antenna	Omni Antenna
Packet size	100 bytes/packet
Transition rate	4 packets/second
Environment size	m *500 m

The results of those scenario when use vary number of nodes are .

**Figure (1.3): Throughput when use and not use GA to optimize no. of nodes.****Figure (1.4): Delay when use and not use GA to optimize no. of nodes.****Figure (1.5): Jitter delay when use and not use GA to optimize no. of nodes.**

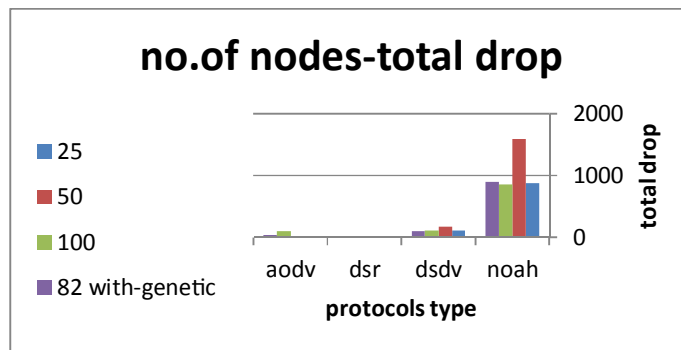


Figure (1.6): Drop packets when use and not use GA to optimize no. of nodes.

Simulation area: in this simulation varied areas of simulation selected randomly and show effect of change areas on performance of WSN. Then use GA to optimize the areas to get better one. Re-simulate the WSN with these parameters that results from GA and draw the results graphically. Table (1.2) show parameters of these scenario.

Table (1.2): WSN Parameters of Area Scenario.

Parameter	Value
The simulator	NS 2.34
MAC	802.11
No. of nodes	25
Routing model	NOAH,AODV,DSR,DSDV
Simulation time	100
Traffic generator	CBR
Antenna	Omni Antenna
Packet size	100 bytes/packet
Transition rate	4 packets/second
Environment size	300 m *300 m, 1000 m *1000 m, 1500 m *1500 m 545m *545m (by GA)

The results of those scenario when use vary number of nodes are:

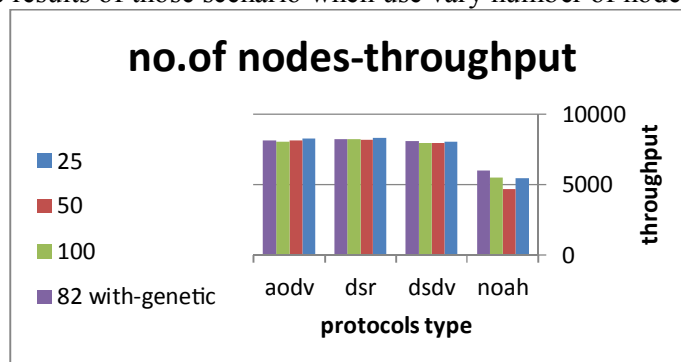


Figure (1.7): Throughput when use and not use GA to optimize areas of simulation.

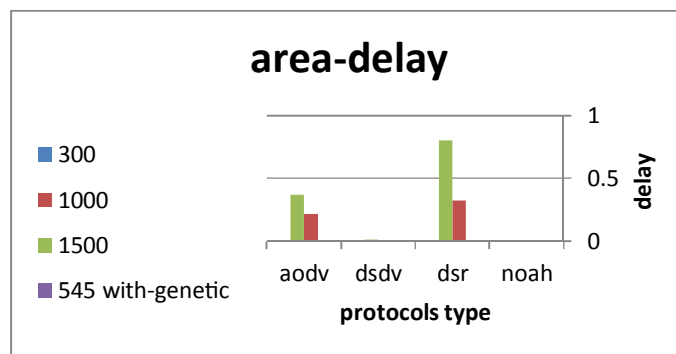


Figure (1.8): Delay when use and not use GA to optimize areas of simulation.

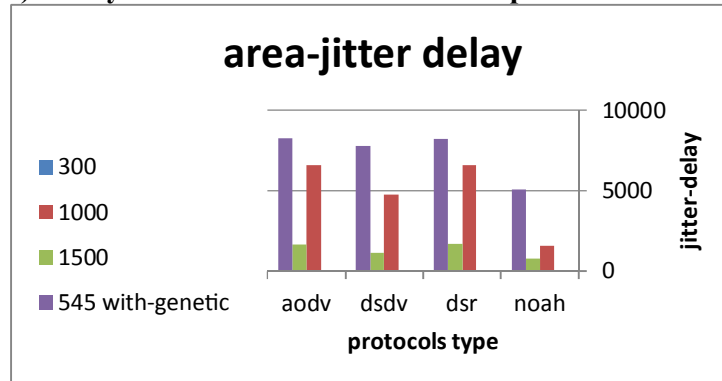


Figure (1.9): Jitter delay when use and not use GA to optimize areas of simulation.

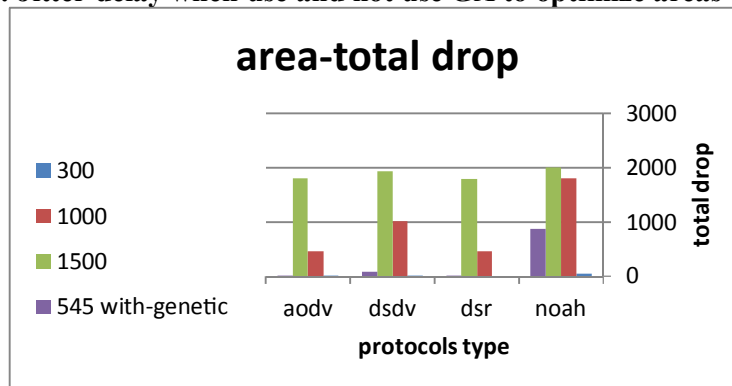


Figure (1.10): Drop packets when use and not use GA to optimize areas of simulation.

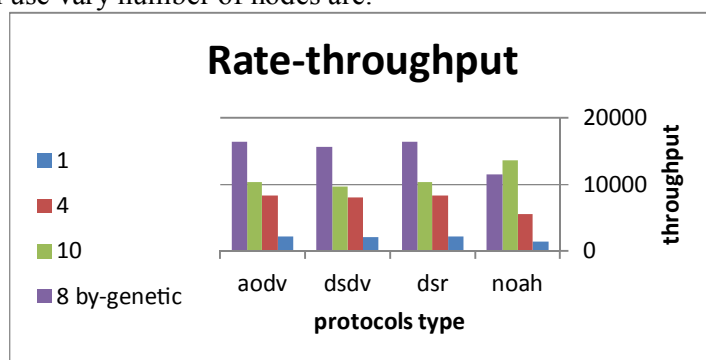
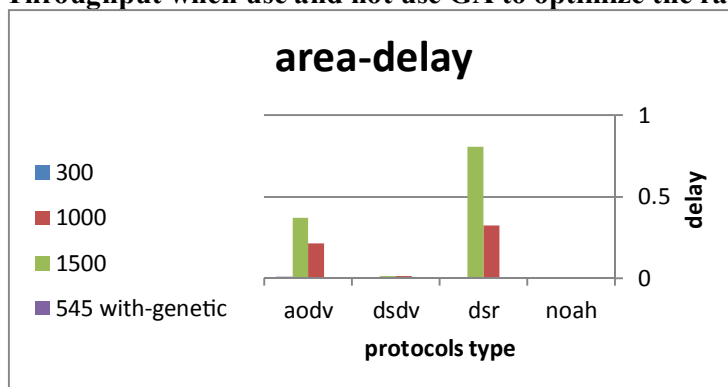
2. Rate of transition: in this simulation different rate of transition that selected randomly to show influence of change rate on performance of WSN then use GA to optimize the rate then re-simulate the WSN with these parameters that get from GA and draw the results graphically.

Table (1.3) show parameters of these scenario.

Table (1.3): WSN Parameters of Rate Scenario.

Parameter	Value
The simulator	NS 2.34
MAC	802.11
No. of nodes	25
Routing model	NOAH,AODV,DSR,DSDV
Simulation time	100
Traffic generator	CBR
Antenna	Omni Antenna
Packet size	100 bytes/packet
Transition rate	1, 4, 10 packets/second 8 packets/second (by GA)
Environment size	500*500

The results when use vary number of nodes are:

**Figure (1.11): Throughput when use and not use GA to optimize the rate of transition.****Figure (1.12): Delay when use and not use GA to optimize the rate of transition.**

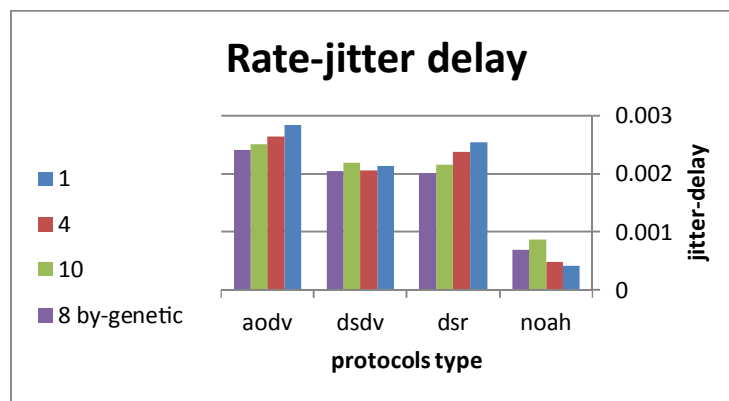


Figure (1.13): Jitter delay when use and not use GA to optimize the rate of transition.

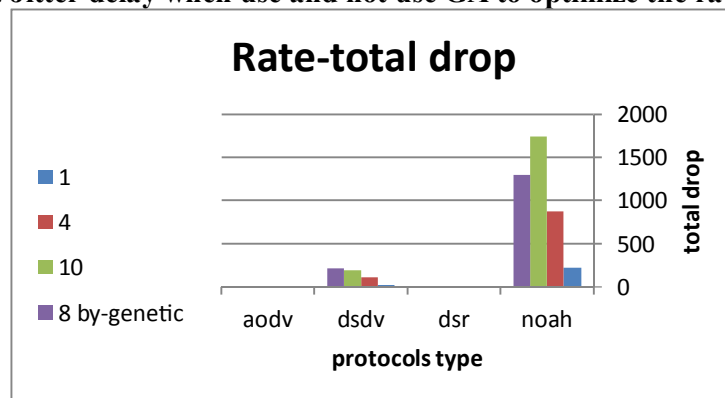


Figure (1.14): Drop packets when use and not use GA to optimize the rate of transition.

8. Conclusion

This paper mitigate congestion in WSNs by using GA identify WSN in general, describe routing protocol (AODV, DSR, DSDV, NOAH) that can be used it in simulation and describe GA and it main operation.

Finally, propose GA framework that can used to optimize the parameters (no. of nodes, simulation area and rate) of WSN.

This thesis make several contributions that are :

1. WSN suffer from congestion problem that cause loss packets, consume energy long delay and other problems. In thesis, present new GA framework for mitigate congestion in WSN.
2. From the work through NS-2, we conclude that it is more suitable to simulate the network.
3. Show by simulation the effect of congestion on performance of WSN.
4. Implement tests on how various parameters affect congestion.
5. Achieve appropriate modification on NS-2 to install NOAH protocol and show the impact of use it in WSN performance.
6. Use of AWK programming that enables to understand the work by analysis trace file produce from execution TCL program in NS-2 simulator.
7. Avoid segmentation fault error by keeping the traffic start time very much farther than the start time of the node send-off.

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