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Comparative Analysis Of Wireless Ad-Hoc Routing Protocols Using Swarm Intelligence Based Model

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Abstract

Wireless sensor networks (WSNs) offers wide variety of applications in different fields of life. Routing in sensor networks face various challenges due to variations in the nature of WSN applications such as their deployment, density of sensor nodes, etc., are a few to name. Since, last few years the Swarm Intelligence (SI) based models are being used to solve the analytical problems based on collective behavior like routing data packets in decentralized and self-organized systems. In our paper we have focused on SI based routing algorithm inspired from Ants to resolve data transmission problem in the wireless medium. We have simulated WAntNet routing technique to route data in sensor networks and compared it with wireless ad hoc routing protocol namely Ad-hoc on-demand distance vector (AODV) using discrete simulator Network Simulator (NS) measuring different performance metrics.

Key words: Wireless sensor network, Swarm intelligence, Ant colony optimization, WAntNet, NS.

1. Introduction

WSNs are collection of discrete and self-directed wireless nodes which are heavily deployed over remote sites to gather physical data from environment which is later used to process the environmental parameters. There are various challenges in WSNs which directly affect the overall design of wireless systems such as WSNs constraints in energy/power [1, 2].
WSN does not provide any infrastructure for mobility between the individual nodes. The prime objective behind providing efficient routing techniques is to increase the network life-time and to provide proficient fault-tolerance mechanism. In WSNs the high proficient routing is the most significant issue that has taken the attention of the many researchers because in sensor networks routing is most likely the regulating mechanism. While there are various routing protocols in WSNs like AODV, DSDV, and DSR which are satisfying a measurable amount of parameters but still there are some deficiencies in them. There are numerous concerns related to optimizations in routing like the information broadcasting, energy consumption, quality of service (QoS), fault tolerance, latency etc. And all these parameters are not satisfied by traditional routing protocols in WSNs. Consequently, there is no means toward the usage of conventional routing techniques

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in wirelessly sensed system and now, there is a room for novel routing techniques that could bring some notified change in WSNs. Since, the routing techniques materialized as swarm intelligence based schemes [8].
Swarm Intelligence is a bio-inspired technique which emphasis on solving the problems in a collaborative manner utilizing decentralized and self-controlled system. Issues related to advance communication network are also answerable by group intelligence of SI based techniques. For this reason, swarm based techniques which includes ant colony optimization (ACO) are in heavy usage scenario. Ant colony optimization routing algorithms are more proficient towards handling the relevant concerns among routing in WSNs as they have the ad-hoc nature [4].
In this paper, we have paralleled ant colony optimization (ACO) based ANT model for WSNs. Assessments are made in considering parameters like energy depletion, scalability, fault-tolerance and considering the QoS parameters and so on. Rest of the paper is structured as the Section II contains literature review. Section III covers detail of ACO based routing protocols furthermore; selected routing protocols for comparison are conversed in Section IV. Simulation specifics and results have been discussed in Section V. Section VI conclude our findings and gives future directions.

2. Related Work

Gianni A. Di Caro gave the first routing algorithm based on the principles of ACO under the supervision of Prof. Marco Dorigo. AntNet was initially developed for wired networks providing features like IP best routing [3- 7]. Zhang et al. in [5] further examined the applicability of AntNet algorithm in WSNs, and proposed three of its variants enhanced from its basic architecture, named Sensor-driven Cost-aware Ant Routing (SC), Flooded Forward Ant Routing (FF), and Flooded Piggybacked Ant Routing (FPAnt) (see Section III).
Radwa Attia, Rawya Rizk and Mahmoud Mariee in [9] present two algorithms inspired from hybrid behavior of ant colony optimization namely HMAnt and HMAnt-QoS designed to solve problems like more overhead and the long convergence time problems caused in ACO based techniques.
They have compared these two algorithms with ANTNET and few other algorithms. Simulation results show that HMAnt performs better than AODV, AntNet and AntHocNet in terms of packet delivery ratio and delay.
Y. Lakshmi Prasanna and Dr. P. Chenna Reddy in [10] compare AODV and AntHocNet. They have computed throughput and packet delivery ratio by placing pause time and speed constant during simulation. After getting simulation results they witnessed that AODV performs better than AntHocNet. AntHocNet devises high loss rate, end to end delay and jitter in the considered simulations.
Abdusy Syarif et. al in [12], have experimented real network topology and compared AntNet routing protocol with distance vector (DV) routing protocol in order to get the real behavior of ants. Results clearly show that AntNet outperforms DV in terms of packet delivery ratio for larger packet size. However, in term of normalized routing load and delay, AntNet creates higher header packet than distance.

3. Ant Colony Optimization (ACO) Based Routing Protocols

ACO is generally a part of swarm optimization methods which involves ant (agents) from ant colonies to explore best possible path from source to destination and come back again to source. Ant colonies use indirect way of communication to spread information about the quality of food they travel. Based on quality of food they select path to travel. Ant colonies use a chemical model called pheromone model to make a link between each other the important property of pheromone model is that it evaporates with the passage of time. Fig. 1 [7] illustrates the food searching behavior of ants. Here we are discussing AntNet routing technique along with its three variants.

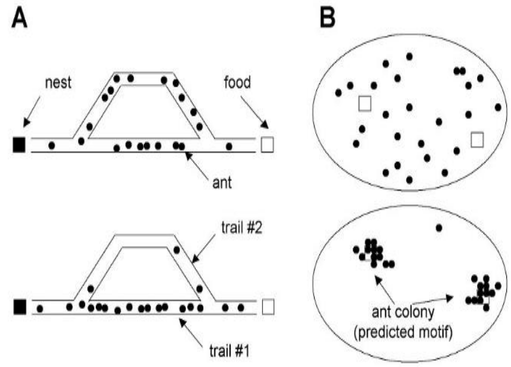

Figure. 1 Ant Colony Optimization

3.1. AntNet

AntNet duplicates the foraging behavior of ant colonies to exploit different paths in a way to get most promising path to provide best solution for combinatorial problems specially. It exhibits stimulating properties like ant agents work in distributed fashion, more tolerant towards network fluxes, provides mobility to ant for flexible motion, robust, deals manifold routes for routing, and instinctively issues traffic in the network. AntNet consist of two types of forager's forward and backward ant. At the outset unicast forward ant is launched from source to explore different routes. Launching intermission is set adaptively. Cost of path travelled is calculated by using number of trips. Forward ant is meant to store information of nodes travelled and time of travel from starting node. After exploring whole path when it reaches the destination node it transmits whole data towards backward ant and get ruined. Backward ant consumes sample cost to bring up to date statistics (stack) about perceived costs from current node to destination [4].

3.2. Sensor-driven Cost-aware Ant Routing (SC)

There were some flows in the design of basic model like when forward ant is launched to exploit different paths then it moves randomly, such that it takes time before pheromone tables to specify worthy routes. This is due to unavailability of previous information and then pheromone variables are adjusted giving random uniform distribution. Zhang et al. in SC proposed that ant agents must have initial estimate in terms of number of hops as the real have certain amount of capacity to smell food which they follow to find route. Each sensor node probability distribution and it stores the estimated values of the cost from its each neighbor to the destination. However, this may mislead ant due to presence of any obstacle [4].

3.3. Flooded Forward Ant Routing (FF)

This routing protocol floods forward ants toward sink node in search of route this happens when there no estimated cost in terms of number of hops. If estimated value is provided then SC become the basic algorithm. When the forward ant ranges endpoint it releases backward ants and updates the routing table [4].

3.4. Flooded Piggybacked Ant Routing (FP)

A new kind of ant is initialized in FP named as data ants which carry data along them in this routing protocol these ants are flooded in the network same as FF along data with them which they deliver on reaching destination. FP is energy-efficient and in this backward ant behaves the same way as they perform in FF routing protocol [4].

4. Selected Routing Protocols for Comparison

For conducting performance evaluation we have implemented AntNet for wireless ad hoc network titled as WAntNet and AODV routing protocols.

4.1. ***WAntNet***

WAntNet is an AntNet based routing protocol which engages intelligent agents forward ants to explore different routes and to build up the stack for information storage and utilizes another agent the backward ants which gets every detail from forward ant and travels back to home by exchanging data from routing table using wireless medium. For analysis purpose WAntNet algorithm is incorporated in network simulator in order to perform multipath routing in sensor networks. Fig. 2 explains the working mechanism of WAntNet routing protocol.

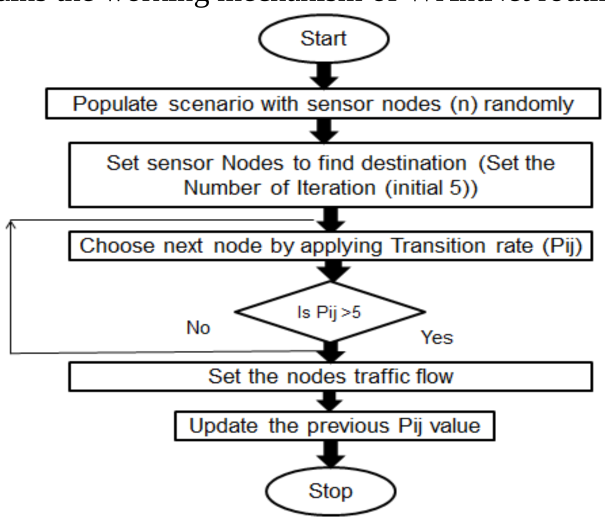

Figure. 2 WAntNet Flowchart

Process of exploring routes starts when the surface is plotted with random nodes and ant agents are set to exploit multiple paths in a distributed manner. Ant agent selects the next node by processing the transition function (Pij); it is calculated by taking parameters from routing table built on each node. Transition rate is checked if its value is greater than past value then that node is selected to be travelled meanwhile the routing table is also updated. Ant agent stops after completing five iterations providing definite shortest path.

4.2. ***Ad-Hoc On-Demand Distance Vector (AODV) Routing Protocol***

A classical routing protocol for wireless ad hoc networks, this protocol is intended to discover single path through which data would be transmitted. It works on the demand. Whenever any node has data to transmit it generates routes request (RREQ) packets and broadcast data to its neighboring nodes. When the transitional nodes receives RREQ packets they start to search for feasible routing table for getting valid route to travel towards destination node. As soon as nodes find some routing table they send unicast message towards source using backtracking. Intermediately nodes continue to update their routing table throughout the process and continue the sending process till the source node obtains RREQ packets. Source node will be accepting call from sink node having less number of hopes involved. AODV uses cross layer technique to avoid routes with high packet loss [11].

5. Simulation

Simulations are performed in Network Simulator (NS) to measure the performance of wireless ad hoc routing protocols. We have analyzed the performance based on different quality of service (QoS) parameters. Simulation parameters are listed below in Table 1.

Table 1: Simulation Parameters

Parameter	Value
Total Number of Nodes	50
MAC	802.11b
Packet Size	512 KB
Routing Protocols	WANTNET, AODV
Number of Nodes Communicating	5,10,15,20
Traffic Generator	CBR
Mobility Model	Random-Way Mobility Model
Simulation Time	600 Seconds
Simulation Area	1000 X 1000 meters
Initial Energy of Nodes	32400.0 Joules

For conducting simulation we have generated 50 nodes transmitting information through IEEE

802.11. We have added dynamicity in scenario by adding random-way mobility model and the number of nodes move under the network area of 1000 X 1000 meters. Every node move towards destination node with incessant speed and when it reaches the end point and it remains there for particular amount of time it may involve activities like updating routing table, maintenance etc. We have performed simulation by varying the traffic size, 5, 10, 15, and 20 in order to check the performance metrics. Fig. 3 illustrates NS-2 Simulation scenarios created in Network Animator (NAM).

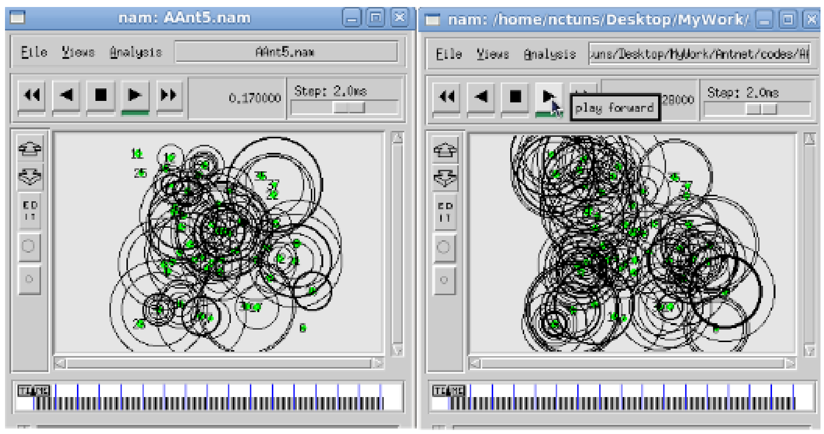

Figure. 3 NS2 Simulation Scenarios

5.1. ***End-to-End Delay***

It is average time taken by the data packets to reach destination. It includes delay caused by route exploration, network congestion, queuing etc [12].Delay is processed by the following equation.

$$Delay = \frac{\sum \quad (Arrival\ Time - Send\ Time)}{\sum \quad Number\ of\ Connections}$$

Two routing protocols have been analyzed by calculating their delay. End to end delay is computed by varying the traffic size. It is shown in Fig. 4 that WAntNet takes less time to deliver data packets to destination because WAntNet performs multipath routing and searches the optimal path rapidly and dynamically change its route if required.

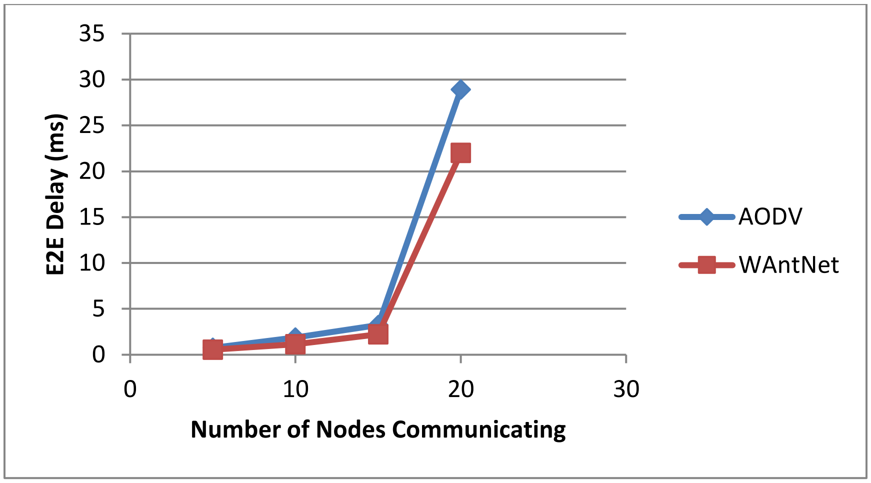

Figure.4 End to End Delay

5.2. **Average Throughput**

Throughput is used to calculate the overall performance of network it is a degree of successfully delivered messages in unit time over communication network [12]. It is computed as:

$$Throughput = Packets\ Rec \times 8/Transmission\ Period$$

Fig. 5 clearly signifies that AODV impresses slightly higher throughput than WAntNet but we can see that as the communication between the numbers of nodes increases throughput significantly increases in WAntNet.

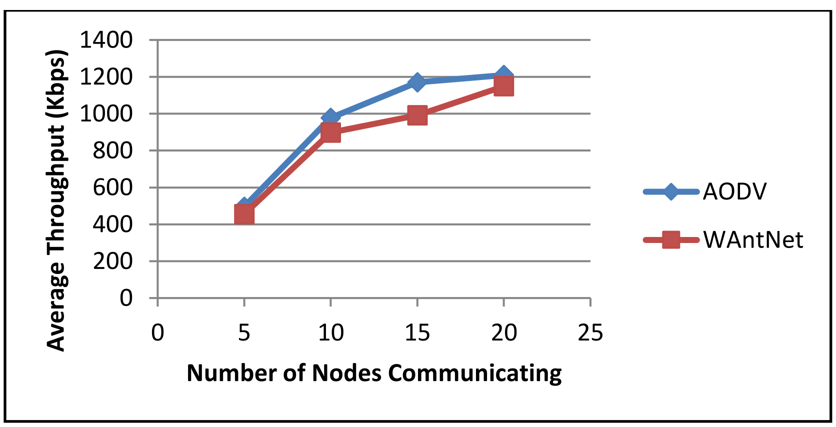

Figure.5 Average Throughput

5.3. Normalized Routing Load

Routing overhead is kind of load on network it calculates that how many routing control packets transferred during simulation and the number of data packets. It can be mentioned as how many routing control packets are needed for one data packet transmission. It is used to assess the scalability of routing protocol under lower bandwidth availability [12]. Fig. 6 shows that WAntNet algorithm gives more routing overhead on network as it performs multipath routing means ant agents are set to explore multiple paths so routing load increases on network as compared to AODV.

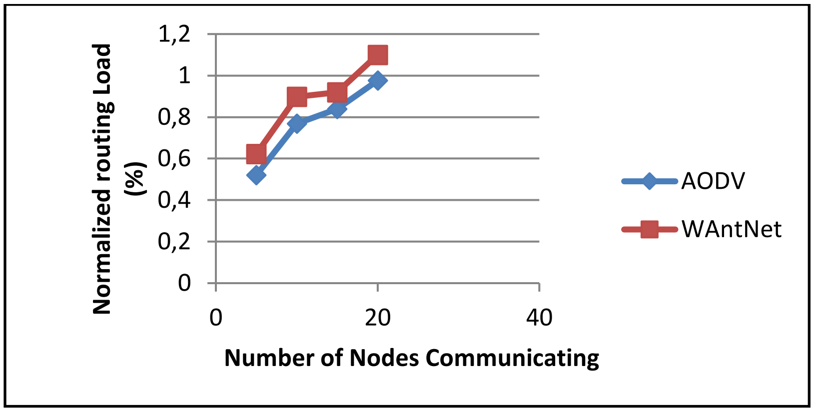

Figure.6 Normalized Routing Load

5.4. Packets Delivery Ratio

Packets delivery ratio is the measure of how many packets got received at destination out of packets sent from the source. This parameter shows the success rate of any routing protocol depending upon traffic, packet size and pause time [12]. Following is the equation:

$$PDR = Packets\ Received/Packets\ Send$$

Packet Delivery Ratio graph (Fig. 7) has been plotted against packet rate, it shows that AODV delivers large number of packets initially but when the packet rate surges its ratio becomes stable on the other side we can experience higher packet delivery ratio in WAntNet as the packet rate rises.

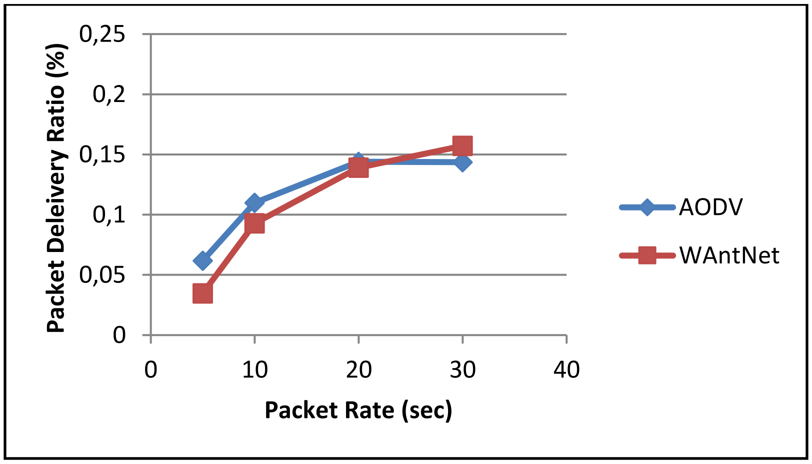

Figure.7 Packet Delivery Ratio

5.5. Energy

Energy consumption is critical parameter to measure in which energy expended by every sensor node is computed in order to know about overall network energy requirement [12]. It is computed as:

$$\Sigma\ Percentage\ Energy\ Consumed\ by\ all\ nodes\ /\ Number\ of\ Connections$$

Energy ingestion graph (Fig. 8) depicts that WAntNet routing protocol consumes slightly more resources than AODV due to its multipath search and hybrid nature.

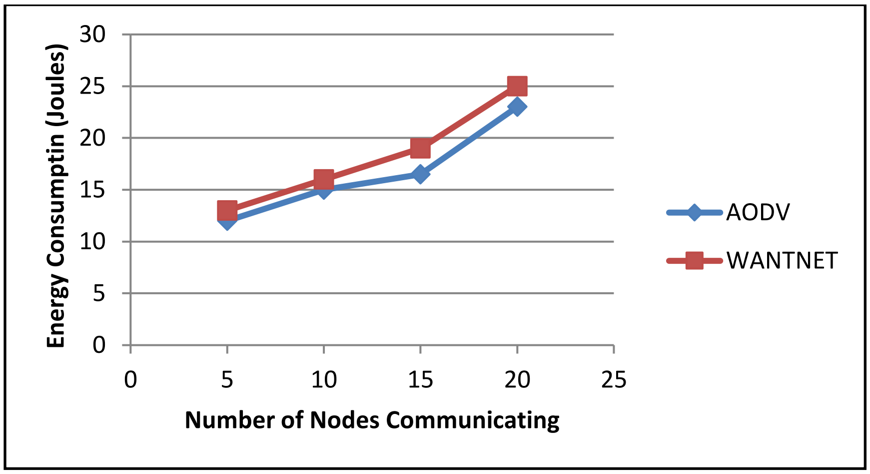

Figure.8 Energy Consumption

6. Conclusion and Future Work

In our work we have analyzed the performance of two routing protocols namely AODV and WAntNet, and compared their performance using dynamic scenario. During simulation few parameters like pause time and speed are reserved constant (0 sec and 20 m/sec) respectively. Average throughput is computed at different times and traffic and it is observed that AODV slightly overtakes WAntNet at 4, 10, 11 and 12 Mbps. When packet delivery ratio was compared then we perceived that primarily AODV delivers more packets than WAntNet but as the traffic increases then WAntNet also performs well as far as the delay and routing overhead WAntNet impresses less delay and provides more overhead on network. Energy consumption is greater in WAntNet routing protocol because of dynamicity of network, mobility etc. WAntNet could possibly outperform in wired domain. Because the link quality between a node and its entire one hop neighbors is unevenly identical. However ANTNET's probabilistic routing pattern consents it to be very strong. It could be a very attractive approach for sensor networks in aggressive environment. In future the WAntNet could be improved by modifying the pheromone levels which could be set and we can control and monitor the evaporation process of pheromone model as well we can secure the packets transmission in WAntNet in order to avoid eavesdropping.

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