International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Simulation of ACO Based Anthocnet using Manhattangrid Mobility Model

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Accepted 31 July 2015, Available online 11 Aug 2015, **Vol.5, No.4 (Aug 2015)**

Abstract

A mobile ad hoc network is a collection of self-organized mobile nodes. This network doesn't require existing infrastructure or central administration. As the nodes have mobility, the biggest challenge in this kind of networks is to find a path i.e., routing between the communications end points. Ant colony optimization (ACO) is a technique to solve problems like routing in ad hoc networks based on food searching behavior of ants. All ant colony algorithms are subset of Swarm Intelligence which means collective behavior of individual ants. All the ant based algorithms are mainly depended on pheromone concentration. Pheromone is a volatile chemical substance secreted by ants from nest to food source in order to influence other ants to follow them. The route will be discovered by the concentration of pheromone values. AntHocNet is based on ideas from ACO. It is a hybrid algorithm consisting of both reactive and proactive components. AntHocNet has a reactive path setup but a proactive path management. It does not maintain routes to all possible destinations at all times but only sets up paths when they are needed at the start of a data session. This is done in a reactive route setup phase, where ant agents called reactive forward ants are launched by the source in order to find multiple paths to the destination, and backward ants return to the source to set up the paths. Routing information is stored in pheromone tables that are similar to the ones used in other ACO routing algorithms. Frederick ducatelle used open and urban scenarios using QualNet and the performance evaluation was done with relevant parameters such as node speed, data send rate, network size etc., in which a number of nodes move in an open, rectangular area along straight line segments with fixed data send rates. This scenario does not provide a correct image of situations that occur in reality. Therefore, observed results are not necessarily representative for what can be expected when the network is deployed for a practical application. In this project, the previous tests are complemented with new ones that use more realistic scenarios. The scenarios that are modeled include ManhattanGrid. Ns-2.34 simulator has been used along with Bonnmotion-2.1a for generating scenarios of different mobility models for limiting node movements to streets and open space of town. A comparative test has been done by calculating metrics end-to-end delay, throughput, packet delivery factor, routing overhead for AntHocNet and AODV routing algorithms. By using this, the limitations of AntHocNet have been identified. The energy consumption of AODV protocol has been evaluated in ad hoc network scenario with different number of source nodes and the performance of energy consumption at different nodes has been observed.

Keywords: *AntHocNet, AODV, ManhattanGrid*

1. Introduction

Wireless networks are formed with interconnecting devices communicating wirelessly within a relatively limited area. An ad hoc network consists of mobile nodes which communicate with each other using wireless medium without any fixed infrastructure. Ad hoc is a Latin word that means for this purpose only. An ad hoc network is a special network that is set up for a particular application. Though wireless systems have existed since the 1980's it is only in recent times that wireless systems have started to make inroads into all aspects of human life. Mobile Ad hoc Network is an autonomous system of mobile nodes connected by wireless links. Each node operates as an end system and a router for all other nodes in the network.

A Mobile Ad hoc Network (MANET) is a self-configuring network of mobile routers connected by wireless links –the union of which forms an arbitrary topology. An Ad hoc network is often defined as an infrastructure less network means that a network without the usual routing infrastructure, link fixed routers and routing backbones. Thus the maturity of wireless transmissions and popularity of portable computing devices have made the dream of communication anytime and anywhere possible. An ad hoc wireless network is a good choice for fulfilling this

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dream. An ad hoc wireless network consists of a set of mobile hosts operating without the aid of an established infrastructure of centralized administration. Communication is done through wireless links among mobile hosts using their antennas.

1.1 Mobile Ad Hoc Networks

Mobile Ad hoc Network (MANETs) is an infrastructure less network in which nodes are mobile. In another words, MANET is an autonomous collection of mobile devices (laptops, smart phones, tablets, sensors, etc.) that communicate with each other over wireless links. The entire MANETs network may be mobile, and mobility may be very high so MANETs have varying topology. With the advent of laptops and 802.11/Wi-Fi wireless networking, MANET is getting popular. Integration of Wi-Fi and Bluetooth like technologies in almost all mobile devices such as Mobile phones, PDAs, notebook, etc. is also aiding in the popularity of MANETs. Because of these features, MANET is regarded as a future of ubiquitous networking and computing.

A MANET is a distributed network that does not require centralized control, and every host works not only as a source and a sink but also as a router. This type of dynamic network is especially useful for military communications or emergency search and rescue operations, where an infrastructure cannot be supported. The nodes that make up a network at any given time communicate with and through each other. In this way every node can establish a connection to every other node that is included in the MANET.

Routing in MANET is extremely challenging because of MANETs dynamic features, its limited bandwidth and power energy. Nature-inspired algorithms like ant colony optimization (ACO) algorithms used for develop the routing algorithms for MANETs. The typical applications where MANETs used are military battlefield, collaborative work, local level, personal area network & Bluetooth and commercial sector.

1.1.1 MANET characteristics

a. **Distributed operation:** There is no background network for the central control of the network operations; the control of the network is distributed among the nodes. The nodes involved in a MANET should cooperate with each other and communicate among themselves and each node acts as a relay as needed, to implement specific functions such as routing and security.
b. **Multi hop routing:** When a node tries to send information to other nodes which is out of its communication range, the packet should be forwarded via one or more intermediate nodes.
c. **Autonomous terminal:** In MANET, each mobile node is an independent node, which could function as both a host and a router.
d. **Dynamic topology:** Nodes are free to move arbitrarily with different speeds; thus, the network topology may change randomly and at unpredictable time. The nodes in the MANET dynamically establish routing among themselves as they travel around, establishing their own network.
e. **Light-weight terminals:** In maximum cases, the nodes at MANET are mobile with less CPU capability, low power storage and small memory size.

1.2 Bio Inspired Networking

Bio inspired networking is one engineering field which has many parallels with Biology and hence the solutions of biology can be used to solve the problems of computer networks. Although the Internet is perhaps the world's newest large-scale, complex system, it is certainly neither the first nor the only one. Certainly the oldest large-scale, complex systems are biological. Biological systems have been evolving over billions of years, adapting to an ever-changing environment.

They share several fundamental properties with the Internet, such as the absence of centralized control, increasing complexity as the system grows in size, and the interaction of a large number of individual, self-governing components, just to name a few. Despite their disparate origins one made by nature, the other made by man, it is easy to draw analogies between these two systems.

Drawing parallels between computer systems and biology is not a new idea the unprecedented complexity and scale of modern networks demands investigation from a different angle. As many researchers have argued there is a great opportunity to find solutions in biology that can be applied to problems in networking.

1.3 Swarm Intelligence

A swarm has been defined as a set of agents like mobiles which are liable to communicate directly or indirectly with each other, and which collectively carry out a distributed problem solving.

A long time ago, people discovered the variety of the interesting insect or animal behaviors in the nature. A flock of birds sweeps across the sky, a group of ants forages for food, a school of fish swims, turns, flees together, a group of Honey bees searches for honey, Fire flies show remarkable synchronization, etc. This kind of aggregate motion is called swarm behavior.

Swarm intelligence is the property of the system whereby the collective behaviors of unsophisticated agents interacting locally with their environment cause coherent functional global patterns to emerge. Swarm intelligence provides a basis with which it is possible to explore collective problem solving without centralized control or the provision of a global model. Based on this generalized concept of a swarm, French researchers have actually been able to simulate the termite's nest-building behavior on a computer by applying a very simple stigmergic algorithm.

Ants show their collectiveness in finding the food source. A group of ants indirectly communicate by just modifying the environment. No direct communication between them takes place. All the ants work towards global objective of collecting food. Common goal is more important than any individual goals. They optimize their behavior to achieve the common goal.

Honey bees show their cooperative behavior in collecting honey. They perform different types of dances and make different kinds of sounds to guide the other honey bees in finding the sources of honey. They work towards single collective objective of collecting honey and depositing at a single place. Honeybees forage for nectar in a fluctuating environment. Scouts search for new nectar sources and provide information about source location and food quality to the colony through decentralized system. Foragers are recruited to nectar sources in appropriate numbers. Without any global decision making, the bees are able to select from multiple available nectar sources the optimal one, the one offering the best ratio of gain to cost. Using our multi-agent simulation of this foraging system that includes nectar sources fluctuating in quality over time in a virtual environment, we found that the honeybee foraging system is robust over a wide variety of fluctuation patterns.

Fish organize themselves into schools as a way to defend against predators and improve foraging efficiency. Similar to herds or flocks of other animals many species of fish gather in shoals or schools without the need for leaders or external cues. Instead, it is thought that the local interactions between the group members lead through processes of self-organization to the evident group structure. Individual fish relate their orientation and speed to that of their neighbors according to a few behavioral rules which we will refer to as avoidance of collisions, attraction and alignments like matching speed and orientation.

1.4 Ant Colony Optimization

ACO routing was originally inspired by mechanisms found in biology: it is based on principles that are present in the foraging behavior of ants in nature, and on the ACO frame work for optimization that was derived from these principles. ACO routing algorithms work in a highly distributed way, and have properties such as adaptivity, robustness and scalability. This makes them particularly interesting to deal with the challenges in adhoc routing. It has been observed that ants from e.g. the family of Argentine ants Linepithema Humile are able to find the shortest path between their nest and a food source. This is remarkable because each individual ant is a rather simple creature, with very limited vision and computing power, and finding the shortest among several available paths is certainly beyond its capabilities. The only way that this difficult task can be realized is through the cooperation between the individuals in the colony. The key behind the colony level shortest path behavior is the use of pheromone. This is a volatile chemical substance that is secreted by the ants in order to influence the behavior of other ants and of themselves. Pheromone is not only used by ants to find shortest paths, but is in general an important tool that is used by many different species of ants (and also by a lot of other social animals) for a wide variety of tasks that involve coordinated behavior. The use of pheromone is an example of a form of indirect communication that is often referred to as stigmergy.

1.4.1 Applications of Ant Colony Optimization

Ant colony optimization algorithms have been applied to many combinatorial optimization problems, ranging from quadratic assignment to protein folding or routing vehicles and a lot of derived methods have been adapted to dynamic problems in real variables, stochastic problems, multi-targets and parallel implementations. It has also been used to produce near-optimal solutions to the travelling salesman problem. They have an advantage over simulated annealing and genetic algorithm approaches of similar problems when the graph may change dynamically; the ant colony algorithm can be run continuously and adapt to changes in real time. This is of interest in network routing and urban transportation systems.

The first ACO algorithm was called the Ant system and it was aimed to solve the travelling salesman problem, in which the goal is to find the shortest round-trip to link a series of cities. The general algorithm is relatively simple and based on a set of ants, each making one of the possible round-trips along the cities. At each stage, the ant chooses to move from one city to another according to some rules:

1. It must visit each city exactly once;
2. A distant city has less chance of being chosen (the visibility);
3. The more intense the pheromone trail laid out on an edge between two cities, the greater the probability that that edge will be chosen;
4. Having completed its journey, the ant deposits more pheromones on all edges it traversed, if the journey is short;
5. After each iteration, trails of pheromones evaporate.

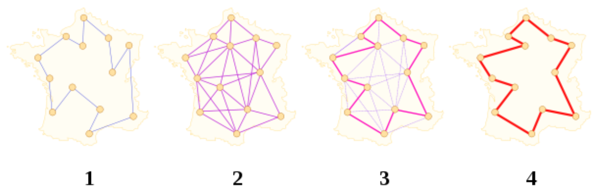


Figure 1.1: Foraging Behavior of Ants

1.5 Mobility Models

The mobility model is designed to describe the movement pattern of mobile users, and how their location, velocity and acceleration change over time. Since mobility patterns may play a significant role in determining the protocol performance, it is desirable for mobility models to emulate the movement pattern of targeted real life applications in a reasonable way. Otherwise, the observations made and the conclusions drawn from the simulation studies may be misleading. Thus, when evaluating MANET protocols, it is necessary to choose the proper underlying mobility model. They play an important role in simulating the Manet protocols and in evaluating the protocol performance. According to the dependence of the movements, these mobility models can be classified in Entity mobility models (independent movements) or Group mobility models (dependent movements). The main Entity mobility models are: Random Walk, Random Waypoint, Random Direction, a Boundless Simulation Area, Gauss-Markov and City Section. On the other hand, the Group mobility models are: Exponential Correlated Random, Column Mobility Model, Nomadic Community Mobility Model, Pursue Mobility Model and Reference Point Group Mobility Model.

In this project, several mobility models have been used in the performance evaluation of ad hoc network protocols.

1.6 Motivation

Reactive routing protocol finds the route from source to destination whenever data request is available at the source, whereas in proactive routing protocol the path to the destination will be established or found at regular intervals of time even without getting the request. AODV is a reactive routing protocol used for discovering the routes. Since reactive and proactive routing protocols have their own advantages, it is better to use both of them at a time, which is known as Hybrid Routing Protocol like AntHocNet. In AntHocNet the route will be discovered in reactive manner and the route will be maintained in proactive manner.

In ad hoc networks, nodes are typically mobile. For instance, nodes can be soldiers of a platoon moving on the battlefield, or members of a rescue squad moving in a disaster area. Thus human mobility plays a major role also in adhoc networks. Mobility models play an important role in protocol performance evaluation, especially when the number of nodes becomes large. Hence, suitable models must be used to deal with the expected network performance through their analysis or simulation.

2. Literature Survey

In recent years, several researches have been made on various ad hoc routing protocols by taking into consideration different metrics as basis for performance evaluation by using different simulators and real-world environment.

Researchers have paid tremendous attention to mobile wireless ad hoc networks. The reason is that MANETs do not require any infrastructure. Thus, they can be quickly deployed. Second, ad hoc networks are self-organizing and self-healing. If a new node is inserted into the network, the network discovers the new node and automatically incorporates it into the network without the need for a system administrator. Likewise, if some nodes fail or leave the network, the network also automatically soon senses this occurrence and re-figures the multi hop graph. As a result, ad hoc networks provide high reliability and adaptability. Multi-hop networks are also scalable to thousands of mobile nodes due to distribution algorithm.

Gianni Di Caro, Frederick Ducatelle and Luca Maria Gambardella, proposed Ant algorithms for distributed discrete optimization. It is an algorithm for routing in Mobile Ad hoc networks. AntHocNet is a hybrid algorithm, which combines reactive path setup with proactive path probing, maintenance and improvement. The algorithm is based on the nature-inspired ant colony optimization framework.

Frederick Ducatelle carried various tests on urban scenario using QualNet simulator. In an extensive set of simulation experiments, he compared AntHocNet with AODV, a reference algorithm in the field. He showed that this algorithm can outperform AODV on different evaluation criteria. AntHocNet's performance advantage is visible over a broad range of possible network scenarios, and increases for larger, sparser and more mobile networks.

In the previous studies on mobility patterns in wireless cellular networks D. Lam, J.G. Markdoulidakis, researchers mainly focued on the movement of users relative to a particular area (i.e., a cell) at a macroscopic level, such as cell change rate, handover traffic and blocking probability. However, to model and analyze the mobility models in MANET, we are more interested in the movement of individual nodes at the microscopic-level, including node location and velocity relative to other nodes, because these factors directly determine when the links are formed and broken since communication is peer-to-peer.

3. Simulations

Parameters	Value
Terrain Size	500*500
Protocol	AODV, AntHocNet
Packet Size	512 bytes
Traffic Type	CBR
No. of Nodes	50,100
Packet Rate	0.5Mbps,2Mbps
Simulation Time	200 seconds
Pause time	0,200 seconds
Maximum Speed	20 m/s
Minimum Speed	5m/s
Maximum Connections	8

3.1 Performance Metrics

3.1.1 Packet Delivery Factor

It is the ratio of data packets delivered to the destination to those generated by the sources. It is calculated by dividing the number of packet received by destination through the number packet originated from source.

Packet delivery factor (%) = (total no. of data packets delivered / total no. of data packets generated) * 100

3.1.2 Average End-to-End Delay

This is defined as the average delay in transmission of a packet between two nodes. This metric describes the packet delivery time: the lower the end-to-end delay the better the application performance.

D = (Tr - Ts) Where Tr = receive time and Ts = sent time

3.1.3 Throughput

It is defined as the total number of packets delivered over the total simulation time.

Average Throughput=(Number of bytes received*8)/(Simulation time x1000) kbps

3.1.4 Routing Overhead

It is the total number of control or routing (RTR) packets generated by routing protocol during the execution. All packets sent or forwarded at network layer are considered as routing overhead. This metric provides an indication of the extra bandwidth consumed data traffic.

Overhead = Number of RTR packets

3.2 ManhattanGrid Mobility Model

Manhattan Grid is proposed to model a city section with streets crossing each other perpendicularly. Therefore, nodes on the streets move only vertically or horizontally on the map. Each mobile node starts from a random point on certain street. The node then chooses a random destination and moves towards this destination within a predefined speed range. Upon reaching the destination, the node pauses for certain time and then repeat the process again. In this model, mobile nodes are allowed to move in to the horizontal and vertical path that crosses each other forming the scenario of the urban area. Nodes are allowed to take turn while moving in predefined path.

Usage example:

bm –f scenario ManhattanGrid –n 100 –d 200 –i 3600 –x 500 –y 500 –u 4 –v 4 –e 5 –h 20 –o 200

Table: Metrics for ManhattanGrid

Protocol	Nodes	Pause time (sec)	Data rate (Mbps)	End-to- End delay (ms)	Routing Over Head	Packet Delivery Factor	Through-put (kbps)
ANTHOCNET	50	0	0.5	261.60	36.652	0.0606	112.97
		200		349.82	41.683	0.0518	113.63
		0	2	123.52	75.872	0.0205	84.62
		200		153.81	127.941	0.0149	47.35
	100	0	0.5	337.25	86.708	0.0343	67.77
		200		287.81	176.195	0.0206	37.40
		0	2	64.069	135.569	0.0228	84.48
		200		138.15	23.136	0.0768	265.16
AODV	50	0	0.5	635.22	0.392	0.2170	344.15
		200		600.70	0.253	0.2372	376.29
		0	2	197.73	0.145	0.1283	253.19
		200		188.71	0.207	0.1009	197.96
	100	0	0.5	596.09	0.656	0.2055	325.82
		200		594.75	1.175	0.1860	295.25
		0	2	209.69	0.586	0.0956	189.10
		200		189.80	0.261	0.1750	342.84

Where -c is speed change probability, -e is minimum speed,-m is mean speed,-o is maximum pause,-p is pause probability,-q is update distance,-s is speed standard deviation,-t is turn probability,-u is no. of blocks along x-axis and -v is no. of blocks along y-axis.

3.2.1 Application of ManhattanGrid Mobility Model

City streets

To calculate the mobility of human in the city streets, the ManhattanGrid model is used. This model uses a grid road topology. It is mainly proposed for the movement in urban area, where the streets are in an organized manner and the mobile nodes are allowed to move only in horizontal or vertical direction.

4. Results in ManhattanGrid Mobility Model

4.1 Varying pause time for ManhattanGrid model

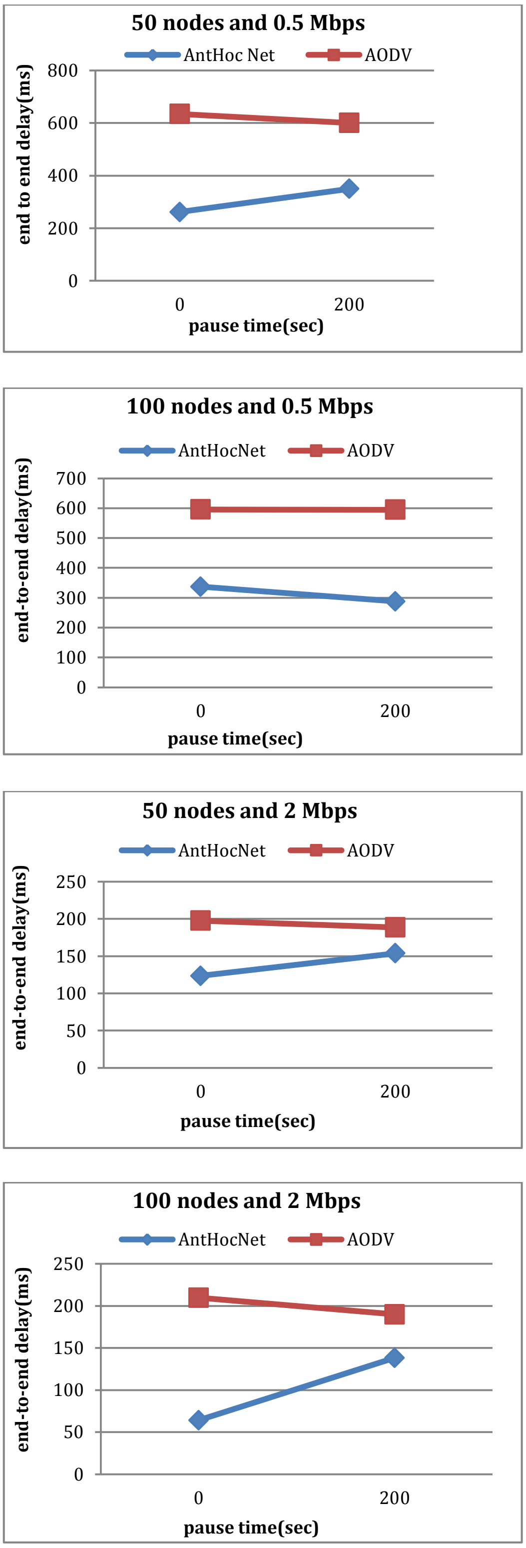


Figure1: End-to-End delay for ManhattanGrid model

From the above figure1, it is observed that AntHocNet has less end-to-end delay than AODV because when pause time increases there is a decrease in the node mobility, therefore network becomes less dynamic.

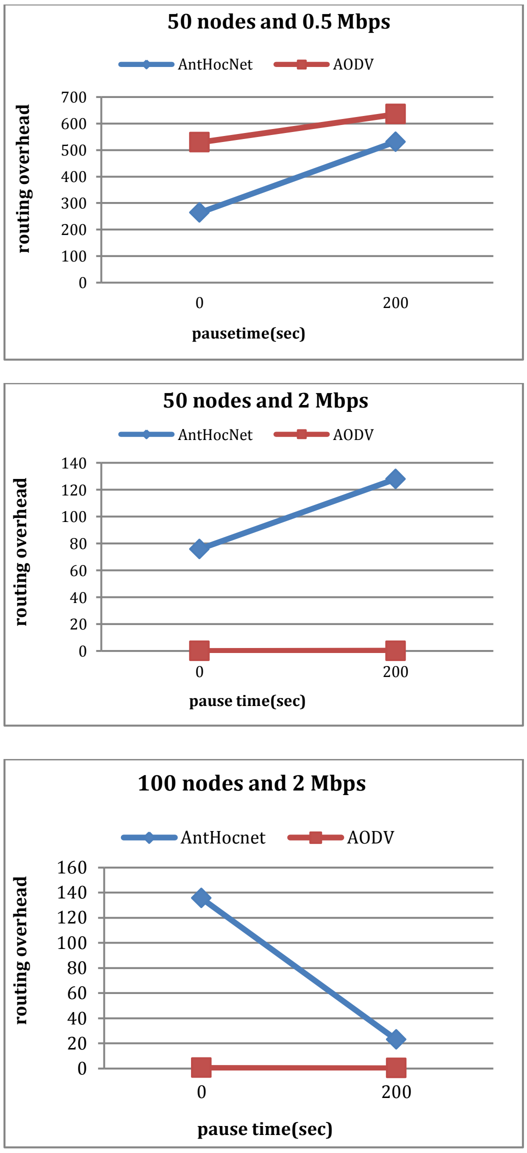
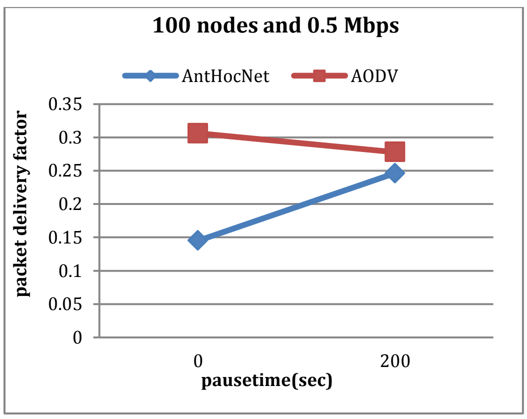


Figure 2: Routing overhead for ManhattanGrid model

From the figure2, it is clear that AntHocNet has more routing overhead than AODV because it has both reactive and proactive route maintenance.



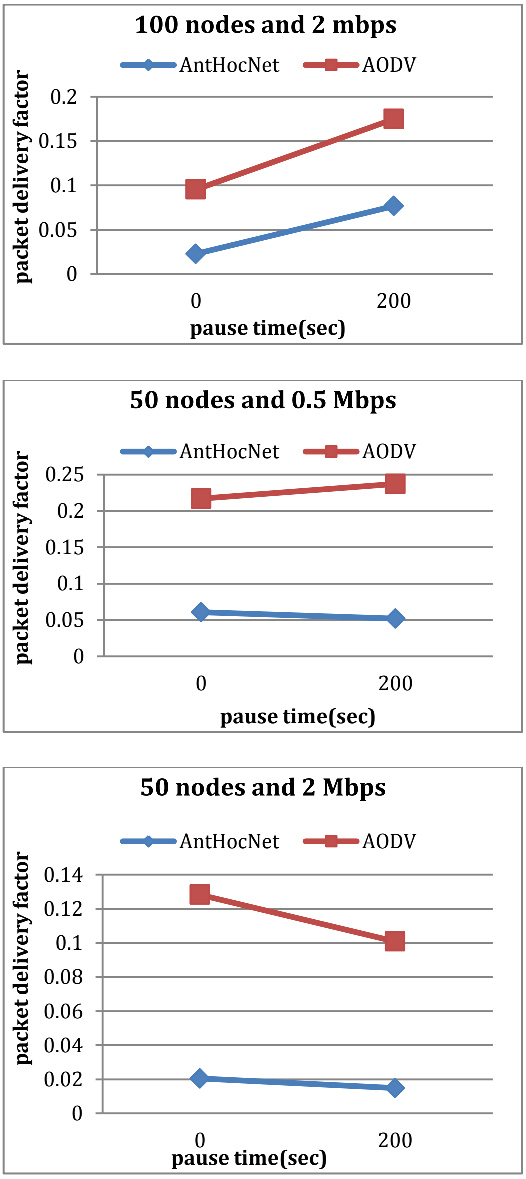
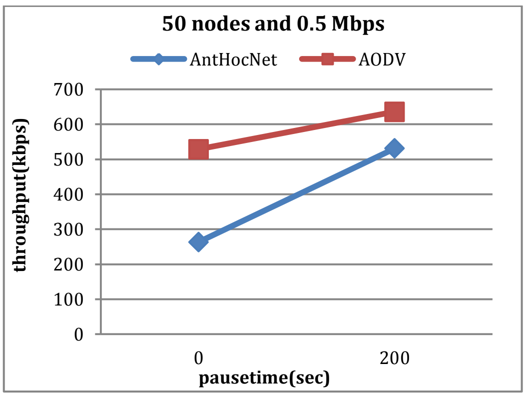


Figure 3: Packet delivery factor for ManhattanGrid model

From the figure3 it is observed that the routing overhead is more for AODV. When pause time is increased up to simulation time AODV outperforms AntHocNet because the node mobility decreases as pause time is increased.



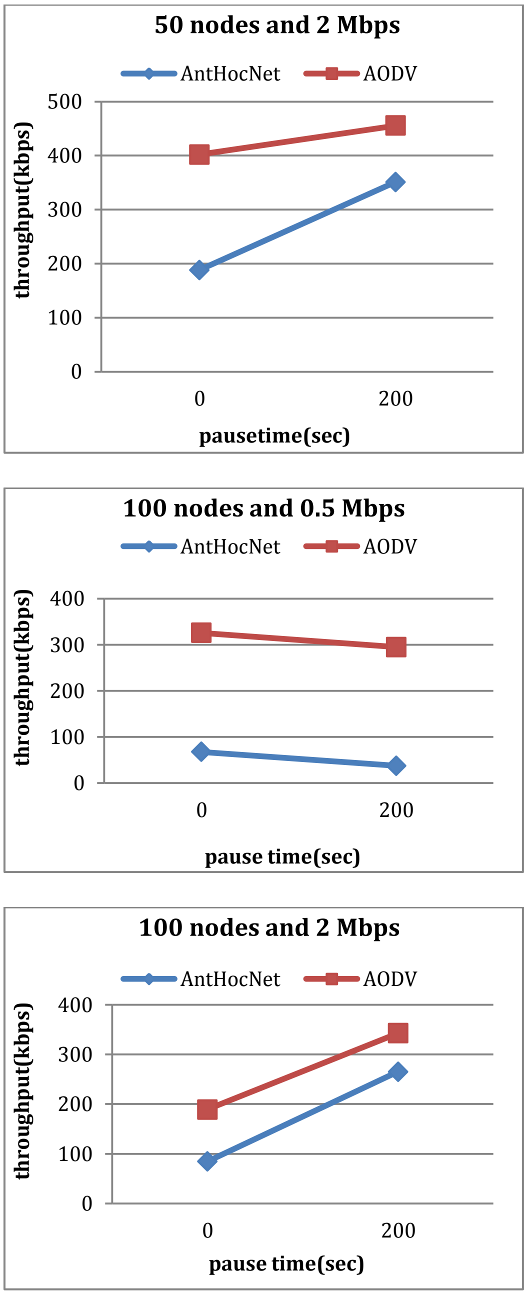


Figure 4: Throughput for ManhattanGrid Model

From the figure4, it is clear that AODV gives better performance in terms of throughput because the expected throughput of AntHocNet decreases as the speed increases because nodes become more dynamic, the route discovery process generates more routing traffic.

Conclusion

The performance of two popular routing protocols AntHocNet and AODV is evaluated by comparing the parameters packet delivery factor, end-to-end delay, throughput and routing overhead. From the results it can be concluded that AntHocNet has higher performance at higher data rates, at higher number of nodes and higher pause time in UDP traffic type.

In case of UDP traffic model results of end to end delay and packet delivery factor shows that AntHocNet's performance is good when compared to that of AODV's by gradually increasing data rates and number of nodes. The routing overhead and throughput shows that AODV's performance is better when compared to that of AntHocNet's at lower data rates.

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