ISSN: 2321-7782 (Online)
Volume 2, Issue 8, August 2014
International Journal of Advance Research in Computer Science and Management Studies
Research Article / Survey Paper / Case Study
Available online at: www.ijarcsms.com

Performance Analysis of AODV and DYMO Routing Protocols in MANETs Using Cuckoo Search Optimization

Jagdeep Kaur[1]
Research Scholar
Department of CSE
RIMT-IET, Mandi Gobindgarh
Fatehgarh Sahib, Punjab – India

Rupinder Kaur Gurm[2]
Assistant Professor
Department of CSE
RIMT-IET, Mandi Gobindgarh
Fatehgarh Sahib, Punjab – India

Abstract: ***Mobile ad-hoc network is a infrastructure less wireless ad-hoc network in which mobile nodes communicate with each other through wireless links without the need of any base station or access point. MANETs has some properties like infrastructure less, decentralized control, dynamic topology. MANETs routing is a challenging task, because mobile nodes are always moves freely and topology changes and sometimes routes are fail and the performance of the network decreases. Cuckoo search optimization (CSO) algorithm is a good technique for developing efficient routing protocols for MANETs. Cuckoo Search artificial intelligence optimization algorithm helps to find the shortest routing path for sending data in MANETs. In this paper, we have discussed AODV & DYMO routing protocols and CSO algorithm. Further we implemented CSO algorithm on AODV & DYMO protocols using NS2 simulator and compared its simulator results with simple AODV & DYMO protocols.***

Keywords: MANETs, Mobile nodes, AODV, DYMO, Cuckoo Search.

I. INTRODUCTION

MANETs is a wireless ad-hoc network in which mobile nodes communicate with each other through wireless links and there is no need of any base station or access point. Wireless networks can be classified as: Infrastructure based network, Infrastructure less network. In infrastructure based wireless network nodes communicate to the Internet by using access points or base stations. For example: Wi-Fi setup in a college where all computers communicate to the internet using access points. In infrastructure less wireless networks nodes communicate with each other through wireless links without the need of access points. For example transferring of data between two mobiles using Bluetooth is an infrastructure less or ad-hoc network [3]. MANET is also an infrastructure less wireless network in mobile nodes communicates with each other without the need of base stations, access points, servers, cables as shown in figure 1.In MANET each mobile nodes acts as a router to forward and receive packets to other mobile nodes in the network. Due to dynamic topology of MANETs some problems occurs like availability of nodes, power and battery lifetime of each node. Some common applications of MANETs are military operations, disaster recovery, and wireless sensor network, remote geographical area where no access points or base stations used for communication [4].

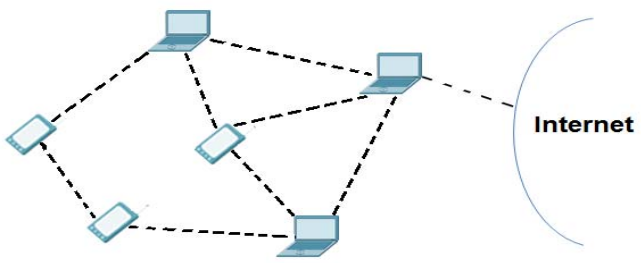

Figure 1: Mobile Ad-hoc Network

In this research paper we focus on the AODV and DYMO On-Demand routing protocols of MANETs. Routing is a difficult task due to mobility of mobile nodes, decentralized control, and dynamic topology. Routing protocol is used for moving packets from source to the destination. Recently the research in the field of MANET routing protocols increases for find efficient path between nodes. Routing protocols can be classified into three categories on the basis of routing strategy: Reactive Routing protocols, Proactive routing protocols, Hybrid routing protocols [3] [4] [9]. The goal of this paper gives the review of on the working of AODV, DYMO routing protocols and Cuckoo search artificial intelligence technique.

This paper is organized as follow. In section II describes the classification of routing protocols in MANET. The section III and IV explains the working of AODV and DYMO routing protocols & CSO algorithm, section V describes the research gap and objectives. In VI section explains the methodology of the work. Finally, in section VII explain simulation environment and results, section VII conclusion and future scope.

II. Classification of Routing Protocols

Routing protocol is the standard of transferring packets from source node to destination node in an internetwork. The routing process transfers packets on the basis of routing tables which records the route information of mobile nodes. Each node acts as router for transferring packets from source to destination. The routing tables are stores in the router or node memory and very important for efficient routing. The routing protocols can be classified into three categories on the basis of routing strategy: Reactive (On-demand) routing protocols, Proactive (Table-driven) routing protocols, Hybrid (Reactive & Proactive) routing protocols [4] [15]. Figure 2 shows the classification of MANETs routing protocols.

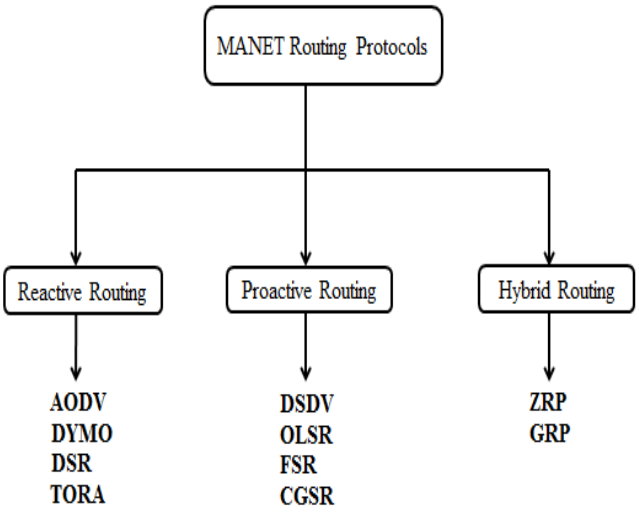

Figure 2: Classification of MANETs Routing Protocols

A. *Reactive or On-demand Routing Protocols*

Reactive routing protocols are also called On-demand routing protocols because route is only constructed when nodes want communication with each other. If any node wants to send data to other node then reactive routing protocol start searching route in an on-demand manner and construct a connection for sending and receiving data. The main goal of on-demand routing protocols is to minimize the network traffic overhead. Route discovery and route maintenance processes are used to communication between any nodes in the network [3]. Some common examples of reactive or On-demand routing protocols are the following:

- AODV (Ad-hoc on-demand routing protocol)
- DYMO (Dynamic MANET On-demand protocol)
- DSR (Dynamic Source Routing)

● TORA (Temporary Ordered Routing Algorithm)

B. Proactive or Table-driven Routing Protocols

Proactive routing protocols are also called table-driven protocols because each node periodically maintains routing information to every other node in the network. The routing tables are periodically updated when topology of the network changes. In proactive protocols source node does not need of route discovery process for find the route to the destination. Proactive protocols require more power and bandwidth for transferring of updated routing information; the main limitation is the chance of creating loops within the network increases [13]. Some common examples of table-driven or Proactive routing protocols are the following:

● DSDV (Destination Sequenced Distance Vector Routing Protocols)

● OLSR (Optimized Link State routing Protocol)

● FSR (Fisheye State Routing Protocol)

● CGSR (Cluster head Gateway Switch Routing Protocol)

C. Hierarchical routing protocols

Hierarchical routing protocol is also known as hybrid routing protocol because it combine the features of reactive and proactive routing protocols. The main advantage of hybrid routing protocol is that the proactive routing used for small distance and reactive routing used for long distance. Routes overlapping and longer delay are the main disadvantages of hybrid routing protocols, and nodes consumes more memory and battery [13]. Some common examples of hybrid routing protocols are the followings:

● ZRP (Zone Routing Protocol)

● GRP (Gathering-based Routing Protocol)

III. WORKING OF AODV & DYMO ROUTING PROTOCOL

In this section we focus on explaining the working of AODV and DYMO routing protocols.

A. Working of AODV routing protocol

Ad-hoc On-demand Distance vector (AODV) is a reactive or on-demand routing protocol. In AODV route is only constructed when it is need. It is a combination of two routing protocols DSR and DSDV. It borrows route discovery and route maintenance features from DSR and borrows hop-by-hop routing feature from DSDV. AODV removes loop problem because it uses sequence number for each route request message. It uses Route Request (RREQ), Route Reply (RREP), Route Error (RERR) control messages to find a path from source to destination [10].

1. AODV Route Discovery process

In route discovery process, when any node wants to communication with other node first it checks its own cache and if it find route entry of the destination node address then it start communication with destination node, if not find route entry then it broadcast RREQ message throughout the network.

As shown in figure 3 source node 1 sends RREQ message to its neighbors 2, 3 nodes. Neighbor nodes 2, 3 checks destination route entry in its own cache, if they find destination node address then give reply to source node 1 and if not find then broadcast the RREQ packet to other neighbor nodes till it reaches the destination node 6.

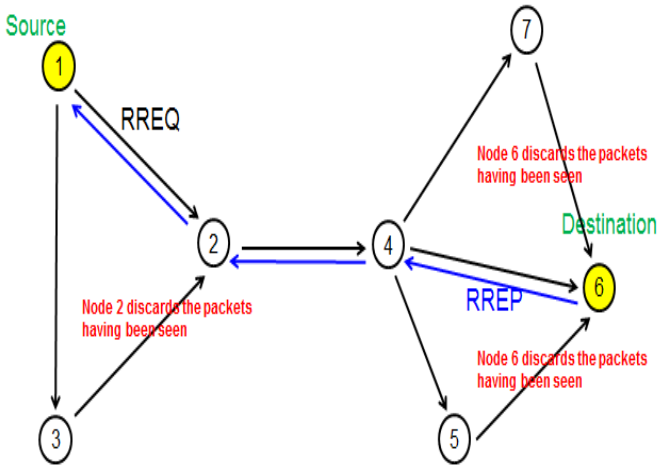

Figure 3: Route Discovery Process via RREQ & RREP message

When destination node 6 receives RREQ message then it unicast the RREP message back to the requesting source node. When RREP message reaches to a source node 1, then route is established to the destination node 6. Now source node 1 starts communication with destination 6 after establishing a path.

2. AODV Route Maintenance Process

AODV established route using Hello messages, for detecting the neighbor nodes is in range or not. When any node detects the link failure in an active route, then error message RERR is generated by node and multicast this message to those nodes which are related with route failure. After receiving this message the nodes updates its routing tables and removes the entry of affected route.

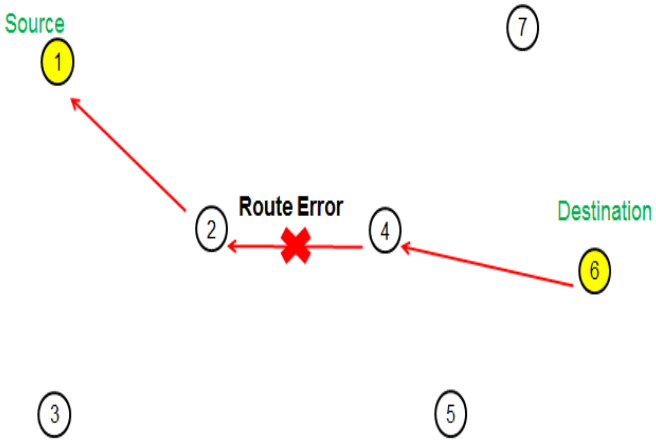

Figure 4: Route Maintenance Process via RERR message

The link from destination node 6 to node 4 is failure as shown in figure 4. Then error message is send to the source node 1, remove the route entry to the destination from routing table and reinitiate route discovery process.

B. WORKING OF DYMO ROUTING PROTOCOL

Dynamic MANET On-demand (DYMO) is a reactive or On-Demand, multihop unicast routing protocol. It is an enhancement of AODV protocol and also called AODVv2. Path accumulation is a new feature of DYMO protocol. DYMO does not use unnecessary HELLO messages and work according to sequence numbers assigned to the packets and it is a loop free protocol [1]. DYMO consists of the following two routing operations.

1. DYMO Route Discovery Process

Route discovery process of DYMO protocol is similar to AODV protocol but one new feature is path accumulation. Route discovery process for DYMO protocol is shown in figure 5. If source node 1 wants to communicate with destination node 6,

first it checks route entry to the destination node in routing table if not find route, then it broadcast the RREQ message to neighbour nodes. When node broadcast RREQ message throughout the network, then each node will attach its address to the RREQ message. As shown in figure 5 each node that broadcast RREQ message makes a note of the backward path. Finally, when destination node 6 receives RREQ message, then it generate RREP message and sends it in backward path and followed path accumulation process.

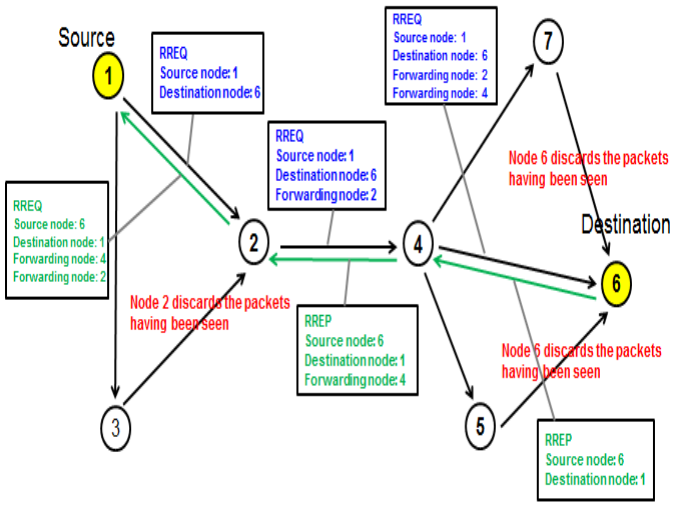

Figure 5: DYMO Route Discovery Process

This makes sure that the forward path is built and each node knows the path to the other nodes along the path. DYMO protocol special feature is that it is energy efficient protocol. If any node has low energy then this node not participate in the route discovery process and node doses not forward any RREQ message for route discovery process and see only the incoming RREP message and update routing table in future use [5].

2. *DYMO Route Maintenance Process*

In route maintenance process RERR message is generated by node when link failure occurs in the created path and multicast RERR message to those nodes which are concerned with the link failure. Each node updates its routing tables after receiving this message and deletes the routing entry of broken link. Now source node stop sending data through this path and reinitiate new route discovery process if needed [1].

IV. CUCKOO SEARCH OPTIMIZATION ALGORITHM

Cuckoo Search optimization (CSO) is an artificial Intelligence algorithm developed by Xin-She Yang and Suash-Deb in 2009. It is a different algorithm which is inspired by the obligate brood parasitism of some cuckoo species by laying their eggs in the nests of other host birds of other species. Due to breeding behaviour of Cuckoo search can be applied for various optimization problems. It is more efficient algorithm as compare to Genetic algorithm and Particle Swarm Optimization algorithm [6].

Cuckoo Search is based on three idealized rules:

- Each cuckoo lays one egg at a time and dumps its egg in a randomly chosen nest.
- The best nests with high quality of eggs will carry over to the next generation.
- The number of available hosts' nests is fixed, and the egg laid by a cuckoo is discovered by the host bird with a probability Pα. The worst nests are discovered and dumped from further calculations [8].

Cuckoo Search in the case of MANET Routing Protocols:

Cuckoo Search (CS) is used in MANET for finding shortest path from source to the destination. This artificial intelligence optimization is applied to nodes in MANET. Due to Cuckoo Search intelligence source node find the best node means shortest path node that easily with consuming less time send data to the destination node. Cuckoo search algorithm avoids congestion in the route and finds shortest path. It increases the energy efficiency, life time and Quality of Service (QoS) of the network.

V. RESEARCH GAP AND OBJECTIVES

In MANETs routing protocols the existing research work is related with comparison between reactive, proactive, hybrid routing protocols. Further research work is done on issues like security, energy consumption, traffic, Quality of Service (QoS). But, there is very less use of Artificial Intelligence techniques in case of MANETs routing protocols. So, we use Cuckoo Search Artificial Intelligence Algorithm for improving the performance of MANETs routing protocols.

The objectives of this research work are the following:

- Enhance the performance of AODV and DYMO routing protocols by using Cuckoo Search Optimization Algorithm.
- Cuckoo Search Optimization Algorithm used to avoid the congestion in the route.
- Proposed Cuckoo Search Optimization Algorithm based MANET improves the QoS of the network and energy efficiency.
- Comparison of proposed Cuckoo Search Optimization Algorithm based MANET with simple AODV and DYMO routing protocols.
- Analyses the proposed solution using Network Simulator-2 (NS-2) under different network parameters like throughput, End-to-End delay, Packet Delivery Ratio, Routing Overhead.

VI. METHODOLOGY OF THE WORK

The Methodology involved in this research is of three phases:

1. **Deep Investigation:** In this phase literature review is done to achieving reliable results and excellent efficiency of the problem solution.
2. **Designing and Development:** In this phase proposed solution considered based on the analysis of the simulation results.
3. **Modeling and Simulations:** Simulation is the process of modelled the behavior of the network by calculating the interaction b/w the different network components using mathematically formulas. The simulation process can be modelled by using Network Simulator (NS2) simulator.

The following Diagram shows the flow of research work.

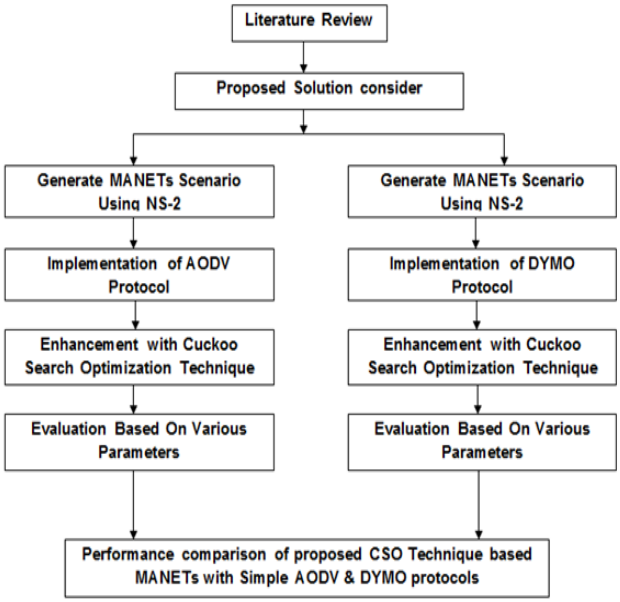

Figure 6: Flow of research work

VII. Simulation Environment and Results

A. *Simulation Environment*

Simulation are done to compare the routing protocols i.e. AODV, DYMO and proposed Cuckoo Search Optimization Algorithm based AODV, DYMO protocols. For performance comparison Network Simulator-2.34 is used. NS 2.34 is a open source and free network simulator software. It is discrete event and object oriented network simulator. It uses C++ programming language to implement a design of protocol but not easy to be visual & graphically shown the design and uses OTcl language to control the simulation scenario, schedule the events. The protocols are implemented using C++ language in the backend and TCL scripting language in the frontend. Trace file record the result of the .tcl script after execution in the network simulator. Network Animator (.nam file) used to records all visual events that happened during the simulation. The simulation parameters are summarized in table1.

Table 1: Simulation Parameters

Simulation Parameters	**Values**
Network Simulator	NS 2.34
Routing Protocols	AODV, DYMO
Algorithm	Cuckoo Search Optimization Algorithm
Channel	Wireless Channel
Area	1000m X 1000m
Traffic Type	CBR, TCP
Minimum Velocity	2 m/sec
Maximum Velocity	20m/sec
Packet Size	512 bytes
Number of Nodes	50 nodes
Simulation Time	200 sec
Propagation Model	Two-Ray Ground
Mobility Model	Random-Way
Antenna Type	Omni Antenna

B. Simulation Results

The following performance metrics have been used to analysis the performance of routing protocols:

1. Packet Delivery Ratio (PDR)

It is the ratio of amount of data packets received by the destination and total number of data packets sends by source. The routing protocol which has better PDR that protocol is best and efficient and provides good performance.

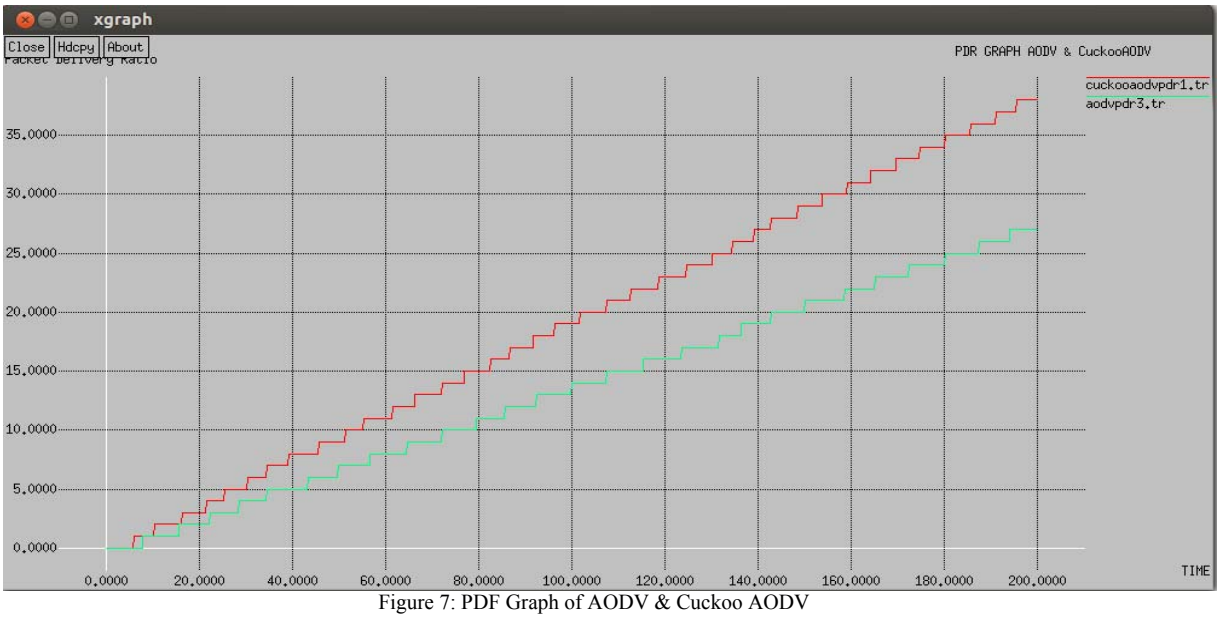

Figure 7: PDF Graph of AODV & Cuckoo AODV

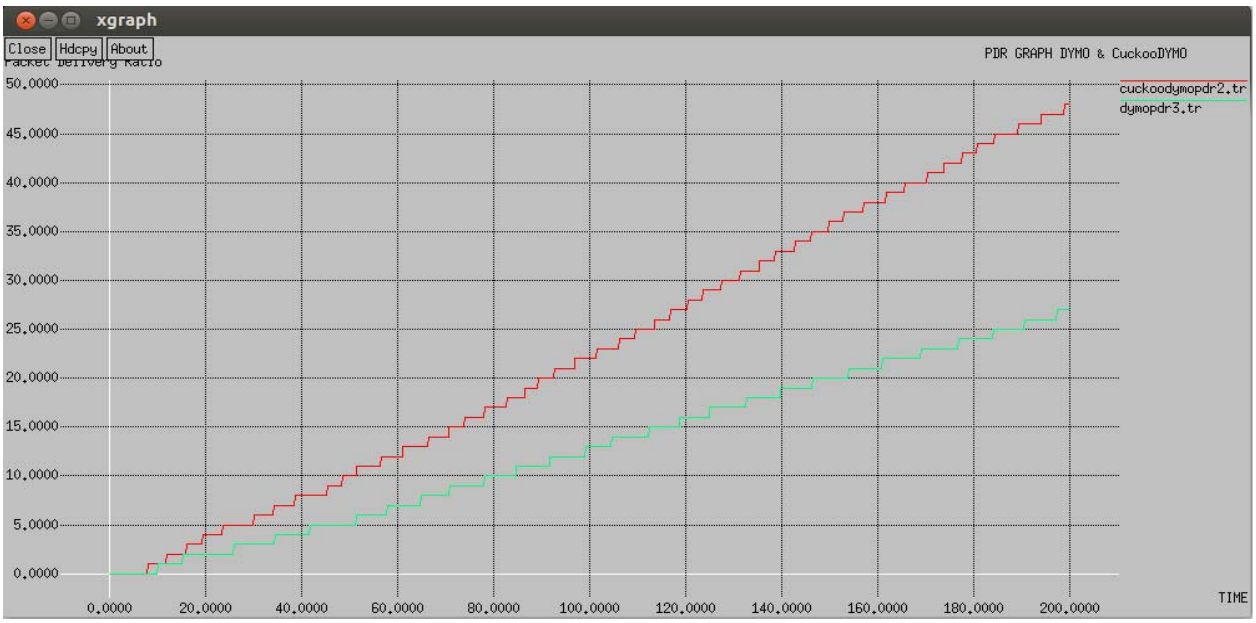

Figure 8: PDF Graph of DYMO & Cuckoo DYMO

The packet delivery ratio (PDF) of AODV and DYMO protocols with Cuckoo Search Optimization algorithm is higher as compare to simple AODV & DYMO routing protocols.

2. *End-to-End Delay*

It is the interval time between sending data by source node and receiving data by destination node. The routing protocol which takes less time for sending data from source to destination node is better protocol and provides good performance.

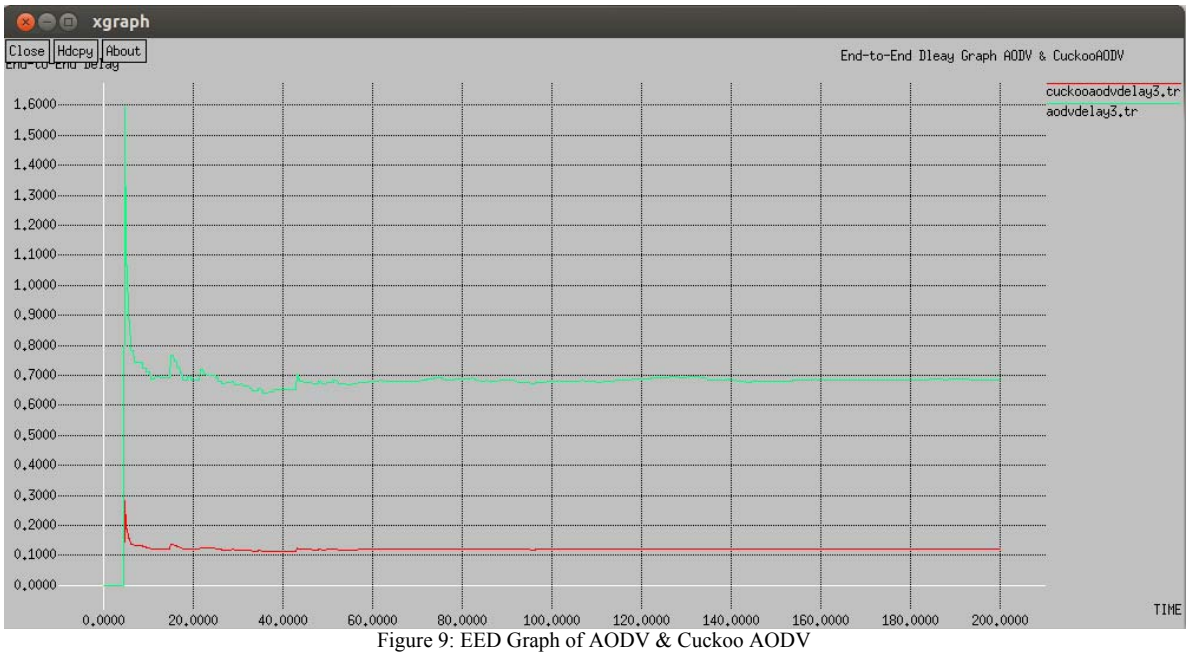

Figure 9: EED Graph of AODV & Cuckoo AODV

Figure 10: EED Graph of DYMO & Cuckoo DYMO

The End-to-End Delay (EED) of AODV and DYMO protocols with Cuckoo Search Optimization algorithm is less as compare to simple AODV & DYMO routing protocols. So, the performance of cuckoo search based AODV & DYMO routing protocols is better as compare to simple AODV & DYMO.

3. Energy Consumed

It is the energy that consumed by each node in the network during simulation process. The routing protocol which consumes less energy is best and efficient protocol.

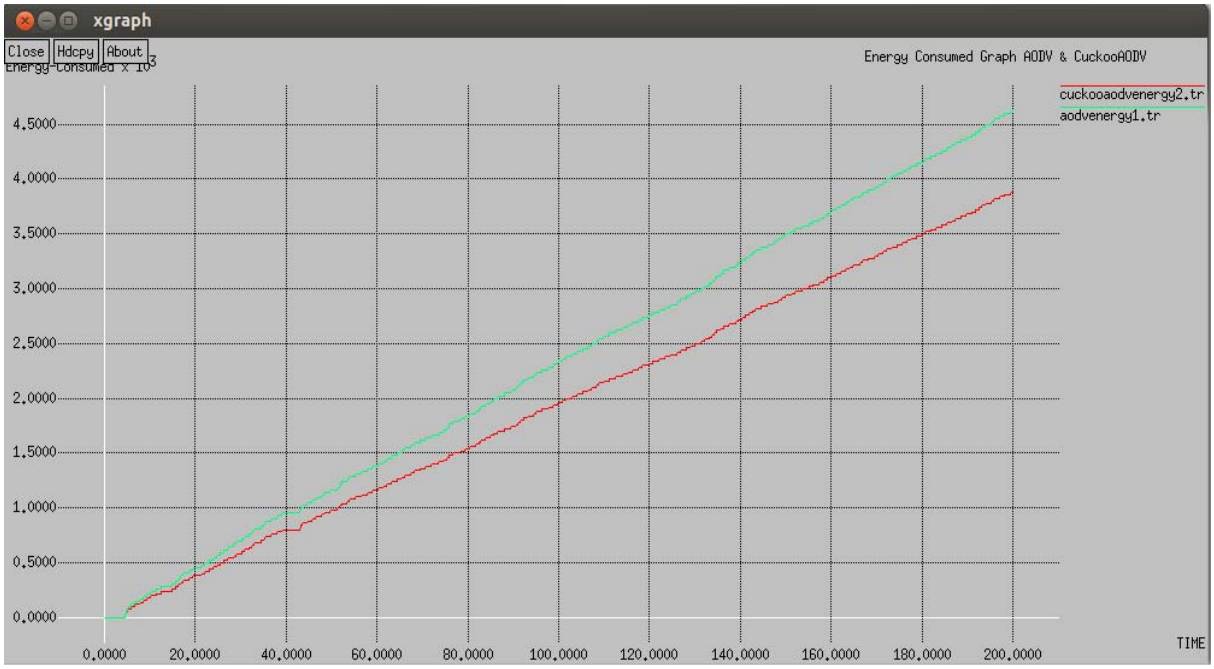

Figure 11: Energy Consumed Graph of AODV & Cuckoo AODV

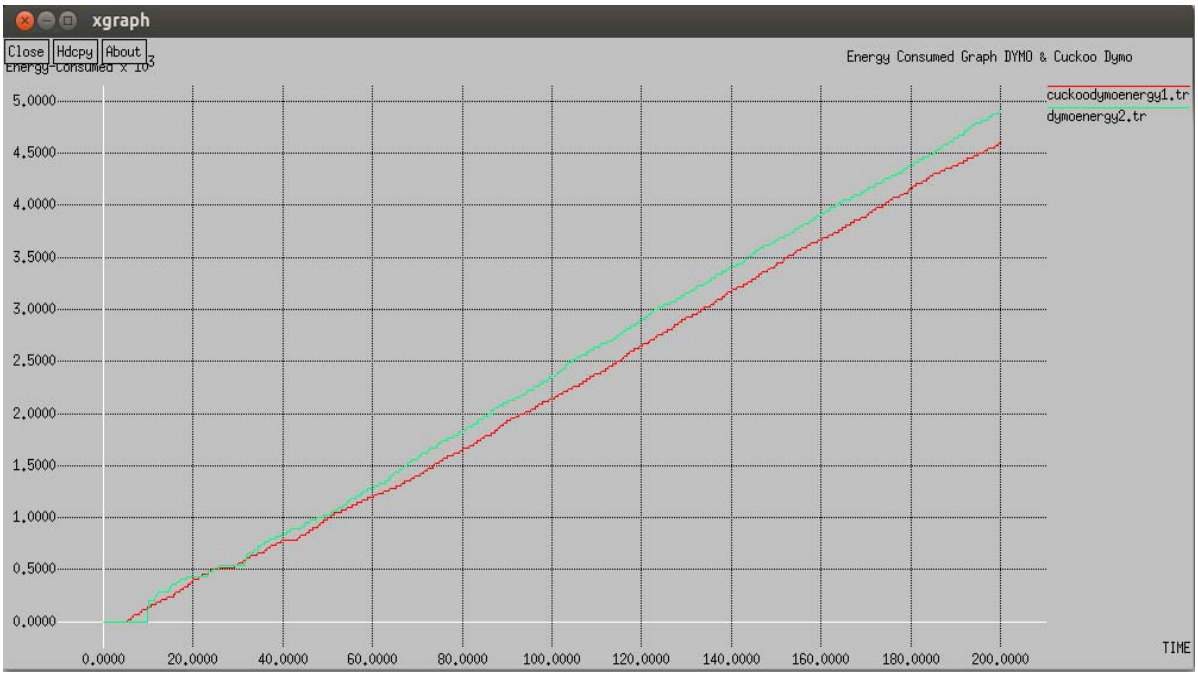

Figure 12: Energy Consumed Graph of DYMO & Cuckoo DYMO

The Energy Consumed by AODV and DYMO protocols with Cuckoo Search Optimization algorithm is less as compare to simple AODV & DYMO routing protocols. So, the performance of cuckoo search based AODV & DYMO routing protocols is better as compare to simple AODV & DYMO.

C. Simulation Result Table

The following table 2 shows the results of routing protocols:

Table 2: Simulation Result

ROUTING PROTOCOLS	AVERAGE PACKET DELIVERY RATIO	AVERAGE END-TO-END DELAY	AVERAGE ENERGY CONSUMED
AODV	13.8	0.854	2.34
AODV Cuckoo	19	0.146	1.94
DYMO	13	0.606	2.34
DYMO Cuckoo	21.2	0.294	2.21

D. Performance Comparison

The following graphs show the comparison of routing protocols:

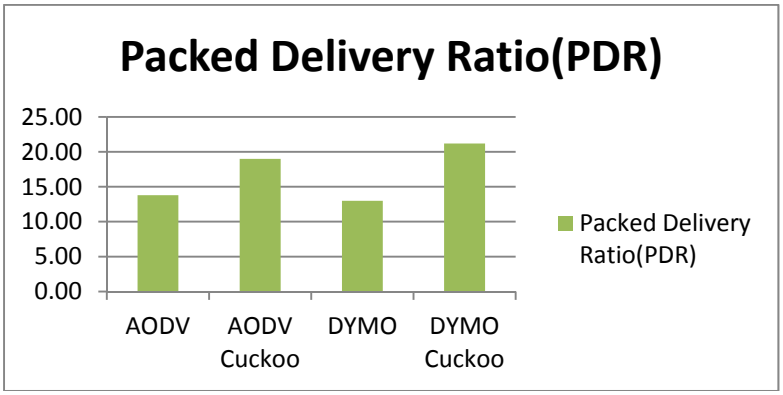

Figure 13: Packet Delivery Ratio Comparison

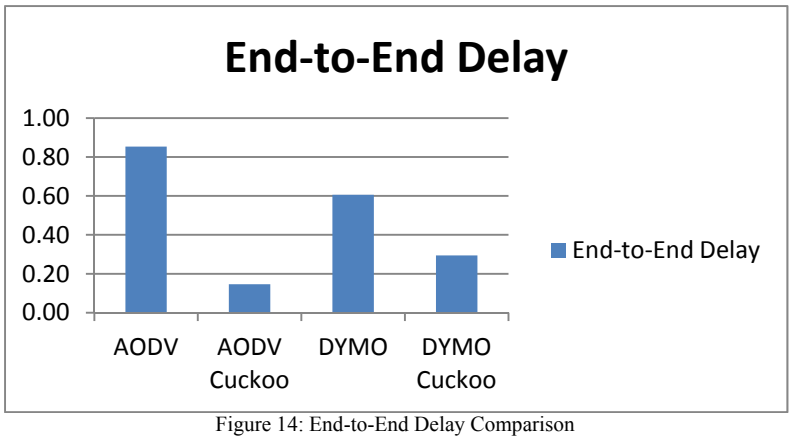

Figure 14: End-to-End Delay Comparison

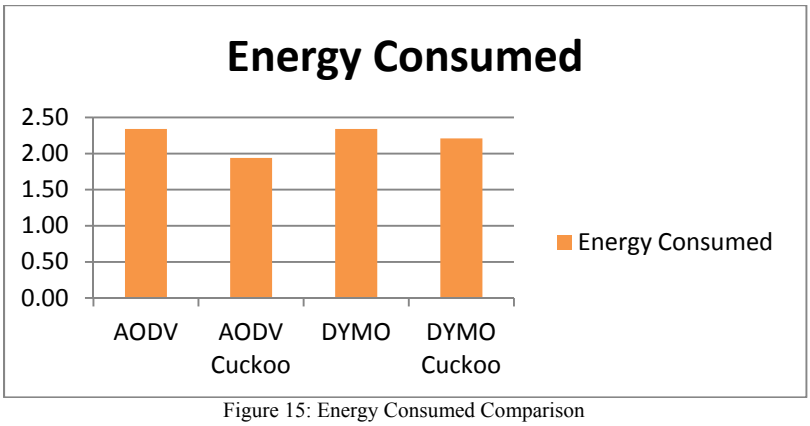

Figure 15: Energy Consumed Comparison

VIII. Conclusion and Future Work

In this paper, we have successfully simulated the AODV & DYMO based on Cuckoo Search Optimization Algorithm and analyzed the performance using various simulation metrics. Cuckoo Search Optimization algorithm find shortest path from source to destination and reduce congestion in AODV & DYMO routing protocols. CSO algorithm has also improved energy efficiency, life time and Quality of Service (QoS) of the routing protocols. Packet Delivery Ratio is higher, End-to-End Delay is less, Energy consumed is low in case of cuckoo search optimization algorithm based AODV and DYMO as compare to simple AODV & DYMO routing protocols. In future we can improve the performance of AODV and DYMO protocols by combining CSO algorithm with other artificial intelligence techniques such as Genetic algorithm, Particle Swarm optimization algorithm, ant colony algorithm. We hope this paper will helpful for researchers who are working for AODV and DYMO protocols.

Acknowledgement

This research work is completed with help of parents, faculty members and colleagues for their continuous support and encouragement. I would like to thank Mrs. Rupinder Kaur Gurm for her valuable guidance and advice.

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