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Routing Optimization Using Swarm Algorithm in Mobile Ad Hoc Networks

A Thesis

Submitted to the Department of Computer Science, College of Computer Science and Information Technology, University of Anbar as Partial Fulfillment of the Requirements for the Degree of Master of Computer Science.

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Dedicate

To my kind father : my role model and My idol in Life , he is the one who taught me how to live with dignity and honor.

To my compassionate mother : She is the epic of love and the joy of a lifetime , I can't find words that give her her due , an example of dedication and giving.

To my wife and companion , the highest symbol of loyalty and sincerity.

To my brother : my arms and share my joy , and sorrows

To my children , lover of my liver.

To all friends.

I dedicate my scientific research to you.

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Abstract

Several advancements in Mobile Ad hoc Networks (MANET) due to the enormous utilization of mobile sensors in the market and it is the huge collection of nodes that can communicate directly or indirectly. Therefore, it grasps the attention of numerous researchers in the research field behalf of its dynamic nature of the network. There are several research issues and challenges in the MANET such as node mobility, optimization problem and network efficiency so on. Further than, all these challenges, optimal path finding is considered most crucial issue in MANET. Because of imbalanced path, fixing the consumption of energy is dramatically increased in MANET network for the reason of dynamic network mobility. During the process of communication between the source node and the destination node, Imbalance path fixing increases the network delay, reduces the packet delivery ratio, reduces the network throughput and increases the packet loss that leads to accept the overall Quality of Service (QoS) of the network. Captivating these challenges into account, these study work mainly concentrated on proposed a new protocol with successful optimal path finding with optimization model.

This thesis proposed a new routing protocol for MANET namely Lion Optimization Routing protocol (LORP) which are mainly based on AODV protocol to generate the pride by gather all possible path by RREQ, and Lion Swarm Algorithm that is one among the set of bio-inspired algorithms which is used to find the best possible path for data transmission between the source and the destination. The general routing processes are Route Request, Route Reply, Error Finding, Hello Message processes are taken from ad-hoc on demand routing protocol, and mainly to find the best path, the Lion Optimization Algorithm is used.

The optimization technique divided into two steps that are Maximization Algorithm and Minimization Algorithm. The major parameters that are used in Maximization Algorithm are Power Efficiency, Throughput, and Packet Delivery Ratio. The parameters that are used in Minimization Algorithm to select the best path are Delay and Short Path. The evaluation of the simulation is carried out in

Network Simulation (NS2 -2.34) and it is discussed elaborately. In these study three scenarios have been used which are 25nodes, 50nodes and 100nodes. The performance of the proposed protocol is calculated and then compared with another protocols such as Ad hoc On Demand Vector Routing (AODV), Dynamic Source Routing (DSR) and AntHocNet. The parameters that are concentrated for comparison are packet delivery ratio, end-to-end delay, packet loss and network throughput. The gathered results show that the proposed protocol performs are better than another protocols in terms of packet delivery ratio , End-2-End delay and network throughput and it greatly helps to improve the overall QoS of the MANET network.

Keywords: Lion Optimization Routing Protocol (LORP), AODV protocol, Throughput, Packet Delivery Ratio, Delay, Lion Algorithm.

Table of Content

List of Table

List of Figure

Abbreviations

ACO	**Ant Colony Optimization**
AODV	**Ad-Hoc On-Demand Distance Vector**
BRP	**Border cast Resolution Protocol**
CBR	**Constant bit rate**
CRCPR	**Constructive-Relay-based CooPerative Routing**
DCFP	**Dynamic Connectivity Factor Routing Protocol**
DCRM	**Dynamic cloudlet-assisted routing mechanism**
DSDV	**Destination Sequenced Distance Vector**
DSR	**Dynamic Source Routing**
ESCT	**Evaluation Self-Cooperative Trust**
FTP	**File transfer protocol**
IARP	**Intra Zone Routing Protocol**
IERP	**Inter-zone Routing Protocol**
LMax	**Lion Maximization**
LMin	**Lion Minimization**
LOA	**Lion Optimization Algorithm**
LORP	**Lion Optimization Routing Protocol**
MANET	**Mobile ad-hoc network**
NS2	**Network Simulation 2**
OTcl	**Object Tool Command Language**
PDR	**Packet delivery ratio**
QOS	**Quality of services**
RAN	**Real Ants in Nature**
RREP	**Route Replay**
RREQ	**Route Request**
SOS	**Self- Organizing Systems**
TTL	**Time To Live**
VANETs	**Vehicular Ad hoc Networks**
VBR	**Variable bit rate**
WRP	**Wireless Routing Protocol**
ZRP	**Zone Routing Protocol**

Chapter One
General Introduction

Chapter One

General Introduction

1.1 Introduction

Wireless communication system has reached top heights in its diversity of applications worldwide. Hasty commitment of independent mobile users has become an effective area of development in wireless communication systems. Emergency search, release mission, disaster respite efforts, mine site operations, conferences, and automated classrooms are some of the examples of diverse mobile applications. Combined networks of such users are termed as Mobile Ad hoc Network (MANET). These kinds of networks is infra-structure less. Each node in the network changes its position correspondingly. This result in high active topology triggering cracked wireless links. The routing in ad hoc networks has been an active area of research and in earlier years, quite a lot of decisive routing protocols have been presented for MANETs. Node mobility, constrained physical security, and limited amount of resources are the major challenges tackled by MANET.

Routing, multicasting, pricing structure, transport layer protocol, security, self-organization, disposition consideration, and scalability are some of the vital features which could distress the performance and design of MANET [1]. The activity of intermediary nodes should be trusted equally to initiate new routing path and make routing protocol of MANET to function in an effective manner. These nodes will function as per the protocol rules. In MANET operation system, believing any intermediate node to function as per the protocol is an important subject of issue. This is mainly due to the dynamic nature of the network. Also these nodes incessantly join or leave any network with respect to connectivity and mobility. There are several disadvantages of MANETs. As following :

- Securing broadcast wireless communication in an un-trusted environment
- Nodes initiating own routes
- Un-static network topology [2]

In MANETs numerous technical issues are also challenged by security protocol designers. Some of the reasons behind the occurrence of technical issues are: crucial resource restraints in memory size, bandwidth, computational power, and unique wireless features such as openness to intrusions, absence of definite ingress and exit points, security threats, susceptibility, unreliable form of communication, and fast changes in topologies or because of node failure [3]. Even though MANETs are adopted for their availability of technological advantages, real-world deployment of MANET is restrained due to several troubles. The huge advancements in technology are exclusively dependent on multimedia based services. The true prospective of MANET could provide these services in case effective protocols are not suitable [4]. Different services, functions, context inclined services were recommended by MANET operation. In an instance where attacks are prone to occur, the primacy is assigned to maintain precise operation of effective services. Appropriate services necessitate capacities and guaranties in encouraging abrupt delivery even in presence of attacks, or failures. Services in MANET are divided into two main categories, specific services and general services [5]. Resolving connectivity concern does not satisfy MANET adoption because its major goal is to exchange or transfer data among mobile users. Service discovery is demarcated as a progression of allowing networked units to:

• Promote their services

• Enquiry about services provided by other entities

• Select the most suitably matched services

• Summon the services [6].

Artificial swarm intelligence is a distributed self-organized system used to solve many problems. Swarm intelligence1 is inspired from the collective behaviour observed in natural systems such as insect societies. Ant Colony Optimization (ACO) is an artificial ant algorithm that mimics the behaviour of the real ants and is widely used to solve optimization problems. ACO makes use of groups of independent artificial ants who are able to communicate with each other through an indirect pheromone-based communication [7]. Ants work cooperatively and share their solutions with each other using pheromone

intensity on each link. This work usually leads to good solutions to problems. Lion optimization algorithm in another type of swarm algorithms which simulates the different natural behavior which tace the behavior of lion in the nature to optimize the routing by selected the best path.

Swarm intelligence uses different types of mobile agents in order to optimize network performance. These autonomous agents have the capability to search, maintain, cooperate and adapt network parameters. Swarm intelligence is motivating techniques which is used to address MANETs routing (8).

The nodes present in a MANET networks are not linked to any power supply source. This might become a knotty issue. Elevating power source in MANET networks has been a highly substantial task while power controlling in MANET is an intricate task. Some of the drawbacks of these networks are high consumption of power, ineffective spatial reuse, and compact Quality of Service. These drawbacks can be overruled by developing a Medium Access Control (MAC) scheme. This MAC sends the data at a least required power estimated to manage the nodes disturbed in that position. This progresses the spatial reuse by allowing as many instantaneous connections probable to happen in an area [9]. The power utilized for transmission cannot be attuned for supporting applications with diverse performance desires in upcoming MANETs. Ignoring the problems of medium contention and interference the former work deliberates special MANETs. Hence, the theoretical outlines of these regions are not found to be suitable for performing energy consumption analysis and packet delivery ratio [10].

MANET requires independently self-organizing kind of campaigns. While almost all wireless communication networks today hinge on centrally deployed expensive hub and spoke networks. This kind of self-organizing abilities makes them well suitable for environs and conditions of pre-defined network infrastructure going out of service. One of the application scenarios is disaster zones in which the communication among the rescue workers, and medical staff needs to be recognized in terms of devastation of network substructure. Moreover, the vehicular applications have given birth to development of Vehicular Ad hoc Networks (VANETs) [11].

1.2 Related Works

This section reviews the related work with respect to routing algorithms and approaches in MANET**. Iborra and Cano**.(**2016**) [12] proposed a novel opportunistic routing protocol called it JOKER working in an opportunistic routing protocol, to address between QoE in multimedia transmissions and energy consumption. Claiming enhances the energy efficiency of routing protocols by employing candidate selection and coordination phases. This work also claimed to perform better than the BATMAN routing protocol, when dealing with multimedia data. On the other hand, the measurement and evaluation did without adding extra overhead.

Subramaniam etal.(**2016**) [13] proposed a new protocol that has been referred to as the Dynamic Connectivity Factor Routing Protocol (DCFP) which relies on neighborhood nodes for MANET. which probes the network status by considering the network connectivity. The suggested DCFP addresses the preset variables also, they claimed the DCFP simulation results show outperforms better than the NCPR as well as the Ad-hoc On-demand Distance Vectors (AODV) in facilities such as normalized routing overhead, end-to-end delay, energy consumption, MAC collision, packet delivery ratio, and network connectivity, depending on its new mechanism for minimizing the redundant RREQ. The DCFP performance compared against AODV and they claimed that it is more efficient concerning the energy efficiency and packet delivery rate. Also, the evaluation of speed and varying error rates does not exist.

Selvi and Manikandan.(2016) [14] proposed an ant-based multi-path backbone routing mechanism for the load balancing in the MANET. In the case where a source wishes to send data toward a destination, it will select the multiple routes with a maximal likelihood of the path preference with the use of the swarm-based ant colony optimization method. The probability of the path preference has been calculated on the basis of the availability of the next-hop, bandwidth, and delay. Throughout the discovery of the route, nodes are subjected to the faults that are found and the relevant path will be discarded. After that, the load of the network on routes has been balanced by an index with every one of the backbone nodes for the equal distribution of the traffic of the data on links between the source and the

destination. According to the results of the simulation, the authors have shown that the suggested approach has resulted in reducing the load on the network.

Hussein.(2017) [15] has proposed a new hybrid approach combining ant-colony optimization and lion optimization to improve path selection depending on energy efficiency and the performance metrics of each node. They introduce ALEEP schema based on an eligible energetic path to determine the best path. His schema estimates the distance between the source node and destination node then alters the power of the transmission for each node in the network. The combination of the ant-colony and lion optimization makes the solution consuming more resources.

Gao and Zhang .(2017) [16] proposed an innovative and efficient dynamic cloudlet-assisted routing mechanism (DCRM) for MANETs. They build a temporary file for recording the information on the route that happened between nodes at a certain time. Also, there approach considered as small data to centers, sharing sets of related tables, and the transaction mechanism between them (i.e. the cloudlets). The cloudlets are the small data Centre's and by utilizing these cloudlets the mobile devices establish routes.

Ramesh. (**2018**)[17] has proposed an energy efficiency routing solution. This solution based on trust metrics and lion optimization algorithm to detect the best route for data transmission depending on the energy factor. This solution depends on the node energy as the main trusted metrics. In some cases, other metrics such as the short path and delay had more influence in the path selection more than power metrics.

Pate etal.(2018) [18] proposed a new attack pattern discovers the transmission route based on a trusted routing scheme. This work performs a sensitive analysis of TRS-PD which is done using the differentiation parameters in the distinct scenarios of the network in the presence of 3 distinct attacks of the packet dropping. They perform a sensitive analysis of the routing scheme by varying the parameters using three different packet dropping attacks.

Chintalapalli and Ananthula .(2018) [19] proposed (M-LionWhale) a multi-objective model meant for presenting a secure routing scheme using optimization. This work performing a hybrid optimization algorithm, called M-

LionWhale, to secure routing. Consider a mix between the Lion optimization algorithm (LA) and whale optimization algorithm (WOA) to select the optimal path of transmission. They claim that their approach takes to account many quality of service (QOS) parameters, like distance, energy, link lifetime, trust, and delay.

Sait et al .(2018) [20] proposed a new routing approach on the basis of fuzzy petri nets and ant system is presented for MANET. This approach computes the minimal investment with reasonable capacities for routing traffic. The routing model is computed by the fuzzy synchronized petri net and the decision of the routing is made with the help of a synchronized fuzzy transition approach.

Sun, et al .(2018) [21] introduced an innovative protocol of Constructive-Relay-based CooPerative Routing (CRCPR). Depending on stored topological information and maintaining in a CooPerative Table also the Relay Table, CRCPR protocol. This work manages itself by establishing relays to forward data. The routes are selected by considering the energy harvesting and link break probability.

Cai, and Chong .(2019) [22] proposed a heavy simulation using an Evaluation Self-Cooperative Trust (ESCT) schema in MANETs. In their work, they evaluate the performance of ESCT schema under many routing attacks. The evolutionary self-cooperative trust mimics the cognitive process of humans and the trust information of nodes is taken into account to deal with different attacks. The trust information collected from the sensor nodes are interchanged between them and are analyzed with the help of cognitive judgment.

Zade.(2020) [23] has proposed a new optimization approach used for transferring the data packets based on the honey bee's intelligence to communicate each other in the form of dancing language that can be useful for finding the shortest route in the wireless networks and also in optimized way of path finding.

Ragavan and Ramasamy (2020)[24] proposed a hierarchical cluster based on routing scheme by implementing Lion Optimization (LO) algorithm. The evolution and performance process is analyzed in terms of average latency, packet delivery rate, network lifetime, and energy consumption. The experimental algorithm indicated such a good result when compared to the existing approaches. As a result, Quality of Services (QoS) is increased rapidly .

Saranraj et al (2021)[25] proposed a new cluster-based data aggregation technique based male lion optimization algorithm (DA-MOMLOA) for evaluating the network based on distance, delay, density, and energy. The results were shown promising and better outcomes as it significantly raises the network efficiency and decrease the packet drop owing to a smaller number of aggregation procedure.

Table 1.1. Summary of related Works

Author Name	Year	Methodology and Description	Results
Sanchez-Iborra and Maria-Dolores Cano	**2016**	Proposed A novel opportunistic routing protocol called it JOKER working in an opportunistic routing protocol, to address between QoE in multimedia transmissions and energy consumption.	Their research claimed to perform better than the BATMAN routing protocol, when dealing with multimedia data. BATMAN where able to receive high results compare to JOKER-ACK and JOKER- timer. Their proposed method obtained 2.4 during the static mode and 1.92 with dynamic. In contrast to JOKER-ACK and JOKER- timer obtained 2.37 and 2.35 in static mode respectively. Moreover, it acquired 1.8 similarly in association with dynamic mode.
Ejmaa, et al	**2016**	Suggested a new protocol that has been referred to as the Dynamic Connectivity Factor Routing Protocol (DCFP) which relies on neighborhood nodes for MANET.	The DCFP performance compared against AODV and they claimed that it is more efficient concerning the energy efficiency and packet delivery rate. Simulation results indicated that DCFP achieved and outperformed both AODV and NCPR in regards with normalized routing overhead end-to-end delay, network connectivity, packet delivery ratio, and energy consumption due to its original mechanism for decreasing redundant RREQ. The average number of neighbors received 12.827 in association with 300 nodes.
Selvi and Manikandan	**2016**	Developed an ant-based multi-path backbone routing mechanism for the load balancing in the MANET.	According to the results of the simulation, the authors have shown that the suggested approach has reduced the load on the network. Their research illustrated the total delay of QAMR, AMBRLB, and NC-AOMDV methods for different number of flows scenario. It is confirmed that the delay of their proposed AMBRLB approach has 61 and 70% of less than QAMR and NC-AOMDV approach, respectively.
Sameer Abdulateef Hussein	**2017**	Introduced A novel hybrid approach combining ant-colony optimization and lion optimization to improve path selection depending on energy efficiency and the	The combination of the ant-colony and lion optimization makes the solution consuming more resources. The study obtained 61.05 (10 nodes) in association with AODV based on packet delivery ratio, while received 106.5 (10 nodes) depends on Remaining Energy.

		performance metrics of each node.	
Li et al	**2017**	Proposed An innovative and efficient dynamic cloudlet-assisted routing mechanism (DCRM) for MANETs.	The cloudlets are the small data Centre's and by utilizing these cloudlets the mobile devices establish routes. The empirical results demonstrated that DCRM can save time and more energy, and show more improvements than the network paradigm without the proposed mechanism. As a result, the authors attempts to enable cloud to offer several services that are more realistic for the future mobile network applications.
Ramesh	**2018**	Proposed An energy efficiency routing solution depended on trust metrics and lion optimization algorithm to detect the best route for data transmission depending on the energy factor.	The author indicated that, the short path and delay had more influence in the path selection more than power metrics. The best route in comparison with all possible routes is choose by the LO algorithm, which is a bio-inspired algorithm. Their proposed approach increased lifetime of the network. The performance is analysed in regards with packet, average latency, delivery rate, network lifetime , and energy consumption.
Jhaveri et al	**2018**	Introduced a new attack pattern discovers the transmission route based on a trusted routing scheme.	They perform a sensitive analysis of the routing scheme by varying the parameters using three different packet dropping attacks. The outcomes show that distrust threshold is a critical component of any trust-based scheme. At the same time control packet drop ratio and data packet drop ratio can provide equal significance during data transmission process.
Chintalapalli and Ananthula	**2018**	Proposed (M-LionWhale) a multi-objective model meant for presenting a secure routing scheme using optimization.	They claim that their approach takes to account many quality of service (QOS) parameters, like distance, energy, link lifetime, trust, and delay. their proposed model achieved the total maximum performance with throughput of 0.2966 kbps, 24.1313% residual energy, and PDR of 0.3051 at maximum simulation time.
Kacem et al	**2018**	Introduced a new routing approach on the basis of fuzzy petri nets and ant system is presented for MANET.	The decision of the routing is made with the help of a synchronized fuzzy transition approach. The achieved results illustrated the effectiveness of the proposed synchronized Fuzzy Ant System (SynFAnt) protocol in comparison to 4 protocols. The selected SynFAnt routing protocol enhances the end-to-end delay, the throughput, the acceptance rate of the QoS flows, and the packet delivery ratio.
Bai et al	**2018**	Proposed An innovative protocol of Constructive-	The routes are selected by considering the energy harvesting and link break probability.

		Relay-based CooPerative Routing (CRCPR).	The obtained Simulation experimental results show the robustness of CRCPR against node mobility with significant enhancement for up to 40% prolonged network lifetime and 60% network throughput.
Cai et al	**2019**	proposed a heavy simulation using an Evaluation Self-Cooperative Trust (ESCT) schema in MANETs In their work, they evaluate the performance of ESCT schema under many routing attacks.	The trust information collected from the sensor nodes are interchanged between them and are analyzed with the help of cognitive judgment. Simulation results confirmed that ESCT scheme ensured the routing effectiveness and promoted network scalability in association with presence of routing disruption attackers in MANETs.
Zade	**2020**	has proposed a new optimization approach used for transferring the data packets based on the honey bee's intelligence to communicate each other in the form of dancing language	The proposed approach shows out performance for the effective and efficient data communication in terms of packet delivery ratio and throughput in the MANET's as compare to the swarm's Ant colony optimization
Ragavan and Ramasamy	**2020**	The authors proposed a hierarchical cluster based on routing scheme by implementing Lion Optimization (LO) algorithm. The evolution and performance process is analyzed in terms of average latency, packet delivery rate, network lifetime, and energy consumption.	The experimental algorithm indicated such a good result when compared to the existing approaches. As a result, Quality of Services (QoS) is increased rapidly with SDN depend on routing optimization of proposed algorithm .
Saranraj et al	**2021**	The authors proposed a new cluster-based data aggregation technique based male lion optimization algorithm (DA-MOMLOA) for evaluating the network based on distance, delay, density, and energy.	The empirical results were shown promising and better outcomes as it significantly raises the network efficiency and decrease the packet drop owing to a smaller number of aggregation procedure.

1.3 Problem Statement:

A Mobile Adhoc Network (MANET) is a dynamic topography based infrastructure less network model which consists of a collection of huge number of nodes which independently transfer the information from source to the destination. MANET network controls maximum of the confidential applications such as military, commercial and education based applications. There are some of the shortfalls are present in MANET network also due to the dynamic nature the frequent issues are imbalance path fixing, recurrent topographical changes, bandwidth limitation and large energy consumption which leads to affect the overall QoS of the network [12] , [18].

Several earlier approaches suffer from that issue from handling one of the weaknesses and ignore them. The statement of the problem is that how to design an adaptive approach which has the ability to handle all those challenges of the MANET network based on the QoS metrics depending on LION optimization algorithm to select the optimal path during the process of data transmission from the source to the destination.

1.4 Thesis Objectives

The aim of this thesis is to propose a new routing protocol to select the best path for data transfer with the help of the QoS metrics calculation and the Lion Swarm Optimization Algorithm.

The main objectives of the research are listed below:

- To develop a routing algorithm in order to find the best path using Lion Optimization Algorithm (LOA) to transfer the data from the source to the destination.
- To verify the impact of packet loss, energy consumption and latency, packet delivery ratio and network throughput which leads to improve the quality of selected path.

1.5 Thesis structure

The presented thesis consists of 5 chapters. The introduction and related work have been provided in chapter one to the entire thesis. In the next section a brief description of each chapter contents will be provided:

Chapter Two: [Technical foundation] presents the theoretical background and basic concept of MANETs and Swarm Algorithms focus on the LOA Algorithm selection procedure.

Chapter Three: [design and implementations] explains the steps of the suggested approach and techniques used. A whole description of the suggested approach is given.

Chapter four: [simulation and comparisons] presents the simulation that has been implemented to estimate the approach performance. Then a comparison between the existing approach and the proposed approach has been provided also.

Chapter five: [Conclusions, Future Works] concludes the thesis, explores directions for future work, and limitations of this research and the technology have been used.

Chapter Two
Technical Foundation

Chapter 2

Technical Foundation

2. Introduction

Duo to the rapid development filed of wireless networking technologies, MANET Mobile Ad-hoc Network become a major field in research and development. MANET considered a promising field under research and development in a wireless network.

In recent years, MANET becomes the most animated and dynamic field in networking and communications. This fame gained from the movable devices that increased significantly. MANET collecting portable devices such as smartphones, laptops, sensors act, connecting them through links in a wireless manner, and cooperate in a distributed state for providing the functionality of the network in a dynamic infrastructure[26]. Such network type, which operates as a separate network or with a single or several attachment points to the Internet or the cellular networks, has paved the way for a wide range of the new interesting applications.

MANET is one of the wireless categories that do not need any infrastructure to work, there is no central control or authority, also all nodes in the communication process act as transmitters as well as receivers with no determination of the topology nor infrastructure.

Those devices communicate with each other for the purpose of offering an essential network function in the appearance of movable devices in a distributed status. MANET creates a way for a variety of innovative and stimulating applications in the independent functionality connecting several points to the internet or cellular networks[27]. Routing the packets from sender to destination done using the cooperation of the MANET nodes. The communication in MANET achieved to the nearest (the transmission in the range of source). In this case the destination easily reaches, otherwise in the case where the destination is outside the range the source node need help from its neighbors to receive the packet and forward it to the destination node.

This procedure shows that each node in MANETs behaves as a router[26]. Links in MANET are bidirectional. That means different nodes have the ability to

communicate and maintain their mobility at the same time these advantages count as the core of MANET strong and weak point at the same time since all nodes in MANET are independent and moving freely, meaning that the MANETs is independent infrastructure.

So, transmission in MANET nodes is limited relay on transmission between the source and destination nodes at the same transmission zone or not, if they were at the same transmission zone the communication and the transmission occur, otherwise the intermediate nodes takeover the transmission process and join between source and destination nodes. Intermediate nodes divided among two main types: (Single Hop Communication) and (Multiple Hop Communication).

This depends on being at the radio range, in the case where both the source and the destination lie on the same area of the radio transmission. They communicate without any intermediate node (Single Hop Communication), otherwise, they should communicate depending on the intermediate node (Multiple Hop Communication). In that case, the intermediate node help, in sending the messages to their destination.

Networks functionality act in a way that they do not depend on anything else or they connect to a network like an internet. These huge networks contain many (Multiple Hop Communication) MHs, which use their wireless links to communicate among them, without the need for any support of communication. Also, this can be called Multi-Hop Wireless networks or mobile radio networks[28].

In this section, the aim is to introduce the MANET characteristic, Metric, and Advantages.

2.1 MANET Properties

MANET has several important properties that difference from traditional network. and be listed as follows:

1- Dynamic Topology

The arbitrarily changing of a node in MANET topology makes the topology dynamic. This arbitrary changing variation from the traditional wired networks. Comes with pros and cons, the pros such as MANET simplicity, overcome tight places. On the other hand the advantages of the traditional network (wired) are reliability, cost, and speed.[4]

The dynamic topology circumstances create problems such as breakage linking, also the radio range transmission limitations, enforce wireless links to become unpredictable and unstable. So the operation of maintaining and discovering the route between source and destination creates a big challenges. As shown in Figure 2.1, partitioning and route establishment.

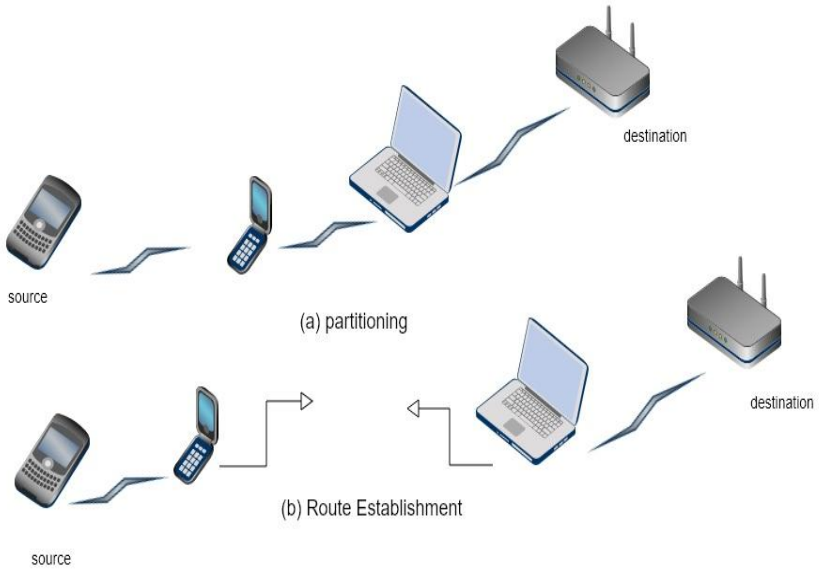

Figure 2.1 dynamic topology[28]

2- Link Issues

MANET as a wireless network depends on time and location, fading signals, interferences of multipath, also the lower capacity. All of these issues increase the possibility of congestion. In addition, consideration of bandwidth, delay, and unpredictability of link quality. Together make a big challenge faced the MANET networks.[4]

3- Energy Limitation

MANET devices depend heavily on batteries or other power suppliers. Taking in to account the frequent recharging and battery changing making a big challenge due to undesirable or impossible to overcome. Many research, protocols, or approaches try to find the best solution for this manner and to achieve energy efficiency. They proposed many solutions depending on different layers like the physical layer, network layer, link layer, and transmission layer[29].

4- Error Problem Faced broadcasting channel

The problem of the hidden and exposed terminals are frequently issuing in MANET. As illustrated in Figure 2.2 , where Figure (a) illustrate the hidden terminal problem, this problem occurs if node A and C stay out of reach and send simultaneously to node B, node B may collide packets and thereby drop by node B. The exposed terminal problem shown in Figure (b). As demonstrated node B transmit to A, while node C must defer the transmission for the node D even in the case where this type of the transmission doesn't disturb the process of the reception in the node A. RTS/CTS acknowledgment and hand-shake in the 802.11 has resulted in the partial solving of the problem of the hidden terminal at a cost of the reduction in the throughput.

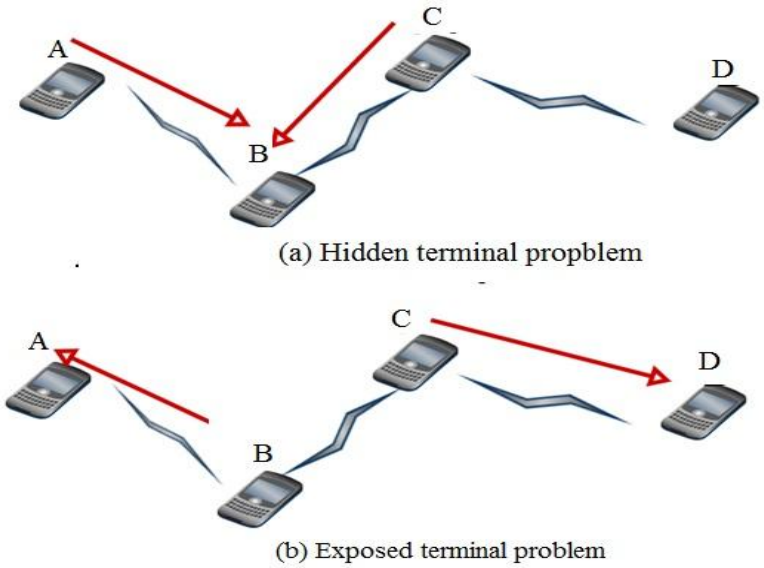

Figure 2.2 Error problem[29]

5- Bandwidth Obstacle

In the case of comparing the wired networks and MANET networks, the node in MANET resulting in low bandwidth comparing to a wired network. This due to the heavy dependence of nodes in MANET on wireless communication and routing protocols. This type focus on maintaining and discovering path more than the packet itself.

6- Resource Limitation

When the resource limitations in MANET nodes come to surface this always relative with some power requirements. In other words, the main resources for MANET nodes are power. According to that issues, many routing protocols focus on the routing path with efficient power conservation.

7- QOS Limitation

Same to resource limitations the routing protocol must handle QOS limitations. What that means, in cases such as multimedia application, which require more bandwidth and more attention on traffic. These cases like multimedia discussed before. A routing protocol must take control over issues such as poor performance, latency, and so on.[6]

8- Security

Unfortunately, MANET inherited the wireless network security issues. The open environment deployment makes routing protocol Exposed to several attacks, such as key distributed, DOS attacks, and so on[30].

2-2 MANET Applications

Frightening [31] increase of portable device beside the advantages of communication over wireless networks, MANET networking becomes an important depends on the significance expanding of across the board applications in multi fields such as business administration, military applications, and personal use. Portable MANET Networks make the access and exchange of data easiest without any constrains on infrastructure or geographic position. Meaning on and off to the network in any place without the heavy configuration, just connect and enjoy[32]. MANET network used in several applications as shown in figure 2.3.

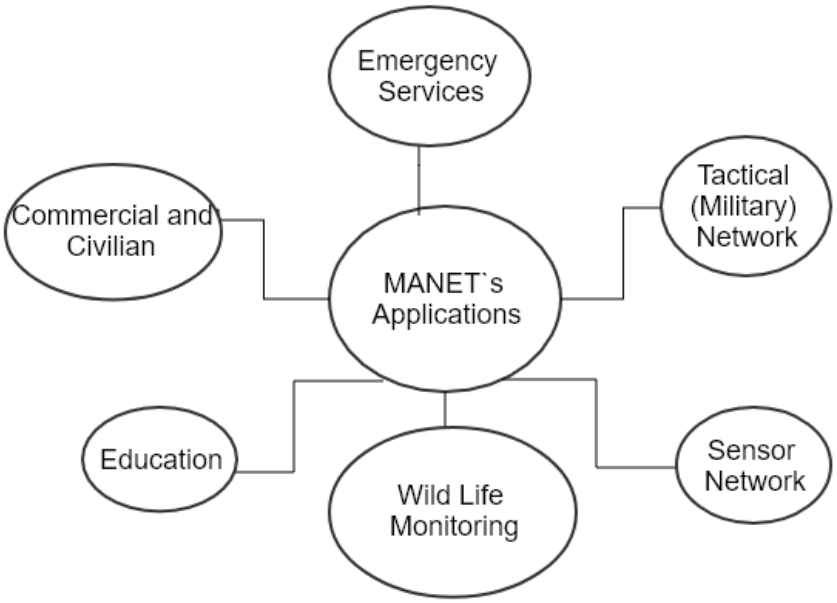

Figure 2.3 MANET application

2-3 Routing Protocols in MANET

In contrast to the wired networks, MANET routing creates distinctive and new challenges. The design process of the protocols of routing in the MANETs requires addressing numerous problems. Those issues have been characterized and classified in the MANET routing protocols. After that, the concept of the protocols like Dynamic Source Routing DSR, AODV, DSDV, and so on, have been explained in the next sections. The advantages and disadvantages of this protocol have been characterized. In this section, will conclude a summary on the MANET routing[24].

2-3-1 Classification of the Routing Protocols

Many classifications were proposed according to routing protocol methodology such as Multicast, Geographical routing, and Energy-aware. Research consensus routing protocol is the appreciate classification for MANET routing protocols, which classified into three main groups according to the network topology [33]. These groups' are proactive, reactive, and hybrid protocols, as illustrated in Figure 2.4.

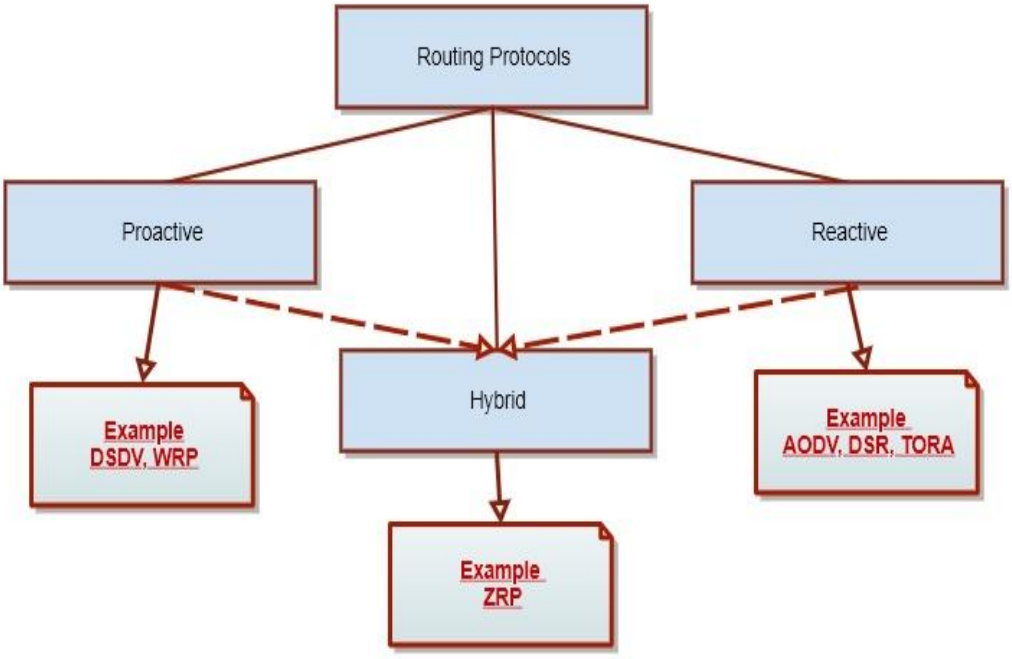

Figure 2.4 routing protocols[34]

- **Table Driven or Proactive Protocols** [34]**:** These groups of routing protocol collecting and maintaining path between nods in the table every period time with or without the nodes to send or receive. In other words, this type of routing protocol continues updating the information of the network. The most popular of this group is the Destination Sequenced Distance Vector. This routing protocol keeps in touch with all updates in the network, which decreases the delay and quickly identifies the destination status. That means more packet or hello packet to send and receive decreasing the network throughput. In the next section, we discuss this routing protocol with more details.
- **Reactive Protocols**: which are referred to as on-demand as well. From its name, we can conclude that the broadcast happened in the case where a source node wants to send some packet to the destination node. In other words, there is no need for updated broadcasting which minimizes the packet flood and decreases the relay[35]. But on the other hand, when the communication is up to happened to send a huge broadcasting packet to maintain and discover paths. That causes congestion. An example of this routing procedure is Ad-hoc On-demand Distance Vector (AODV) routing protocol. Also, DSR which is Dynamic Source Routing is following this procedure to maintain and discover routing paths[36].

- **Hybrid Protocols**: A combination of pro and reactive routing protocol presented by this procedure for detecting and collecting routing paths. *ZRP* (Zone Routing Protocol) hybrid model example. *ZRP* divides the network into multi-zone each zone with a specific area count as a sub network. Each zone generates information about the node in it. And take benefits of the pro and reactive routing protocols. ZRP cons illustrated on the extra information that requires more resources[37].

2-3-2 Destination Sequenced Distance Vector (DSDV) Routing Protocol

The Distributed Bellman-Ford algorithm [19] is the base of the DSDV protocol. Thus it inherits the main characteristic of the DBF algorithm which maintains the information table of neighbor nods. These maintenances include the next node, path, and distance to reach the node of the destination depending on the number of nodes in each path. The definition sequence destination or destination sequence refers to the destination which is identify using updated to determine a particular path avoiding routing loop. In case there are two paths equal in the sequence number, the path, which has the shortest path distance will be advertised. The sequence number is increased upon each update. In a periodical manner, each node broadcasts its table to its neighbors to maintain and update the network infrastructure. Two ways to update the table either through a full dump or vis incrementally. An incremental update happened in case there is not any major change in the network infrastructure. But the full dump required in case there is a significant change happened or in case the incremental process needs more Network Packet Data Unit.

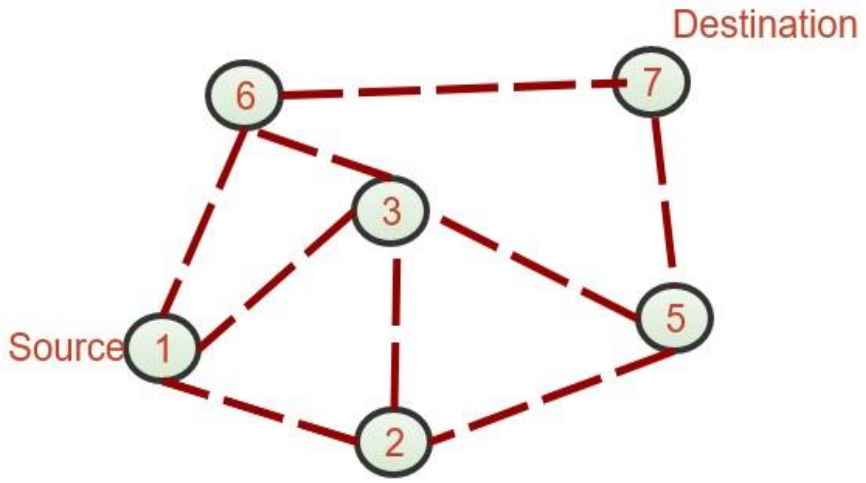

Figure 2.5 An illustration of network topology[19]

To make more comprehension of the routing mechanism using DSDV protocol let have an example. Suppose to have the node illustrated in Figure 2.5 is to determine the network table between these nods. The illustration of the node in the network in Figure 2.5 shows the real structure of the network topology. represented each node info table this table maintains the route between nodes in this network in the establishment process. If a link breaks the end node of that break link establish a new routing table with an updated message assigned the broken link to infinity. Each node, in turn, broadcast the updated message to the neighbor. The broken link represented as an odd sequence number and an ordinary link by an even number of the sequence. In case node1 wants to send a message to node7, it will check the neighbor of the next hop which is node2, then send the packet.

Table 2.1 network topology table

Destinations	Next hops	metrics	Sequence numbers
1	-	0	S10_1
2	2	1	S410_2
3	3	1	S33_3
5	2	2	S67_5
6	3	2	S21_6
7	4	2	S82_7

What happen if node 7 moves. In Figure(2.6) an illustration provided for more comprehension in case of node 7 moves. Links 6-7 and 5-7 are broken. Immediately a new info table will be generated. Table 2.2 shows the reorganized modification of node 7, node 4 modifies its table then sends a new broadcast to all other nods containing the new info table. This eventually reaches node1 so to communicate with node7. Node1 changes next hop to become 6, metric, and sequence number entry in the routing table for 7.

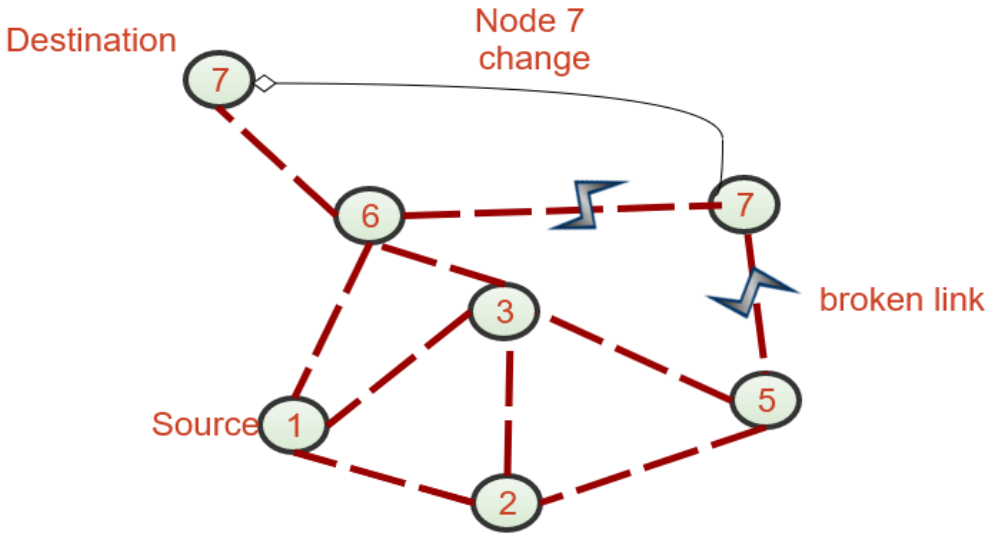

Figure 2.6 Changing in node 7

Table 2.2 node 7 modification

Destinations	Next hops	metrics	Sequence numbers
1	-	0	S10_1
2	2	1	S410_2
3	3	1	S33_3
5	2	2	S67_5
6	3	2	S21_6
7	2	3	S81_7

2-3-3 Wireless Routing Protocol (WRP)

Like the DSDV routing protocol, the WRP use table and also based on Bellman-Ford method [34]. But WRP uses four tables to maintain links in the MANET network. These tables are like to follow.

a. Routing table (RT): RT new table added to handle each update happened and maintain network view to identify all the destinations. This table registers the predecessor and successor for each destination, also a flag to identify the path status.

b. Link Cost Table (LCT): LCT table or by other word the relaying cost table. This table stores cost of relaying in each link. Also, store updates each period and identify the last update success degree to detect link break. Link break cost assigns as infinity.

c. Distance Table (DT): DT table or number of nodes in the path, responsible for storing the number of hops between nods.

d. Message Retransmission List (MRL): The MRL interest in recoding each retransmitted message and generate a counter for every one of the entries that are retransmitted following the process of sending a message. Also containing fields, which are interested in register an acknowledgment flag and a list of updates.

In a periodically way each node must send an update message for all neighboring nodes, new broadcast in a periodically way. This transmission includes a list of updates and responses to identify which nods must concern an acknowledge updates. If a node detects a link out of reach, and acknowledge sends with a link cost of infinity to that broken link. Node with an active path to the nodes uses broken link to update their entries. Depending on the information of the predecessor node also forcing its neighbors to check the correctness of the information. WRP considers a perfect routing protocol in avoiding count to infinity problem as will be illustrate in the next sections.

2-3-4 The Protocol of the Dynamic Source Routing (DSR)

The DSR [35] has been based on the source routing concept. The procedure followed in the DSR routing protocol. In the case, where the source node needs to transmit a packet to the destination node. The list of all the nodes in path between source to destination will be In the header of packet. In another words, this procedure means that each node in the path acts as a forward to next hop which is identified in the header of the packet without any need for check routing tables. Furthermore, there is not any need to broadcast tables between nods. This procedure implements two main phases that must be done in this phase is Routing discovery and maintenance. They will be discussing in the following sections.

A.Route Discovery in DSR:

RREQ is a broadcast route request send by the source node to all neighbors. Each node in turn sends rebroadcast an RREQ to their neighboring nodes. In the case where it has not to send already. Also, identify if it is the destination node or not. In another words, the neighbors re-sending the RREQ that source node sends after checking if the node is destination or the destination is in its neighbor's node. Also, each node must provide a TTL (Time To Live) counter and must be more than zero. In addition, a request *id* is determined if that any route request has done previously received by the node. This means that no loop has been happened (two RREQ from the same node). In every one of the nodes, an initiator and a request *id* list produced in pairs. In the case where 2 route requests have an identical request *id* and initiator node resend one of them to avoid the formation of the routing loops in the network. So the dropping of duplicated request *id* and initiator minimize the resource consuming and prevent network packets infinity looping. This also prevents. In the case where the packet has reached the destination node, it will unicast a reply packet (RREP) on a reverse path back to the sender. Such a reply packet includes a route to that destination. Figure 2.7 illustrates the discovery phase. If node1 want to send a packet to node7. Initially, node1 will initiate a route discovery phase by sending an RREQ to all neighbors. Node which in the illustration is 2, 3, and 4, in that case, as illustrated in Figure 2.7 node 3 will receive an RREQ from node2 and node 4 which denoted as a duplicated packet in this case. So node 3 will check the request id and initiator, then drop these packets. As will as, each node in the network will follow the same procedure and store a list of request id and initiator. After that, (a list of resend of the RREQ between nods in the network) the packet arrives at node 7. The packet record will address and reverse the route and unicast it back on the inverse path to the destination.

In the destination node (in node 7). First node 7 unicasts the best route depending on the sequence of the received packet to identify the best routing and caches the rest of the routes for the future. This route cache will be responsible for the maintenance of each value in each node in the network. So in the case where the node has received a route request and found a route for the node of the destination in its cache, it will send an RREP packet itself with no further broadcasting it.

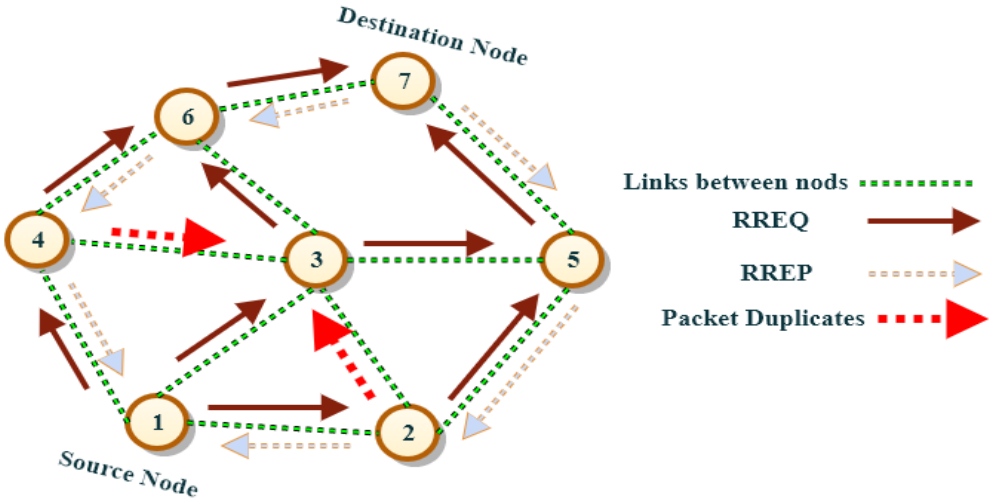

Figure 2.7 DSR Discovery Phase

B.Route Maintenance in DSR:

The next phase in the DSR routing protocol is route maintenance. This phase happened when a broke link happened. Meaning whenever a link breaks this phase must take responsibility (occurred). The detection of a broken link occurs by passively monitoring the link. Figure 2.8 illustrates the movement of node 7 and the break link between node 6-7, this will generate a RERR. And this RERR will be sent by an intermediate node to originating one. So the source node must re-initiate the phase of the route discovery to identify a new route to destination node. doing that source node must clear all the information restored in the cache about the destination node.

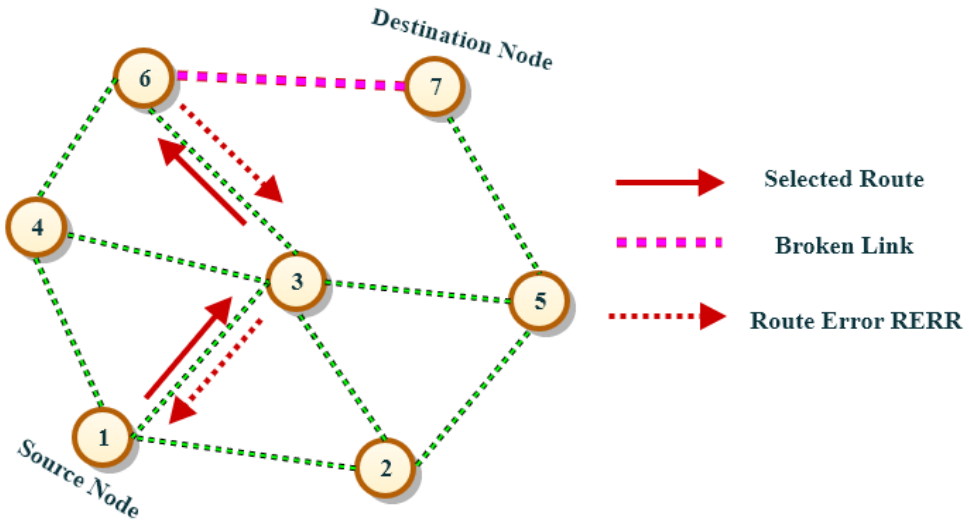

Figure 2.8 DSR Maintain Phase

The major benefits of DSR are avoiding periodically updating the routes by choose the minimum node number path and doing the send. On the other hand, DSR also avoids the multi-broadcasting phase to use hello messages. However, in cases where the network size increases. Routing faces issues such as overhead increases. Also connecting the packet with the route information about the whole route to destination. Using caches of the route is a good approach for the reduction of the delay of the propagation. However, overusing the cache could be resulting in weak performance [19]. On the other hand, DSR in case break link happened a RERR packet will generate, this packet is propagated to the original source, that means an initiate will be created. Anew discovery phase will attend. Duo to un locally repaired for the link. Many Optimization algorithms are possible to avoid. Like the non- propagating route requests, this mechanism which send an RREQ setting the hop limit to 1, will prevent them from the re-broadcast. in addition to, that the gratuitous route replies (in the case where a node overhears a packet with its own address that has been listed in the header, it will send an RREP to the originating node that by-passes the previous hops), and so on. A thorough DSR optimization explanation may be seen in [36].

2-3-5 Ad Hoc On-demand Distance Vector Routing Protocol

AODV routing protocol inherits the good characteristics of the DSR and DSDV [19]. In the structure of AODV based on reactive approach, which means first the AODV finds the routes then identifies the appreciate path using a proactive approach. The phase of find routes depends on the reactive approach. So AODV is a mix between DSVD and DSR. In other word AODV find the routes using the discovery phase such as DSR. Also, use the sequence number to compute fresh routes like DSDV.

A. Route Discovery in AODV

In the phase of the route discovery, as DSR routing protocol an RREQ packet has been generated from the source node. That RREQ packet includes more information than an RREQ packet in DSR. RREQ contains the following information, the Source Identifier (SId) , the Source Sequence number (SSeq), from the destination, the Destination Identifier (DId), and the Destination Sequence

number (DSeq), also, the broadcast identifier (BId) and TTL fields. In the case where the node exist in intermediate receive RREQ, immediately forward an RREP in case it has a valid route link it to destination node. In AODV two main checks happened to determine if an RREQ received more than one time to eliminate duplicates, this identifier is (SId, BId) in pairs used to determined the RREQ receiver. In each check in the node exist in the intermediate, intermediate node will enter the address of the preceding node and its broadcast identifier at the time of the forwarding of an RREQ packet. In addition, this timer is used to delete RREQ packets that expired before a reply received.

When an RREP received, node store information on the preceding node for the purpose of forwarding the packet to it as next hop toward destination, which will act as a "forward pointer" to destination node. Which is why, the node maintains the information of the next-hop only, in contrast to the DSR or other routing protocol that has stored all information about intermediate nods and the connection to each other.

Figure 2.9, illustrates the AODV discovery phase. As usual, if node 1 wants to send a packet to the node7. Also, assume that no route caches were done before. So node 1 need to initiates a route discovery phase using the RREQ packet broadcast to its neighbor's nods.

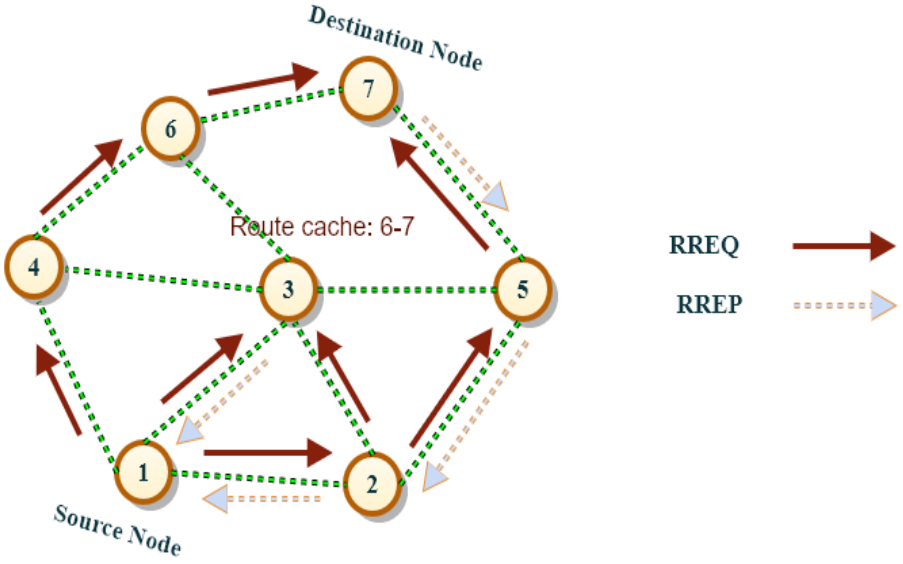

Figure 2.9 AODV Discovery Route

In RREQ node 1 insert information about the DId, SId, DSeq, SSeq, BId, and time to live TTL fields. All these fields embedded in the RREQ packet. Now each node in the intermediate receive the RREQ packet, in the presented illustration, these nodes are 4,3 and 2. Firstly, they check the caches of the route to observe this RREQ has been received lately if they have received this RREQ they drop it. Otherwise, they will forward the RREQ packet to their neighbors. In case there is a fresh route in cache they send an RREP to the source. In the other case, the DSeq in the RREQ packet has been compared to DSeq in the corresponding entry in the cache of the route. In the case where DSeq in the RREQ packet was higher, in this case it will reply to source node with an RREP packet that contains the route to the destination. In Figure 2.9 , the node3 has a route to node7 in the cache and its DSeq is greater than the DSeq in the packet of the RREQ. Which is why it will send an RREP back to source node1. Which is why path 1-3-6-7 has been stored in the node1. The node of the destination must send an RREP back to the source node. For instance, one of the potential routes is 1-2-5-7. Intermediate nodes on path between the source and the destination update the routing tables with the latest DSeq in the packet of the RREP.[34]

B. Route Maintenance in AODV

In the phase of the route maintenance, if a node detects a link break using layer acknowledgments or HELLO beacons [28], each node in the network notify using a RRER packet. This packet is similar to DSR RRER packet. Figure 2.10 illustrates if a link break between node 3 and 5 on the path 1-3-5-7, then 5,3 send RRER to notify all the nodes in the network.

One enhancement that is possible in the maintenance of the AODV route is using an expanding ring search for controlling the RREQ flood and discovering the routes to the unknown destinations [19]. The fundamental benefit of the AODV is the fact that it can avoid the routing of the source, as a result, decreasing the overload of the routing in large networks. In addition to that, it will provide the numbers of the destination sequence which permits the nodes to be having more updated routes. None-the-less, the AODV needs bi-directional links as well as the periodical link-layer acknowledgments for the detection of the broken links. Moreover, it must be maintaining the routing tables for maintaining the route in contrast to the DSR.

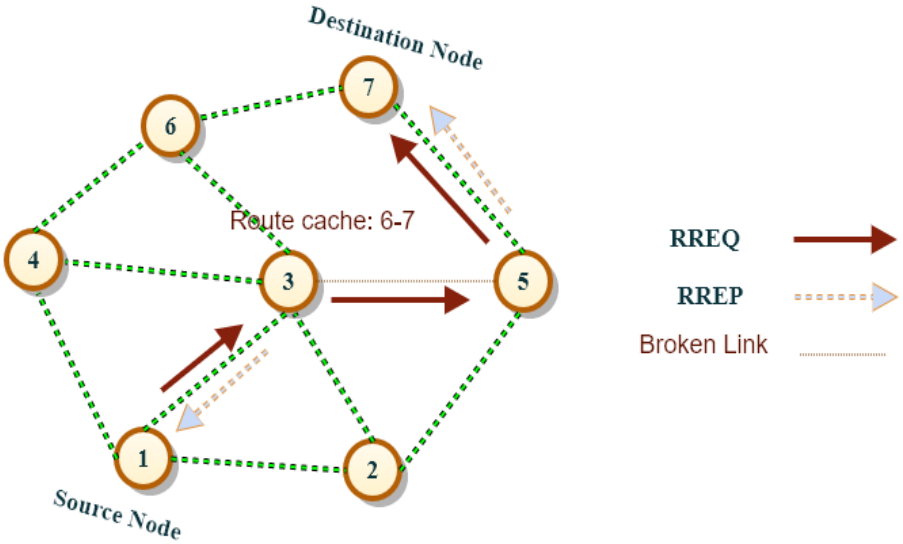

Figure2.10 AODV Maintain Route

2-3-6 Comparing DSR and AODV

In this section, a comparison between AODV and DSR provides. Table 2.1 using some feature and compare DSR with AODV routing protocols as follow:

Table 2.1 DSR a against AODV

Feature	DSR	AODV
DSeq	No	Yes
Link-Layer Acknowledgements	No	Required
Routing procedure	Several route caches for every one of the destinations	1 entry for each one of the destinations that have used sequence number
Store route	Using caches	Utilizing the Table
TTL	No	Yes
Multipath caches	Used	Not used
Optimization	Salvaging, Gratuitous route replies (RREPs) and (RERR), nonpropagating route requests	Expanding the ring searching

In DSR a source routing is employed but in AODV a table-driven routing is utilized. Because of this, in the DSR a higher load of the routing is needed when the network size has been increased because the packet header has information in comparison with the AODV. So in a small network, DSR is preferred over AODV. Also, the acknowledgments of the AODV link layer or HELLO beacons in periodic intervals for the detection of the link breaks. On the other hand, DSR avoids this so DSR is more sufficient. Also, the DSR stores in caches information about the destination while the AODV does not storing information. It was discovered that this affects the delivery fraction and the end-to-end delays with the increase in the network size [19]. DSR was discovered to be performing efficiently in the lightly loaded networks, while the AODV has been efficient in the networks that are more stressful (with nodes of higher density). The AODV has benefitted as well, from its mechanism of the timer through the maintenance of the fresher route entries in comparison with the DSR that does not implement any timer. In addition to that, in the DSR all the requests which reach a destination node are replied to, while in the AODV, destination replies once only to the request which arrives first and ignores the rest.

2-3-7 Reactive Routing Protocols advantages and disadvantages

The most important benefit of the protocols of the proactive routing is that the periodic updates of the routing are not necessary. This is why, the amount of the routing packets in the network is decreased, as a result reducing the load on the network. In addition, the breakages of the link are found by a mechanism of the route maintenance only in the case where it is needed, unlike the table-driven protocols, maintaining the updated routes through the propagating periodical updates. Generally, on-demand protocols of routing are more sufficient under the nodes' higher rates of mobility and show low latency in the moderate to large network types [27][19].

2-3-8 Zone Routing Protocol

ZRP [36] can be defined as a hybrid protocol, combining the optimal characteristics of the reactive as well as the proactive protocols of routing. The protocol includes 4 elements: (a) Intra Zone Routing Protocol (IARP) (b) Reactive Inter-zone

Routing Protocol (IERP), (c) Border cast Resolution Protocol (BRP). The working concept of the ZRP can be summarized below.

Firstly, it divided the entire network to zones, every one of those zones is representing a small portion of the network. Every one of the nodes in that zone has a routing table that contains information of each one of the other nodes in that zone. The zone radius specifies to represent the maximal amount of the hops for reaching all of the nodes in that zone. In the zone, routing has been carried out with a table-driven approach, with the use of IARP. On the other hand, the node can be in more than one zone. Figure 2.11 illustrates the zone radius and principle of the routing zone. The nodes in the same zone exchange the periodical updates of the route. Between the zones, they are communicating with the use of IERP, where a node that wishes to be communicating with one of the nodes in another zone transmits a packet of route requests to all of the nodes on the zone border. For instance, in Figure 2.11 if node2 wants to be communicating with the node7, it sends request packets to node 1, node 3, and node 5.

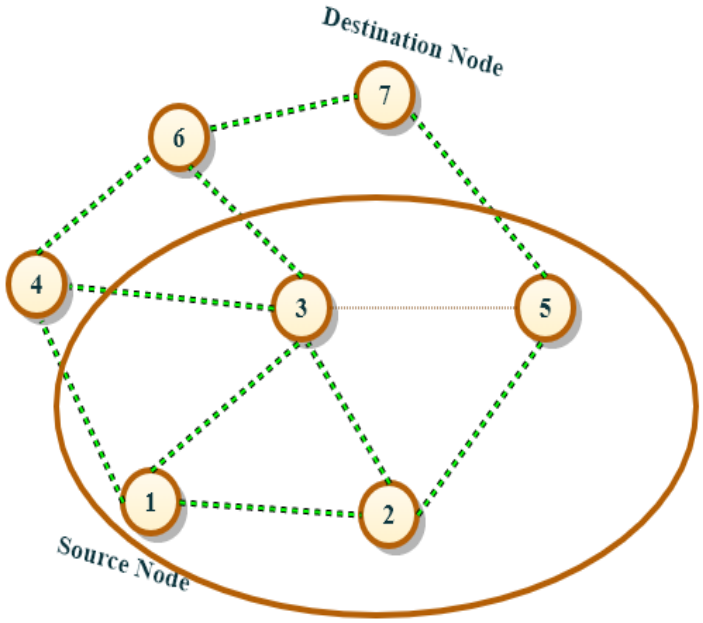

Figure2.11 Node 2 Radius Zone of 1 node[36]

For the purpose of finding a border node, BRP has been utilized. In the case where the border node finds the entry of the route to a destination node in the intra zone routing table, after that, it will send a reply packet in a direct way to source

node, otherwise, it will re-broadcasts request to the peripheral nodes. This procedure continues to the point of reaching the destination node that will unicast back a reply to the source node with the route in the header. If several route replies have been obtained by the source, it will select the optimal route, according to metrics like the latency, number of hops, and so on.

In the case where the node detects a broken link, a reconfiguration of the local path is performed, through the selection of a shorter path that connects the broken link ends. The source node will be notified about that new route.

2-3-9 Hybrid Routing Protocols advantages and disadvantages

The hybrid routing protocols have inherited the desirable characteristics of the reactive as well as the proactive protocols of routing. By extension, the delays and overhead are avoided since locally the routes are always available. It avoids the periodical updates for the nodes existing at the far distance with the use of a reactive method, due to the reduction of the control overhead in the large network types.

2-4 Quality of Service (QoS) issues

Quality of Services defined as a set of performance services, which must exist in each system to guarantee a high level of capability of these systems. So, these services or sets of services must have measurement tools or metrics to calculate or to ensure that these systems conform to the performance requirement. In QoS, these tools called metrics. In terms of supporting the transmission process in MANET and enable routing protocol terms like the end to end throughput, delay, and packet delivery ratio must be considered[38]. In the next section, these metrics will be discussed in more details.

- **End to end throughput**

Throughput is a definition used to describe the ratio or efficiency of the network deliver process, in other words, it is the number of packets that have been delivered in elapsed time. The equation to calculate throughput is like this:

$$th = \frac{Pd}{Te} \text{----------(2.1)}$$

Where this throughput and measurement unit to calculate is *p/s,* means packet per second. *Pd* represents the packet delivered, and *Te* represents the elapsed time in delivering the packet[38]. Throughput refers to the efficiency of delivering packets except the duplicated one. There is a dependency relationship between throughput and bandwidth. In case of knowing the available bandwidth of the network, the actual throughput should be obtained to ensure the efficient use of bandwidth in the network. If throughput is higher meaning better bandwidth utilized.

- **Delay or latency**

Delay refers to the time between the initialized source node packet and the receiving of the destination node. Perhaps the time-consuming in the transmission process change according to long queue time or the congestion in the network. it can be concluded that the delay is an additive process depending on the relay in node and time-consuming. From that, it has been concluded that the delay calculates using the following equation[38]

$$T = Ts + T1 + T2 + \ldots\ldots + Tn - 1 + Tn + Td \text{----------} (2.2)$$

Where T_s & T_d denoted as time-consuming in the source node and destination node. Buffer time is the delay time in each node. In case the buffer time set to a higher value, that means packet will spend a long time in the buffer this happened when link broken occurred[38]. On the other hand, in the case where the buffer time is short, that means the performance of the delay will be improved, but dropping the packet will increase as well. So, delay and delivery ratios are a tradeoff process[39].

The delay depends on the layer where it must calculate in each layer so delay is a layer dependent. For synchronization in round trip delay and single trip, delay differs according to the application. So, delay counts as the main major in applications such as video streaming.

- **Jitter**

Jitter mainly used in signal as a measurement of the deviation of some pulses. In MANET it refers to the average of differ between instantaneous delay and average delay[39].

$$\Delta J = \frac{\sum_{i=1}^{n} |(Ti - \Delta T)|}{n} \text{----------(2.3)}$$

where *n* represents the number of the effectively received packet, ΛT denotes the average of delay, and T_i symbolizes delay difference enation[39]. Jitter effect the video streaming as much as packet loss rate increase, so in packet loss decrease jitter decrease video quality increase [39].

- **Packet delivery ratio**

New metrics that affect the QoS is the ratio of the packet delivery, where this ratio represents the differentia between the effectively received packets and the total packets. The following equation illustrates the packet delivery ratio.

$$PDR = \frac{Pr}{Pt} \text{----------(2.4)}$$

Where PDR denoted the packet delivery ratio, and P_r, P_t symbolized the effectively received packet and the total amount of the packets respectively[39]. The retransmission process demeans of PDR according to the increase of denominator. MANET's sake for PDR to avoid the bandwidth limitations in wireless networks.

2-5 An Overview of Swarm Intelligent in MANET Routing

Nature mystery becomes a main resource in optimizing and analyzing problem. Behavior such as ant and flocks consider as a mine to find solution to many problems faces the researchers. Where others such as the falling of the rain-drops and rivers, which have considered as fact that always run to sea. From those phenomena, many research inspired solution. The researchers dedicate resources to study these phenomena to understand the mystery behind it. The base of these mysteries and secret considered the foundation of Swarm Intelligence (SI), which is a new AI science. SI inspired from the behavior of social like insects or animals and use to solve problem of optimization. The individuals interact with each other to complete the full picture in a cooperative manner. This organization behavior proof that their success is not dependent on the ability nor on strength but lie on organized social behavior. Researchers mimicked these behaviors into the approaches of the optimization.

SI has become a good substitute for facing challenges such as non-deterministic polynomial-time hard (NP-hard) optimization problems more than the traditional

search. The same is non-deterministic polynomial-time hard (NP-hard) problems of optimization if the problem consume more computational and need more time and computation power were needed in solving it. In MANET routing NP hard problem is represented. Because of power challenges and routers time, many methods proposed to solve this problem. SI is a famous method used to adapt and solve routing problem. In the following section the intension is to present methods using SI and their application adopting to solve routing problem.

2-5-1 Self- Organizing Systems (SOS)

This type of system contains a dynamic mechanism which keep changing states reflecting modifications in structure or organization in an unpredictable way. These changes (modifications) happened or take place as a result of change in operating or environmental conditions [40]. SOS is a dark backs algorithm, in another words, best solution do not guaranteed. An instability may appear especially on opposing actions that appeared between system units.

Several of the artificial SOS implemented depending on mechanism of self-organizing which have been inspired by the nature. In nature, the SOS categorized to 3 main types (categories) which are: Social self-organizing, biological self-organizing, and physical self-organizing systems.

Social self-organizing such as termite, ant, and bee colonies. Also schools of fish and flocks of birds. On the other hand, small bacteria cells, up to human behavior can represent social behavior. Where they interact individually to serve a global idea.

The development of first self-organizing theories is due to the use of macroscopic patterns out of physical and chemical processes. A common characteristic shared among Physical self-organizing systems. If states of system reach threshold point, the entire system state change immediately. For example the mix of chemicals that may result in organized oscillation [40]. Also the joint of raindrops taking the best path to river or sea. Another example of biological SOS are the mammalians of immune system, and selection and evaluation processes of nature.

2-5-2 Ant Colony Optimization

ACO represents an AI algorithm that mimics ant behavior in real live in addition this algorithm is widely used in solving optimization problems. ACO lies in the ability of ants to communicate depending on an indirect pheromone. That creates a

sort of communication-based. In a cooperative manner, ants work together sharing solutions based on pheromone intensity on every one of the links. ACO using usually find good solutions for the issues.

In 1991 Dorigo M. et al. firstly presented an Ant-System (AS) as a heuristic algorithm [42][43]. Also, the Travelling Salesman Problem (TSP) represents a problem handled by the heuristic algorithm of ant. TSP aims to find shortest paths loop tour in visiting all cities. Where each city visit once. TSP which has been viewed as an NP-Hard issue which is used widely for testing optimization problems[44].

2-5-3 Particle Swarm Optimization

particle swarm optimization (PSO) is considered a powerful technique that handle a computational method in order to optimizes a problem by iteratively attempting to enhance a candidate solution by providing measure of quality. This kind of algorithm find real solution for a problem by having a dubbed particles, population of candidate, and moving these particles around in the search-space based on statistical and mathematical equation.

MANET needs a well-structured approach for raising the network connectivity utilizing Multipath routing method. The Fuzzy-Enabled (PSO) based Energy Efficient (FPSOEE) approach for a number of path routing is implemented to send the total number of packet when the connection failure happens and escalation the Quality of Service. In regards to the route discovery level of FPSOEE, the main source node selects such an optimized way by forwarding the significant message to all its neighboring nodes. This can lead any route breakdown resultant in terms of data loss of failure and overhead will occur. However, the multipath routing is associated with the node movement [45].

Robinson et al [45] applied the PSO-based energy efficient approach. The main and root node collects the vast majority of mobile node data based on their energy effectiveness. In order to deal with this information, the node calculates the total amount of communication range of the portable nodes. Moreover, Fuzzy idea is implemented mostly to enhance the multipath routing performance and accuracy in MANET.

Caro et al, defined AntHocNet, as an approach for routing in mobile ad-hoc networks (MENT). This techniques that were proposed by the authors is considered

a combined algorithm, which hybrid reactive way operation with proactive way probing, improvement, and maintenance. The selected algorithm is depended on the ant colony optimization framework. Caro et al included a number of limited routing information in terms of hello messages, which is considered a very popular techniques to check the performance of nodes so that can spread information over the network from node to node in specific kind of messages. However, due to the slow spreading via s hello messages, this routing information is considered unreliable for data packets to be applied, but might be a optimal for proactive ants colony approach, allowing their search for better and new paths with less blind. In order to achieve such an excellent outcomes, the authors attempted to use an extensive simulation experiments, trough comparing Ant Hoc Net with AODV. It is indicated that the proposed algorithm can outperform AODVon using various evaluation criteria [46].

2.6 Lion Swarm Algorithm (LSA)

2.6.1 The behavior of real lions

In the animal kingdom, the lion is the most social animal because it is highly cooperative and provides high level of antagonism [47]. The lions maintain its groups only with two types of organization. They are resident lions and nomadic lions. In general resident lions are usually more than fifteen in numbers as average they will stay together with more adult lionesses, around four to five lions as well as the cubs. The lions are otherwise called as apex predators and it is the alpha, since lions occupy the top position of the food chain. The social dominance hierarchy of the lion's family is described in the Figure 2.12. It is the generalist hyper carnivore as it has a natural division of labors they supports for the lions survival and development.

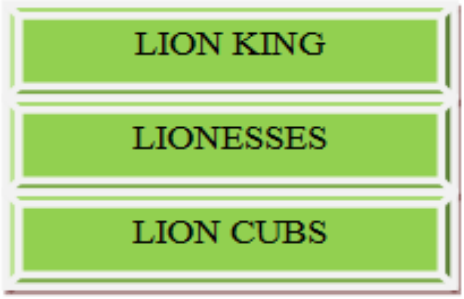

Figure 2.12 Lion's social dominance hierarchy[47]

A. Lion King:

The strongest male lion in the lions pack is chosen as the lion king, as well as it is the head of the jungle which is emerged from the huge struggle by the concept of survival of the fittest the lion king can mate with all the lionesses of the cluster for the process of reproduction. The responsibility of the lion is more because it has to protect the territory within and without the cluster and it also needs to safe guard the cubs and provides food to it. Furthermore the lion king must be stronger to secure himself from danger[48]. Otherwise the lion king position can be reallocated to other lions in or around the cluster. In case if the king is defeated by other lion then it might be dead or separated from the cluster and those lions are called as nomadic lion. The new king can right away compel the lionesses for the process of mate for its offspring. Simultaneously, it will kill the cubs of that nomadic lion.

B. Lionesses:

The lionesses are otherwise called as hunting lions and it also has its own responsibilities, which are lion cubs breeding, hunting as well as maintaining the cluster coordination. The lionesses go behind the wide range trail prey, while approaching they understand the location of the prey and cover them[49].

C. Lion Cubs

In general the lion cubs are called as the following lions and the lion king is responsible for the protection of the lion cubs. The cubs are always stands together with its king and its mother for any kinds of actions. More often than not the actions of lion cubs are separated as three, they are during their hunger time they will reach their king for food, after the food they will go behind the lionesses to learn hunting and finally once after reaching their sexual maturity they have to prove they are stronger than the resident male lions otherwise they will be scattered away from the group and becomes the nomadic lions. In some cases, those nomadic lions will get trained and return one day and challenge the king. If the nomadic lion defeats the king then the lion king might be replaced by the nomadic male lion[50].

The cooperation between the lions is simple. Similar to swarm yet they have to be cooperative with themselves to become a team to carry out the process of food search in their social hierarchical order. In general the lion king, lionesses and lion

cubs has its own natural division of labor and according to the law of survival of the fittest the winner can rule all and in this way our new algorithm is designed namely Lion Swarm optimization (LSO) algorithm. In this algorithm, the principle of location updating consists of three populations. The law of "survival of fittest" is implemented in the LSO algorithm which includes few processes namely the lion king has to safe guard the territory as well as it has the highest priority of food compared with others. Certainly lioness do hunting, cubs falls for eating, cubs learn hunting and separated from the group which it reaches its sexual maturity if they are not stronger than the resident male lions[49].

2.6.2 Parameter Definition of LSO algorithm:

A. Adult Lion Proportion Factor α:

Adult lion proportion factor is very important because it is related with the end optimization outcome. The model with larger proportion values of adult lions affects the quantity of lion cubs. Moreover the localization process of lion cubs are distributed which leads to improve the strength of the lion group as well as the algorithm's detection capacity. Adult lion proportion factor α is denoted in a positive random number lies in between the range of '0' and '1'. As so to assure the convergence speed of the algorithm we fix the value of α is lesser than 0.5.

B. The coverage area trouble factor of lionesses' β_{tf1}:

The major difficulty in the optimizer is its global exploration ability that has to be concentrated. Initially the estimated location of the optimal solution has to be fixed then the strength of the local exploration ability has to be increased. The major parameters which are used to strengthen the local exploration ability of the optimizer are starting stage convergence speed, trouble factor β_{tf1} which is used by the lionesses to find the prey. After initiating the updating process increasingly reduces the coverage area of the lionesses. Secondly, local search is started in the optimal solutions adjacent domains which lead to improve the precision and local search capability of the optimal solution[48]. The initiation of trouble factor β_{tf1} greatly helps to manage the local as well as global exploration, increase the convergence speed and protect it from the premature issues.

C. The coverage area trouble factor of lion cubs β_{tf2}:

The lion cubs reach its lion king for food using certain condition or it travels the path of lioness to get trained in hunting with in the coverage area. The coverage area trouble factor $\beta_{tf2,}$ used the linear downward trend, can enlarge the coverage area of the lion cubs which leads the cubs to search for food in large area after that it will reach the local search area of the adjacent domain[48].

2.8 Summary

Chapter two demonstrated the most related works for the proposed methods, theoretical background, basic concept of MANETs, and Swarm Algorithms focus on the LOA Algorithm selection process. It explained and provided a fully description of the suggested approach. The results of these methods demonstrate that the proposed methods proved to be better than the traditional fixed-time control strategy. It is also observed that researchers used various systems' parameters to model to derive the optimal solutions. Many of the researches involve the investigation of problems that are associated with energy, delay, and others of success in finding the optimum results. This research work aims to extend the threshold of studies done so far in this domain with the use of a Lion Optimization routing (LORP protocol) based on Lion swarm algorithm and AODV protocol. Next Chapter will discuss more elaborately about design and implementation of MANET network.

Chapter Three
The Proposed Methodology

Chapter Three

The Proposed Protocol (LORP)

3.1 Introduction

This chapter describes a new proposed protocol to optimize the routing in MANET. The proposed protocol is based on Lion Swarm Algorithm (LS) the new routing protocol namely Lion Optimization Routing Protocol (LORP) as a reactive protocol .

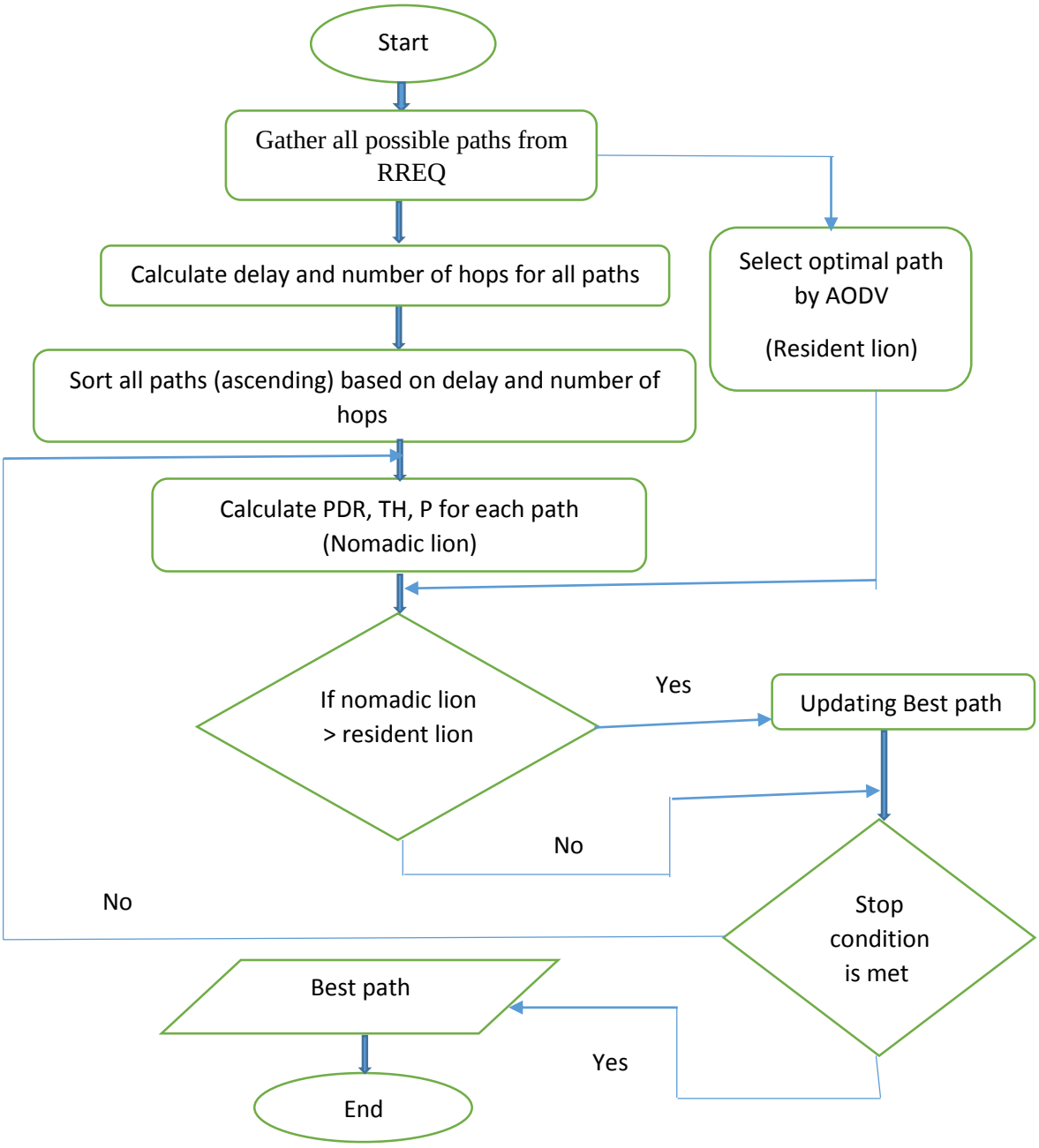

Figure 3.1 Flowchart of **The Proposed protocol**

Two function in this protocol which are route discovery and rout maintenance. In route discovery, the source node broadcast the Route Request to its neighbors, and each neighbor broadcast route request until reach the destination. The destination node send route reply on the paths, which reach it with the route request. There are two steps in this approach; firstly, minimization lion selection based on two metrics (delay and short path) and sorting the routing from lowest value to highest value has been used. Finally, maximization Lion selection is used to select the optimal path based on three metrics (throughput, lifetime, and Packet Delivery Ratio (PDR)). Figure (3.1) show the proposed structure of work.

3.2 Network Simulator:

The performance evaluation of our research work is simulated in the software network simulator (NS2). It is discrete event simulator, designed in object-oriented language. It is a combination of C++ and OTcl (Object Tool Command Language). At the initial stage this simulator is used in local area network and wide area network. And recent days it is mainly used for Wireless Sensor Network [49]. Network simulation allinone version 2.34 is used for our current examination. It stores the traffic information and produces the trace files for output performance analysis.

Network simulator is generally based on TCP/IP model which consist of five layers which are Physical layer, Data link layer, Network layer, Transport layer and application layer. The network layer protocols which are used in this software are TCP- Transmission control protocol and UDP – User datagram protocol. The various application layer protocols are CBR-constant bit rate, FTP-file transfer protocol as well as VBR-variable bit rate [50]. The pre defined link layer managing methods are Drop Tail and RED, several routing protocol are also used in the network layer.

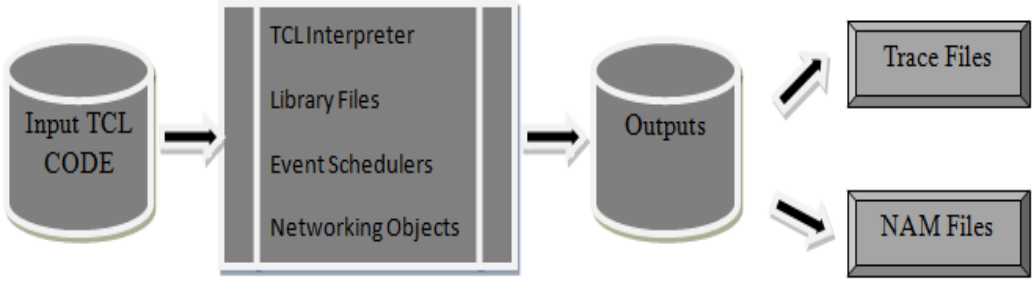

Figure 3.2 Simplified View of Network Simulator [50]

The operational model of network simulator is explained in the figure 3.2. The major sections are simulation event scheduler based Object-oriented tool script interpreter and supporting libraries included. The major input languages are C++ and OTCL [51]. OTCL is a front-end language, which helps in the creation of events, network topology, traffic models and transmission slot allotments. C++ is a back end language, which consists of all the routing models and libraries [52].

3.3LORP Protocol

A new routing protocol for MANET namely Lion Optimization Routing protocol (**LORP**) are mainly based on lion optimization algorithm (population-based algorithm) and AODV protocol were proposed. Lion optimization algorithm is one among the set of bio-inspired algorithms, which is used to find the best possible path for data transmission between the source and the destination. In this section, a new modeling approach is introduced to analyze the properties of the MANET network. At the initial stage, a number of nodes (n) deployed in the traditional ad-hoc network which is represented as an idle set $\{I\}$. Sink nodes is located anywhere around the network and it is monitored. Secondly, the Euclidean distance is represented as d(x,y) and the coverage area is less than its radio transmission radius as well as it is related to the distance between the node x and y respectively. According to the data-link-layer bi-directional transmission is performed with the help of undirected graph. Finding optimal path during the process of communication between the source and the sink is the main objective as so to create population by improve the energy efficiency of the network in the effective manner.

3.4Lion Swarm Optimization (LSO) Algorithm:

The lion swarm algorithm searched optimal path based on two unique lions behavior namely territorial defense and territorial takeover. The territorial defense is carried out between the resident lion and nomadic lion. The territorial takeover is carried out between the old lion and new lion.

The basic structure of lion algorithm can be separated into four major component based on the nature of its function which are

- **Pride Generation :**

  The pride is generated by gathering all possible paths from RREQ and Route RREP to transmit data from source to destination, and calculated the minimization equation and sorting from lowest value to the highest value.

- **Mating :**

  Mating is the process deriving new best paths from the existing paths that includes crossover and mutation for deriving new solution. This step doesn't work in this study because all possible path available in pride. When applied the mating operations the result infeasible path, to convert the infeasible path to feasible path should applied repair mechanism. The result of repair mechanism is available in pride because all possible paths are gathering from RREQ.

- **Territorial defense :**

  The territorial defense is the process of evaluating the maximization equation of resident path (best path of AODV) and nomadic path from the pride generation.

- **Territorial Takeover :**

  The territorial take over is the process to keeping only best path which are competent over new path and vanishing existing path in the pride.

3.5 Optimal Route Selection using LSO algorithm

The major objective of our research work is finding the optimal route in routing using lion swarm optimization in MANET which helps to reduce the energy consumption and to improve the efficiency of the network. The drawback in MANET network is mobility management and dynamic topology. According to the characteristics of MANET finding the optimal path becomes a complicated task. Due to dynamic topology the energy consumption is so high which it leads to reduce the lifetime of the network. An efficient routing model is essential to overcome this problem. This work provides a routing algorithm to find an optimal path for data transmission between the source and the destination. Hence it is a MANET network with dynamic multiple routes the optimal route is chosen using

the LSO algorithm. The proposed approach is achieved using three sections involve of networking model, trust model and optimal route finding. In networking model, the path finding is completed using the LORP routing protocol that gives the entire positive path for the data to reach the destination from the source. In the trust model all the nodes are aligned for each and every route path. At last, the LSO algorithm is used to select the optimal route from the possible routes.

3.6 Networking Model

LORP protocol is one among the reactive routing protocol that is based on (on-demand) function. This protocol is designed in a hop-by-hop model where the neighbor hop node decides the path of packets where it has to be forwarded next. The routing information of the node includes the routing table to secure the new path details which consists of hop count, neighbor node details and sequence number. LORP is a type of distance vector function. Only in the essential situation it requests for a path otherwise it will not take any help of inactive nodes to fix the path to the destination. Some of the other characteristics of LORP protocol are loop release and link breakages. LORP routing includes two sections they are Route discovery and Route maintenance. At the initial stage, it will send hello packets to find the hop nodes in the network. The other message types are, Route Request (*RREQ*), Route Reply (*RREP*) and Error Message (*RERR*).

3.6.1 Route Request (*RREQ*)

When the source node want to send data packet to the destination, if there is no active route found by the source node then it starts sending the *RREQ* message.

The major sections of *RREQ* packets are given as follows:

- Identification of source
- Identification of destination
- Sequence number of source node
- Sequence number of destination node
- Broadcast identifier
- Time stamp

The sender node will transmit the RREQ message when the path to the destination is inactive. The routing table will maintain all the information includes node *ids*, sequence number and so on. In Figure (3.3) the structure of route request method is showed. It consists of nine nodes and three possible paths. The possible paths are *N1 N2 N5 N9, N1 N3 N6 N9* and *N1 N4 N7 N8 N9.*

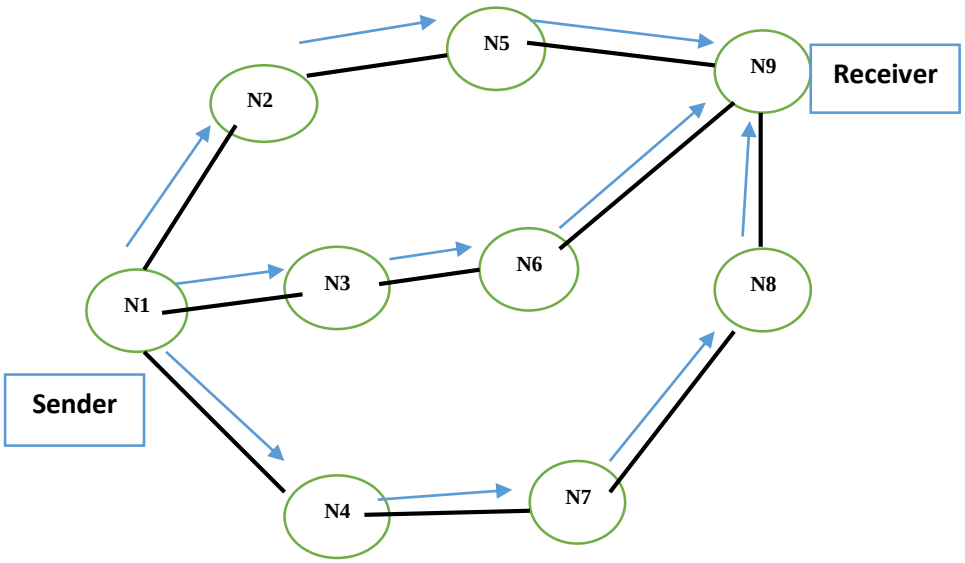

Figure.3.3 Route Request Propagation

3.6.2 Route Reply (RREP)

In order to achieve all the possible route networks, this study used Route Reply (*RREP*). The data transmission among the sender and the receiver follows a duplex model. The receiver sends a message to the sender once receiving the message from the sender. The major sections of *RREP* packets are given as follows:

- Identification of source
- Identification of destination
- Sequence number of destination node
- Intermediate neighbor count
- Energy efficiency

The purpose of sending *RREP*message in this experimental study is to create a reverse path which help the message when its turn around to reach the sender node. After the identification of valid path between the sender to the receiver or the hop

node then it will send a *RREP* message to the sender by the use of that reverse path. The validation between the hop node and the destination node is done by using the sequence number comparison. The nodes which are participated during the process of *RREQ* will be active during RREP from the receiver to the sender and it saves the hop details in the routing table.

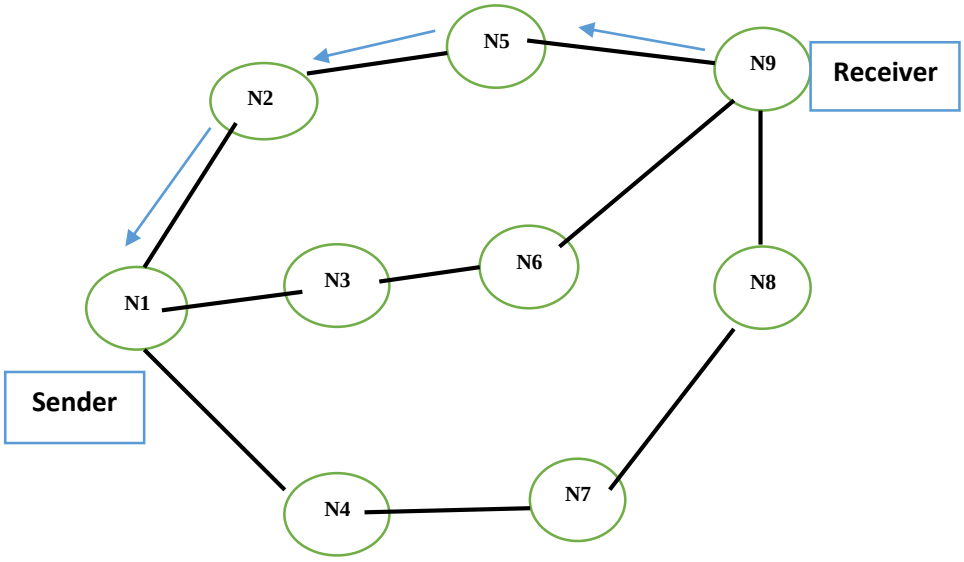

Figure 3.4 RREP from receiver to the sender

In Figure (3.4) the structure of route reply *RREP* method is showed. It consists of nine nodes and a possible path is *N1 ☍N2 ☍N5 ☍N9.*

3.6.3 Route Maintenance

The process of route maintenance in the proposed method is considered one of the quality of *LORP* protocol. Once selecting the path to the destination for one hop neighbor are identified using the hello message. In case if the path is not in the active mode then there will be power supply. The time stamp is used for this research to send the route expiry information to the network.

3.6.4 Route Error (RERR)

The routing agents in this thesis are responsible to identify the link breakage in an active route whenever. In this aspect, an error message (RERR) is transmitted to the nodes which are active in the route path. Once message reaching the sender, the RERR messages are processed to create new route. During route discovery in the

current study, the messages are transmitted in a flooding model where the sender node sends the hello messages to all the nodes within coverage area. In this thesis, every node check whether the messages received correctly or not. Otherwise, the messages can be sent again to all the nodes. This process gradually increases the energy consumption which leads to reduce the energy efficiency of the network. A probability factor is introduced in this empirical study to reduce the energy consumption of *LORP* protocol. The core idea is redundant broadcasting of messages to the nodes with predefined probability function.

3.7 Optimal Route Selection using LSO algorithm

The major objective of this research work is to discover the optimal route in routing using Lion Swarm Optimization in MANET. An efficient routing model is essential to overcome this problem. This work provides a routing algorithm to find an optimal path using *LOA* maximization and *LOA* minimization concepts.

3.7.1 LOA maximization and LOA minimization

In the current proposed method, the main purposes behind using the *LOA* maximization and *LOA* minimization are to handle energy values, packet delivery ratio, network throughput, delay and short path. The initial energy allocation is the basic necessity of the node. This thesis discovered that, the node with highest energy value can work better than the node with lowest energy values. For this reason, the node with minimal energy value crosses the cut-off or link breakage issue in any instant of that leads to increase the packet drop and traffic collision within the network.

Therefore, power consuming is considered such a trust model for this study. Secondary factor is packet delivery ratio, it is also considered as one among the trust model that is used to calculate the input and output data. During the data transfer both the input and output data rate is measures, if it is more or less equal then the node is considered as a consistent node. The network with more number of consistent nodes provides effective packet delivery ratio. Then throughput is concentrated which is the overall packets transmitted according to the time taken.

A. LOA Minimization

Delay: Sum all the delay in each path to destination

$$D_{total} = \sum_{i=1}^{n} Di \quad \text{---------- (3.1)}$$

where *n* is number of node in the path

Short path: Calculating using the path weight, which count number of hops using by the path between the source and destination

$$SH = number\ of\ hope\ in\ the\ path \quad \text{---------- (3.2)}$$

$$Lmin = D\ \&\ SH \quad \text{---------- (3.3)}$$

B.LOA Maximization:

The following section provides the detailed explanation about the maximization model. At the initial condition, the initial energy of the nodes ranges from (0, 1). The node which is inactive is represented with the energy values 0. The highest energy value for the node is 1. The resident energy of the node is the modifier in node life time, so path stability depends on the energy, cases in nil energy causing congestion and packet losing. Hence energy is an important factor in identifying the path life time or stability.

$$P_c = P_w + P_d \quad \text{----------(3.4)}$$

where P_c represented the electronic energy, and P_w represent the power consuming in transmission energy, and P_d indicates data aggregation energy. So to calculate the current energy of node i after transmission the formula become

$$p = P_n - P_c \quad \text{----------(3.5)}$$

where P_{power} is the power remaining in node after transmission process, P_n is the power of node, when we calculate the p for each node in the path will become

$$P = \frac{\sum_{i=1}^{n} pi}{n} \quad \text{---------- (3.6)}$$

where, N is the number of nodes in the path.

Finally, the P take as percentage between 0 to 1, where 1 denoted the full energy, and 0 denoted the nil energy the number resulting the life time of the path from calculating the entire P_{power} for all nodes in the path.

Likewise, we calculated the input and output packet delivery ratio of the node. At the initial stage the input and output data rate may vary. At certain condition, the node will forward all the input information then that node is considered as trustworthy node in the network. In case, if the output ratio is below the half rate of the input ratio then the particular node is considered as selfish or malicious node in the network. Those nodes are calculated as an inactive node and it cannot able to participate in any of the routing activities.

The packet delivery ratio of the node is ranges between (0, 1). The node which transmits all the packets and null packets are allocated as 1 and 0 correspondingly. The network reliability will be more when the network consists of more number of nodes with highest packet delivery ratio.

The packet delivery ratio is the relationship between the incoming packet and outgoing packet the percent of dividing the outgoing in the follow formula:

$$PDR = \frac{outgoing\ packet}{in\ comming\ packet} \text{---------- (3.7)}$$

The number always between the 0 and 1, where 0 denote nil forwarding ability for the node, and 1 denote high level of the ability.

Throughput:

The throughput is the message queue length, meaning calculating the number of message (packet) in queue in the node, the follow formula show throughput.

$$TH = \frac{MC}{Total\ number\ of\ node} \text{----------(3.8)}$$

Where, MC denotes the total number of messages in queue.

Now the calculation of the above equation to identify a value to select using the Lion Swarm Algorithm, the equation to calculate the previous equations is

$$L\ max = \frac{(p+PDR+TH)}{3} \text{---------- (3.9)}$$

where, L*max* is the final value of the model. Immediately after the calculation of the value we can use the LSO algorithm to find the optimal path for the network.

3.7.2 Optimal Path Finding

Among the entire possible path, the best optimal path is selected used lion swarm optimization (*LSO*) algorithm. *LSO* algorithm is one amid of the bio-inspired algorithms because it is developed using the characteristics of lion's kingdom. The group of lions which lives together is called pride. This pride consists of two categories of lions called as resident lions and nomadic lions. A pride is a collection of five to six lions, lionesses and their cubs. Once the cubs become lions it has to prove its strength to others. In case if it fails then that particular lion will be thrown out from the pride and it is called as nomadic lions. Once after getting trained the nomadic lions will again reach the pride to show its strength to occupy its pride. This strategy is used in the LSO algorithm to find the optimal path in the network.

At the initial condition, population of lions are generated which includes both the pride and the nomadic lions. The pride of lion controls the overall region, the lioness mainly concentrated on hunting and teaching the cubs to hunt. In the algorithm with respect to the fitness values the nomadic lions are arranged. The lion with highest fitness value is selected as a pride, minimal fitness values is selected as a resident lions and with least fitness values are considered as a nomadic lions and those are thrown out from the pride. The process is continued until to reach the best fitness values. The fitness calculation of the proposed work is mathematically given below.

$$F_{value} = \frac{\sum_{i=1}^{N} (Lmaxi)}{N} \text{ ---------- (3.10)}$$

The best fitness value can be calculated using the equation 3.17 and here the optimal path is chosen by using the LSO algorithm. Like this the optimal path is selected from the possible path which helps to reach highest level of reliability which leads to improve the overall performance of the network. This algorithm selects the best possible path other than selecting the shortest path. When the shortest path is chosen as a route then the quality and strength of the path is not accessed. This may cause link failure, increase latency during transmission. So

rather than selecting the shortest path, it's advisable to select the path which is naturally examined.

Algorithm of LORP protocol

Step 1: Input: Detected routes from source to destination
Begin
Step 2: Gather all possible routes from RREQ;
For each nomadic lion
Compute delay and number of hopes by Eq (3.3)
Sort the fitness from lowest to highest with order value;
End for;
Select the highest route from sorting list ;
Compute the maximization fitness (nomadic lion) by Eq(3.10)
Compute Fvalue for resident lion (AODV) ;
If (F_v(nomadic lion)>F_v (resident lion))
replaced resident lion by the nomadic lion;
else
select another routes from sorting list
End if;
If there is no new route
Store the best path;
Else
select another route from sorting list
End;
Step 3: Output: best route selection

3.8 Summary

This chapter discussed the main proposed protocol to optimize the routing in MANET. The proposed approach is based on Lion Swarm Algorithm (*LS*) that generates a new routing protocol namely Lion Optimization Routing Protocol (*LORP*). Two steps were discussed in this chapter; firstly, minimization lion selection based on two metrics (delay and short path). secondly, maximization Lion selection is used to select the optimal path based on throughput, lifetime, and Packet Delivery Ratio (*PDR*). Next chapter will discuss the results and comparison of the simulation experimental study.

Chapter Four
Results and Discussion

CHAPTER 4

Results and Discussion

4.1 Introduction:

This chapter introduces the simulation evaluation of the proposed LORP protocol. The performance of proposed protocol presented and compared with the earlier protocols like AODV, DSR and AntHocNet using NS2.34. In order to obtain high performance and accuracy, the performance of the proposed LORP protocol is calculated and then compared with the earlier protocols i.e. Ad-hoc On Demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR) and AntHocNet that is the hybrid model of Ant Colony Optimization and adaptive routing algorithm of MANET network.

Generally, the parameters that are concentrated for comparison are the Packet Delivery Ratio, End-To-End Delay, Packet Loss and Network Throughput. The obtained results shows that the proposed protocol performs are better when compared with the earlier existing protocols, and it greatly helps to improve the overall QoS of the MANET network. The performance evaluation of routing protocol in MANET network for the experimental is calculated using the behavior and the accessibility of the protocol.

4.2 Simulation model and performance metrics:

The performance analysis of out LORP protocol is measured by calculation the output parameters such as delay, throughput, packet delivery ratio and network lifetime. LORP protocol compared with few other earlier protocols i,e. AODV, DSR and AntHocNet. These protocols are one among the reactive routing protocols. Whereas DSR is based on source routing, both AODV and AntHocNet utilizes hop-by-hop communication model during the process of data transmission. In our simulation model, mobility impact for all protocols and it varies according to the number of nodes in the scenario which have been used. In these thesis, three types of scenarios have been used which are 25 nodes, 50 nodes and 100 nodes with variable traffic connections. The simulation parameters and their values are described in the Table 4.1.

Table 4.1 – Simulation parameters details for LORP protocol

Parameters	Values
Simulator	NS-2.34
Simulation Period	100 ms
Coverage Area	1000*1000 m
Number of Nodes	25, 50, 100
Standard	IEEE 802.11
Propagation Model	Two Ray Propagation Model
Antenna	Omni-directional Antenna
Traffic Type	FTP
Traffic rate	0.01 sec to 0.50 sec
Agent Type	TCP
Routing Protocol	LORP
Initial power	1000 J
Idle Power	0.1 J
Queue Type	Drop-Tail

4.3 Analysis of Scenario 1 – 25 nodes

● Packet Loss Calculation

Table 4.2 shows the performance of proposed approach and its comparison in terms of packet loss and simulation time. The proposed approach produces such a great achievement that reduced packet loss to 32 packets that are comparatively less than the another protocols. It is indicated the AODV method received the best rate with 45 in association with 50 times percentage. The percentage for each method and time as noticed increased gradually.

Table 4.2 Values for packet loss calculation scenario 1

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	15	12	10	8
20	24	21	19	13
30	25	22	19	15
40	32	30	28	26
50	45	38	36	32

The lowest rate that obtain in the experimental study related to LORP, which reached 32. It is the data counts which are successfully transmitted to the destination from the source, as shown in Figure 4.1, the x-axis represents the simulation time and the y-axis represents packet loss of the network. The number of nodes which are deployed for the simulation is 25 nodes. Comparing to the earlier protocol, these thesis proved that the proposed LORP protocol performed less than other protocols in terms of packet loss.

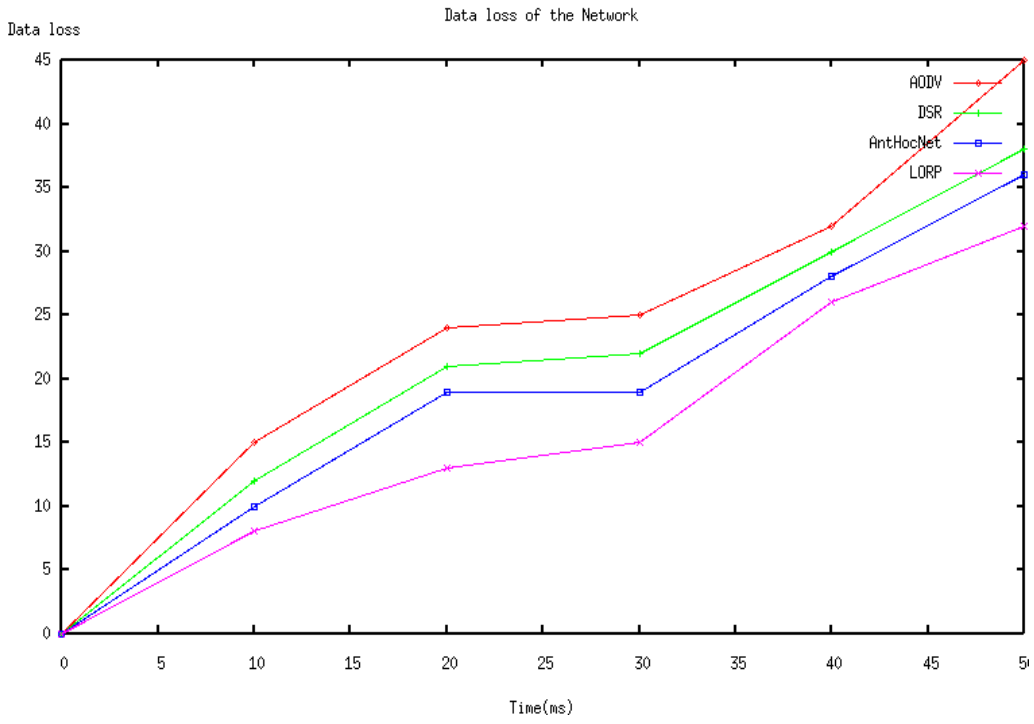

Figure 4.1 – Packet loss calculation scenario 1

- **End-to-end Delay calculation**

The end-to-end delay calculation begins when the application on the source node forward a packet to the final destination. Table 4.7 shows the results for end-to-end delay calculation in scenario-1. The proposed protocol LORP obtained such an optimal outcome with the lowest value 169.39 ms in comparison with other AODV, DSR, and ANTHOCNET with value 180 ms, 175 ms, and 171 ms, respectively.

Table 4.3 Values for end-to-end delay calculation scenario 1

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	139	136	130	127
20	148	147	140	139
30	169	164	157	152
40	175	174	169	163
50	180	175	171	169.39

Figure 4.2 shows the end-to-end delay performance of AODV, DSR, AnHocNet and LORP protocols. The x-axis in the graph shows the time taken in and the y-axis shows the end-to-end delay of the network. While comparing the earlier protocols and the proposed LORP protocol, LORP rises from 0ms and reaches the utmost level up to 169.390ms. Which are comparatively less than the earlier routing protocols.

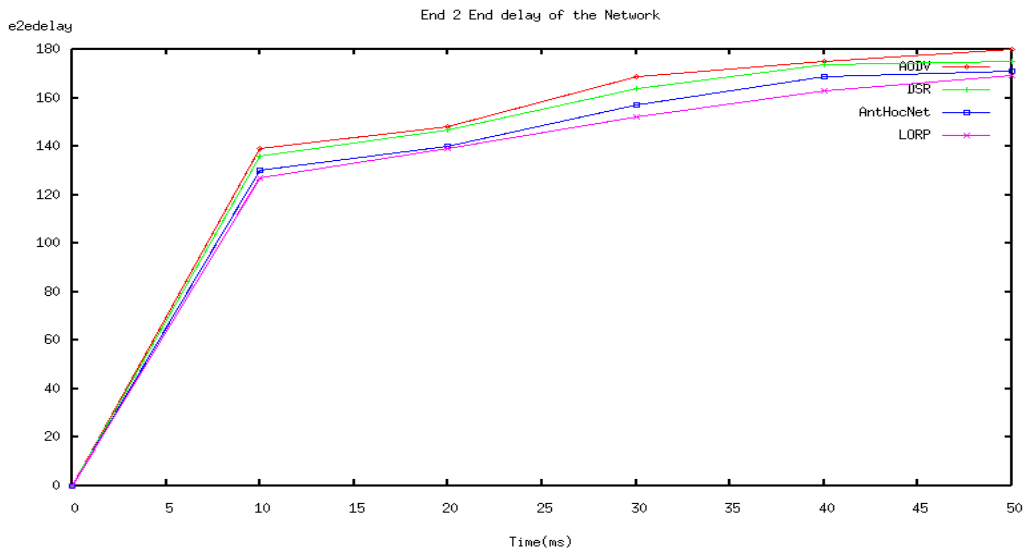

Figure 4.2 end-to-end delay calculation scenario 1

● **Packet Delivery Ratio Calculation**

The performance of various number of algorithms that used in this experimental study related to AODV applied in specific kind of simulator named NS2. The value of Packet Delivery Ratio calculation is totally similar to the routing algorithm, due to the number of node raised gradually. The AODV is obtained the lowest ratio with rate 0, 15, 29.3, 38.5, 42.5, 65.8 respectively. While, the LORP algorithm received the optimal outcomes with rate 0, 45.4, 49.5, 72.5, 88.1, 93.1, respectively. It can be seen from Table 4.4, the LORP is greater than AODV, DSR, and ANTHOCNET.

Table 4.4 Values for packet delivery ratio calculation scenario 1

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	15	20.2	32.4	45.4
20	29.3	33.5	38.2	49.5
30	38.5	42.8	51.5	72.5
40	42.5	49.5	69.1	88.1
50	65.8	76.4	82.5	93.1

Figure 4.3 shows the plot of AODV, DSR, AnHocNet and LORP protocols with the pause time of 20ms. The x-axis in the graph represents the simulation time and the y-axis represents the packet delivery ratio of the network. In the scenario-1 the number of nodes which are deployed for the simulation is 25 nodes and the packet delivery ratio of LORP is 93.1 percent. The performance of earlier protocols is AODV is 65.8 percent, DSR is 76.4 percent and AntHocNet is 82.5 percent. Comparing to the earlier protocol is proved that our proposed LORP protocol performed better in terms of packet delivery ratio.

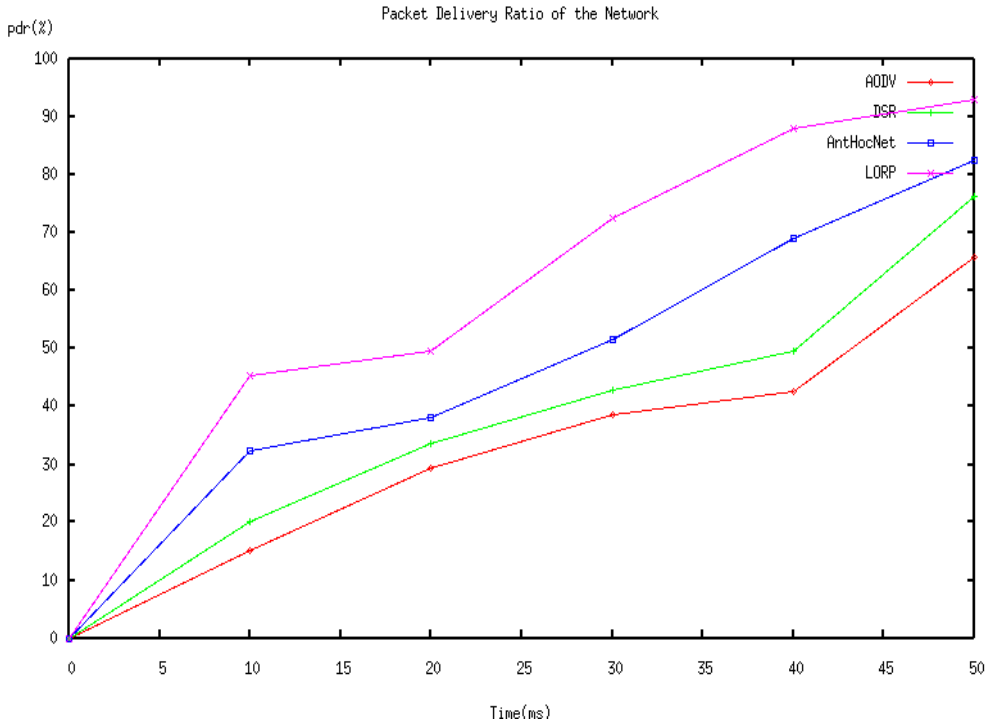

Figure 4.3 Packet delivery ratio calculation scenario 1

- **Network Throughput Calculation:**

Throughput is one among the major quality of communication in the networks. It is shortly defined as the total number of data received according to the periodic time. The proposed method obtained such an optimal results in terms of Network Throughput Calculation with 119 Kbps, which are comparatively less than the earlier proposed methods as shown in Table 4.5.

Table 4.5 Values for throughput calculation scenario 1

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	2.5	2.6	3.1	4.8
20	2	4	6	8
30	10	12	24	32
40	25	43	58	63
50	76	89	92	119

Figure 4.4 illustrates the throughput comparison for AODV, DSR, AntHocNet and LORP protocols. The throughput of the network according to number of packets delivered per second is measured and calculated by Kbps. In this scenario-1 the number of nodes which are deployed for the simulation is 25 nodes and the throughput of LORP is 119 Kbps. The performance of earlier protocols i.e. AODV is 76 kbps, DSR is 89 kbps and AntHocNet is 92 Kpbs respectively. Comparing to the proposed protocol is proved that our proposed LORP protocol performed well in terms of network throughput.

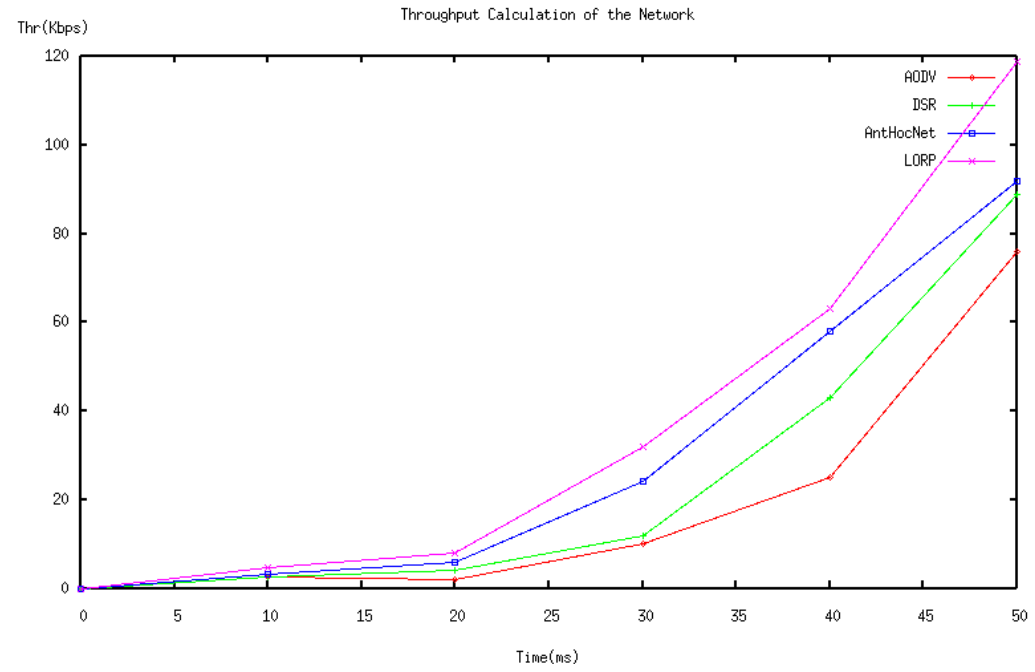

Figure 4.4 Throughput calculation scenario 1

4.4 Analysis of scenario 2 – 50 nodes

●Packet Loss Calculation:

The total number of nodes retransmitted during scenario-2 and packet loss in association with the proposed algorithm in LORP with total rate loss 42 as much less compared to the retransmissions in AODV, DSR, and ANTHOCNET 55, 48, 44, respectively. The main reason behind that due to the characteristic and features of the lion hunting in special kind groups and resident property. In LORP, the node attempted to delay for a certain time to transmit that defers based on distance matrix is evaluated as shown in Table 4.6.

Table 4.6 Values for packet loss calculation scenario 2

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	15	12	10	8
20	24	18	17	16
30	35	32	29	25
40	42	40	38	36
50	55	48	46	42

In Figure 4.5, the x-axis represents simulation time and the y-axis represents packet loss of the network. In this scenario, the number of nodes are deployed for the simulation is 50 nodes and the packet loss of LORP is 42. The performance of AODV is received 55, while DSR is 48 and AntHocNet is 46. It can be seen, the proposed LORP protocol is performed and obtain better result in terms of packet loss compare with others protocol.

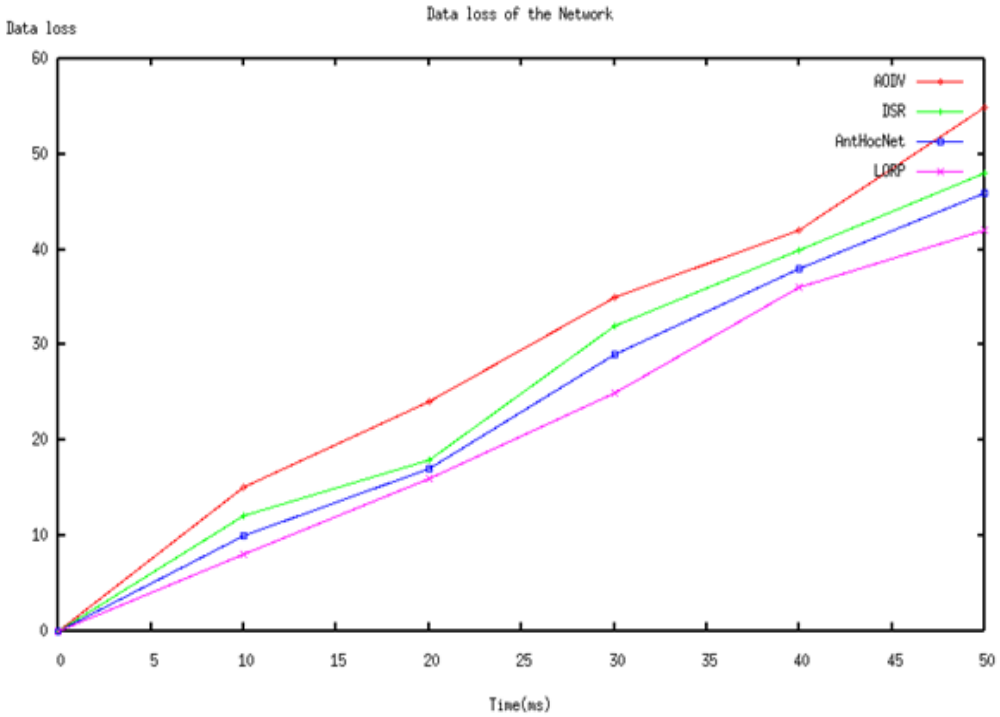

Figure 4.5 Packet loss calculation scenario 2

●End-to-end Delay Calculation

The end-to-end delay calculation begins when the application on the source node forward a packet to the final destination. Table 4.7 shows the results for end-to-end delay calculation in scenario-2. The proposed protocol LORP obtained such an optimal outcome with the lowest value 131.51 ms in comparison with other AODV, DSR, and ANTHOCNET with value 150 ms, 142 ms, and 139 ms, respectively.

Table 4.7 Values for end-to-end delay calculation scenario 2

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	100.4	96.4	94.0	93.8
20	120	116	106	100.6
30	128	117	114	110.4
40	140	136	132	124.5
50	150	142	139	131.51

The x-axis in the graph shows the simulation time and the y-axis shows the end-to-end delay of the network. While comparing the earlier protocols and our proposed protocol, LORP rises from 10.245ms and reaches the utmost level up to 131.51 ms, which are comparatively less than the earlier routing protocols. Here the end-to-end delay of scenario 2 is less than scenario-1, which proves that when number of nodes increases it reduces the end-to-end delay of the network. Figure 4.6 shows the end-to-end delay performance of AODV, DSR, AnHocNet and LORP protocols.

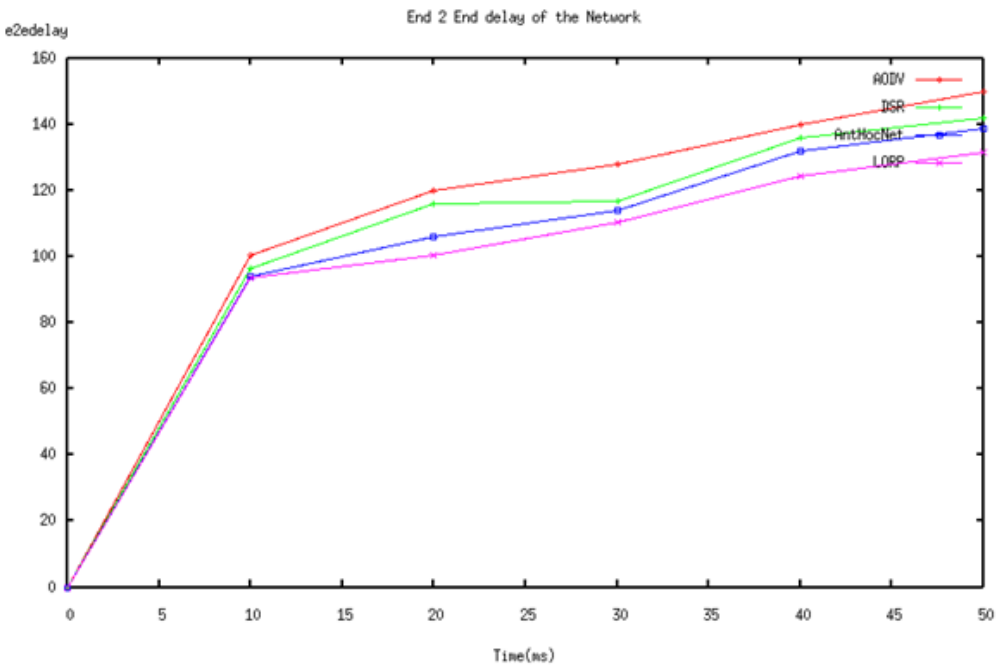

Figure 4.6 End-to-end delay calculation scenario 2

●Packet Delivery Ratio Calculation

The performance of Packet Delivery Ratio Calculation remains constant for raising the total number of routes but LORP illustrates better results than other protocols. Table 4.8 shows the proposed protocol with value 93.7, which considered the highest number in contrast when compare with the performance of earlier protocols i.e. AODV with 78.3 percent, DSR with 84.9 percent and AntHocNet with 90.0 percent. This indicated that our proposed LORP protocol performed well in terms of packet delivery ratio.

Table 4.8 Values for packet delivery ratio calculation scenario 2

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	20.5	35.7	47.9	50.9
20	34.8	49.0	53.7	65.0
30	44.0	58.3	67.0	78.0
40	68.0	75	84.6	90.6
50	78.3	84.9	90.0	93.7

Figure 4.7 shows about the plot of AODV, DSR, AnHocNet and LORP protocols. In the scenario-2 the number of nodes which are deployed for the simulation is 50 nodes and the packet delivery ratio of LORP is 93.7 percent.

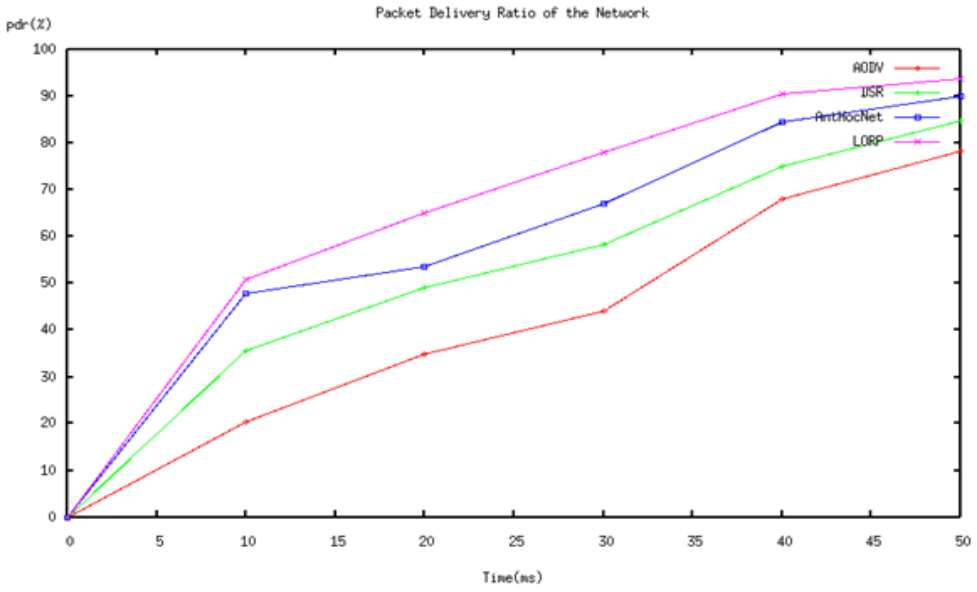

Figure 4.7 Packet delivery ratio calculation scenario 2

●Network Throughput Calculation:

The last measurement in scenario-2 is Network Throughput. In this section, the LORP yield such a great outcomes with values 95 Kbps in comparison with others protocols. Table 4.9 demonstrates the total number of values of each protocols based on time range from 0 to 50. The number of nodes in the scenario-2 are deployed with 50 nodes and the throughput of LORP is 95 Kbps.

Table 4.9 Values for throughput calculation scenario 2

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	0.5	2.8	3.1	4.8
20	4	8	10	12
30	15	26	29	32
40	38	42	48	55
50	66	73	86	95

Figure 4.8 examines the throughput comparison for AODV, DSR, AntHocNet and LORP protocols. It can be seen that the proposed LORP protocol performed well in terms of network throughput.

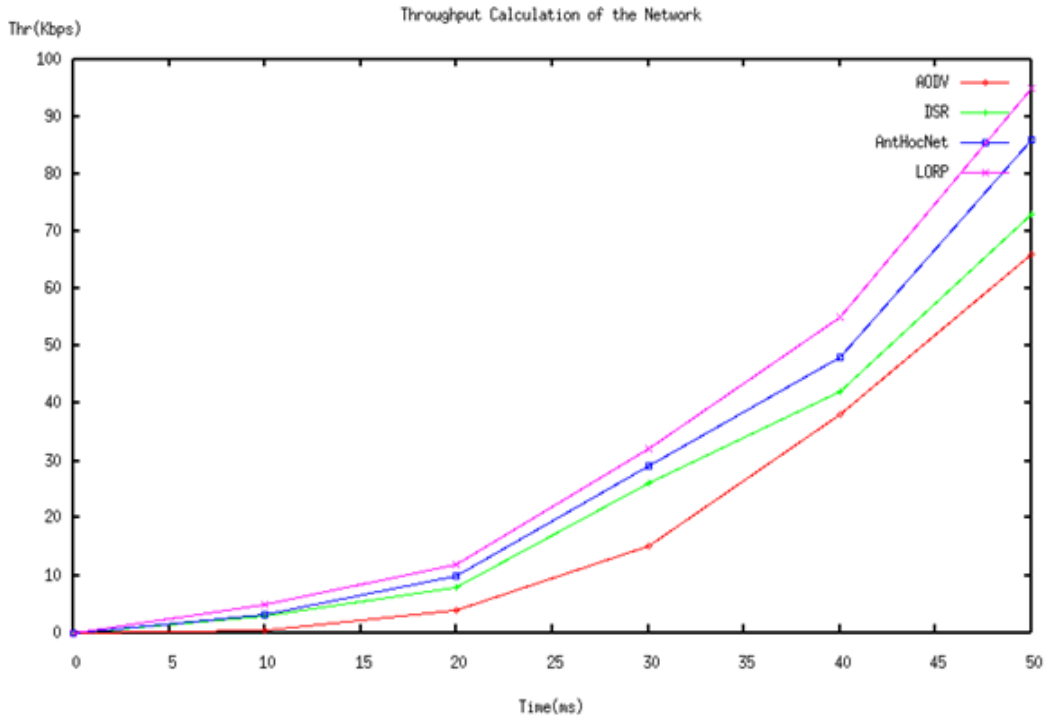

Figure 4.8 Throughput calculation scenario 2

4.5 Analysis of scenario 3 – 100 nodes:

●Packet Loss Calculation:

In this section, the first calculation in scenario-3 is concentrate on 100 nodes which is considered optimal with packet loss calculation. Table 4.10, shows the total number of value with regards time 20 is obtained 6 for the proposed protocol. While, the same proposed protocol LORP increased gradually with time 50 and acquired 25. The performance of earlier protocols is AODV is 35, DSR is 32 and AntHocNet is 29. Comparing to the earlier protocol is proved that the proposed LORP protocol performed well in terms of packet loss.

Table 4.10 Values for packet loss calculation scenario 3

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	10	8	7	4
20	12	11	10	6
30	15	12	10	8
40	24	18	17	16
50	35	32	29	25

Figure 4.9, the x-axis represents Time and the y-axis represents packet loss of the network. In the scenario-3 the number of nodes which are deployed for the simulation is 100 nodes and the packet loss of LORP is 25 ms.

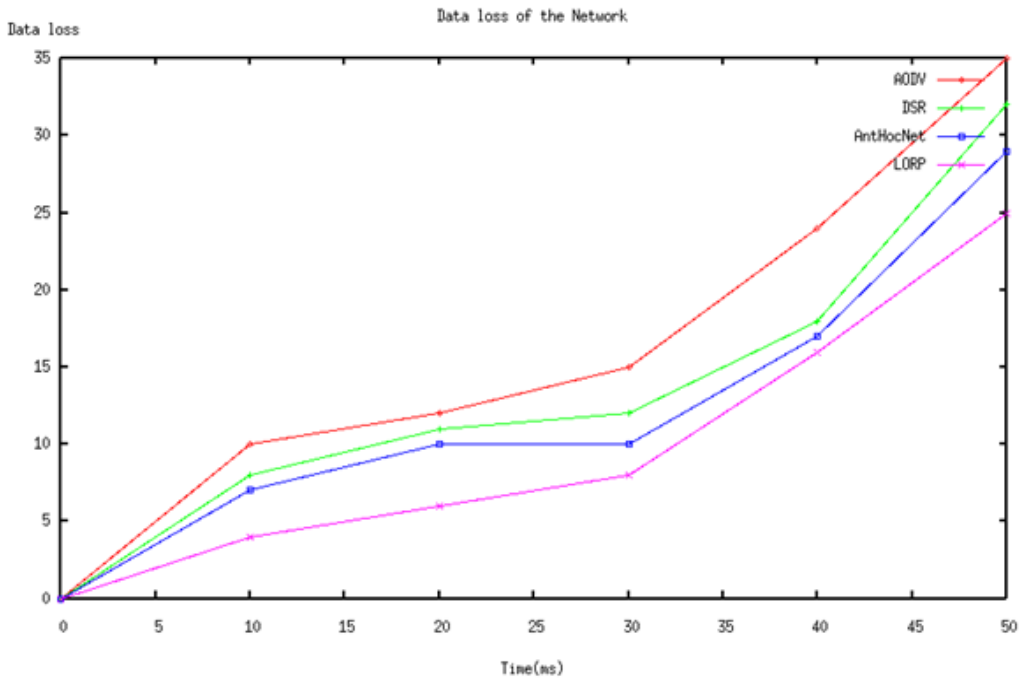

Figure 4.9 Packet loss calculation scenario 3

● End-to-end Delay Calculation:

The end-to-end delay for the proposed protocol LORP is achieved best results with value 178.9 depends on time 50. While, the LORP is received 153 while ANTHOCNET is obtained 159 based on time 30 as demonstrated in Table 4.11.

Table 4.11 Values for end-to-end delay calculation scenario 3

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	124	120	117	110
20	145	142	139	135
30	171	162	159	153
40	179	172	168	165
50	185	183	179	178.9

The end-to-end delay calculation performance of AODV, DSR, AnHocNet and LORP protocols as shown figure 4.10. The proposed protocol LORP reaches the highest level to 178.9 ms in association with time 50 which are considered less than the previous routing protocols.

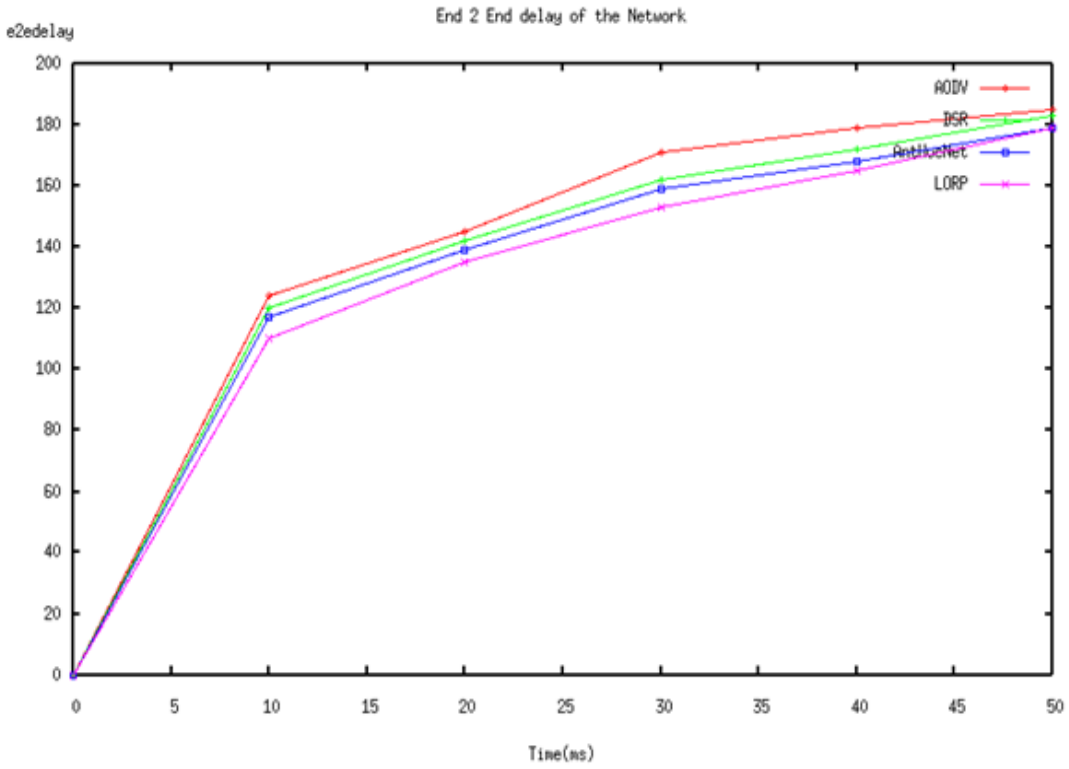

Figure 4.10 End-to-end calculation scenario 3

- **Packet Delivery Ratio Calculation**

The packet delivery ratio is considered very effective tools to estimate the total calculation between the sender and final destination. Table 4.12, shown that the proposed protocol obtained the highest value with 98.2 ms in association with 50 time. The lowest value is received in terms of AODV protocol with 82.8 depends on 50 time.

Table 4.12 Values for packet delivery ratio calculation scenario 3

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	25	40.2	52.4	55.4
20	39.3	53.5	58.2	69.5
30	48.5	62.8	71.5	82.5
40	72.5	79.5	89.1	95.1
50	82.8	89.4	94.5	98.2

In this scenario, the number of nodes are deployed for the simulation is 100 nodes. The experiment study perform highest value in term of PDR comparing to earlier protocols as shown in figure 4.11

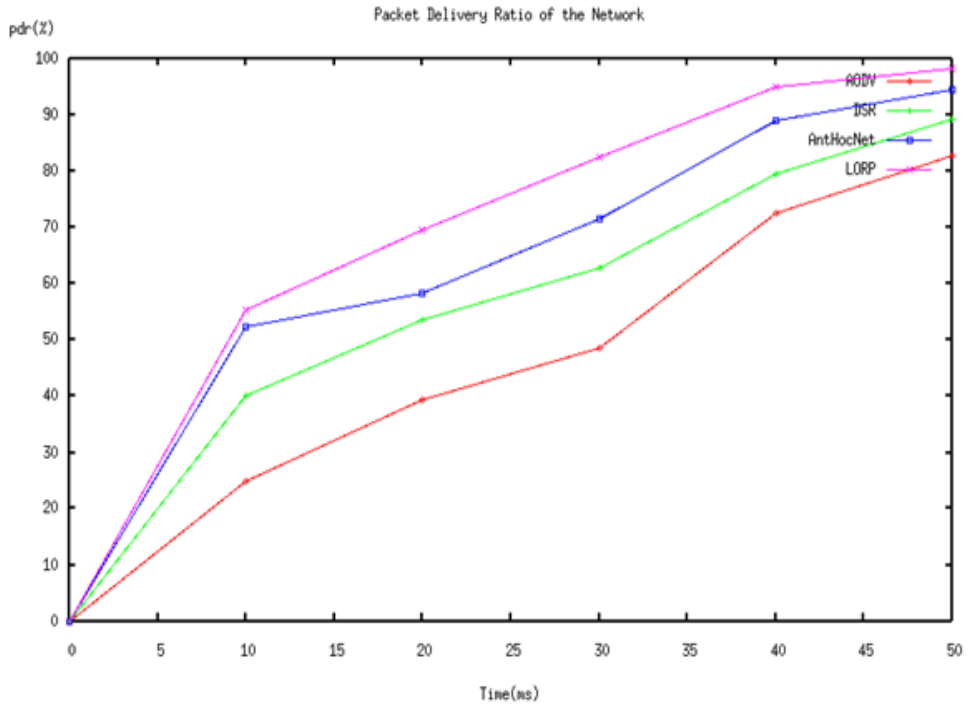

Figure 4.11 Packet delivery ratio calculation scenario 3

- **Network Throughput Calculation:**

The Network Throughput is calculated the total number of value between the start node and final destination. In order to achieve such an optimal results, it is very important to select the proper protocol. In the current experimental simulation study, it is discovered that the LORP obtains a highest number with value 155 ms in terms of 50 time as optimal path as shown in Table 4.13.

Table 4.13 Values for throughput calculation scenario 3

Time	AODV	DSR	ANTHOCNET	LORP
0	0	0	0	0
10	2.5	3.8	5.1	8.8
20	10	18	20	25
30	25	46	50	60
40	48	62	88	110
50	76	93	136	155

Figure 4.12. shown the comparison the proposed approach to the earlier protocols, it is proved that the proposed LORP protocol performed well in terms of network throughput. While comparing the scenario-1, 2 and 3 the scenario-3 produces the highest throughput. So it understood the performance of the network increases by increasing the number of nodes in the network.

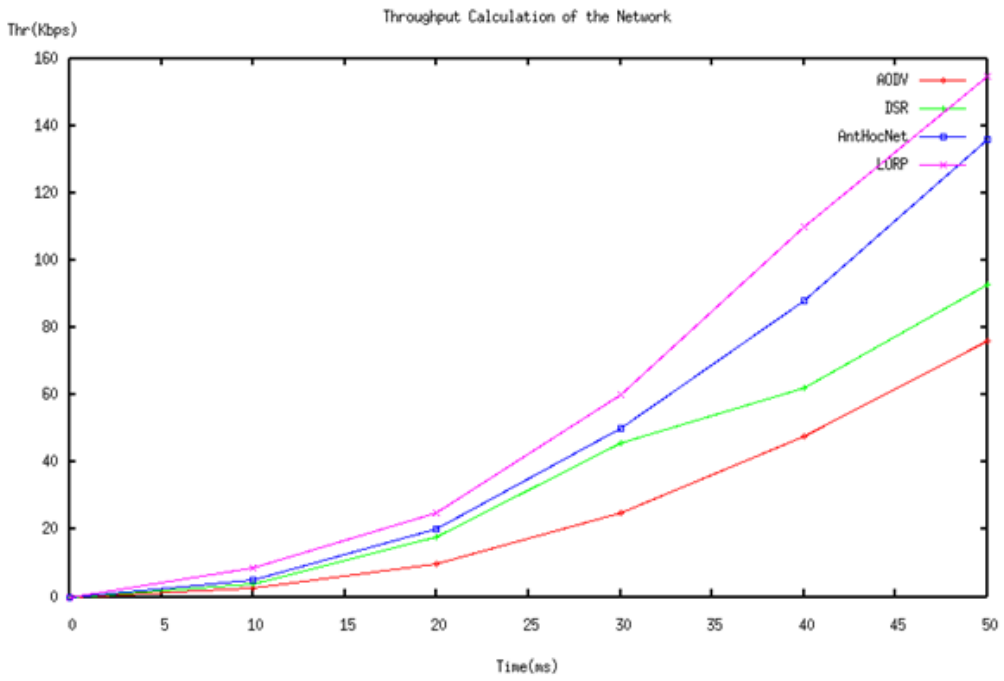

Figure 4.12 Throughput calculation scenario 3

4.6 Results Discussion

In this thesis, three scenarios implemented and the results details described. Scenario-1:- number of nodes are used only 25. In this aspect, the initial scenario is simulated and produced the required tables and plot of the results. It is discovered that, the LORP is received 119 while AODV is obtained 72. The x-axis denotes the number of nodes comparing the earlier protocols and our proposed protocol, LORP rises from 15.245ms and reaches the utmost level up to 169.390ms based on End-to-end delay. Scenario-2: the plot were illustrated using 4 kinds of protocols which called AODV, DSR, AnHocNet and LORP protocols. In scenario 2, the number of nodes which are deployed for the simulation is 50 nodes and the packet delivery ratio of LORP is 93.7 percent. Scenario-3: the total number of value with regards time 20 is obtained 6 for the proposed protocol in association with packet loss. While, the same proposed protocol LORP increased gradually with time 50 and acquired 25. The performance of earlier protocols is AODV is 35, DSR is 32 and AntHocNet is 29. Comparing to the earlier protocol is proved that our proposed LORP protocol performed well in terms of packet loss. For AODV protocol, it varies with raising number of nodes and shown worst-performance, which remains less and worst outcomes in all scenario and parameters. The LOPRP achieved such an optimal and best results with all scenario and parameters as shown in Figure 4. 2 to 4.12 and Tables 4.2 to 4.13.

Table 4.14 compression between the three scenarios

Metrics	Scenario-1 25 nodes	Scenario-2 50nodes	Scenario-3 100 nodes
Packet loss	32	42	25
Ens-2-end delay	169.39	131.51	178.9
Packet delivery ratio	93.1	93.7	98.2
Network throughput	119	95	155

When compered between the three scenarios the result shown that scenario-3 better than another scenarios in terms of packet loss , packet delivery ratio and network throughput as shown in table 4,14. In this case, the lion algorithm in large network work better than small network. Scenario-2 batter than other scenarios in term of end-2-end delay.

4.6 summary

The current empirical simulation results are presented realistic comparisons of a number of protocols that used in three types of scenarios that are considered both reactive and position depends on routing protocol. The various scenarios were applied in the particular platform called NS2. This kind of platform is very effective and robust tools to deal with scenario protocols. This study proposed a novel routing protocol for MANET namely Lion Optimization Routing protocol (**LORP**) which are mainly based on lion optimization algorithm (population-based algorithm) and AODV protocol. The general routing process of Route Request, Route Reply, Error Finding and Hello Message processes are taken care of ad-hoc on demand routing protocol and mainly to fix the optimal path use Lion Swarm Optimization Algorithm is used.

The major parameters of optimal path finding are networking model, trust model and optimal path finding model. AODV protocol is enhanced in the networking model. At the initial stage of path selection, we use an optimization technique that is mainly divided into three categories. They are energy optimization, Maximization Algorithm and Minimization Algorithm. The major parameters which are used in maximization algorithm are Power Efficiency, Throughput, and Packet Delivery Ratio. The parameters which are used in minimization algorithm to select the best path are Delay and Short Path. The core idea of the maximization model is to find the max path value likewise for minimization the metrics are used to find the low values.

In this research, the simulation for 25 nodes, 50 nodes, and 100 nodes are run and produce analysis and calculation using the proposed protocol **(LORP)**. With each scenario, this research used time that started from 0 to 50s. In this scenario, the nodes were simulated using AODV, DSR and ANTHOCNET , and **LORP** routing protocol were evaluated by various parameters, Packet Loss Calculation, End-to-end Delay Calculation Packet Delivery Ratio Calculation, and Network Throughput Calculation.

Chapter Five
Conclusion And Future Work

Chapter Five

CONCLUSION AND FUTURE WORK

5.1 Introduction

In this research work, the author studied and analyzed about the MANET networks, routing protocols, earlier optimization techniques and lion swarm optimization algorithm in a detailed manner. Routing in ad-hoc on demand network becomes more complicate due to its dynamic behavior and bandwidth limitation during data transmission. According to the optimization based analysis, swarm intelligence based models are more suitable to handle the imbalance path fixing issues and perform effectively than the earlier routing protocols such as AODV, DSR and AntHocNet. These algorithms are enthused by a variety of living organisms like ant, bee, glue, termite, birds and animals which contains an exclusive behavior to handle the groups and communicate between one another.

5.2 Research Contribution

- This research developed a routing algorithm to find the best path using Lion Optimization Algorithm (LOA) which able to transfer the data from the source to the destination.
- This research applied optimization for path finding process utilizing value maximization and value minimization models.
- This research proposed a new approach that able to reduce the packet loss, energy consumption and latency.
- This research improved the packet delivery ratio and network throughput which leads to improve the overall QoS of the network.

5.3 Research Limitation

There are two main research limitation encountered during the completion of this thesis. Firstly, due to the lack of knowledge in this field, more time was required to do more research and learn about the LORP to be developed. Secondly, Coronavirus pandemic was major problem during this research.

5.4 Research Recommendation and Future Work

This project has been successfully proposed and implemented. However, it can be improved to target more advanced and better application in the next stage of research. Hence this thesis focused on the optimal path selection in order to improve the QoS of the network. In the future work, the author planned to concentrate the energy efficiency maximization of the network by reducing the energy consumption because still there is a research gap present in this area of energy optimization. So the research will get continued by reviewing several energy based models to find the new objectives to proceed further.

5.5 Conclusion

The final Chapter concludes the whole research finding of this project .The proposed protocol results in the simulation evaluation is carried out in NS-2.34 test bed and it is discussed elaborately. In order to find the optimal path in the network the new protocol is proposed namely LORP protocol. The major parameters of optimal path finding energy factor, packet delivery ratio and throughput of the node for value maximization and delay, short path finding for value minimization process. These parameters play an important role in finding the optimal path. Among the entire possible path the optimal path is chosen using the LSO algorithm.

The results section shown the various features and performance evaluation metrics of another protocols and proposed protocol in a tabular manner and graphical manner. These protocols are analyzed as well as compared on the basis of the following metrics such as PDR, packet loss, network end to end delay and network throughput. From the comparison table and the results of the proposed LORP protocol performed better than other protocols AODV, ANT-hoc-Net, DSR. Hence it proved that the proposed LORP protocol is most capable to handle several routing challenges such as topographical issues, network scalability and maintenance which are created due to dynamic topography.

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الخلاصة

حدثت العديد من التطورات في شبكات الجوال المخصصة (MANET) بسبب الاستخدام الهائل لأجهزة الاستشعار المحمولة في السوق وهي المجموعة الضخمة من العقد التي يمكنها الاتصال بشكل مباشر أو غير مباشر. لذلك فهي جلبت انتباه العديد من الباحثين للبحث في هذا المجال بسبب الطبيعة الديناميكية للشبكة. توجد العديد من المشكلات والتحديات البحثية في هذا المجال مثل حركة الأجهزة، إيجاد المسار الأمثل ومشكلة التحسين وكفاءة الشبكة وما إلى ذلك. علاوة على كل هذه التحديات ، فإن العثور على المسار الأمثل هو القضية الأكثر أهمية التي تواجهها (MANET). بسبب المسار غير المتوازن ، يتم زيادة استهلاك الطاقة بشكل كبير في شبكة MANET بسبب التنقل الديناميكي للشبكة أثناء عملية الاتصال بين المرسل و المستلم. يؤدي إصلاح مسار عدم التوازن إلى زيادة تأخير الشبكة ، وتقليل نسبة تسليم الحزم ، وتقليل معدل نقل الشبكة ، وزيادة الخسارة التي تؤدي إلى قبول الجودة الشاملة للخدمة (QoS) للشبكة. أخذ هذه التحديات في الاعتبار يركز عملنا البحثي بشكل أساسي على تطوير بروتوكول جديد لاكتشاف المسار الأمثل بنجاح مع نموذج التحسين. اقترحت هذه الرسالة بروتوكول توجيه جديدًا لـ MANET وهو Lion Optimization Routing Protocol (LORP) والذي يعتمد بشكل أساسي على Lion Swarm Agorithm وبروتوكول AODV. تعد خوارزمية Lion swarm algorithm واحدة من الخوارزميات المستوحاة من طبيعة سلوك الحيوانات والتي تُستخدم للعثور على أفضل مسار ممكن لنقل البيانات بين المرسل والمستلم . البروتوكول المقترح اخذ العديد من المعاملات ولم يعتمد في عمله لايجاد المسار الاقصر. عملية التوجيه العامة لطلب المسار ، والرد على المسار ، والبحث عن الخطأ ، وعمليات ارسال Hallo message يتم الاعتناء ببروتوكول AODV وبشكل أساسي لإصلاح المسار الأمثل يتم استخدام خوارزمية LSA في المرحلة الأولية من اختيار المسار . تم تقسيم تقنية التحسين إلى مرحلتين وهي خوارزمية Max وخوارزمية MIN. المعاملات الرئيسية المستخدمة في خوارزمية MAX هي كفاءة الطاقة والإنتاجية ونسبة تسليم الحزم. المعاملات المستخدمة في خوارزمية MIN لتحديد أفضل مسار هي ,وقت التاخير و ايجاد اقصر مسار . يتم إجراء تقييم المحاكاة في برنامج اختبار محاكاة الشبكة 2 (NS-2 2.34) وتتم مناقشته بشكل متقن. يتم حساب أداء البروتوكول المقترح ثم مقارنته مع البروتوكولات الأخرى مثل (AODV Ad hoc On Demand Vector Routing) و Dynamic source Routing (DSR) و AntHocNet. المعاملات التي تتركز للمقارنة هي نسبة تسليم الحزم ، و التأخير ، وفقدان الحزم وانتاجية الشبكة. تظهر النتائج المجمعة أن البروتوكول المقترح في هذه الرسالة يعمل بشكل أفضل عند مقارنته بالبروتوكولات السابقة ويساعد بشكل كبير في تحسين جودة الخدمة الشاملة لشبكة MANET.

وزارة التعليم العالي والبحث العلمي
جامعة الأنبار
كلية علوم الحاسوب وتكنولوجيا المعلومات
قسم علوم الحاسبات

تحسين التوجيه باستخدام خوارزمية سرب في شبكات الجوال المخصصة

رسالة مقدمة الى قسم علوم الحاسبات – كلية علوم الحاسوب وتكنولوجيا المعلومات – جامعة الانبار وهي جزء من متطلبات نيل شهادة الماجستير في علوم الحاسبات

تقدم بها
علاء صبري عواد

إشراف

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