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Optimized Path Evaluation For Mobile Ad Hoc Wireless Networks Using Enriched Protocols

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Abstract

Performance measurement is an important factor in any network since it is used to determine the capability of the network. Mobility characteristic makes it different from other wireless or wired networks. Generally, shortest path algorithm was used for routing in MANETs but the performance measured using this system does not achieve high throughput. This paper introduces a novel method using Markov chain model in both proactive and reactive routing protocols of MANETs for achieving high throughput. By implementing Markov chain in each protocol, the performance of each protocol is improved individually. The performance measurement proves that the proposed system minimizes delay, thereby increases throughput with decrease in power consumption and packet loss ratio. Various performance metrics of MANET using Markov chain model in proactive and reactive protocol are presented and analyzed.

Keywords: MANET (Mobile Ad hoc Networks), Proactive routing, Reactive routing, AODV, OLSR, Markov chain model.

Introduction

The wireless communication revolution is bringing fundamental changes to data networking, telecommunication and making integrated networks a reality. Focusing on the networking and user aspects of the field, wireless networks provides connection flexibility between users in different places. Moreover, the network can be extended to any place or building without the need for a wired connection. Wireless networks are classified into two categories: Infrastructure networks and Ad hoc networks [1].

Ad hoc networking is a concept in computer communications. Each node participating in the network acts both as host and a router and must therefore is willing to forward packets for other nodes. An Ad hoc network has certain characteristics, which imposes new demands on the routing protocol [2]. The most important characteristic is the dynamic topology, which is a consequence of node mobility. Nodes can change position quite frequently which means a routing protocol is needed, that quickly adapts to topology changes. The node in an Ad hoc network might consist of laptops, personal digital assistants and are often very limited in resources such as CPU capacity, storage capacity, battery power and bandwidth. So the routing protocol should try to minimize control traffic, such as periodic update messages.

Mobile Ad hoc Network (MANET) is a rapidly deployable, self configuring network of mobile nodes. There is no need for existing infrastructure like base station or access point to function properly. The nodes are connected via wireless links to form an arbitrary topology. As the nodes are mobile, the network environment is highly dynamic [3].Routing protocols in MANETs typically fall under two classifications: Unicast Routing Protocol (URP) and Multicast Routing Protocol (MRP).

Mobile Ad Hoc Routing Network

In MANET, there are different types of routing protocols each of them is applied according to the network circumstances. URPs in MANET are broadly classified into proactive (table-driven), reactive (on-demand) and combination of both reactive and proactive, referred as hybrid. This classification is based on how a protocol manages to determine the route correctly in the presence of topology changes. The unicast mobile Ad hoc routing protocol is further classified according to their routing strategy as shown in Fig.1

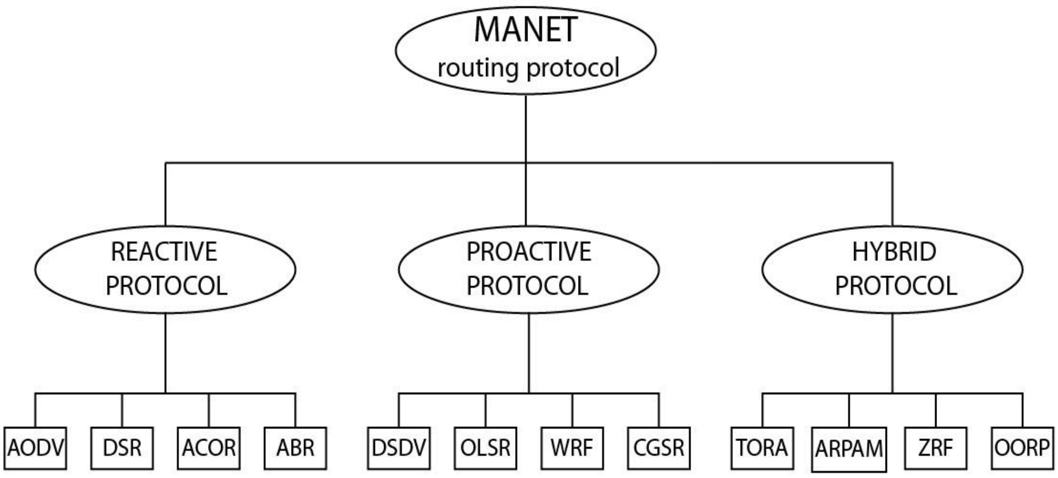

Fig.1 MANET Routing Protocols

Proactive Routing Protocol

Proactive routing [4] is also known as table driven routing. This class of routing protocol keeps track of routes from a source to all the destinations whether or not the routes are required. To maintain the routes, periodic routing updates are exchanged between the nodes in the network. The main advantage of such an algorithm is that there is no delay in establishing a communication session and routing table is updated as soon as there is a change in topology. Disadvantages are additional control traffic to keep the routing table up to date irrespective of whether all the routes are used in a session or not. In this work, Optimized Link State Routing (OLSR) is chosen from proactive algorithm.

Reactive Routing Protocol

Reactive routing is also called on-demand routing as the routes are established only when needed to forward the data packets. This algorithm has significantly low routing overhead when the traffic is light and network is less dynamic, since there is no need to maintain the routes when there is no data traffic. The major disadvantages are longer delay in establishing the routes for forwarding the data and excessive flooding of the control messages that may lead to network clogging. In this work, Ad hoc On-demand Distance Vector (AODV) is chosen from reactive algorithm.

Hybrid Routing Protocol

Often reactive or proactive features of a particular routing protocol might not be enough instead a mixture might yield better solution. Hence, in recent days, several hybrid routing protocols are also used. The hybrid protocols include some characteristics of proactive protocols and some characteristics of reactive protocols.

Related Work

To determine network organization, link scheduling and routing in MANETs, various types of routing protocols are studied such as reactive and proactive routing [4].

To understand the delay performance in MANET, a discrete time Markov chain model was developed to control packet delivery delay. The control in delay was achieved through two-hop relay algorithm [5].

Routing in MANET using Cluster based Approach (RIMCA) a new routing protocol was designed for efficient routing of message from source to destination. The communication was carried out without any centralized control per cluster [7].

Distributed Coordination Function (DCF) and Enhanced Distributed Coordination Function (EDCF) are used by the Medium Access Control (MAC) protocols to study the Quality of Service (QoS) in MANET by using effective routing [8].

In Threshold-based Hybrid Routing Protocol (THRP) for MANET a node may either join a proactive cluster, in which all nodes move relatively slowly or act as a single reactive node with high moving speed. The theoretical analysis and results of routing protocol and other typical routing protocols are presented [9].

Sharp Hybrid Adaptive Routing Protocol (SHARP) which automatically finds the balance point between proactive and reactive routing by adjusting the degree to which route information is propagated proactively versus the degree to which it needs to be discovered reactively [10]..

Location based Multicast Addressing (LMA) to build content and context based routing. Content-based publish-subscribe models make it very appealing for dynamic wireless networks that often occur in pervasive computing scenarios. In this model, middleware do not fit the requirements, as the network is subjected to frequent topological reconfigurations due to mobility of the nodes [11].

A hybrid routing intelligent algorithm was proposed to study the performance of MANET in [12]. Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO) algorithm are combined to improve the performance metrics in MANET routing [12].

Proposed Method

The proposed method uses both the proactive and reactive routing protocols using Markov chain model to find the best next hop neighbor. Earlier, these routing protocols uses shortest path algorithm to find the next hop neighbor. But using RIMCA algorithm, the performance of the MANET was not improved. In this work, the performance of MANETs using Markov chain model, AODV protocol from reactive routing and OLSR protocol from proactive routing are taken for analysis.

AODV: Ad hoc On-demand Distance Vector

Ad hoc On-demand Distance Vector (AODV), as the name suggests is an on-demand protocol designed for mobile Ad hoc networks. This protocol responds quickly to changing link conditions and link breakages. The nodes mark the routes as invalid whenever there is a link breakage. AODV does not require a node to maintain routes to destinations that are not in active communication. Loop freedom in AODV is ensured by using destination sequence numbers. These also allow nodes to use the most recent route to a destination. The routing table information includes the destination address and the next hop address with the number of hops required to reach the destination. Also, the most recent destination sequence number associated with destination and lifetime of the route is stored in the table. If during the lifetime, the route is not used, the routing table entry is discarded.

The basic operation of AODV can be divided into three phases:

1. Route discovery
2. Route maintenance
3. ACK messages

The message types defined by AODV are Route Request (RREQ), Route Reply (RREP) and Route Error (RERR).

OLSR: Optimized Link State Routing

The Optimized Link State Routing (OLSR) is proactive table driven protocol for mobile Ad hoc networks. It facilitates efficient flooding of control messages throughout the network by using selected nodes called Multipoint Relays (MPRs). MPRs are selected by each node and are used to forward control messages resulting in a distributed operation of the protocol. In addition to this, a node continuously maintains routes to all destinations in the network, thus making the protocol suited for traffic pattern that is random and sporadic. Furthermore, the proactive nature makes OLSR suitable for networks where communicating pairs change over time.

The protocol is an optimization of classical link state routing algorithm and uses the concept of Multipoint Relays (MPRs).

The core functioning of OLSR can be divided into three processes namely:

1. Neighbor/Link Sensing
2. Efficient control flooding using MPR
3. Optimal path calculation using shortest path algorithm

Markov Chain Model

A link connectivity model is that implicitly models node mobility. The link connectivity model, in a simple form uses two-state Markov chain to model the link between each pair of nodes. The state of each link, UP (connected) or DOWN (disconnected).

The link connectivity model uses an N X N connectivity matrix, where represents the topology of a MANET with *N* nodes. The elements in the matrix are two-state random variables. Element M_{ij} specifies the status of link (i, j), the link between node i and node j. If $i \neq j$, $M_{ij} = 1$ when link (i, j) is in the UP state and $M_{ij} = 0$ when link (i, j) is in the DOWN state. *Mii is* defined as the degree of node *i*, for all *i*.

The link UP lifetime and the link DOWN lifetime are random variables. The mean values of the link UP lifetime and link DOWN lifetime for link (i, j) denoted as T_{ij} is UP and T_{ij} is DOWN, respectively. The link UP lifetime and link DOWN lifetime are exponentially distributed random variables in the initial investigation that all links have the same mean link UP lifetime and link DOWN lifetime, denoted as T_{UP} and T_{DOWN}, respectively. These two parameters, T_{UP} and T_{DOWN}, fully characterize the simple version of the link connectivity model.

The link connectivity model has three advantages when compared to the random way point model

(i) It is easier to vary link stability in a controllable manner
(ii) Much shorter warm-up periods are required for link stability statistics to reach steady state
(iii) Simulations tend to require less computation time.

In the two-state Markov model, a channel can be in one of two possible states, “good” or “bad.” The state transition diagram is shown in Fig.2. The probability of dropping a packet, i.e., the probability of a packet error, is different in each state. Given a present state, a channel may transit to the other state or stay in the present state with certain probabilities. The probabilities are

1. P1 is the probability of staying in the good state

2. P2 is the probability of staying in the bad state
3. 1-P1 is the probability of a transition from the good to the bad state
4. 1-P2 is the probability of a transition from the bad to the good state
5.

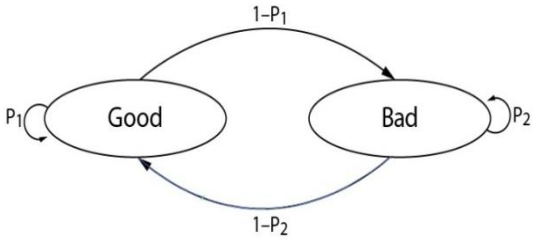

Fig.2 Two-state Markov chain for the Packet loss Model

The Markov chain model in Fig.2 is used for AODV and OLSR protocols for acquiring their routing information and maintaining them in the mobile nodes.

In this work, Markov chain model is implemented for path evaluation of MANET protocols. The algorithm used for proactive OLSR routing and reactive AODV routing, gives better performance metrics than the shortest path algorithm.

Simulation

The proposed work is implemented using NS2 simulator tool. Performance analysis is carried out by setting 100 nodes with a grid size of 1000×1000 m. The performance evaluation is based on the different parameters such as packet size, data packets send, data packets received and number of packets delivered. Packet delivery ratio, throughput, end-to-end delay, packet loss ratio and power consumption are measured to know the performance of the proposed method.

The chosen simulation parameters are summarized in the Table.1

Parameter	Value
Surface of the network	$1000m^2$
Number of nodes	100
Size of data packet	500 Byte
E_{el}	50nJ/bit
RTS,CTS,ACK size	30 Bytes
Traffic type	Constant Bit Rate(CBR)
Routing Protocol	AODV, OLSR
Antenna type	Omni-Antenna
Channel bandwidth	20kpbs
Initial Energy	2J
Transmission Range	250m

Table.1 Simulation Parameters

Performance Metrics

Packet Delivery Ratio (PDR)

The ratio of the data packets successfully received at the destination and total number of data packets generated at source. PDR is calculated by using PDR = (DataR)/(DataS), where DataR is data packets received by the CBR agent at destination node and DataS is data packets sent by the CBR agent at source node.

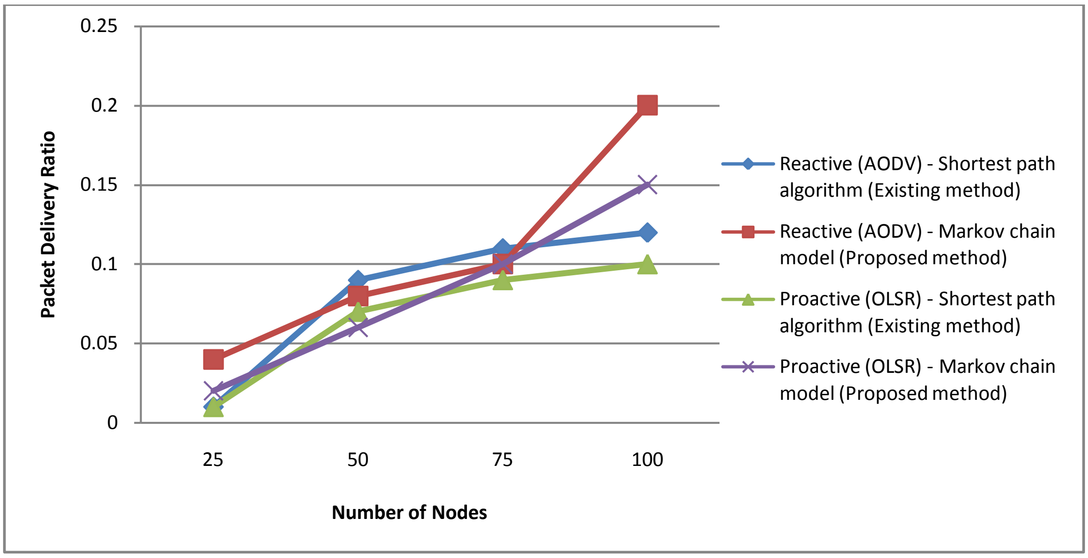

Fig.3 Packet delivery ratio

Fig.3 displays the packet delivery ratio of AODV protocol for reactive routing and OLSR protocol for proactive routing using Markov chain model and also the existing AODV protocol for reactive routing and OLSR protocol for proactive routing using shortest path algorithm method for comparative purpose are taken for analysis.

For reactive AODV protocol using Markov chain model, the packet delivery rate is increased to 0.2 with 100 nodes, whereas for 25 nodes it is 0.04 and also for proactive OLSR protocol with Markov chain model, the packet delivery rate is increased to 0.15 with 100 nodes, whereas for 25 nodes it is 0.02.

For reactive AODV protocol using shortest path algorithm method, the packet delivery rate is increased to 0.12 with 100 nodes, whereas for 25 nodes it is 0.01 and also for proactive OLSR protocol with shortest path algorithm method, the packet delivery rate is increased to 0.1 with 100 nodes, whereas for 25 nodes it is 0.01.

For 100 nodes, reactive AODV protocol delivers 5% more than proactive OLSR protocol with Markov chain model and also 2% more than proactive OLSR protocol with shortest path algorithm.

Average End-to-End delay

MANET has the characteristics of packet transmissions due to weak signal strengths of nodes, connection make and break, and the node mobility. These are several reasons that increase the delay in the network. Therefore the end-to-end delay is the measure of how a routing protocol accepts the various constraints of network and shows reliability. This metric gives the overall delay, from packet transmission by the application agent at the source node till packet reception by the application agent at the destination node.

Delay is calculated (seconds) by using Delay = (T_DataR) – (T_DataS), where T_DataR is Time data packets received at destination node and T_DataS is Time data packets sent from source node.

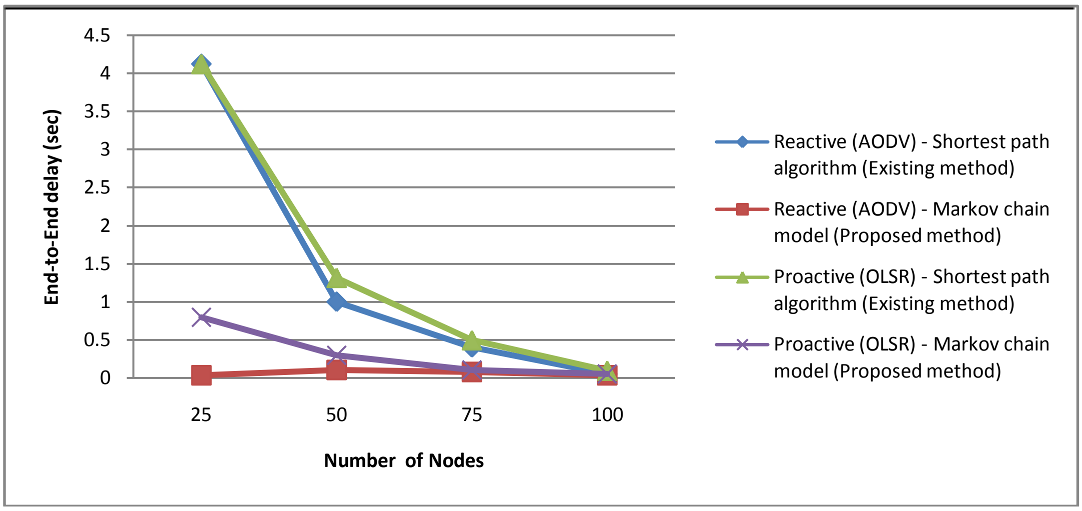

Fig.4 End-to-End delay

Fig.4 displays the end-to-end delay (sec) of AODV protocol for reactive routing and OLSR protocol for proactive routing using Markov chain model and also the existing AODV protocol for reactive routing and OLSR protocol for proactive routing using shortest path algorithm method for comparative purpose are taken for analysis.

For reactive AODV protocol using Markov chain model, the end-to-end delay (sec) is decreased to 0.04 with 100 nodes, whereas for 25 nodes it is 0.04 and also for proactive OLSR protocol with Markov chain model, the end-to-end delay (sec) is decreased to 0.05 with 100 nodes, whereas for 25 nodes it is 0.8.

For reactive AODV protocol using shortest path algorithm method, the end-to-end delay (sec) is decreased to 0.05 with 100 nodes, whereas for 25 nodes it is 4.13 and also for proactive OLSR protocol with shortest path algorithm method, the end-to-end delay (sec) is decreased to 0.1 with 100 nodes, whereas for 25 nodes it is 4.13.

For 100 nodes, reactive AODV protocol delivers 1% less than proactive OLSR protocol with Markov chain model, and also 5% less than proactive OLSR protocol with shortest path algorithm.

Throughput

Throughput (packets/second) is the ratio of total amounts of data that reaches the receiver from the source to the time taken by the receiver to receive the last packet. In the MANET unreliable communication, limited energy, limited bandwidth and frequent topology change affect throughput. A network requires high throughput and can be represented mathematically by,

$$\text{Throughput}=\frac{\text{Number of delivered packet}*\text{packet size}*8}{\text{Total duration of simulation}}$$

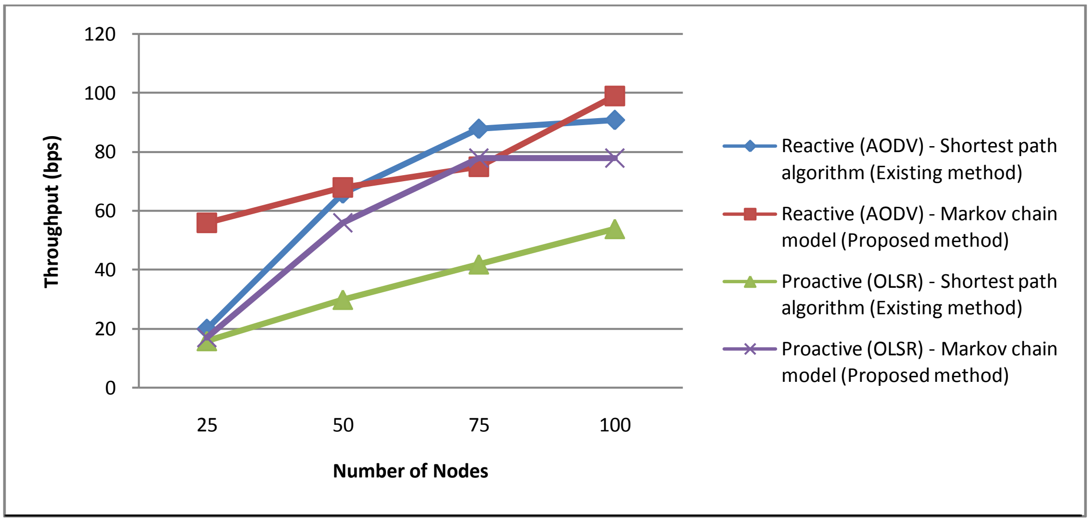

Fig.5 Throughput

Fig.5 displays the throughput (bps) of AODV protocol for reactive routing and OLSR protocol for proactive routing using Markov chain model and also the existing AODV protocol for reactive routing and OLSR protocol for proactive routing using shortest path algorithm method for comparative purpose are taken for analysis.

For reactive AODV protocol using Markov chain model, the throughput (bps) is increased to 99 with 100 nodes, whereas for 25 nodes it is 56 and also for proactive OLSR protocol with Markov chain model, the throughput (bps) is increased to 78 with 100 nodes, whereas for 25 nodes it is 17.

For reactive AODV protocol using shortest path algorithm method, the throughput (bps) is increased to 91 with 100 nodes, whereas for 25 nodes it is 20 and also for proactive OLSR protocol with shortest path algorithm method, the throughput (bps) is increased to 54 with 100 nodes, whereas for 25 nodes it is 16.

For 100 nodes, reactive AODV protocol delivers 21% more than proactive OLSR protocol with Markov chain model and also 37% more than proactive OLSR protocol with shortest path algorithm.

Power Consumption

Power consumption of a node after time t is defined as summation of number of packets transmitted by the node after time t (Nt) with number of packets received by the node after time t (Nr).

Power consumption (J) is calculated by using Pcon(t) = (Nt * C1) + (Nr * C2),where Pcon(t) is power consumed by a node after time t, Nt is number of packets transmitted by the node after time t, Nr is number of packets received by the node after time t, C1 and C2 are constant factors having a value between 0 and 1, The residual power PRes of a node at time t, can be calculated by using PRes = P – Pcon(t),where PRes is residual power, Pcon is consumed power, P is the initial power of a node.

Total energy consumption of all nodes is measured as the summation of all node's residual energy plus the product of initial energy and number of nodes is TPcon = N * (Initial Power –PRes), Where TPcon is total consumed power and N is total number of mobile nodes in MANET.

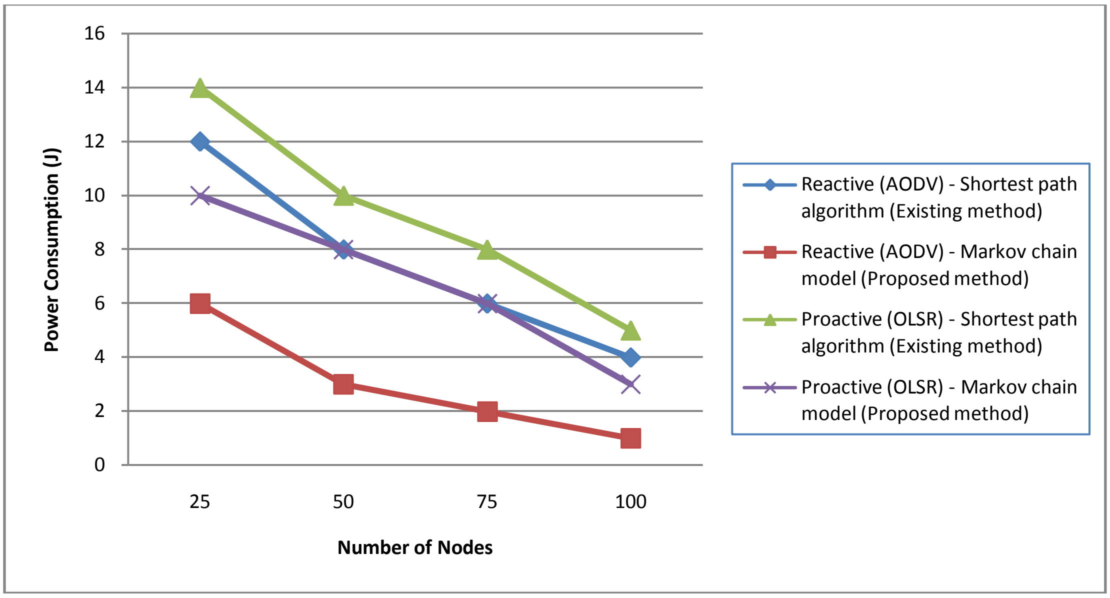

Fig.6 Power Consumption

Fig.6 displays the power consumption (J) of AODV protocol for reactive routing and OLSR protocol for proactive routing using Markov chain model and also the existing AODV protocol for reactive routing and OLSR protocol for proactive routing using shortest path algorithm method for comparative purpose are taken for analysis.

For reactive AODV protocol using Markov chain model, the power consumption (J) is decreased to 1 with 100 nodes, whereas for 25 nodes it is 6 and also for proactive OLSR protocol with Markov chain model, the power consumption (J) is decreased to 3 with 100 nodes, whereas for 25 nodes it is 10.

For reactive AODV protocol using shortest path algorithm method, the power consumption (J) is decreased to 4 with 100 nodes, whereas for 25 nodes it is 12 and also for proactive OLSR protocol with shortest path algorithm method, the power consumption (J) is decreased to 5 with 100 nodes, whereas for 25 nodes it is 14.

For 100 nodes, reactive AODV protocol delivers 20% less than proactive OLSR protocol with Markov chain model and also 10% less than proactive OLSR protocol with shortest path algorithm.

Packet Loss Ratio

The ratio of the total number of packets missed to reach the destination.

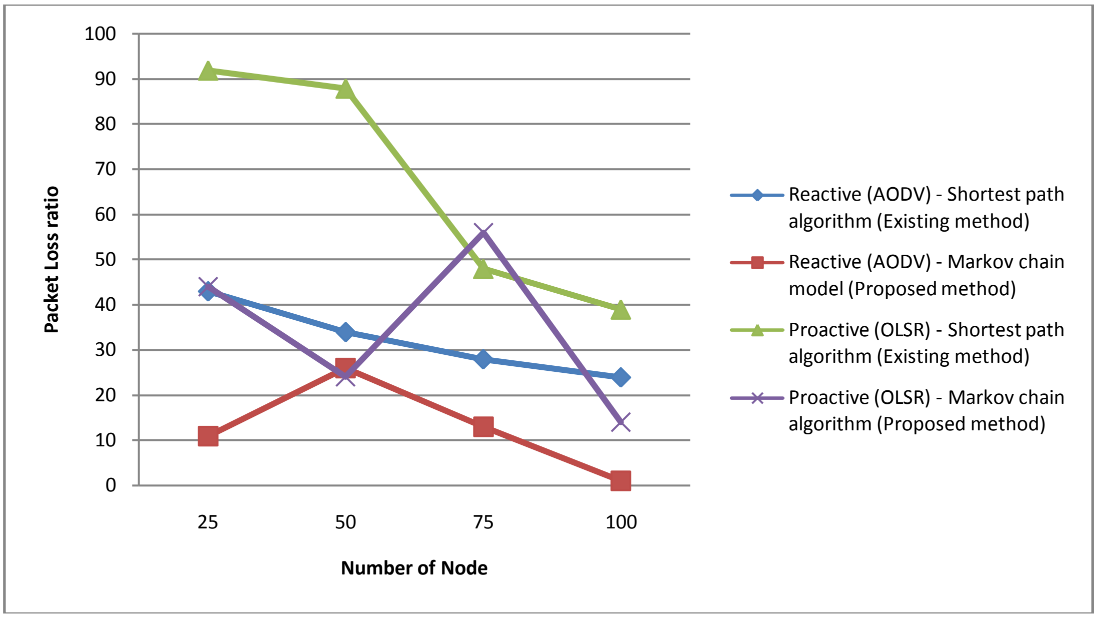

Fig.7 Packet Loss ratio

Fig.7 displays the packet loss ratio of AODV protocol for reactive routing and OLSR protocol for proactive routing using Markov chain model and also the existing AODV protocol for reactive routing and OLSR protocol for proactive routing using shortest path algorithm method for comparative purpose are taken for analysis.

For reactive AODV protocol using Markov chain model, the packet loss ratio is decreased to 1.1 with 100 nodes, whereas for 25 nodes it is 11 and also for proactive OLSR protocol with Markov chain model, the packet loss ratio is decreased to 14 with 100 nodes, whereas for 25 nodes it is 44.

For reactive AODV protocol using shortest path algorithm method, the packet loss ratio is decreased to 24 with 100 nodes, whereas for 25 nodes it is 43 and also for proactive OLSR protocol with shortest path algorithm method, the packet loss ratio is decreased to 39 with 100 nodes, whereas for 25 nodes it is 92.

For 100 nodes, reactive AODV protocol delivers12.9 % less than proactive OLSR protocol with Markov chain model and also 15% less than proactive OLSR protocol with shortest path algorithm.

Table.2 shows the performance metric for 100 nodes, for both AODV protocol for reactive routing and OLSR protocol for proactive routing for Markov chain model and shortest path algorithm method.

Performance Metric	**Reactive (Aodv)Shortest Path Algorithm (Existing Method)**	**Reactive (Aodv) Markov Chain Model (Proposed Method)**	**Proactive (Olsr)Shortest Path Algorithm (Existing Method)**	**Proactive (Olsr) Markov Chain Model (Proposed Method)**
Packet Delivery Ratio	0.12	**0.2**	0.1	0.15
Delay	0.05	**0.04**	0.1	0.05
Throughput	91	**99**	54	78
Power Consumption	4	**1**	5	3
Packet Loss Ratio	24	**1.1**	39	14

Table.2 Performance Measure

Conclusion

The chosen Markov chain model based routing in proactive OLSR and reactive AODV protocol in MANETS is simulated using NS2 simulator. Various performance metrics such as packet delivery ratio, delay, throughput, power consumption and packet loss ratio are calculated and presented. The shortest path algorithm based proactive OLSR and reactive AODV protocols are also presented for comparison. The results shows that the reactive AODV protocol routing using Markov chain is better in packet delivery ratio, delay, throughput, power consumption and packet loss ratio than the proactive OSLR protocol with Markov chain model and also the existing proactive OLSR and reactive AODV with shortest path algorithm.

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