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PACKET DELAY AWARE MULTIPATH ROUTING PROTOCOL (PDAMRP) FOR HETEROGENEOUS MOBILE AD HOC NETWORKS

Karthik S
Department of Computer Science and Engineering, SNS College of Technology,
Coimbatore, Tamilnadu, India.
profskarthik@gmail.com

Senguttuvan A
Department of Mathematics and Statistics, Caledonian College of Engineering,
Muscat, Sultanate of Oman.
senkutvan@gmail.com

ABSTRACT

This research work presents packet delay aware multipath routing protocol (PDAMRP) for heterogeneous mobile ad hoc networks. Initially service time of each packet is estimated. By using Markov chain model, stationary queue length at the departure epoch, length of busy period, packet delay are efficiently modeled. For finite buffer case stationary queue length is distributed along with packet delay and overflow probability are measured. The proposed protocol is an extension to ad hoc on demand multipath distance vector (AOMDV) routing protocol. Simulations are carried out using NS2 and the results portray that the proposed protocol PDAMRP outperforms than that of the compared routing mechanisms.

Keywords:PDAMRP, AODV, Prediction, Path, Weight, RPGM pattern, RWP mobility pattern, MG mobility pattern, GM mobility pattern.

1. INTRODUCTION

Wide usage of IEEE 802.11 based wireless networks could prompt sending of limited wireless information correspondence situations called specially appointed networks. Such networks don't backing wired correspondence and settled foundation too. The wireless hubs in mobile ad hoc networks (MANETs) are permitted to run applications, which share information of distinctive sorts and qualities. Applications running on MANETs may have distinctive qualities like system size, recurrence of topology change, correspondence prerequisites and information attributes. Each hub exists in the scope region of the MANET and can correspond with some other hubs in the system inside it and could call its own transmission range. Then again, hubs are allowed to move inside of the scope region of the MANET. A hub is permitted to correspond with another hub not existing in its transmission range, by means of multi-jump courses, where every hub along the course goes about as a switch of the message. In the meantime, new hubs can join the system at whatever time and existing hubs can leave the system whenever as well.

A mixture of routing protocols has been proposed by distinctive creators that viably bolster multi-jump communications in MANETs. Such protocols can be all around sorted as: on-demand or receptive protocols like dynamic source routing (DSR), Ad Hoc On Demand Distance Vector AODV and TORA; table-driven or proactive protocols, for example, destination sequenced distance vector protocol (DSDV). In on-demand routing protocols, a course is set up between the obliged source and destination preceding the communication what's more, uprooted after the communication is over. In table-driven routing protocols, every hub actualizes a routing table, which for all time stores the routing information to all conceivable destinations, regardless of whether a communication is started or not. In table-driven methodology, dormancy included in course acquisition is irrelevantly little.

2. LITERATURE REVIEW

Yujian Fang et al., 2014 focused on maximum allowed delivery delay which imposed to each packet and examines the impact of such delivery delay constraint on its real achievable performance in terms of throughput and packet end-to-end delay. *Juntao Gao and Xiaohong Jiang., 2013* demonstrated the potential application of the Quasi-Birth-and-Death process (QBD) theory in MANETs delay analysis by applying it to the end-to-end delay modeling in broadcast-based two-hop relay. *Jia Liu et al., 2014* explored the packet end-to-end delay in a 2HR (Hop Relay) MANET, where each node equipped with a bounded and shared relay-buffer for storing and forwarding packets of all other flows. In *Wazid et al., 2013*, a modified TCP namely Efficient Transmission Control Protocol (ETCP) which is capable of handling congestion in the network caused by Jelly Fish Attackers was proposed. *Kumar and Singh., 2014* proposed congestion control in the particular channel, queue length of packet, traffic rate based overall congestion standard, packet loss rate and packet dropping ratio to monitor the congestion status.

Ito et al., 2013 provided an adequate comparison between the performances of two transmission methods of MANET and DTN, with an aim of reducing the number of transmissions. *Nurain et al., 2014* developed a mathematical model for energy consumption of MANETs focusing on end-to-end delay. *Hakak et al.,2014* evaluated the routing protocol, packet size and node mobility pause time was evaluated i.e. Average Delay and Average Jitter, as these parameters were crucial for network performance and which directly affects the buffering requirements for all video devices and downstream network. *Yujian Fang et al., 2013* proposed 2HR-fτ algorithm that extends the traditional two-hop relay algorithms with deliver delay constraints. *Peng Yang and Biao Huang., 2008* proposed a routing protocol which can provide QoS guarantee. Finding the paths meeting delay requirement with great link stability factor and monitoring network topology changes through delay prediction and performs rerouting in time. *Singh et al., 2012* evaluated the applicability and capability of fuzzy logic based model for prediction of end-to-end packet delay in mobile ad hoc network environment. *Kamatam et al., 2014* proposed a Self Congestion Prediction (SCP) algorithm for congestion prediction and modified the AODV with SCP to propose a novel A-SCP protocol for alleviating congestion and efficient routing. Jyoti Prakash Singh et al., 2014 established a regression equation between path length and end-to-end delay, which provided an analysis for packet delay estimation using various network parameters along with fuzzy time series. *Karthik et al., 2015* provided Stochastic probability distribution mechanism (SPDM) for buffer queuing delay to overcome the shortcomings of Shannon’s entropy with various parameters.

3. PROPOSED WORK

In MANET, the channel service in each block is a random variable of positive real numbers. Therefore, the queue size $Q(n)$ cannot be guaranteed an integer when counting at some fixed epochs such as the beginning of each blocks n^{+}. Therefore, the queuing process is a discrete-time continuous-state Markov process. Unfortunately, few results are available for such processes. However, some transformations are performed on the queuing process here, and finally, we will construct a discrete-time discrete-state $D/G/1$ queue when the average signal-to-noise ratio (SNR) is low. In particular, the buffer size is assumed infinitely long.

3.1 Service Time of Each Packet

First, the cumulative distribution function (cdf) of the instantaneous capacity c_n is given by

$$F_c(x) = 1 - e^{\frac{-1}{p}\left(e^{\frac{x}{W}-1}\right)}$$

In the low-SNR scenario considered in this paper, particularly for the wideband communications, the following holds:

$$F_c(x) = 1 - e^{\frac{-x}{Wp}}$$

In the case of middle/high SNR or non-Rayleigh fading analysis, the memory less property of the service provided in each block will no longer hold. As a result, we have to resort to other techniques such as state-space quantization or stochastic analysis in [Ghiasian et al., 2013].

Therefore, in the low-SNR regime, the cdf of the service in one block (s_n) will be given by

$$F_s(x) = 1 - e^{\frac{-x}{v}}$$

which is a negative exponential distribution, where v is defined as

$$v = WT_{Bp}$$

It can be seen that the service of k successive blocks $S_k$follows the Gamma distribution, whose pdf is given by

$$f_s(x) = \frac{1}{\Gamma(k)v^k} x^{k-1} e^{\frac{-x}{v}}$$

where $\Gamma(k) = \int_0^\infty e^{-t}\, t^{k-1}\, dt$ is the Gamma function.

The service time T_n of a packet is the number of complete blocks of the period in which the service of the packet is finished.

Therefore, T_n is a nonnegative integer random variable. First, the probability that a packet is served within one block can be derived as follows:

$$p_0 = \Pr(T_n = 0) = \Pr(s_n > L_p) = e^{\frac{-L_p}{v}} = e^{-\theta}$$

where $\theta = L_p/v$

3.2 Markov Chain Model

In this way, the problem of information transmission over a block-fading Rayleigh channel can be transformed into a classical discrete-time $D/G/1$ queueing problem. Its arrival process is $\{A_n = 1, n \geq 1\}$ $(unit\!: L_p)$, and its service time T_n (unite: block) is a Poisson distributed random variable, whose probability generating function (PGF) is given by

$$G(z) = E[z^{T_n}] = e^{-\theta} + \sum_{k=1}^{\infty} \frac{1}{k!} e^{-\theta} (\theta z)^k = e^{\theta(z-1)}$$

According to the relationship of the moments and PGFs,

$$E[T_n] = G'(t)|_{t=0} = \theta$$

3.2.1 Stationary Queue Length at the Departure Epochs

Let $L^+ = lim_{n\to\infty} L_n^+$ be the limit of the queue length process, which is called the stationary queue length at departure epochs. Denote

$$\pi_j = \Pr[L^+ = j] = lim_{n\to\infty} \Pr[L_n^+ = j], \quad j \geq 0$$

Then, vector $\vec{\pi} = \{\pi_0, \pi_1, \dots\}$ the stationary queue length at the departure epochs.

3.2.2 Length of Busy Period

Busy period B is defined as a time interval during which the channel is continuously transmitting packets, and idle period I is a time interval when the buffer is empty. Thus, the system repeats cycles of busy and idle periods.

The PGF and the average value of busy period B are, respectively, given by

$$B(z) = \frac{-1}{\theta z} W\left(-\theta z e^{-\theta}\right) \qquad E[B] = \frac{\theta}{1-\theta}$$

where $W(z)$ is the Lambert W function [Chen. 1996]. The average idle period is given by $E[I] = \frac{1}{e^{\theta}} - 1$

3.2.3 Packet Delay

The packet delay D is defined as the time interval between the arrival of a packet and its departure. First, the packet delay consists of service time T. Second, if the packet arrives seeing a nonempty buffer, it must wait for a waiting time W for its service. Finally, for the formulation in this paper, there is another piece of time that the packet spends in the system, i.e., the vestige time. In this paper, $T = k\,(k = 0, 1, \ldots)$ means that the service of a packet is not finished until the k + 1th block. According to the memory less property of the negative exponential distribution, although part of the service ability has been consumed, it is considered as a brand new block. However, the packet still has to spend a part of that block in the system, which is called the vestige time. Thus, we know that

$$D = T + W + V$$

3.3 Queuing Model Formulation: Finite-Buffer Case

In the practical engineering, the size of a buffer must be finite. Thus, it is more useful to investigate the finite-buffer aided communications.

Denote the buffer size as K. If a packet arrives at the buffer when the queue length is K, an overflow happens. Here, we are interested in the overflow probability. In this case, the $(K + 1) \times (K + 1)$ transition probability matrix of the queue length process at the departure time $\{\hat{L}_n^{+}, n \geq 1\}$ is given by

$$\grave{p} = \begin{bmatrix} p_0 & p_1 & p_2 & p_3 & \cdots & p_{k-1} & \grave{p}K \\ p_0 & p_1 & p_2 & p_3 & \cdots & p_{k-1} & \grave{p}K \\ 0 & p_0 & p_1 & p_2 & \cdots & p_{k-2} & \grave{p}K-1 \\ 0 & 0 & p_0 & p_1 & \cdots & p_{k-3} & \grave{p}K-2 \\ \vdots & \vdots & \vdots & \ddots & \ddots & \ddots & \vdots \\ 0 & 0 & 0 & 0 & \cdots & p_1 & \grave{p}2 \\ 0 & 0 & 0 & 0 & \cdots & p_0 & \grave{p}1 \end{bmatrix}$$

where $\grave{p}k = \Pr\{T_n \geq k\} = 1 - \sum_{j=0}^{k} \left(\frac{\theta^j}{j!}\right) e^{-\theta}$ is the probability that the number of arrival packets (equal to the service time) is equal to or more than k during a service of current packet.

3.3.1 Stationary Queue Length Distribution

First, the stationary distribution of the queue length process for the infinite-buffer model can be obtained with its PGF. It is noted that $\pi_0 = 1 - \theta$

3.3.2 Packet Delay

For the finite-buffer model and the FIFO discipline, the average packet delay (the period from the arrival of a packet to its departure) is given by

$$E[\grave{D}] = \frac{1}{2} + \frac{\sum_{j=0}^{K-1} \varphi_j - K\theta\varphi_K}{1 - \theta\varphi_K} + \int_0^1 (x+1) e^{\frac{-\theta}{x}}\, dx$$

where $\varphi_{-1} = 1$

3.3.3 Overflow Probability

Define the overflow probability P_{overflow} of a finite-size buffer as the long-run fraction of packets that are rejected due to the finite capacity of the buffer. This is also the probability that the buffer is in the overflow state at packets arriving epochs.

4. RESULTS AND DISCUSSIONS

NS is an object oriented simulator, written in C++, with an OTcl interpreter as a frontend. The simulator underpins a class chain of importance in C++ (additionally called the ordered progressive system in this record), and a comparative class pecking order inside of the OTcl interpreter (additionally called the deciphered progressive system in this report). The two pecking orders are firmly identified with one another; from the client's point of view, there is a coordinated correspondence between a class in the translated progression and one in the incorporated progression. The foundation of this pecking order is the class TclObject. Clients make new simulator objects through the interpreter; these objects are instantiated inside of the interpreter, and are firmly reflected by a relating object in the ordered chain of importance. The translated class progressive system is naturally settled through strategies characterized in the class TclClass. Client instantiated objects are reflected through techniques characterized in the class TclObject. There are different progressive systems in the C++ code and OTcl scripts; these different chains of command are not reflected in the way of TclObject.

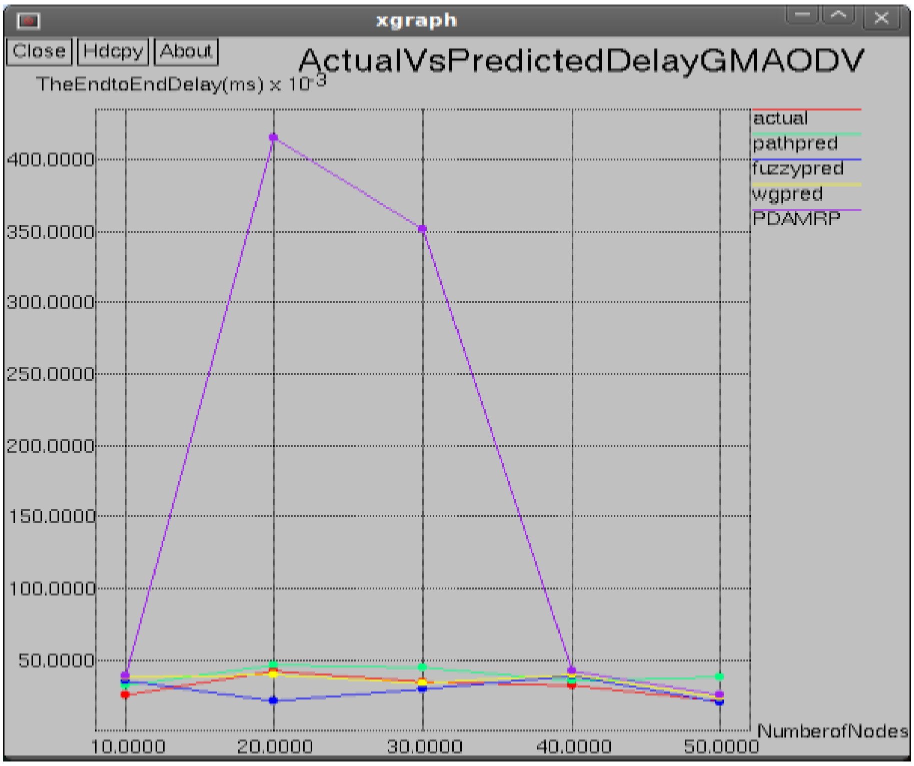

Fig. 1 Actual vs. predicted delay for network following GM mobility pattern with AODV routing protocol.

Table 1: Actual vs. predicted delay for network following GM mobility pattern

Packet-Id	Actual	Path-Pred	Fuzzy-Pred	Wg-Pred	PDAMRP
10	0.02512	0.03212	0.03512	0.03785	0.03896
30	0.04236	0.04625	0.02147	0.03947	0.41561
30	0.03478	0.04456	0.02936	0.03363	0.35123
40	0.03176	0.03572	0.03867	0.03948	0.04212
50	0.02148	0.03804	0.01997	0.02347	0.02563

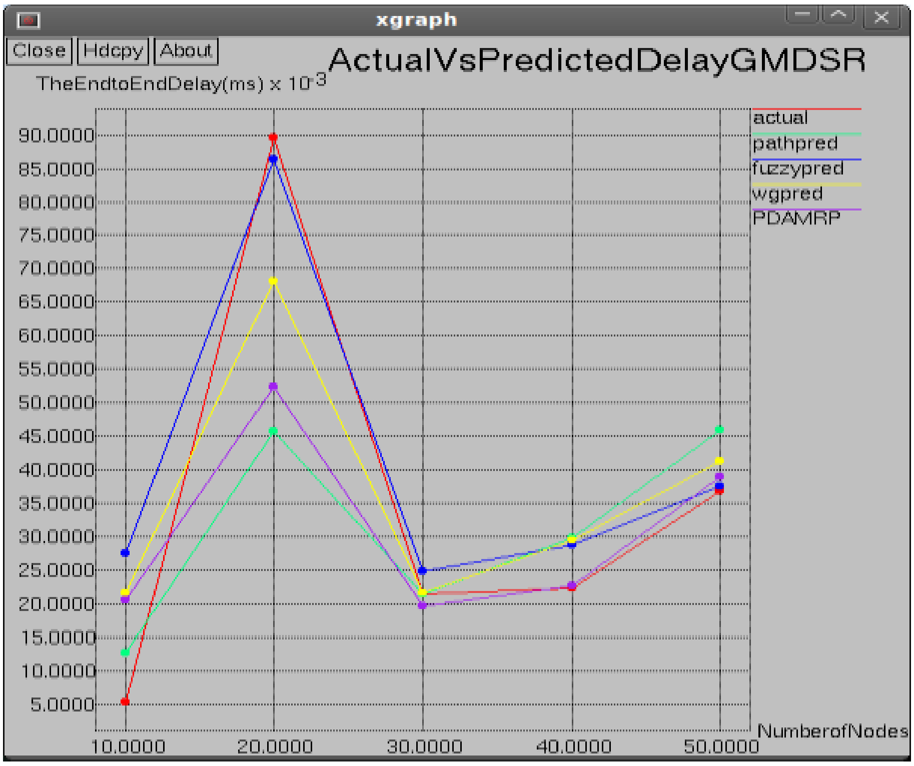

Fig. 2 Actual vs. predicted delay for network following GM mobility pattern with DSR routing protocol.

Table 2: Actual vs. predicted delay for network following GM mobility pattern

Packet-Id	Actual	Path-Pred	Fuzzy-Pred	Wg-Pred	PDAMRP
10	0.00521	0.01269	0.02744	0.02149	0.02047
30	0.08965	0.04578	0.08632	0.06814	0.05234
30	0.02145	0.02145	0.02486	0.02162	0.01952
40	0.02237	0.02973	0.02874	0.02946	0.02268
50	0.03678	0.04599	0.03749	0.04127	0.03896

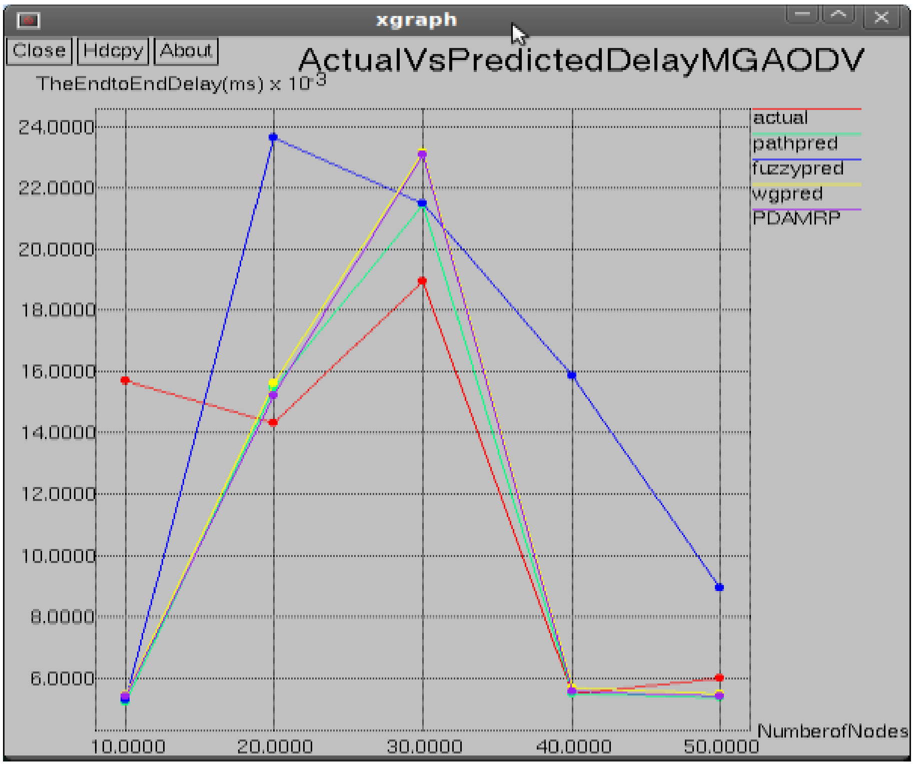

Fig. 3 Actual vs. predicted delay for network following MG mobility pattern with AODV routing protocol.

Table 3: Actual vs. predicted delay for network following MG mobility pattern

Packet-Id	Actual	Path-Pred	Fuzzy-Pred	Wg-Pred	PDAMRP
10	0.01568	0.00519	0.00529	0.00546	0.00541
30	0.01433	0.01546	0.02366	0.01563	0.01522
30	0.01896	0.02147	0.02149	0.02318	0.02311
40	0.00547	0.00547	0.01587	0.00566	0.00556
50	0.00598	0.00536	0.00891	0.00549	0.00541

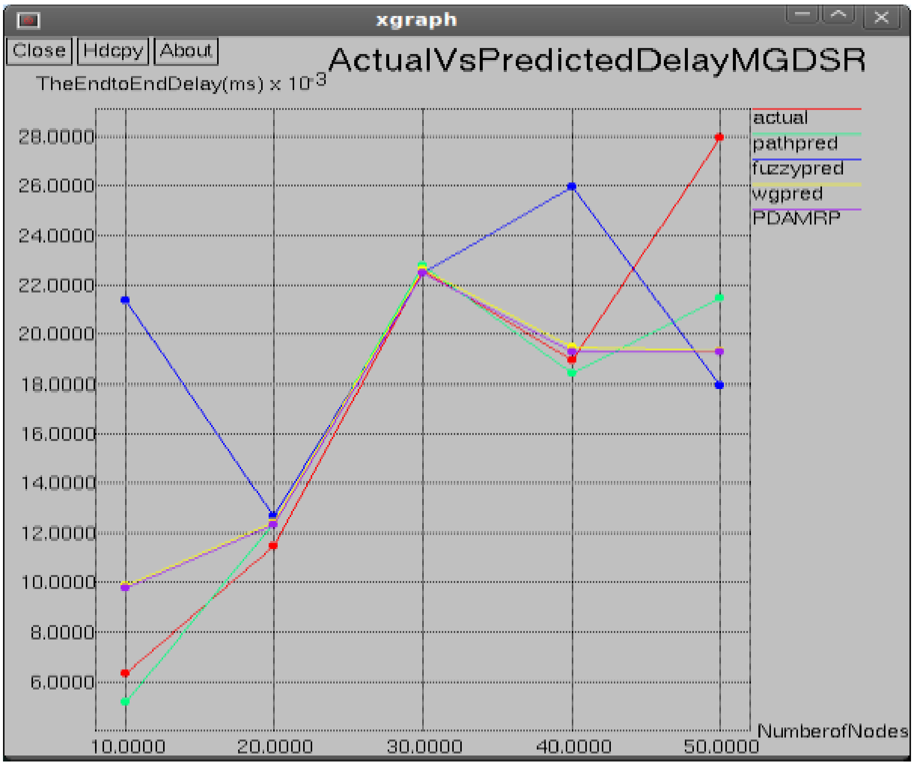

Fig. 4 Actual vs. predicted delay for network following MG mobility pattern with DSR routing protocol.

Table 4: Actual vs. predicted delay for network following MG mobility pattern

Packet-Id	Actual	Path-Pred	Fuzzy-Pred	Wg-Pred	PDAMRP
10	0.00632	0.00516	0.02136	0.00987	0.00978
30	0.01146	0.01239	0.01266	0.01245	0.01235
30	0.02258	0.02279	0.02247	0.02263	0.02246
40	0.01896	0.01841	0.02598	0.01946	0.01931
50	0.02796	0.02147	0.01796	0.01934	0.01927

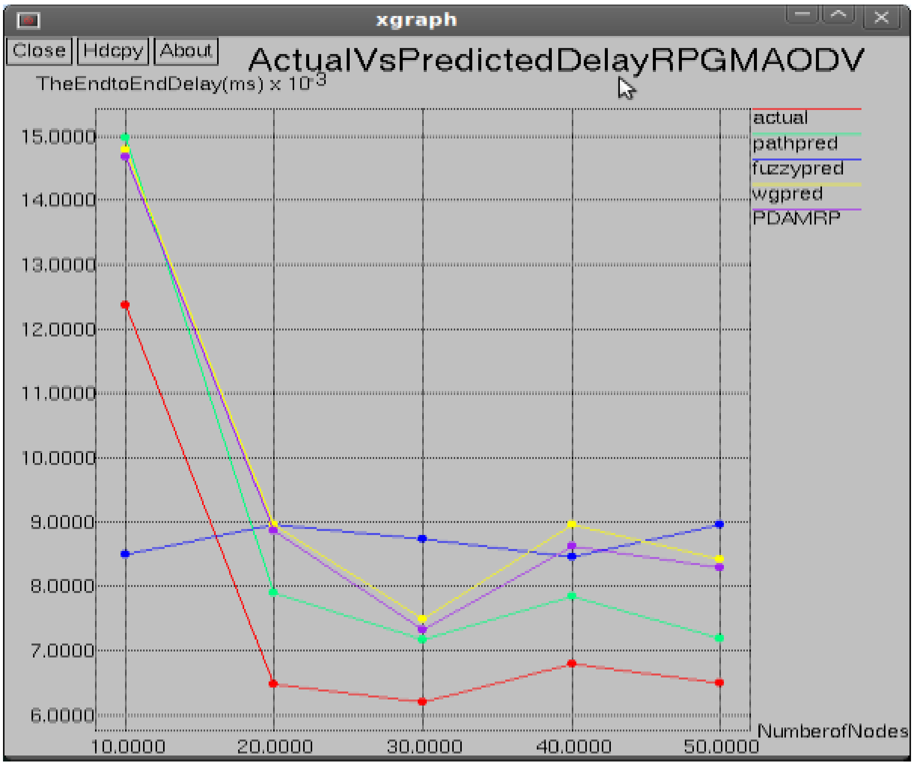

Fig. 5 Actual vs. predicted delay for network following RPGM pattern with AODV routing protocol.

Table 5: Actual vs. predicted delay for network following RPGM pattern

Packet-Id	Actual	Path-Pred	Fuzzy-Pred	Wg-Pred	PDAMRP
10	0.01236	0.01498	0.00849	0.01478	0.01467
30	0.00647	0.00789	0.00896	0.00896	0.00887
30	0.00619	0.00716	0.00874	0.00748	0.00731
40	0.00679	0.00783	0.00846	0.00896	0.00862
50	0.00649	0.00719	0.00896	0.00841	0.00828

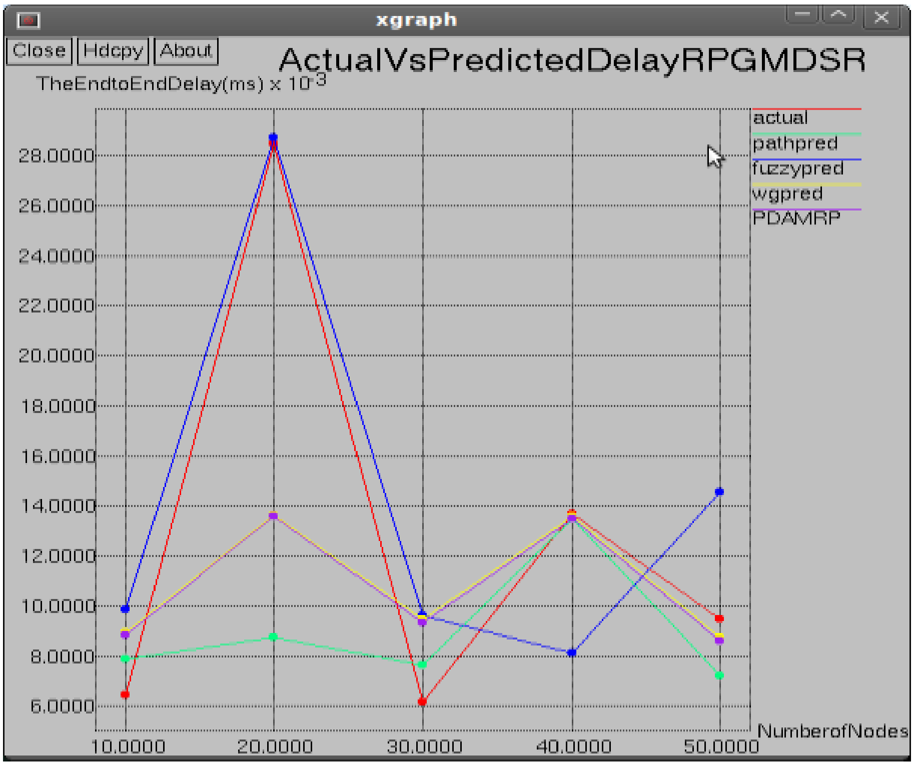

Fig. 6 Actual vs. predicted delay for network following RPGM pattern with DSR routing protocol.

Table 6: Actual vs. predicted delay for network following RPGM pattern

Packet-Id	Actual	Path-Pred	Fuzzy-Pred	Wg-Pred	PDAMRP
10	0.00647	0.00789	0.00986	0.00896	0.00886
30	0.02846	0.00874	0.02874	0.01364	0.01358
30	0.00614	0.00763	0.00963	0.00947	0.00932
40	0.01369	0.01349	0.00814	0.01358	0.01347
50	0.00945	0.00719	0.01456	0.00874	0.00861

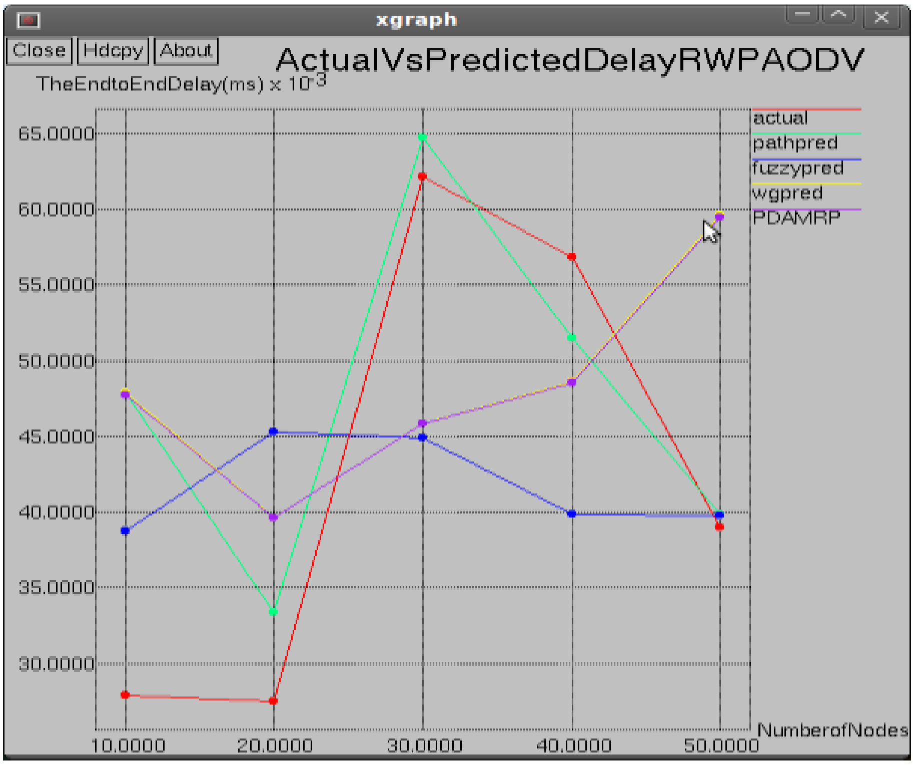

Fig. 7 Actual vs. predicted delay for network following RWP mobility pattern with AODV routing protocol.

Table 7: Actual vs. predicted delay for network following RWP mobility pattern

Packet-Id	Actual	Path-Pred	Fuzzy-Pred	Wg-Pred	PDAMRP
10	0.02789	0.04789	0.03874	0.04789	0.04777
30	0.02748	0.03335	0.04533	0.03961	0.03959
30	0.06214	0.06478	0.04488	0.04589	0.04587
40	0.05681	0.05147	0.03987	0.04863	0.04857
50	0.03896	0.03985	0.03974	0.05963	0.05949

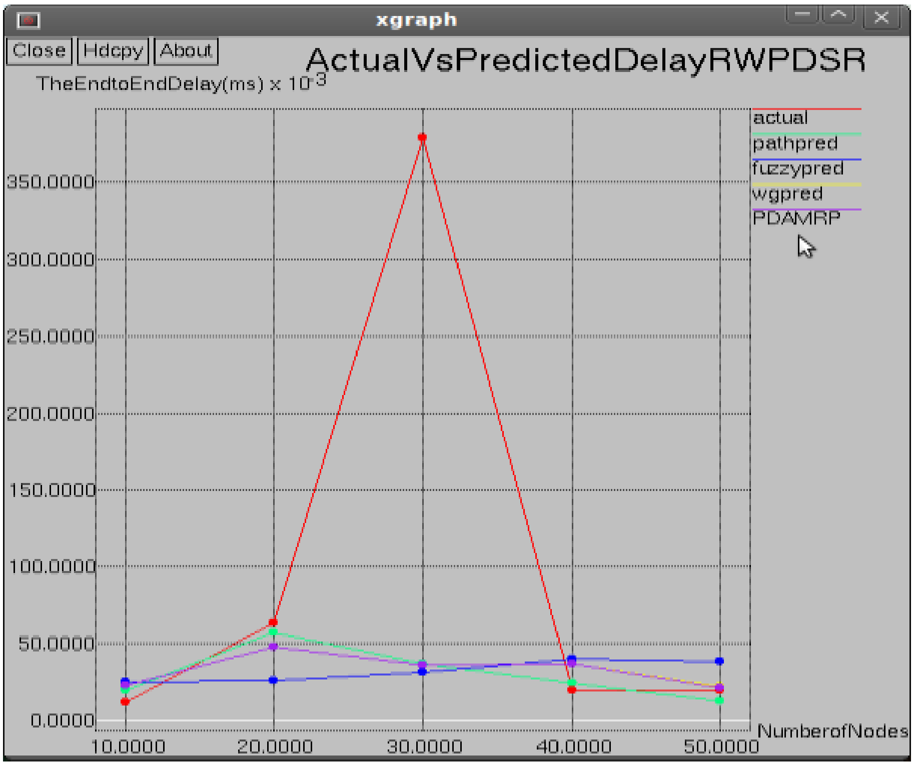

Fig. 8 Actual vs. predicted delay for network following RWP mobility pattern with DSR routing protocol.

Table 8: Actual vs. predicted delay for network following RWP mobility pattern

Packet-Id	Actual	Path-Pred	Fuzzy-Pred	Wg-Pred	PDAMRP
10	0.01147	0.01974	0.02476	0.02247	0.02241
30	0.06319	0.05678	0.02596	0.04789	0.04778
30	0.37953	0.03637	0.03147	0.03599	0.03591
40	0.01987	0.02396	0.03987	0.03685	0.03678
50	0.01954	0.01278	0.03855	0.02186	0.02144

5. CONCLUSIONS

The proposed research work is coined as packet delay aware multipath routing protocol (PDAMRP). At first service time of each packet is estimated. By using Markov chain model, stationary queue length at the departure epoch, length of busy period, packet delay are efficiently modeled. For finite buffer case stationary queue length is distributed along with packet delay and overflow probability are measured. The proposed protocol is an extension to ad hoc on demand multipath distance vector (AOMDV) routing protocol. Simulations have been carried out using NS2 and the results portrayed that the proposed protocol PDAMRP has outperformed than that of the compared routing algorithms.

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