Evolutionary Algorithm based Integrated Metrics Multipath Routing Protocol (EA-IMMRP) for Quality of Service in Mobile Ad hoc Networks

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Abstract
Mobile ad hoc network is the significant research area in the field of wireless communication and advanced communication systems research. Due to the wide range of application requirements in MANET, quality of service is the paradigm of importance for ensuring reliable as well as ensured transmission from source to destination. In this research work, achieving QoS in MANET is accomplished by amalgamating almost all metrics like signal frequency, location information, Euclidean distance, signal strength and moving speed of the nodes. Evolutionary algorithm based on-demand routing is performed. Performance metrics such as packet delivery ratio, throughput, packets drop, overhead and packets delay are taken for evaluating the efficiency of the routing protocol. From the results it is inferred that, EA – IMMRP performs better than the chosen protocols.

Keywords: MANET, wireless link, throughput, packet delay, MAC.

1. INTRODUCTION

As innovation is developing quickly, it requires many hand-held gadgets like workstation, palmtop, cell phones and so on that are progressed by expanding CPU time, disk space, power consumption and memory size. MANET [1, 2], opens the entryway for these gadgets. MANET is self-mending, multi-hop, framework fewer networks allowed to move starting with one spot then onto the next spot. There are a few uses of MANET like sound, video, multimedia and so forth, which requires great correspondence and QoS [3, 4]. Essentially different wireless network CDMA, GSM and Wi-Fi, MANET is unfit to give solid QoS [5]. Consequently, choosing fitting convention is significant and testing task, because of number of conventions introduced in the writing, vary from one another and required assurance of stringent QoS [6]. The primary point of QoS routing [7] is to discover applicable way that must fulfill QoS limitation necessities, for example, packet loss, bandwidth, delay, jitter, energy consumption which are transmission qualities of topology. The routing issue is NP finished if two QoS limitation are fulfilled for example two added substances or blend of added substance or multiplicative measurements. QoS routing additionally fulfills imperative like connection, way and tree requirement [8]. Where, bandwidth, jitter-delay and start to finish delay are primary, connection and way limitation individually [9]. Hence, to fulfill the above imperatives with various goals, there is need of conceivably new methodology or procedure for tackling the QoS routing. Hence, confusion in the issue is considered, and open arrangement is given utilizing metaheuristic calculation as opposed to different strategies. To illuminate QoS routing, past scientists utilized different metaheuristic algorithms [10, 11]. Be that as it may, there is need of improving routing conventions in MANETS, to give stringent QoS upgrade [12, 13].

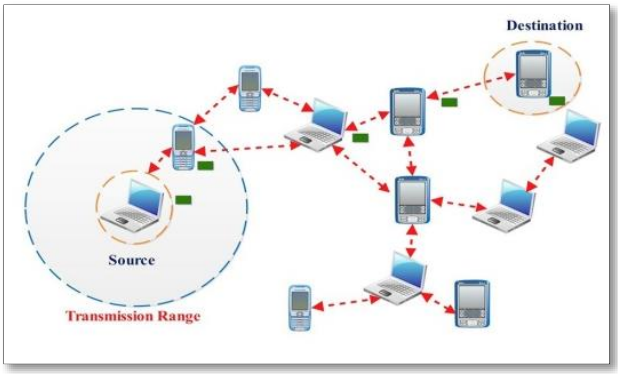

Fig.1. MANET illustration

An illustration of MANET is shown in Fig.1.

2. Related Works

Kaixin Xu et al. [14] contributed a Scalable QoS provisioning architecture that improves the scalability in mobile ad hoc networks. In this scalable QoS architecture, majority of the task is carried out by the source nodes and the intermediate nodes are restricted to carry out least amount of work without considering the purpose of information that relates to its state. This scheme is also an extension of the LANMAR routing protocol that performs efficiently under the influence of thousand numbers of nodes in a large scale ad hoc network topology. It uses mobile backbone network infrastructure for enhancing the performance of the network in term of QoS.

Further, Adaptive Reservation and Pre-allocation Protocol (ASAP) were proposed by Jianbo Xue et al. [15] for enabling higher resource utilization. ASAP uses two signaling messages for facilitating fast and efficient QoS support by maintaining adaptation flexibility and minimizing wasted reservations. Likewise, Jangeun Jun and Mihail L. Sichitiu [16] investigated the issue of QoS called the significant fairness problem that generally co-exist in all practical wireless multi-hop networks. A number of several network layer possibilities for resolving significant fairness problem of QoS were proposed. It also aids in improving the fairness index that relates to the cumulative resource investment of the network. They proved that solution implemented in the network layer can enhance fairness by properly utilizing the bandwidth efficiency. They also verified that MAC layer priorities are effective enough in restoring network efficiency by facilitating fairness in the network layer. Furthermore, Michael Gerharz et al. [17] investigated and evaluated DLite algorithm that provides service differentiation in ad hoc networks. DLite algorithm incorporates a fair queuing mechanism that allocates differentiated queues depending upon the class of service that need to be facilitated. The class of service that facilitates delay in packets is in the intermediate routers. It also provides an ambient environment for adaptive multimedia applications. Duc A. Tran and Harish Raghavendra [18] proposed a Congestion-adaptive Routing Protocol (CRP) for enhancing QoS in mobile ad hoc networks. CRP is more adaptive to congestion when compared to the routing protocols of QoS available in the literature.

This superiority of CRP is mainly due to its proactive nature of preventing congestion rather than the reactive scheme available in the other benchmark protocols. The proactive approach of CRP reduces overhead to a considerable level by maintaining bypass paths. The bypass paths maintained by CRP are highly trustworthy as a bypass path is characteristically short with the potential of initiating maximum packet forwarding. Link availability-based QoS-aware (LABQ) routing protocol was innovated by Ming Yu et al. [19] for mobility prediction and link quality measurement. LABQ aids in estimating energy consumption and its core aim is to provide reliable and trustworthy communication links with energy-effectiveness. LABQ is found to reduce link breakages that minimize reconnection and retransmission overheads to a considerable level. It also enhances the lifetime of the nodes by facilitating reduced average end-to-end delay in data transmission for providing reliable routing decisions. Xiaoqin Chen et al. [20] proposed a congestion-aware routing protocol that an integrated metric which combines packet data-rate, MAC overhead, and buffer delay for resolving congestion. This integrated metric for congestion is mainly used for avoiding mismatched routes that occurs due to link failure. This scheme is highly adaptive to congestion as it tackles the problem of link failure, packet drop due to congestion and reliable packet delivery. In addition, an Enhanced Mesh Coordinated Channel Access eMCCA [21] was proposed in which the mesh points of the network are utilized for forwarding large number of data packets. eMCCA avoids collision by using a unique designated traffic indication message through which the reservations of specific slots for future transmission of data packets are achieved.

The reservations of slots are facilitated by means of two categories of channel reservation process such as Priority Reservation category (PRC) and Non Priority Reservation Category (NPRC). PRC process establishes the option of performing reservation for future communication by reducing the degree of contention. This PRC process uses a preemption method of channel access since the mobile nodes of this category initiation avoids the preemption the NPRC processes as they delay the access of the channel for reliable data packet delivery. Then another notable contribution, Multichannel MAC (MMAC) allocation method [22] is proposed for dynamic utilization of multiple channels with synchronized pattern. In MMAC, the switching of channels takes in a rapid manner but with holding a synchronized way. The process of communication in MMAC is achieved only when the source nodes get synchronized with the receiver. After synchronization, beacon messages are spread over a common control channel and the required data channels are identified based on the least prioritized channel allocated to the nodes. The allocated channels are also categorized into three significant thresholds based on the kind of preference list that differentiates the degree of preference into high, medium and low. The final decision of allocation is carried out through the identification of level count that quantifies how a channel is chosen by the node for raid and reliable transmission.

3. Proposed Work

This proposed work depicts a mechanism of designing EA-IMMRP. Two stages are considered such as the design of the new route metric and the EA based optimized routing algorithm.

A novel routing metric determines the suitability of a communication link which is denoted as L_w will be to route information between two points i and j separated by some distance, d_{ij}. The Global Position System (GPS) coordinates of each mobile node is used to compute the Euclidean distance d_{ij}, expressed as

$$d_{ij} = \sqrt{(y_i - y_j)^2 + (x_i - x_j)^2} \quad \ldots (1)$$

where $(x_i - x_j)$ and $(y_i - y_j)$ represent the coordinates of mobile nodes i and j respectively. The transmission power, P_{tx} of 0 dBm in accordance with the IEEE 802.11 standard.. The Received Signal Strength (RSS) at the destination node d_v, and the path loss, PL_w across each link, L_w provides a measure for the quality of the communication link. The PL_w is modeled considering free space path loss (in dB) as:

$$PL_w = 20\log_{10}(d_{ij}) + 20\log_{10}(f) - 147.55 \ldots (2)$$

where f is the signal frequency in Hz, and d_{ij} is the Euclidean distance in meters computed via (1). The free space model for the purpose of simplicity because it is presumed that the distance between mobile nodes are often obstruction free and fall within the line of sight. Future works may consider path loss models that are more realistic without necessarily violating the common strategy. The RSS at dv is then computed as

$$RSS_w = P_{tx} - PL_w \ldots (3)$$

Hence the route metric r_w, of the individual links L_w, making up a single communication route, P, from mobile node i to j is given by

$$r_w = \frac{\alpha \exp\left[1 - \frac{RSS_w}{RSS_{Th}}\right]}{v_{ij} + \beta} \ldots (4)$$

where RSS_{Th} is the maximum received signal strength (a threshold value) above which the link fails, α is a scale parameter computed using the standard deviation of the changing velocity v_{ij} of mobile nodes logged in the routing table and b is a corrector parameter introduced to guarantee that (4) exists at zero velocity (when a mobile node is stationary). Eq. (4) is a normalized route metric, which we have proposed to evaluate how suitable a route will be for data transmission. Essentially, we constructed this route metric by considering the following relationships: a stationary mobile node is better suited to form a good communication link than a mobile node since mobile nodes are highly susceptible to fading channel conditions. Consequently, as a mobile node decelerates, it becomes easier to establish a stable communication link. This requirement accounts for the inverse relationship in Eq. (4) between the route metric and the mobile node's velocity. Furthermore, we note that stronger received signal strength (RSS) values at a mobile node's transceiver typically characterize a good link. This quality thus accounts for the direct relationship between the RSS and the route metric in Eq. (4). However, to ensure that our new metric does not tend to infinity when a mobile node halts (velocity = 0), we have introduced a corrector parameter b in Eq. (4), while we introduced the parameter a to normalized the exponential effect of the RSS. We call a the scale parameter because it simply amplifies the small values typically produced by the exponential function of the RSS. These parameters take up typical values of $\alpha = 10$, and $\beta = 1$. Typically, each mobile node measures its velocity using its speedometer and communicates this velocity value to other mobile nodes within its transmission range. Furthermore, there is a possibility of having multiple potential routes between the source mobile node s_v and the destination node d_v. Thus, K denotes the total number of links, for a given route, P. Therefore, the overall route metric R (P) for a given P is the product of the route metric of all the connected links that form the route:

$$R(P(s_v, d_v)) = \prod_{w=1}^{K} r_w \ldots (5)$$

Therefore, the routing task reduces to the choice of a candidate route P* from within the set of all possible routes $P_n(n = 1, 2, ..., M)$ that exists between i and j. Thus, we maximize the objective function as follows:

$$Z(P^*) = \arg\max_{P \in M} \{R(P_n)\}, \forall n = 1, 2, ..., M \ldots (6)$$

where M is the total number of possible routes between the source mobile node s_v and the destination Infrastructure d_v. The ultimate goal is to maximize the route metric given in (6) by using the proposed routing algorithm called EA - IMMRP.
In EA - IMMRP, GA selection method is replaced with the grouping technique leveraging from a similar concept for route optimization. EA - IMMRP uses the number of mobile nodes involved in a MANET communication scenario to initialize

randomly the population of individuals, which serves as the initial solution within the intended search space. EA - IMMRP evaluates the fitness of each individual solution using the communication system model presented in (6).

A non-probabilistic approach of grouping technique chooses individual chromosomes for the reproduction process in EA - IMMRP. This technique selects the Good Group Chromosome Collection (GGCC) in each generation thereby enhancing diversity in the population. The algorithm achieves this by evaluating the fitness of the individual chromosomes and clustering them into two non-overlapping groups based on their fitness value. The reason behind the choice of two groups for clustering is to ensure that each chromosome belongs to either GGCC or the Fair Group Chromosome Collection (FGCC). Essentially, EA - IMMRP uses grouping during the selection process to group the chromosomes into these two distinct groups GGCC and FGCC.

Here, GGCC contains the fittest chromosomes based on their fitness values, while FGCC contains the weaker chromosomes. Consequently, EA - IMMRP uses this deterministic approach of grouping to filter out weaker chromosomes during the selection process instead of using the probabilistic roulette wheel approach in the generic GA algorithm. This approach interestingly guarantees that stronger chromosomes are passed to subsequent generations implying that better routes with higher route metrics will be computed during the iteration process. Instantaneously, this explains the relationship between the chromosomes and the route metric since each route metric per link in the network is typically encoded as a chromosome in the EA - IMMRP process.

Furthermore, using grouping approach increases the convergence speed of the EA process by introducing a high selection pressure and increasing the average fitness value by selecting the collection of GGCC. The iterative grouping algorithm minimizes the sum of the distance between each chromosome and its cluster centroid. Grouping task also moves the chromosomes of individuals in the population into a cluster to group them all appropriately based on their respective distances from the centroid. Mathematically, let T be the total scatter points for a set of N chromosomes in the i^{th} generation expressed as

$$T = \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} d\left(x_i, x_j\right) \ldots (7)$$

where $d\left(x_i, x_j\right)$ is the distance between two chromosomes. In this work eqn (7) is expressed in a general form as

$$T = W(C) + B(C) \ldots (8)$$

where $W(C)$ is the within class scattered distance, $B(C)$ is thebetween cluster distance and C_i denotes the cluster number forthe ith observation.

The mechanism selects the chromosomes in the cluster with larger distances for the maximization operation. The size of the initial chromosome population typically reduces due to the grouping process as only the GGCC is selected. This chromosome population in the GGCC typically increases back to the initial population size using the method of elitism selection. This probability replacement ensures that the algorithm randomly selects certain percentage of the fitter individual chromosomes in order to increase the population size in the GGCC. The population then undergoes a two-point chromosome inversion process during crossover in order to produce new offspring. The algorithm then uses a one-point chromosome inversion to ensure diversity in the population in the form of mutation. Elitism operation is employed to ensure convergence to a global solution. The algorithm forms a new population after the iteration process is completed and the generation counter is increased by one. Our proposed EA - IMMRP with elitism continues to iterate until it satisfies a convergence criterion or a predefined number of generations elapses, which serves as the stopping criterion.

The algorithm is depicted below that performs grouping.

1. Randomly Select two chromosome fitness cluster centroid C1 and C2.
2. Compute the distance between each individual fitness value and the cluster centroid.
3. Assign individual fitness value into the appropriate cluster based on the computed centroid distance.
4. Recomputed the two-centroid position after assigning the fitness value of the chromosome to a cluster.
5. Re-iterate step 2 3, and 4 until centroid stability is attained and no change is observed in cluster of chromosome fitness value resulting in the GGCC and FGCC
6. The two centroids are compared, and the one with the higher numerical centroid value is assigned to the GGCC while the other cluster is assigned to the FGCC
7. Terminate the clustering process

The node infrastructure receives the sensed data and hosts it in a database for other mobile nodes to gain access concerning the link status and for route maintenance routines. The following steps are involved in our proposed routing protocol EA - IMMRP:

1. The source mobile node, s_v, that senses a road anomaly sends out a broadcast request to all mobile nodes within its transmission range to determine the address of the destination infrastructure d_v. The packet contains the Source MAC Address $\left(S_{mac}\right)$,Destination MAC Address $\left(D_{mac}\right)$, Source GPS $\left(S_{gps}\right)$, Source Velocity $\left(S_v\right)$ and Generic Destination Flag (GDF) field.

2. All mobile nodes within the transmission range of the source mobile node receive the broadcast packet and then examine the ‘‘Generic Destination Flag” field to determine if the message is for that destination node or not. When the flag is set to 1, the mobile nodes simply append information to the header of the packet: Hop MAC Address (H_{mac}), Hop GPS (H_{gps}), Hop Velocity (H_v) and then rebroadcast the message for onward transmission towards the destination mobile node. During the rebroadcasting process by each hop mobile node, each mobile node examines the hop fields of each packet in order to determine whether the originating hop address already exists in the packet or not. If it exists, the hop mobile node simply discards the packet; else, it appends its own hop information before onward transmission. This mechanism helps to prevent the problem of broadcast flooding within the network. Furthermore, it ensures that the message from the source mobile node always proceeds toward the destination infrastructure without looping through the network.
3. Based on a defined maximum number of hops, the source message is transmitted through multiple hops to the destination node. During this process, the initial source packet arrives at the destination infrastructure along with the different hop information appended to it.
4. At the destination node, the mechanism extracts the information within the packet. The destination node then uses the information within the packet to develop a complete routing table of the entire network.
5. Based on the acquired information about the entire network, the destination node uses the evolutionary algorithm to compute the optimal path back to the source mobile node.
6. The destination node sends an acknowledgement back to the source mobile node using the optimally computed path.
7. The source mobile node then uses the optimal path placed within the acknowledgement packet to send the sensed data back to the destination node. The data is stored in the destination database and regularly updated for future access if required.
8. After convergence has occurred within the network, the destination node’s database is considered updated based on the current condition of the entire mobile ad hoc network.

4. Simulation Settings and Performance Metrics

Table – 1. Simulation Settings

Parameters	Values
Simulation area	1500 X 1500 m
Mobile nodes	100
Mobility model	Random way-point
Node placement	Random
Propagation type	Two – ray ground
Transferal power	20 dbm
MAC procedure	802.11
Data Rate	128 Kbps, 256 Kbps and 512 Kbps
Pause time	10 s
Minimum velocity of node	10 m/sec
Simulation time	100 s

Performance Metrics

- Packet delivery ratio
- Throughput
- Packets drop
- Overhead packets (and)
- Delay
-

5. Results and Discussions

Table - 2 showcases the performance results of the existing protocols and the proposed protocol in terms of packet delivery ratio. From the results, it is evident that the proposed protocol EA – IMMRP obtains better performance than that of existing protocols. It is inferred that EAIMMRP is performing ~25% better than that of PA-AOMDV protocol, ~17% better than that of CSOAODV protocol, ~11% better than that of EMAC – DAMR protocol, ~5% better than that of FTRMRP in terms of packet delivery ratio.

Table 2. Packet Delivery Ratio of the Protocols with varying Data Rate

Pausetime (seconds)	128 Kbps					256 Kbps					512 Kbps				
	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP
10	0.72	0.78	0.85	0.91	0.95	0.71	0.78	0.86	0.92	0.95	0.71	0.79	0.83	0.92	0.95
20	0.72	0.75	0.85	0.92	0.96	0.70	0.77	0.83	0.92	0.95	0.74	0.81	0.85	0.92	0.96
30	0.71	0.76	0.86	0.91	0.96	0.74	0.76	0.85	0.92	0.94	0.70	0.74	0.85	0.92	0.96
40	0.73	0.78	0.83	0.91	0.95	0.70	0.80	0.84	0.91	0.96	0.70	0.79	0.84	0.93	0.96
50	0.71	0.79	0.85	0.92	0.96	0.70	0.75	0.84	0.93	0.95	0.72	0.77	0.85	0.91	0.97
60	0.75	0.74	0.84	0.93	0.97	0.73	0.76	0.86	0.91	0.95	0.73	0.78	0.85	0.91	0.97
70	0.69	0.79	0.86	0.91	0.97	0.70	0.80	0.84	0.91	0.94	0.73	0.80	0.84	0.91	0.96
80	0.72	0.75	0.84	0.90	0.95	0.73	0.80	0.85	0.92	0.96	0.74	0.74	0.83	0.92	0.95
90	0.71	0.77	0.85	0.91	0.96	0.74	0.78	0.86	0.92	0.97	0.72	0.80	0.85	0.91	0.96
100	0.72	0.80	0.87	0.92	0.95	0.71	0.81	0.84	0.91	0.97	0.71	0.80	0.84	0.93	0.95

Table - 3 presents the performance results of the existing protocols and the proposed protocol in terms of throughput. From the results, it is observed that the proposed protocol EA – IMMRP obtains better performance than that of existing protocols. It is observed that EAIMMRP is performing ~23% better than that of PA-AOMDV protocol, ~16% better than that of CSOAODV protocol, ~12% better than that of EMAC – DAMR protocol, ~6% better than that of FTRMRP in terms of throughput.

Table - 4 portrays the performance results of the existing protocols and the proposed protocol in terms of packets drop. From the results, it is evident that the proposed protocol EA – IMMRP obtains better performance than that of existing protocols. It is known that EAIMMRP is performing ~85% better than that of PA-AOMDV protocol, ~81% better than that of CSOAODV protocol, ~71% better than that of EMAC – DAMR protocol, ~51% better than that of FTRMRP in terms of packets drop.

Table - 5 showcases the performance results of the existing protocols and the proposed protocol in terms of overhead. From the results, it is evident that the proposed protocol EA – IMMRP obtains better performance than that of existing protocols. It is inferred that EAIMMRP is performing ~83% better than that of PA-AOMDV protocol, ~80% better than that of CSOAODV protocol, ~72% better than that of EMAC – DAMR protocol, ~45% better than that of FTRMRP in terms of overhead.

Table - 6 showcases the performance results of the existing protocols and the proposed protocol in terms of packets delay. From the results, it is evident that the proposed protocol EA – IMMRP obtains better performance than that of existing protocols. It is inferred that EAIMMRP is performing ~76% better than that of PA-AOMDV protocol, ~69% better than that of CSOAODV protocol, ~43% better than that of EMAC – DAMR protocol, ~70% better than that of FTRMRP in terms of packets delay.

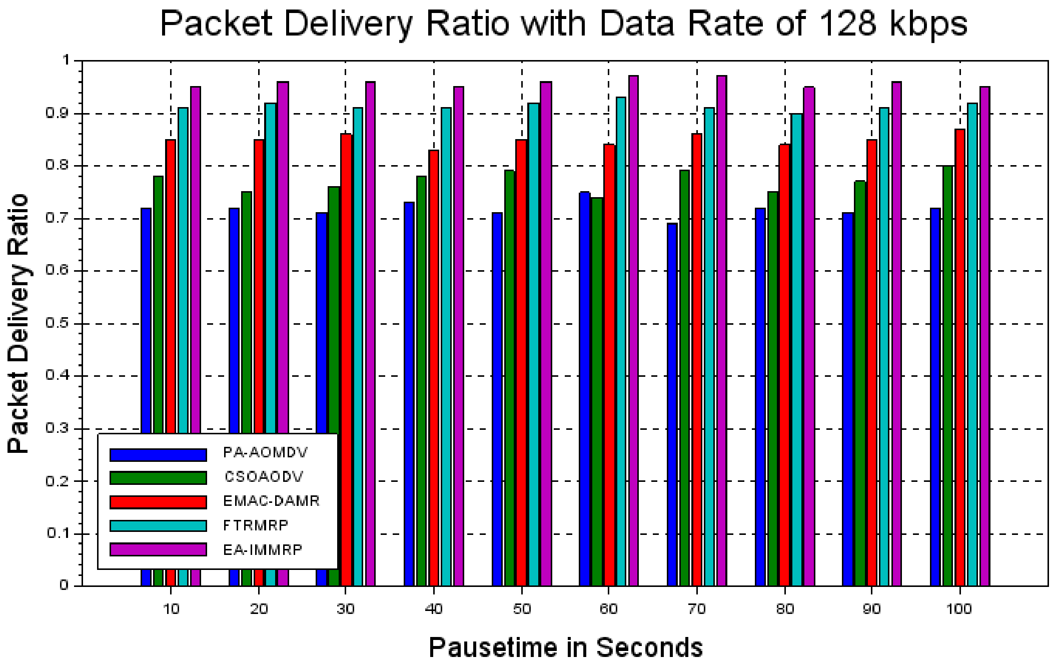

Fig. 2. Packet Delivery Ratio with Data Rate of 128 kbps

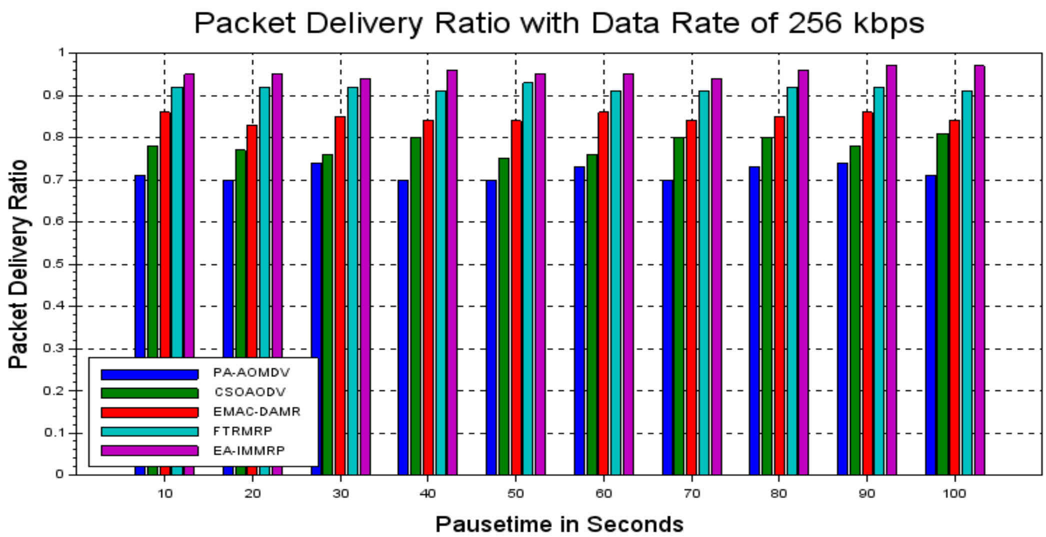

Fig. 3. Packet Delivery Ratio with Data Rate of 256 kbps

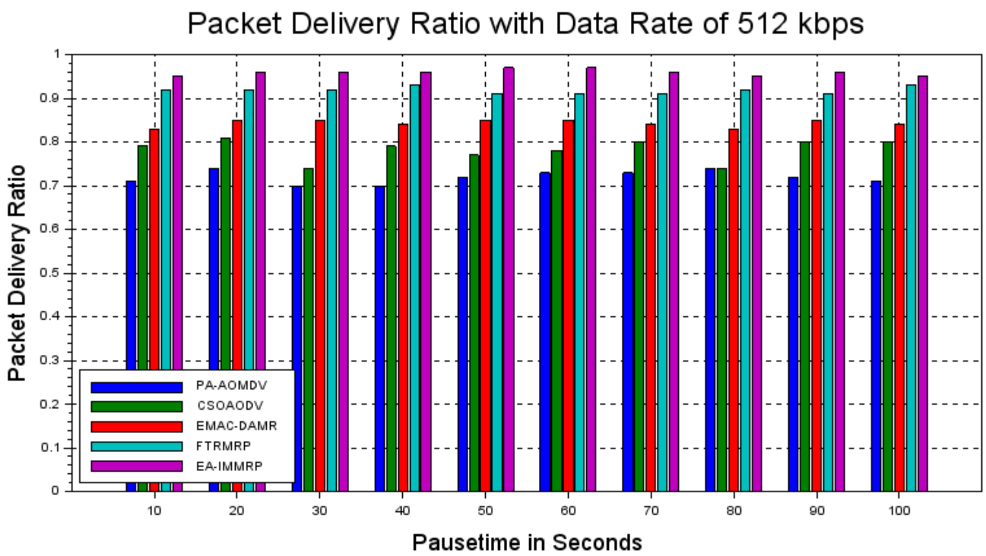

Fig. 4. Packet Delivery Ratio with Data Rate of 512 kbps

Table 3. Throughput of the Protocols with varying Data Rate

Pausetime (seconds)	128 Kbps					256 Kbps					512 Kbps				
	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP
10	922	995	1091	1165	1216	1810	2000	2201	2355	2432	3659	4021	4255	4710	4864
20	1834	1916	2183	2355	2458	3572	3962	4250	4710	4864	7605	8289	8711	9421	9830
30	2712	2902	3313	3494	3686	5658	5803	6556	7066	7219	10703	11420	12989	14131	14746
40	3727	4014	4261	4659	4864	7196	8180	8626	9318	9830	14377	16228	17196	19046	19661
50	4572	5077	5455	5888	6144	8918	9580	10755	11904	12160	18527	19679	21767	23296	24832
60	5722	5709	6413	7142	7450	11230	11673	13133	13978	14592	22284	24041	26018	27955	29798
70	6206	7052	7698	8154	8691	12529	14341	14957	16307	16845	26203	28665	30162	32614	34406
80	7362	7722	8609	9216	9728	14988	16373	17500	18842	19661	30451	30495	34142	37683	38912
90	8131	8840	9813	10483	11059	17061	17897	19748	21197	22349	33189	36770	39392	41933	44237
100	9151	10216	11130	11776	12160	18288	20724	21588	23296	24832	36401	41208	43204	47616	48640

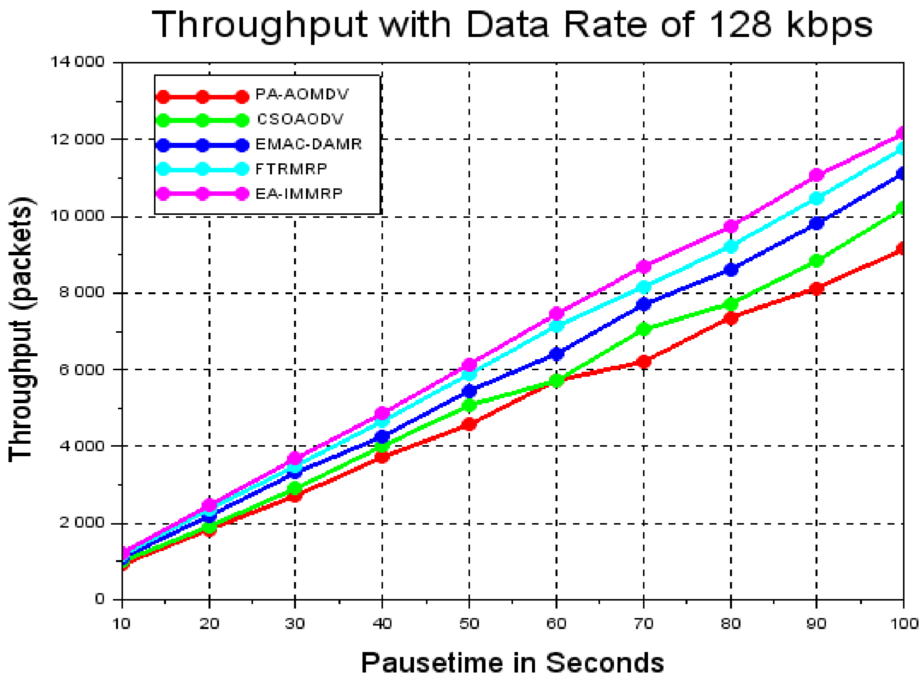

Fig. 5.Throughput with Data Rate of 128 kbps

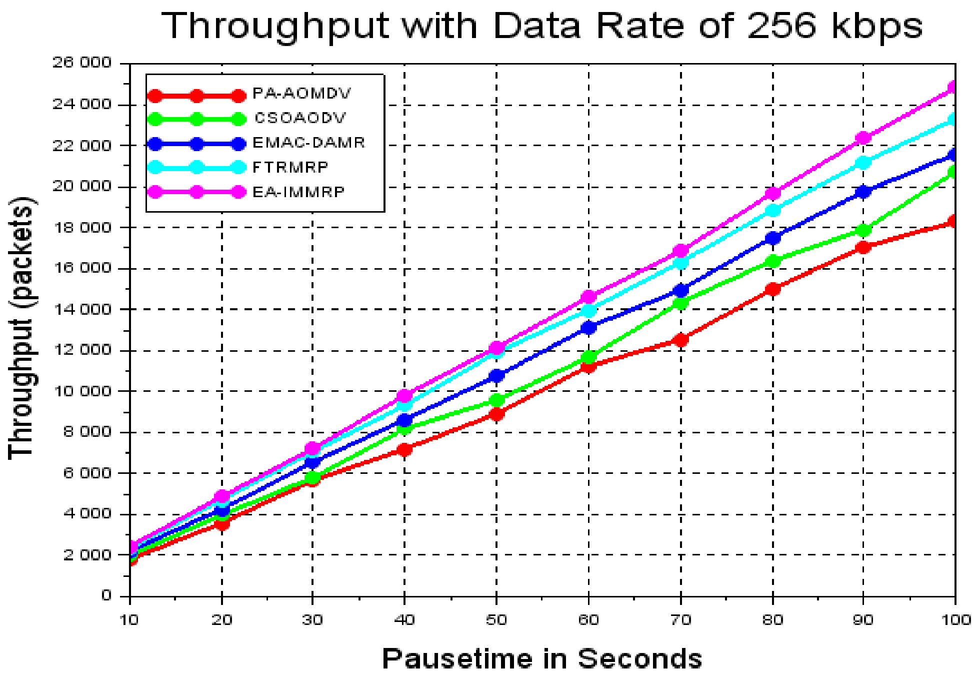

Fig. 6. Throughput with Data Rate of 256 kbps

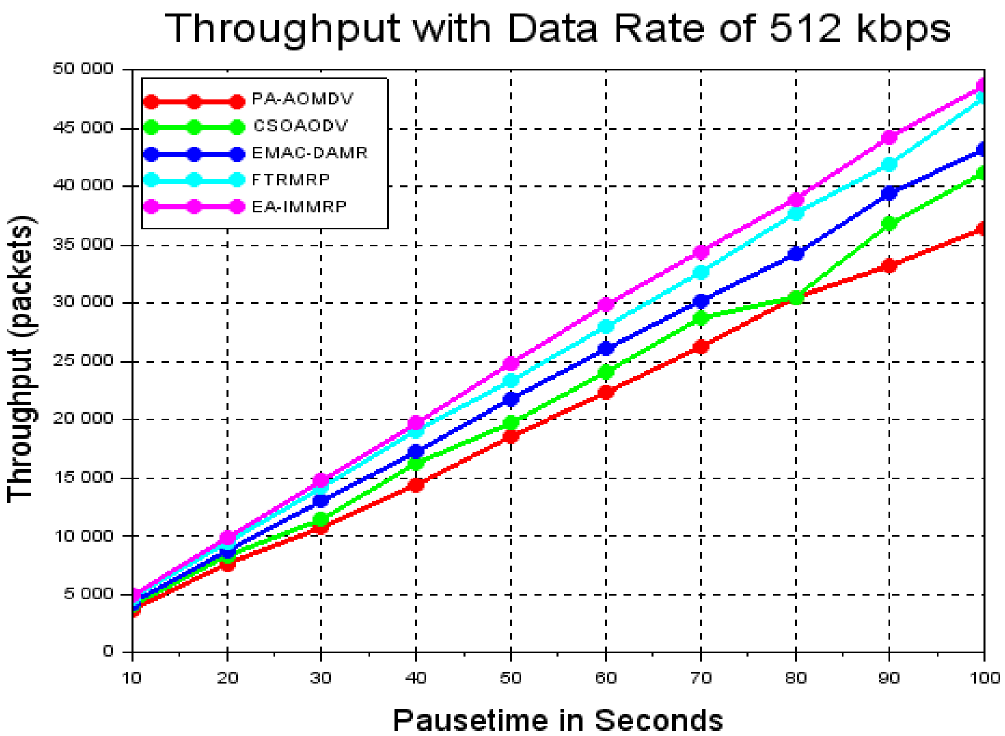

Fig. 7. Throughput with Data Rate of 512 kbps

Table 4. Packets Drop of the Protocols with varying Data Rate

Pausetime (seconds)	128 Kbps					256 Kbps					512 Kbps				
	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP
10	358	285	189	115	64	750	560	359	205	128	1461	1099	865	410	256
20	726	644	377	205	102	1548	1158	870	410	256	2635	1951	1529	819	410
30	1128	938	527	346	154	2022	1877	1124	614	461	4657	3940	2371	1229	614
40	1393	1106	859	461	256	3044	2060	1614	922	410	6103	4252	3284	1434	819
50	1828	1323	945	512	256	3882	3220	2045	896	640	7073	5921	3833	2304	768
60	1958	1971	1267	538	230	4130	3687	2227	1382	768	8436	6679	4702	2765	922
70	2754	1908	1262	806	269	5391	3579	2963	1613	1075	9637	7175	5678	3226	1434
80	2878	2518	1631	1024	512	5492	4107	2980	1638	819	10509	10465	6818	3277	2048
90	3389	2680	1707	1037	461	5979	5143	3292	1843	691	12891	9310	6688	4147	1843
100	3649	2584	1670	1024	640	7312	4876	4012	2304	768	14799	9992	7996	3584	2560

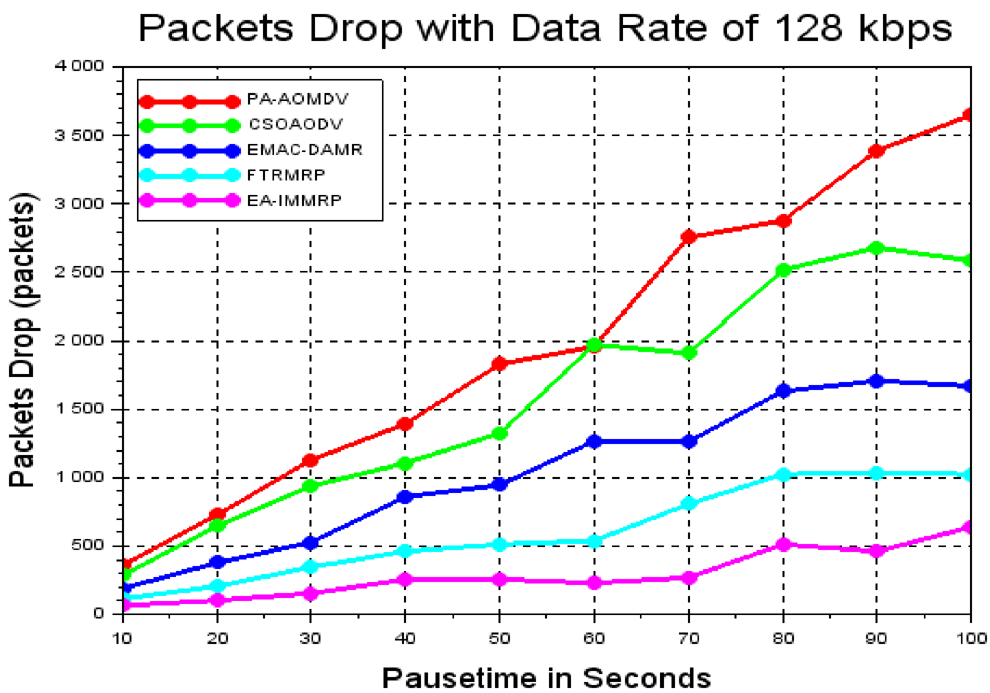

Fig. 8. Packet Drop with Data Rate of 128 kbps

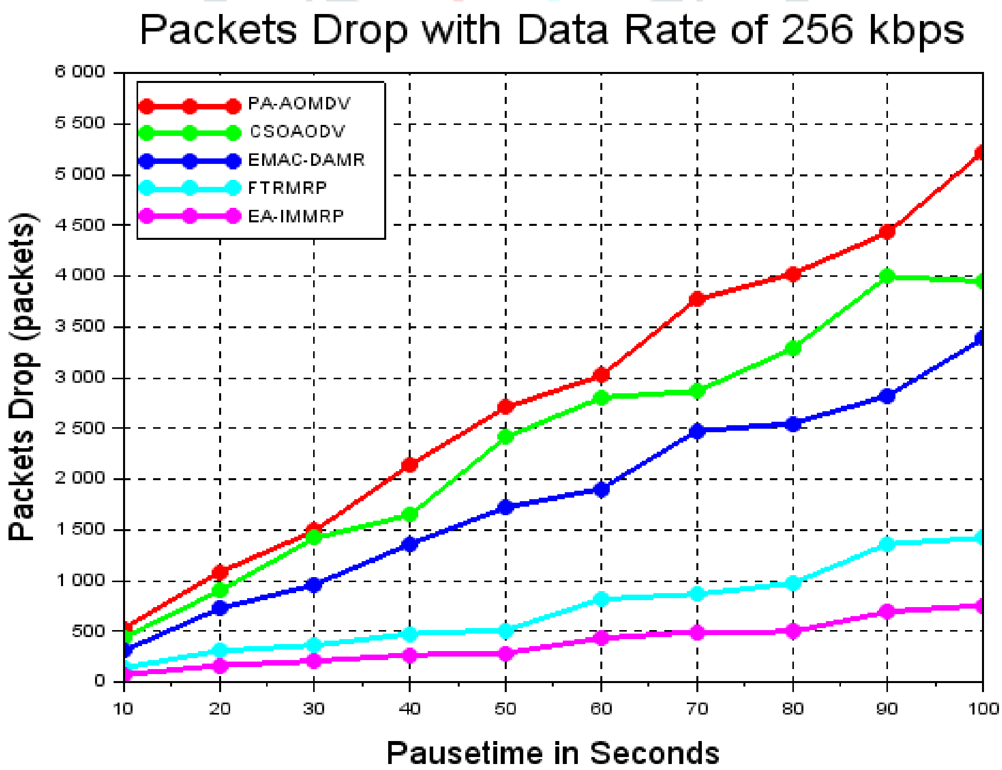

Fig. 9. Packet Drop with Data Rate of 256 kbps

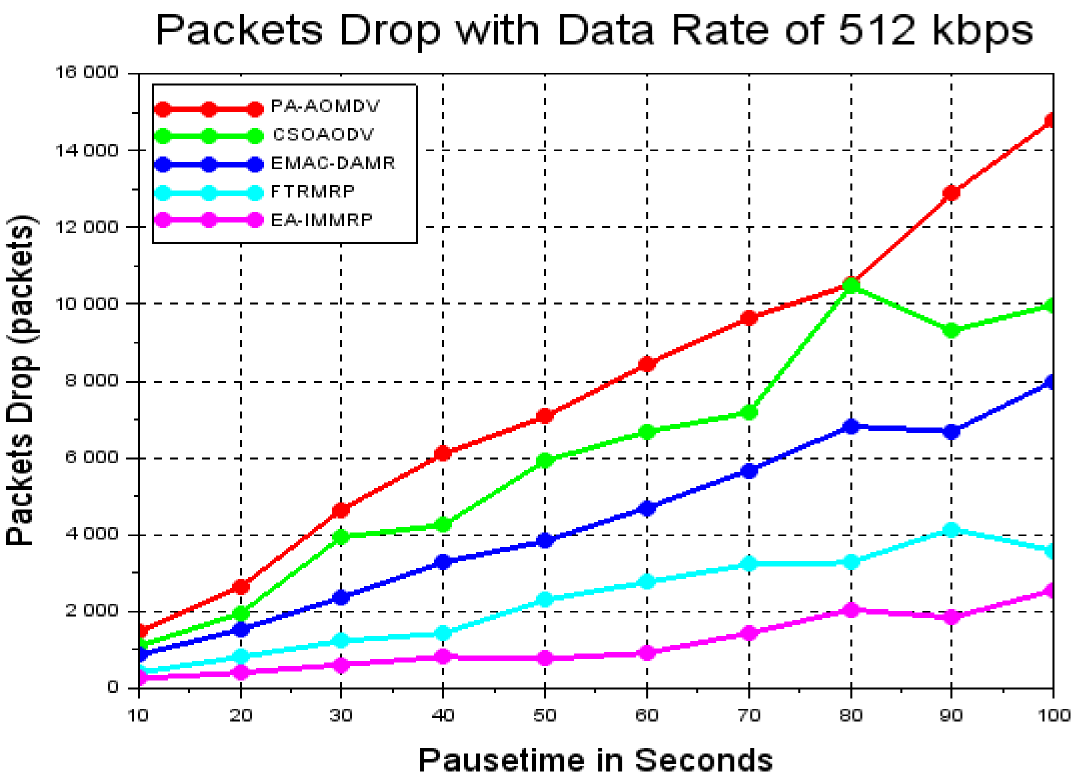

Fig. 10. Packet Drop with Data Rate of 512 kbps

Table 5. Overhead Packets of the Protocols with varying Data Rate

Pausetime (seconds)	128 Kbps					256 Kbps					512 Kbps				
	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP
10	258	221	161	101	55	530	438	309	139	74	1044	863	719	422	228
20	520	482	321	212	114	1080	896	722	307	163	1957	1579	1301	726	370
30	797	709	455	228	128	1490	1418	960	363	207	3245	2929	2005	881	476
40	1014	867	715	345	183	2139	1646	1360	475	266	4284	3369	2757	1280	666
50	1306	1050	805	397	226	2705	2410	1719	511	286	5119	4551	3259	1511	846
60	1459	1465	1058	489	279	3019	2802	1904	816	432	6120	5227	3982	1678	940
70	1908	1502	1084	501	266	3769	2864	2473	866	494	7045	5738	4778	2227	1203
80	2069	1899	1371	622	336	4019	3283	2547	972	496	7813	7791	5683	2441	1294
90	2392	2056	1454	687	385	4427	3995	2821	1360	694	9285	7429	5718	2976	1518
100	2609	2063	1452	704	380	5224	3947	3383	1422	754	10521	8042	6748	3193	1628

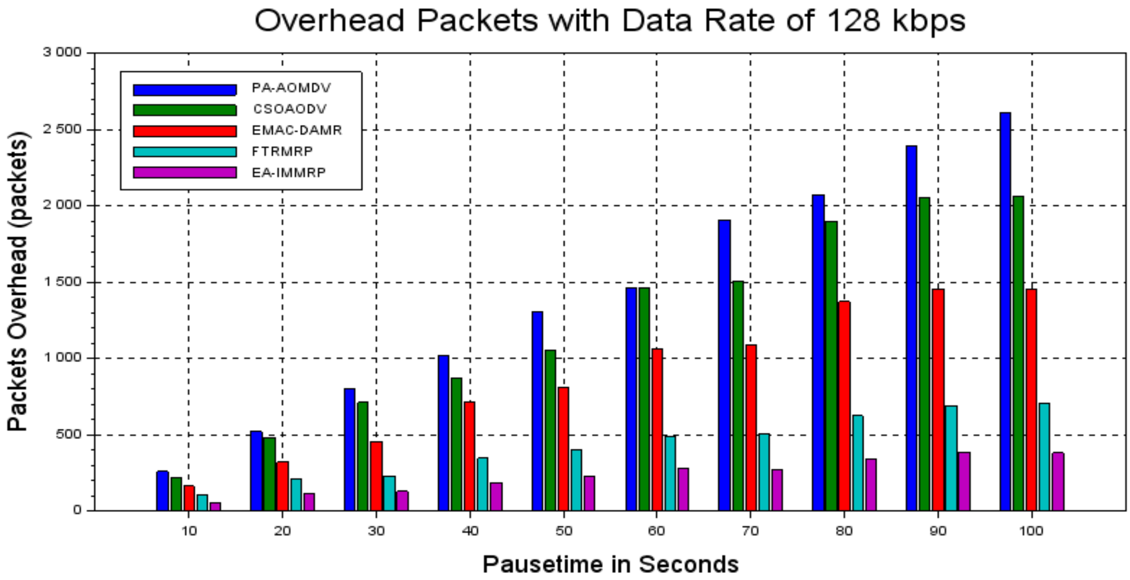

Fig. 11.Packet Overhead with Data Rate of 128 kbps

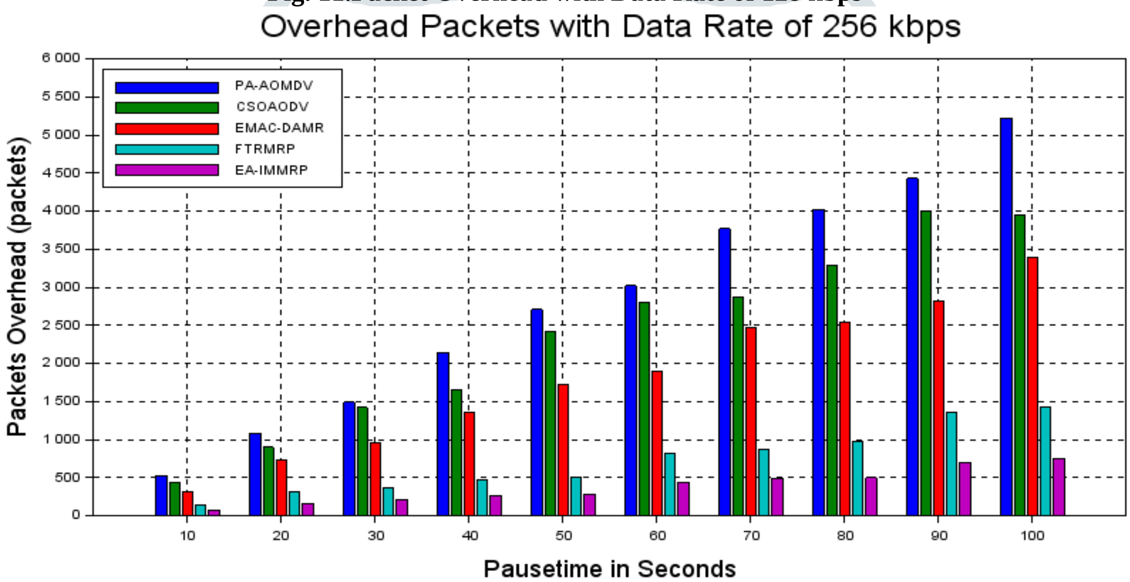

Fig. 12. Packet Overhead with Data Rate of 256 kbps

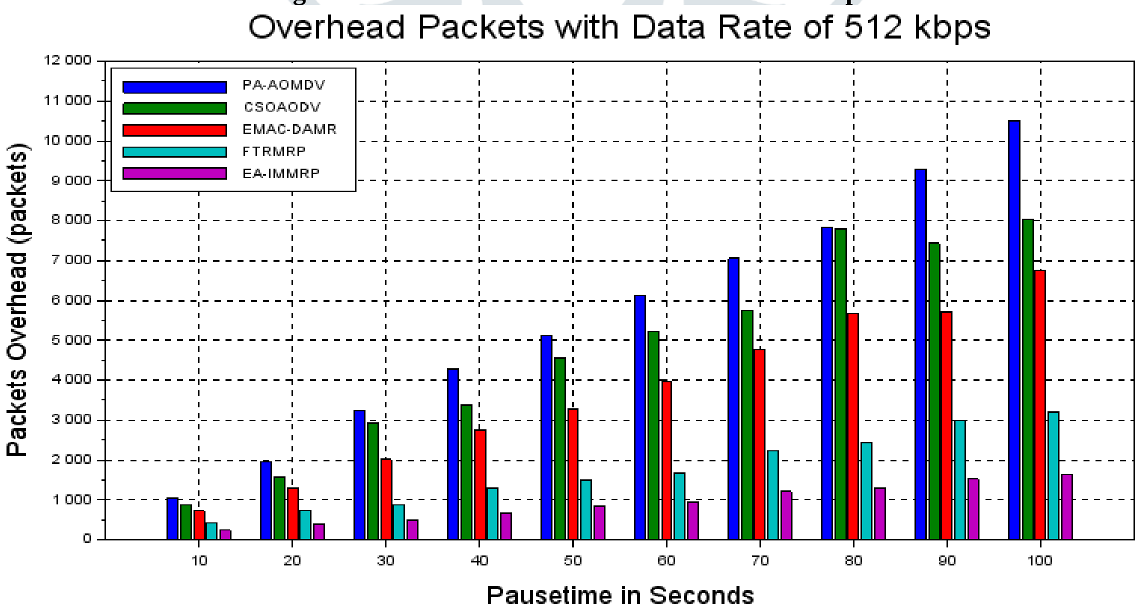

Fig. 13. Packet Overhead with Data Rate of 512 kbps

Table 6. Packet Delay of the Protocols with varying Data Rate

Pausetime (seconds)	128 Kbps					256 Kbps					512 Kbps				
	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP	PA-AOMDV	CSOAODV	EMAC – DAMR	FTRMRP	EA-IMMRP
10	0.447	0.331	0.257	0.132	0.101	0.467	0.333	0.304	0.121	0.106	0.424	0.336	0.274	0.131	0.099
20	0.432	0.321	0.300	0.138	0.109	0.431	0.355	0.270	0.123	0.104	0.410	0.378	0.258	0.132	0.106
30	0.413	0.371	0.269	0.139	0.105	0.432	0.336	0.257	0.124	0.108	0.464	0.373	0.279	0.132	0.107
40	0.442	0.324	0.282	0.140	0.106	0.435	0.346	0.306	0.128	0.104	0.398	0.332	0.275	0.136	0.101
50	0.397	0.371	0.284	0.140	0.109	0.435	0.375	0.294	0.128	0.103	0.427	0.371	0.301	0.137	0.098
60	0.426	0.321	0.253	0.141	0.103	0.427	0.368	0.304	0.130	0.105	0.422	0.360	0.267	0.137	0.098
70	0.448	0.331	0.299	0.144	0.104	0.452	0.369	0.274	0.133	0.103	0.393	0.375	0.265	0.137	0.098
80	0.462	0.350	0.285	0.146	0.100	0.453	0.336	0.284	0.134	0.109	0.431	0.322	0.270	0.140	0.105
90	0.409	0.365	0.267	0.147	0.099	0.468	0.345	0.292	0.139	0.109	0.457	0.334	0.273	0.142	0.099
100	0.425	0.376	0.307	0.149	0.101	0.455	0.342	0.291	0.141	0.106	0.439	0.362	0.278	0.143	0.108

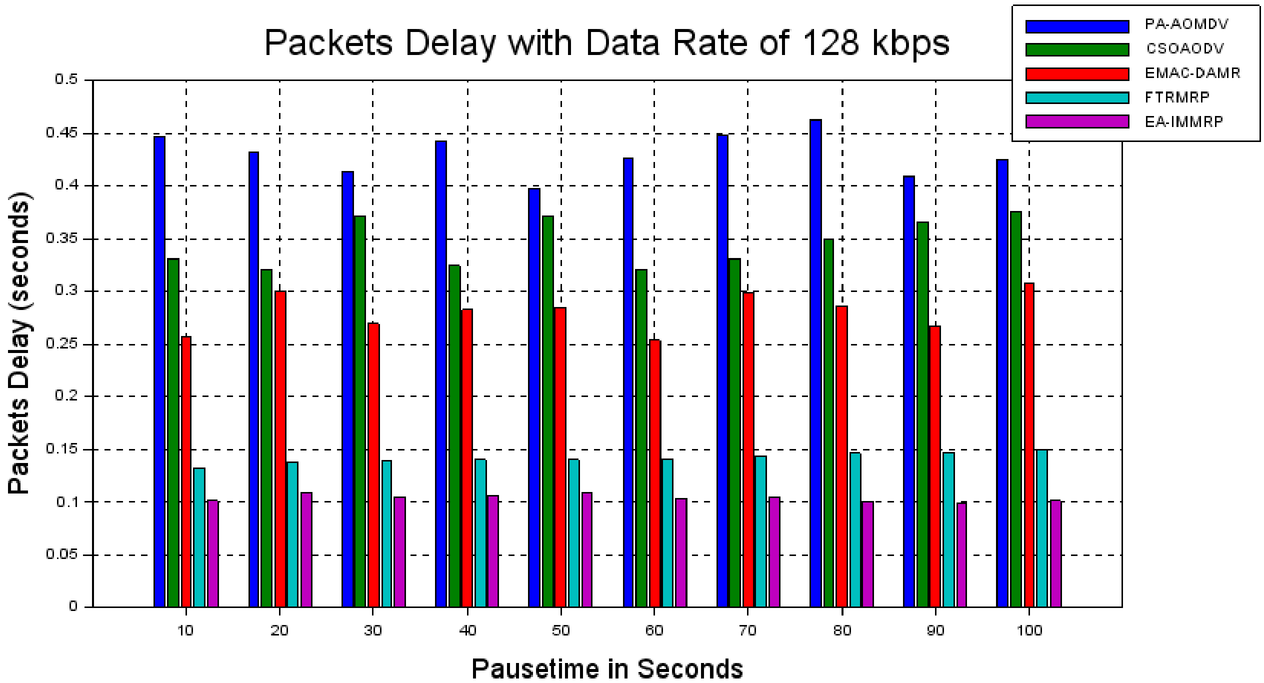

Fig. 14.Packet Delay with Data Rate of 128 kbps

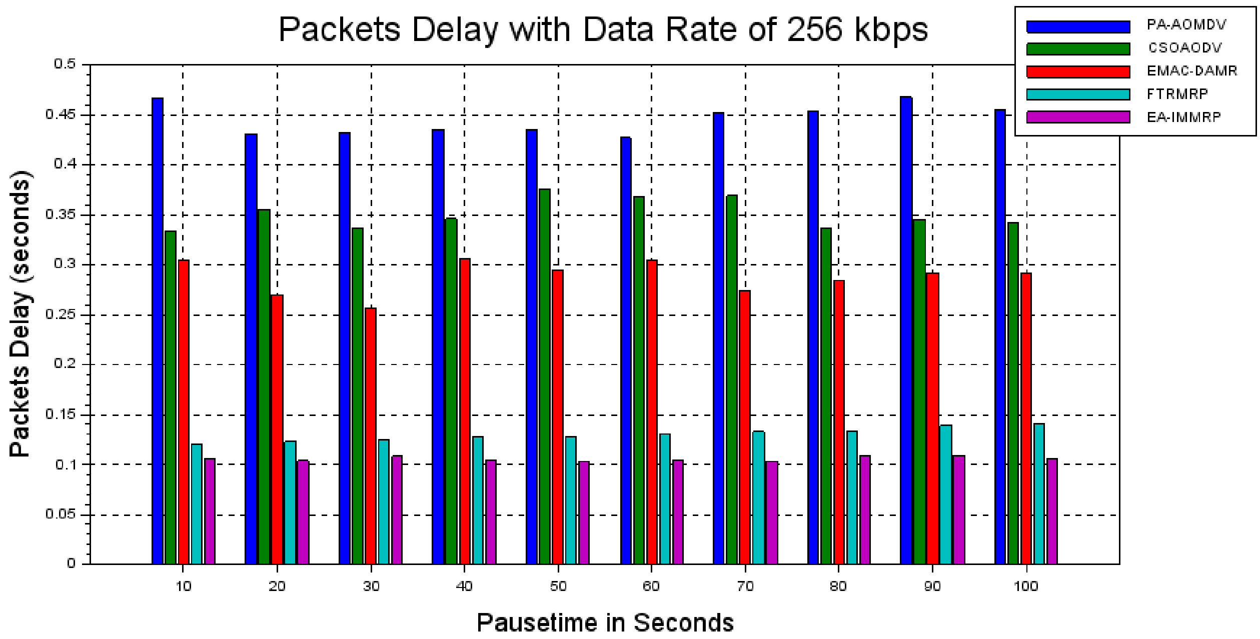

Fig. 15. Packet Delay with Data Rate of 256 kbps

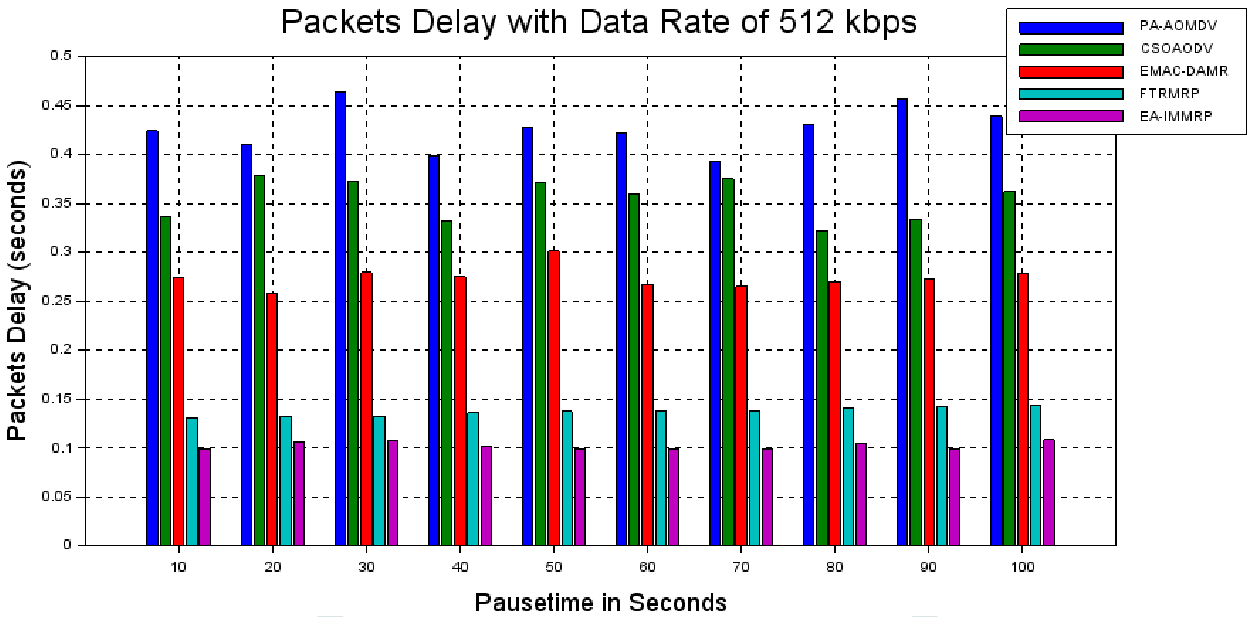

Fig. 16. Packet Delay with Data Rate of 512 kbps

6. Conclusions

QoS based routing in mobile ad hoc networks is always a propounding task. For that reason, the metrics such as signal frequency, location information, Euclidean distance, signal strength and moving speed of the nodes are taken and optimization of routes is done by evolutionary algorithm. The simulation is conducted and the results are promising. From the results it is ensured that EAIMMRP performs better in terms of improved packet delivery ratio, increased throughput, decreased overhead, reduced delay and minimum packets drop.

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