Mobility based Performance Analysis of MANET Routing Protocols

K. Natarajan
Research scholar,
Department of Computer Science and Engineering,
Rayalaseema University,
Kurnool, India.

G. Mahadevan, PhD
Research supervisor,
Principal, Annai college of Engineering and Technology,
Kumbakonam, India.

ABSTRACT
Mobile Ad Hoc Network (MANET) offers unique characteristics and application scenarios that create a great research attention recently. Designing an efficient and robust routing protocol is a challenging task and crucial to the core network operations owing to the dynamic properties of the MANET. The robustness of the routing protocol is an essential feature that adapts well to the dynamic changes in the network environment. A variety of routing protocols has been proposed depending on the network scenarios and applications. The routing protocols designed for MANET has individual and unique characteristics. The performance evaluation significantly determines the efficiency and robustness of the routing protocols used in a specific network scenario. Considering the significance of routing performance, this research work evaluates routing performance of proactive, reactive and hybrid routing protocols under various simulation scenarios to obtain the exact performance useful for different network conditions and application scenarios. This paper evaluates the performance evaluation of routing protocols such as AODV, DSR, LAR, DSDV, OLSR, FSR, and ZRP under different network scenarios for achieving the identical result to the realistic context. In realistic MANET, several factors such as node density, dynamic topology, and traffic influence the routing protocol performance and a single routing protocol unlikely to attain better performance under all scenarios. Therefore, it is crucial to consider many factors in clearly understanding the distinct characteristics of a routing protocol and estimating its relationship with others. This work analyzes the efficiency of routing protocols using different network scenarios under mobility of nodes using ns2 network simulation tool. As in the simulation results under the mobility scenario, the DSDV exhibits attractive performance under TCP traffic irrespective of speed.

Keywords
MANET, MAC IEEE 802.11,ns2, AODV, DSR, LAR, DSDV, OLSR, FSR, and ZRP

1. INTRODUCTION
1.1 MANET and Routing
Due to the proliferation of ubiquitous mobile devices, wireless communication becomes very popular and receives a great deal of attention in research. The widely used wireless network scenario is Mobile Ad-hoc NETwork (MANET). The MANET is a multi-hop autonomous network formed by a set of mobile nodes without using any centralized administration [2]. The mobile nodes operate on a limited transmission range and battery power. Owing to the limited resource support, multiple nodes should cooperatively involve in the provision of end-to-end communication for a long distance [1]. The nodes can act as a sender, receiver, and also as a router. To support the multi-hop communication, several topologies based routing protocols have been suggested in MANET. The pre-requisition of the topology based routing is the maintenance of end-to-end route from the sender node to the destination. The factors affecting the multi-hop wireless communication protocols are unpredictable node mobility and the resource-constrained mobile nodes. The suggested routing protocols have to adapt the widely varying network topology of nodes. However, the conventional topology based routing protocols have a limitation when the size of the network area is large. The possibility of creating a fully connected network and an end-to-end communication path is challenging in MANET due to the network dynamics [3]. This topology based routing protocols result in additional communication delays and routing failures.

Due to the topology issues in MANET environments, there is a necessity for using different routing strategies to establish the wireless communication among the distant mobile nodes [4] [5]. Initially, the protocols are designed with the updation of complete topology information, named as proactive routing. Thus, the proactive protocols always enable each node to retain the up-to-date routing information in their routing table, and they can initiate the communication to any node in the network without delay [7]. However, frequent topology changes of MANET simultaneously create the changes in previously updated routing table entry. Despite the proactive routing, the reactive type protocols [6] are designed to discover the routing path only when needed. Furthermore, the reactive type protocols achieve a smaller amount of overhead since they do not periodically broadcast the control packets [8]. To utilize the advantages of both proactive and reactive routing protocols, the hybrid routing has been introduced. Due to this combined performance, the hybrid protocols attain less delay as in proactive type and less overhead as in reactive type [9].

The key contributions are listed as follows:

- By considering the profound effects of mobility on network characteristics, the performance analysis efficiently reveals the real behavior of each protocol in different metrics that produces almost equal results to the realistic scenario.
- By considering the different traffic impacts at the transport layer on the comparative analysis, the well-performed protocols are differentiated based on their performance execution in various metrics.
- The performance evaluation of the proposed method is simulated using the extensive NS-2 simulator. The

simulation result proves the fair performance of the proposed method.

2. RELATED WORKS

The routing [4] is a tough task in a MANET environment due to the high dynamic and decentralized nature. The studies on various features of MANET routing protocols have been an active area of analysis for many years. The numerous protocols have been proposed to keep applications and the type of network in their view [10]. Essentially, routing protocols are widely categorized into two types named as (i) Proactive or Table Driven Protocols and (ii) Reactive or On-Demand Protocols. Both the protocol properties are combined to produce a third one named as hybrid protocols [9]. Mobility is a major challenging factor in MANET as the unpredictable movement of the nodes creates a highly dynamic network topology, and it leads to the frequent link breaks. Normally, the disruption is likely to occur due to the random movement of the intermediate nodes or the end nodes. Hence, the routing protocols must have the ability to perform with effective and efficient mobility management. The mobility scenario considers the speed and pause time of nodes at different mobility patterns [11]. In comparing the AODV, DSR and DSDV routing protocols, the packet delivery ratio and throughput of all the routing protocols decrease as the speed of nodes increases. Moreover, the high speed generates a lot of event-triggered updates. This problem is not present in DSR, AODV since the routes are discovered in both the protocols only based on the on-demand fashion. The DSR achieves long delay than AODV and DSDV due to its stale route cache issues. Comparing OLSR with AODV and DSR, the OLSR exhibits poor packet delivery at maximum speed. The DSR achieves superior performance in terms of packet delivery, throughput, and delay. Thus, the DSR can quickly observe about lost links using link acknowledgments. Additionally, the DSR has an overhearing property which allows intermediate nodes to cache the routes to the destination for future use. The pause time of nodes also affects the performance of protocols. The Pause time is defined as the waiting time before moving to another destination, and it shows the mobility of the nodes. For instance, the high pause time means that the node has to wait for a long time. Thus, it creates a low mobility scenario. In [12], the AODV, DSDV, and DSR protocols compare with varying pause time. The AODV performs better due to its hop-by-hop routing manner than DSDV and DSR except for the routing overhead. The DSR performs well, but the average delay is high. In [13], The AODV, DSR, DSDV are compared with OLSR with varying pause time. The DSR exhibits good performance in terms of the packet delivery ratio and control overhead at low to high pause time. The main design issue of routing protocols for real MANET is to attain the optimum values of performance metrics under various network scenarios where nodes are diffused to various types of mobility [15]. The various mobility models support to evaluate the performance of routing protocols in a realistic view [14]. Numerous mobility models have been proposed in the recent years [13]. This section briefly describes the review of how the different routing protocols that are proactive or reactive are performed in different mobility patterns.

3. OVERVIEW OF MOBILITY SCENARIO BASED ANALYSIS

The reason for selecting the mobility as a scenario in the simulation is because the speed is an impassive metric for an ad-hoc environment that is intended to capture and measure the kind of motion relevant for the routing protocols. The protocols must take some action when the movement of the node causes the link break or link form. The mobility metric must be proportional to such events. The random movement of nodes is generated on the various mobility models used, and that creates the most realistic scenario in the network. The proactive type protocols do not adapt to escalated mobility due to their constant update intervals. On the other hand, the on-demand type protocols find and react to link failures due to the mobility resulting in increased control packet overhead. In such a way, most of the protocols attain the poor performance regarding overhead. Conversely, when all the nodes move towards the same direction with high speed, there arises no necessity to increase the probability of link breaks. Several protocols expose much better performance under a higher mobility than other protocols, while with low mobility, there is no difference. Also, several protocols perform better than the others in low moving speed. The mobility consideration assures the protocol performance, according to their fundamental behavior. Therefore, the mobility of nodes has been taken into protocol comparison regarding speed.

The MANET [2] needs some distributed algorithms to organize the network topology with multiple intermediate routers in term of routing. The routing procedure assists the source node to find a routing path for forwarding the packets appropriately to the target destination [5]. Due to some difficulties in MANET, there is a necessity for using different routing strategies to establish the wireless communication among distant mobile nodes. The routing strategies are differentiated from each other depending on which type of information is being updated either topology or position. Different routing protocols have been introduced for wireless transmission [14].

4. PERFORMANCE EVALUATION

4.1 Performance Metrics

The performance metrics are essential aspects of the decision-making process that decide the performance of a protocol in the given scenario. The performance metrics employed to evaluate the performance are delineated as follows.

Throughput: Throughput is defined as the rate of successful data delivery to the destination. The throughput ensures the reliability of packet delivery.

$$\text{Throughput (bits/Sec)} = \frac{\text{Number of Received data}}{\text{Duration of data transmission}}$$

Packet Delivery: The packet delivery is the ratio between the total number of packets delivered to the destination and the number of packets sent from the source.

$$\text{Packet Delivery (\%)} = \frac{\text{Number of packets delivered to the destination}}{\text{Number of packets sent from the source node}}$$

Routing overhead: The total amount of routing packets exploited throughout the simulation.

End-to-End Delay: End-to-End delay is the average time taken for a packet to reach the destination from the source node.

$$\text{End to End Delay (Sec)} = \frac{\sum(\text{Delay for each data packet})}{\text{Total number of delivered data packets}}$$

4.2 Simulation setting for mobility scenario

The settings of simulation parameters for mobility scenario are shown in Table 1. The following Table 2. analyzes the mobility scenario in term of varying node speed. The TCP and UDP traffic types impact the performance of protocols depending on the data rates and therefore, the protocols are implemented under both the TCP and UDP traffic scenarios.

Table 1. Simulation settings for mobility scenario

Simulation Parameter	**Value**
Simulator	NS-2
Routing Protocols	AODV, DSR, LAR, DSDV, OLSR, FSR, and ZRP
Network Area	1000x1000m
No. of nodes	150
Mobility Model	RWP
Speed	10,15,20,25,30 m/s
Pause Time	10s
CBR Connections	15
Traffic Type	TCP, UDP
Traffic Generator	FTP,CBR
MAC Protocol	IEEE 802.11
Queuing Model	Drop Tail/Priority Queue
Priority Queue Size	50
Simulation Time	100s

5. RESULTS AND DISCUSSION

5.1 Results of Simulation Scenario with TCP

The comparative performance analysis of AODV, DSR, LAR, DSDV, OLSR, FSR, and ZRP routing protocols in TCP traffic with varying speed of nodes from 10 to 30m/s is shown in figure 1. The scenario settings are followed as illustrated in Table 2. It is investigated that for TCP traffic, the DSDV performs well than other protocols in both the low and high speed.

Table 2: Node Speed Based Scenario Settings

Speed Investigations	
Type of Scenario	**Description**
Scenario-1 Low Mobility	This scenario is designed for node speed 10 to 15m/s with a pause time of 10 Sec, the MAC standard of IEEE 802.11, the network size of 150 nodes, and the file size of 491.520kb.
Scenario-2 Medium Mobility	This scenario considers the evaluation of routing protocols while the speed varies from 15m/s to 20m/s in a medium size network. The other simulation setting values such as pause time, size, and MAC protocol type is same as found in scenario 1.
Scenario-3 High Mobility	Similar to the scenario 1 and 2, the network scenario is designed with different network entities and configured with a network size of 150 nodes. The node speed is increased to 30m/s with a pause time of 10 sec. The aim of designing such scenario is to exactly evaluate the impact of high speed on the performance of each routing protocol. It investigates the behavior of protocols when the speed is varied between 20m/s to 30 m/s.

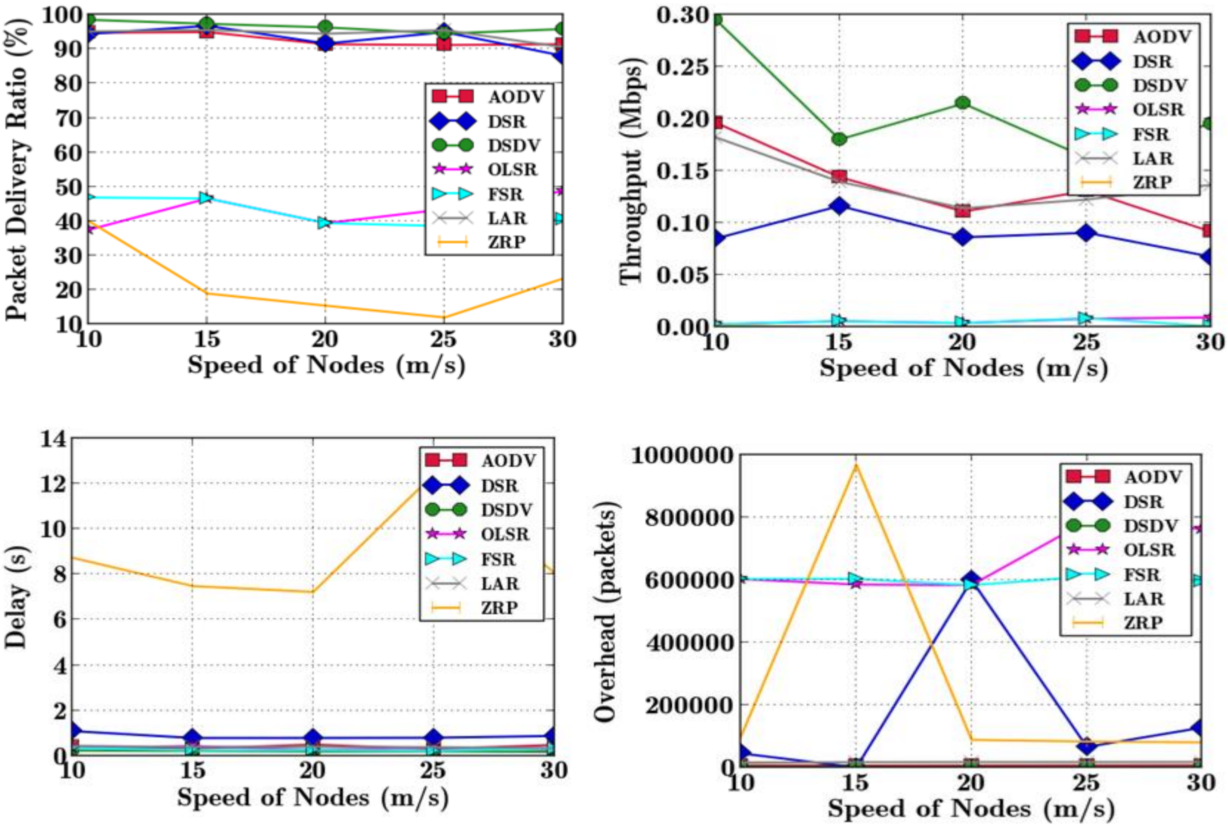

Fig.1: Performance comparison with varying number of nodes

The DSDV attains nearly 100% PDR when the speed is low such as 10m/s. This is because DSDV maintains updated routes for all nodes in the network at all the times. Thus, the routes are available even in high mobility. The other protocols such as AODV, DSR, and LAR have a comparable PDR rate to DSDV from 10 to 30m/s speed as shown in figure 1(a). Instead, the ZRP reveals very poor PDR rate when compared with others. It attains 39.9% PDR 10m/s speed. In ZRP, the intra-zone nodes continually update the topological changes in a proactive manner. The continuous updation with increasing speed creates high traffic within the zones resulting in packet loss and congestion. When attaining the 30m/s speed (as scenario 3 in Table 2), the nodes are lacking to update the frequent changes continuously. Thus, the PDR rate begins to rise from 30m/s. With increasing speed, the OLSR tries to beat the performance of FSR due to the ability of recent and reliable route selection via MPR set. Also, the OLSR, FSR, and ZRP have very poor performance in throughput as exposed in Figure 1(b).

The LAR and AODV retain almost comparable result. However, the AODV fails to keep it in 30m/s, and it has 32.8% less throughput in that speed. The frequent and unpredictable changes lead to link failure. Comparing all, the DSDV has high throughput in 10m/s speed as it continuously updates all available routes in its routing table. With the increase in speed, it shows a little decrement. In 20m/s speed, it has 16% increased throughput as there is adequate path availability without congestion. The prime factor in routing is overhead that is depicted in figure 1(c). The acknowledgment expectation in the TCP nature leads to overhead in terms of retransmission when the mobility occurs. In this, the ZRP and DSR attain peak overhead in 15m/s and 20m/s speed respectively. The 15m/s speed is adequate to impact the inter and intra-zone updation process in ZRP.

Moreover, the cache overhead and staleness together result in degradation of DSR performance in 20m/s. Both have failed to cache the routes due to the frequent topology changes after attaining the peak overhead. The LAR achieves relatively very less overhead than in traditional flooding methodology using location information. Comparing OLSR and FSR, the OLSR obtains peak overhead on the speed escalation. Because the nodes which exclude MPR set to begin the retransmission when packet loss occurs due to high mobility. Also, considering the delay shown in figure 1(d), all of them attain almost comparable as well as the acceptable delay between 0.23s and 1.08s except ZRP. The ZRP has 97.9% more delay than DSR due to the link failure among nodes in zones during high mobility. The route repairing takes time over inter and intra-zone structure.

5.2. Results of Simulation Scenario with UDP

Figure 2 shows the comparative performance analysis of AODV, DSR, LAR, DSDV, OLSR, FSR, and ZRP routing protocols in UDP traffic with varying speed from 10 to 30m/s. For UDP traffic, the LAR and AODV perform better than the other protocols. They successfully deliver almost 50% to 60% data packets irrespective of the speed as shown in figure 2(a). In this, the AODV exploits hop-by-hop routing method, and it has more fresh and on-demand paths in increasing speed. Hence, it gets more PDR than LAR at such high speed. The DSR, DSDV, OLSR, and FSR initially achieve quite comparable delivery rate, and all of them decline with escalating the speed. The DSR has some caching entries which facilitate a significant benefit up to a certain speed. However, at increasing speed such as 30m/s, the PDR rate declines. The FSR and OLSR begin to rise after 20m/s since there is the possibility of efficient link state updation, and more connectivity among MPR set respectively.

In terms of a PDR as well as throughput as exposed in figure 2 (b), the ZRP reveals unsound performance as, the distance between source and destination raises with increasing speed, zone area increases which lead to collision and packet loss. The LAR retains more throughput than others, irrespective of speed due to the intention of flooding overhead reduction using location information. Also, it efficiently retains the connectivity among the nodes in the restricted flooding area. Moreover, the AODV attains 30% higher throughput than DSDV as well as 71.5% higher than DSR. When comparing DSR and DSDV, the DSDV achieves 59% higher throughput than DSR at 10m/s speed as well as the DSDV maintains quite a high throughput irrespective of speed since there is more availability of new routes by continuous updation of the routing table. Moreover, AODV, DSDV, and LAR attain comparable control overhead and except ZRP and DSR protocols as well as the OLSR and FSR have much more overhead as illustrated in figure 2(c). The DSR has delayed until all cached routes have failed. In high mobility, the chances of the cache routes being stale are high. Finally, when initiating a route discovery, a great number of replies are received that associate with high control overhead. It has 62.5% raised overhead in 30m/s speed than in low speed. The LAR attempts to lessen the overhead by calculating the request zone that represents the boundary. Thus, it maintains 181536 packets on average irrespective of speed. Furthermore, due to the lack of clarity about distant nodes make the FSR fail to perform. As shown in figure 2(d), the ZRP has a higher delay than other protocols. The DSDV outperforms other protocols due to the fresh path availability of all possible destinations. Also, the DSR exhibits 53% and 95% high delay than AODV and DSDV protocols respectively due to its cache staleness. The following Table 3 illustrates the performance of routing protocols which exhibits the best performance results at different speeds. The following Table 3 illustrates the performance of routing protocols which exhibits the best performance results at different speeds.

6. CONCLUSION

The mobility based scenario has demonstrated a comparative analysis of routing protocols such as AODV, DSR, LAR, DSDV, OLSR, FSR, and ZRP for correctly estimating the protocol characteristics under various network scenarios. Different scenarios assure the original view of the realistic environment. The TCP and UDP traffic type based protocol analysis efficiently assist the comparison in obtaining the routing protocols which behave well over much important scenarios of MANET such as mobility. Eventually, the simulation results estimate the exact performance of routing protocols as equal to the realistic environment. The following table 4 illustrates the performance comparison of protocols in different metrics.

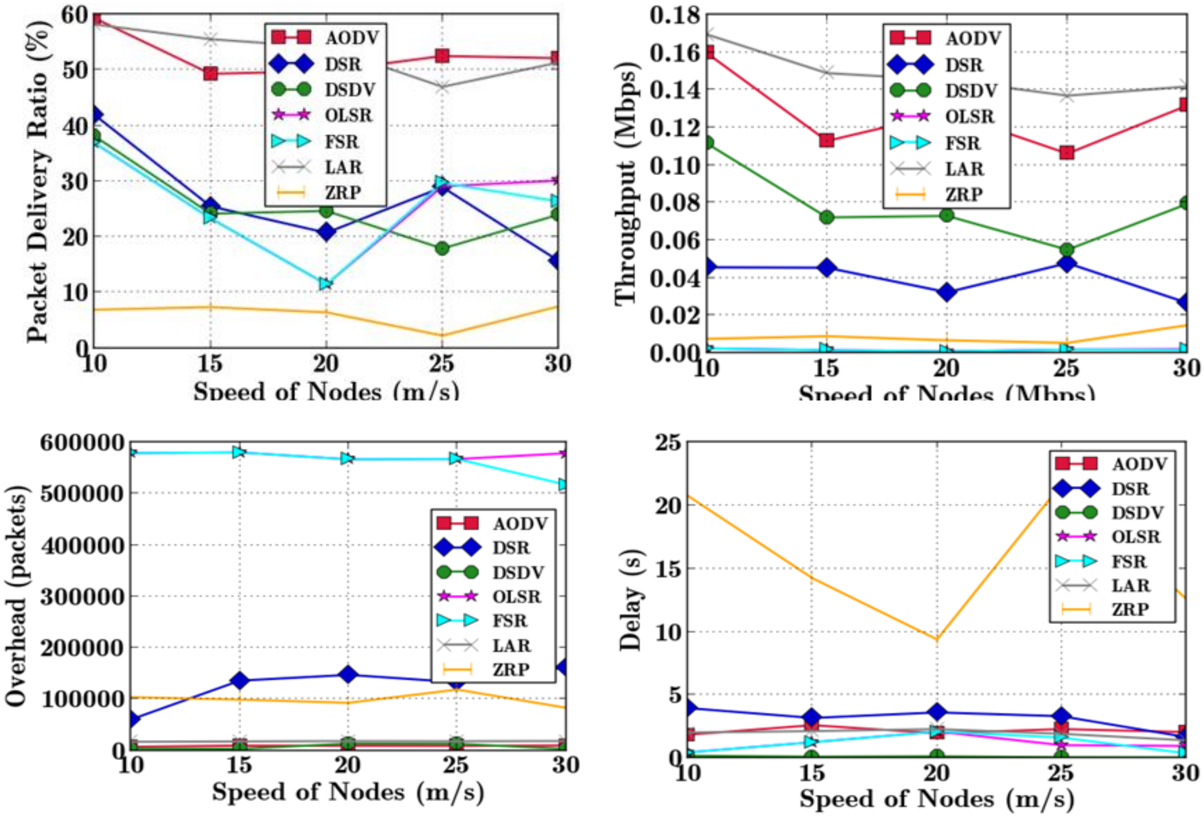

Fig 2: Performance Comparison with Varying Speed of Nodes

Table 3: Performance of Protocols

Traffic Type	Nodes Speed	Suitability			Description
		Reliability	Energy Sensitive	Delay Sensitive	
TCP	Low	DSDV	DSDV	DSDV	In TCP scenario, the DSDV protocol reveals good performance at all speeds. It retains all available routes at all the time due to the capability of updating the routing table.
	Medium	DSDV	DSDV	DSDV	
	High	DSDV	DSDV	DSDV	
UDP	Low	LAR, AODV	DSDV	LAR	In UDP, overall the LAR shows the appreciable performance even in high speed. The high mobility does not severely impact the LAR performance.
	Medium	LAR, AODV	DSDV	LAR	
	High	LAR, AODV	DSDV	LAR	

Table 4: Comparison of Simulation Results for the Mobility Scenario

Network Scenario	Metrics	Traffic Type	AODV	DSR	LAR	DSDV	OLSR	FSR	ZRP
Mobility	PDR	TCP	High	High	High	High	Medium	Medium	Low
	Throughput		Medium	Medium	Medium	High	Low	Low	Low
	Overhead		Low	Medium	Low	Low	Medium	Medium	Medium
	Delay		Low	Low	Low	Low	Low	Low	High
	PDR	UDP	High	Medium	High	Medium	Medium	Medium	Low
	Throughput		High	Medium	High	Medium	Low	Low	Low
	Overhead		Low	Medium	Low	Low	High	High	Medium
	Delay		Low	Low	Low	Low	Low	Low	High

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