A STUDY ON THE BENEFITS OF DYNAMIC SWITCHING BETWEEN AD HOC ROUTING PROTOCOLS[1]

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ABSTRACT

Wireless ad hoc networks are used for a variety of applications and many routing protocols are available to suit their demands. Although monolithic protocols have their advantages, they do not perform well in all conditions. We argue that these limitations can be removed by a system that allows for dynamic switching between multiple routing protocols. We propose a framework that decides which protocol works better for a given scenario based on various metrics. In this paper, we demonstrate that ad hoc applications will benefit from such a system by means of simulations.

KEYWORDS

Wireless ad hoc network, routing protocol, switching framework, mobility model, decision algorithm.

INTRODUCTION

Ad hoc networks are those which do not depend on pre-established infrastructure for organization and routing between independent mobile nodes [2]. Due to the absence of a hierarchy among the nodes, there is no central authority that performs routing tasks [2]. Hence, all nodes participate in routing other nodes' packets. This makes ad hoc networks a good choice for applications where deployment and dismantling of the networks need to happen within a short span of time. Once the

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network has been established; various mechanisms can be adopted to carry out routing. Some routing protocols that have been widely used are DSR, AODV, DSDV, etc.

The choice of protocol for deployment is based on the application scenario and the boundary conditions that it comes with [1]. Monolithic protocols have worked well where the system has been restricted to certain well documented conditions. However, when the conditions are open to change, the monolithic protocols may not work efficiently. One of the solutions provided to counter this has been the use of a hybrid protocol [3]. A more dynamic approach would be to execute seamless interoperability among protocols, hence deploying the most relevant protocol atthe given point in time.

The performance of ad hoc networks depend on several factors such as the mobility model, traffic encountered, network topology, radio interference, etc. [2]. However, the parameters used for measuring performance are throughput, packet delivery ratio, end to end delay, etc. The performance of a network in a specific environment describes the characteristics of the target environment and hence dictates the choice of protocol to be used. But these factors are liable to change and hence these changes can cause the environment to demand different approaches from the already deployed and functioning network. This calls for a system wherein the network has the capacity to work in various modes and has the ability to switch between them. This also calls for the design of an algorithm which decides when a switch is required and the mode that it needs to switch to. We propose that different routing protocols represent the different modes of operation of the network. Depending upon a study of the target environment, a set of routing protocols may be adopted. In this paper, we describe how a switching mechanism can be beneficial in improving the performance of the mobile ad hoc nodes. This has been done by means of a study based on simulations on ns2.

RELATED WORKS

New routing protocols are usually proposed to improve upon the current efficiency or performance. These protocols usually either have a novel design or are hybrid in nature. A hybrid protocol’s task is divided into two or more parts and each part uses a monolithic protocol for its working. In the case of HARP [3] a zone level hierarchical routing methodology is used. For nodes in the same zone, reactive routing is employed whereas for nodes in a different zone proactive routing is used. The protocol ZRP [4] is also very similar to HARP. Various monolithic protocols like AODV [5], DSR [6], and DSDV [7] were originally proposed for effective routing purposes. These protocols may be adapted or modified so that they are tailored to a specific application.

FRAMEWORK OVERVIEW

There is no generalized routing protocol that works best for each and every type of scenario. There is always a specific protocol that works better for a given scenario than any generalized protocol. However the specific protocol is likely to perform poorly in other scenarios. The idea of a switching framework aims at eradicating the concept of one single protocol. Instead of a designing a new one-size-fits-all protocol, such a framework can choose an appropriate protocol for the specific scenario. This protocol can be hybrid or monolithic.

The switching framework uses a decision algorithm to choose most appropriate protocol. This decision algorithm acts based on various metrics like energy consumed, throughput achieved, end to end delay, packet delivery ratio, bit error ratio etc. These metrics vary due to node mobility and node density. Node mobility is the speed of a node in a network and node density is the number of nodes in a given area.

The switching is governed by a value called protocol favourability. This value is unique for each protocol in contention, in a given scenario. For a given scenario, if a protocol has been chosen by the decision algorithm, then it implies that this protocol had the highest value of favourability among all protocols.

$$Pf = [\sum_{k=1}^{k=n} a_k x_k]_{\mathrm{P}} > [\sum_{k=1}^{k=n} a_k x_k]_{\mathrm{P1}} > [\sum_{k=1}^{k=n} a_k x_k]_{\mathrm{P2}} \dots\dots\dots\dots\dots\dots > [\sum_{k=1}^{k=n} a_k x_k]_{\mathrm{Pn}}$$

Here 'x' stands for the metric value and 'a' stands for importance of the metric in a given situation. Since the user will be best suited to decide importance that each metric should receive, the value for 'x' should be given by the user. P_f stands for protocol favourability. In the given equation the value of P_f is the highest for protocol P when compared to protocols P_1 to P_n. Hence protocol P will be chosen.

Some metrics like energy consumed cause a depreciating effect on protocol function. Such metrics must be negated before plugging into the equation.

MOBILITY MODELS

This section contains the description of various mobility models used in simulations.

A. *Random Waypoint model (RWP)*

The parameters specified for generating a scenario in RWP model are pause time, minimum speed and maximum speed. Minimum speed and maximum speed are the speed limits defined for every node in the network. The time for which a mobile node stays at a position is called pause time. All nodes are at a random position at the start. A random destination and a random speed are picked for the mobile node. After the pause time expires the mobile node will move towards the destination picked with the selected speed. This process starts over again once it reaches its destination.

B. *Gauss Markov model*

Instead of total randomness as in the case of RWP model, Gauss Markov model introduces a probabilistic dependency in choosing the speed of the node and the direction of the node for the next iteration. The next iteration's speed and direction depend on previous iteration's speed and direction. Thus this can be modeled to suit personal communication systems and be implemented for practical use. Gauss Markov mobility model uses Gaussian distribution to determine speed and angle of movement and thus have the ability to produce smooth curves. The mobile nodes generally stay inside the simulation area [8].

C. *Manhattan Grid model*

This model represents a city that has perpendicular roads crossing each other. This model also has a pause time and a speed range parameter. Mobile nodes move either horizontallyor vertically towards their randomly chosen destination. After reaching the destination, the node stays till the pause time expires, after which all processes are repeated for the next iteration.

SUMMARY OF AD HOC PROTOCOLS USED

This section contains a brief description of AODV and DSR.

A. *Ad Hoc on demand Distance Vector routing (AODV)*
AODV is an on demand algorithm, capable of both unicast and multicast routing. Each node maintains a routing table that contains only the next hop information thereby minimizing the table size. AODV builds routes using a route request / route reply query cycle. When a source node desires a route to a destination for which it does not already have a route, it broadcasts a route request (RREQ) packet across the network. Nodes receiving this packet update their information for the source node and set up backwards pointers to the source node in the route tables. A node receiving the RREQ may send a route reply (RREP) if it is either the destination or has a route to the destination. Else it simply rebroadcasts the RREQ. If a link break occurs while the route is active, the node upstream of the break propagates a route error (RERR) message to the source node to inform it of the now unreachable destination(s). After receiving the RERR message if the source node still desires the route, it can re-initiate route discovery.

B. *Dynamic Source Routing (DSR)*
In DSR, when a source node wants to send a packet it will check for a route in its cache. If it finds a route to the source, it will add the entire route till the destination node, in the header of the packet, after which transmission to the first node begins. If no route to the destination is available, source will broadcast a route request message to its neighbors. This message will contain the initiator, target and a unique id.
When an intermediate node receives a route request message, it will check its own route cache for the stored route to destination. If there is a stored route, the route will be sent to the source else route request message will be broadcasted with the intermediate node's id in the message.

SIMULATION ENVIRONMENT

To understand the feasibility of switching between routing protocols in ad hoc environment, simulation experiments have been conducted in network simulator -2 (ns-2). The outline of the scenarios used and its parameters have been mentioned.

A. *Parameters used in simulation*
The underlying MAC layer protocol used was of 802.11 standards [0]. The number of nodes used in the simulation was varied so as to understand the effect of node density in the process of switching. The simulation area was taken to be 2000 m x 2000 m. These scenarios were used to generate various trace files on which analysis was done for supplying data for the decision algorithm.

B. *Mobility and traffic generation.*

Bonn motion [9] was used to generate scenarios of the previously specified models. To understand the effect of node mobility on the performance of each protocol various speeds were used to generate movement patterns. The speeds that were used are 5,10,15,20,25,30,35 (m/s). The traffic load was provided by various CBR traffic streams. Both routing protocol were run over various mobility models along with various set of scenarios. About 300 simulations were performed and analyzed. The energy consumption model used is given in [1].

RESULTS OF THE SIMULATION

The analysis of the 450 simulations is presented here.

A. *Effect of node density and node mobility on various metrics in Gauss Markov mobility model.*

The metrics presented here are energy consumed, throughput achieved. These two metrics are important for various applications and hence shown first. The other metrics considered for decision making algorithm are packets lost, packet delivery ratio, end to end delay, buterror ratio.

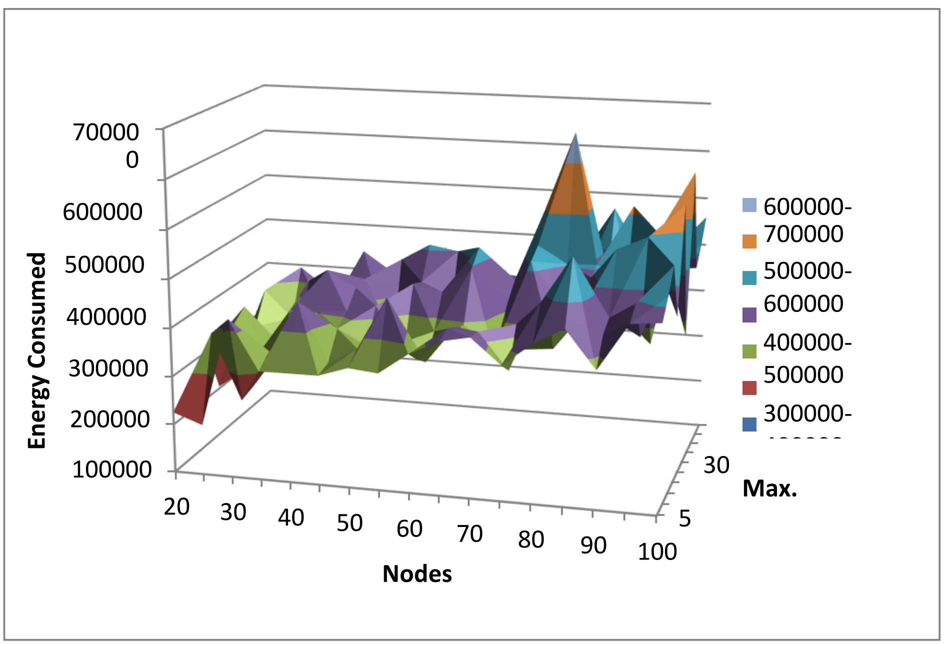

Fig 1: A surface chart for energy consumption while using AODV protocol in Gauss-Markov model

The above graph shows energy consumed versus node density in prominence. There is a gradual increase in energy consumed because of increase in number of nodes, which results in more transmission and reception of packets.

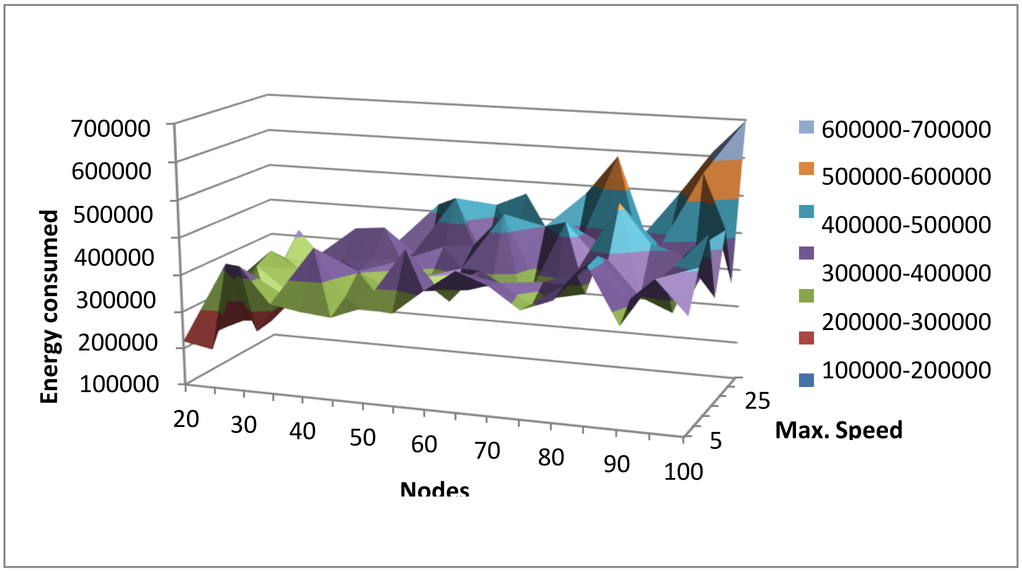

Fig 2: Energy consumed in using DSR protocol while applying Gauss-Markov mobility model

The above surface charts show the difference between energy consumption between AODV and DSR protocol for the same scenarios. As the node density increases, energy consumed decreases while using AODV protocol. Also, there are multiple areas where due to fluctuation, there is no clear favourite among AODV and DSR. Thus, instead of following a single protocol, choosing a routing protocol specific to a scenario will be more efficient.

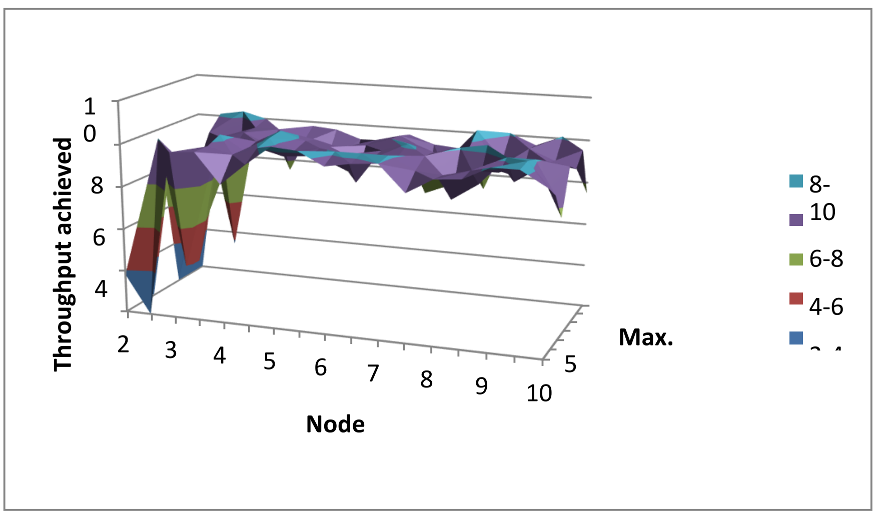

Fig 3: Throughput achieved by using AODV protocol in Gauss Markov mobility model

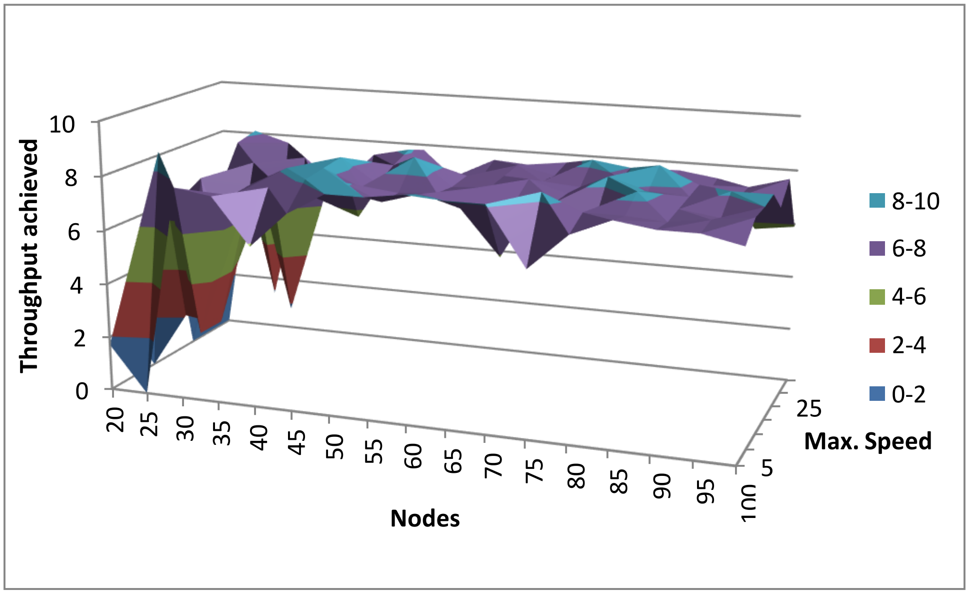

Fig 4: Throughput achieved by using DSR protocol in Gauss Markov mobility model

The above graphs show us that there is no clear favourite between AODV and DSR for throughput achieved in Gauss Markov model. The following table shows the favourability factor for AODV and DSR model in Gauss Markov model for various metrics.

Factors | Protocols	AODV	DSR	Either
Energy consumed	34.45	65.55	0
Throughput	20.17	12.61	67.23
Packets lost	20.17	70.59	9.24
Packet delivery ratio	14.29	21.85	63.87

Table 1: Summarization of graphs for Gauss Markov model

B. Effect of node density and node mobility on various metrics in Random Waypoint mobility model.

Random Waypoint model can be applied to scenarios where nodes have no defined style of movement. It usually happens in places with lot of crowd movement such as museums, parks. Random Waypoint can also be applied to chaotic situations such as markets where vehicular movement is also present.

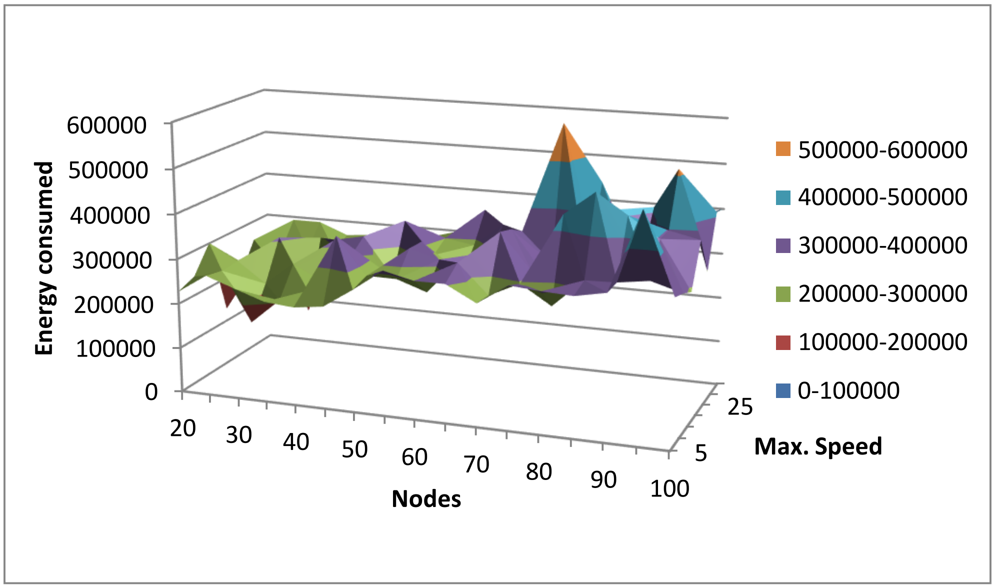

Fig 5: Energy consumed in using AODV protocol for Random Waypoint mobility model

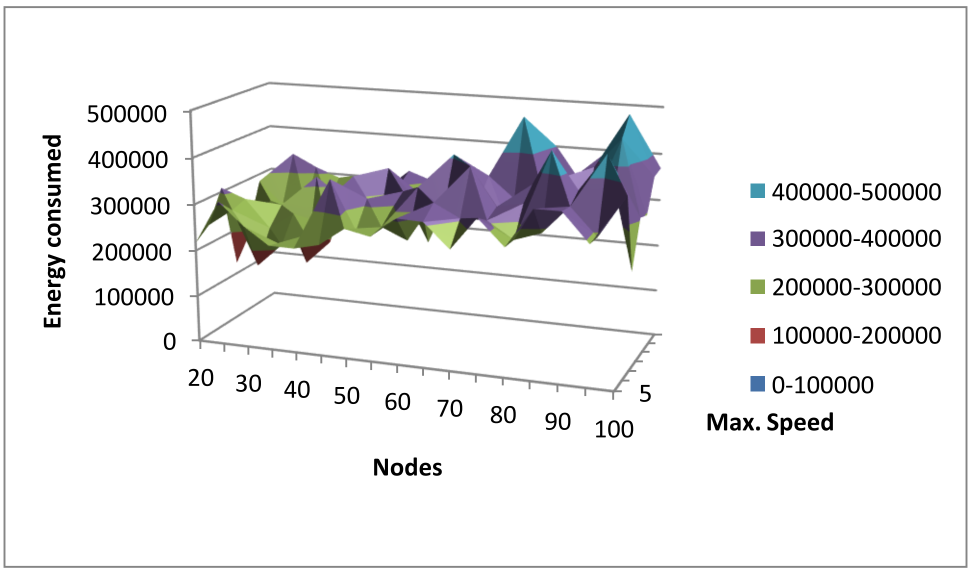

Fig 6: Energy consumed in using DSR protocol for Random Waypoint model

Just as in Gauss Markov model, a single protocol is not favoured for all the scenarios. Thus to save energy, a protocol switch can be applied.

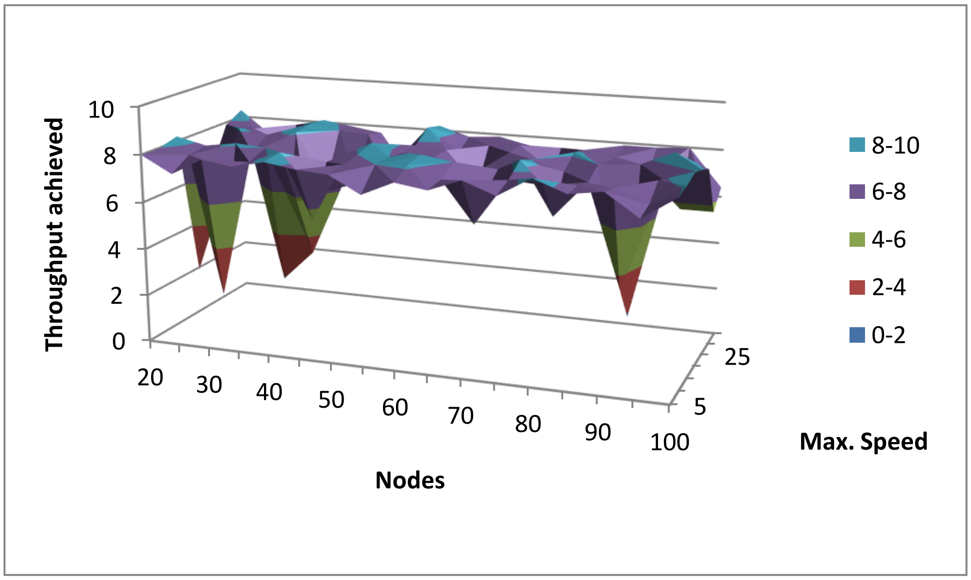

Fig 7: Throughput achieved by using AODV protocol for Random Waypoint model

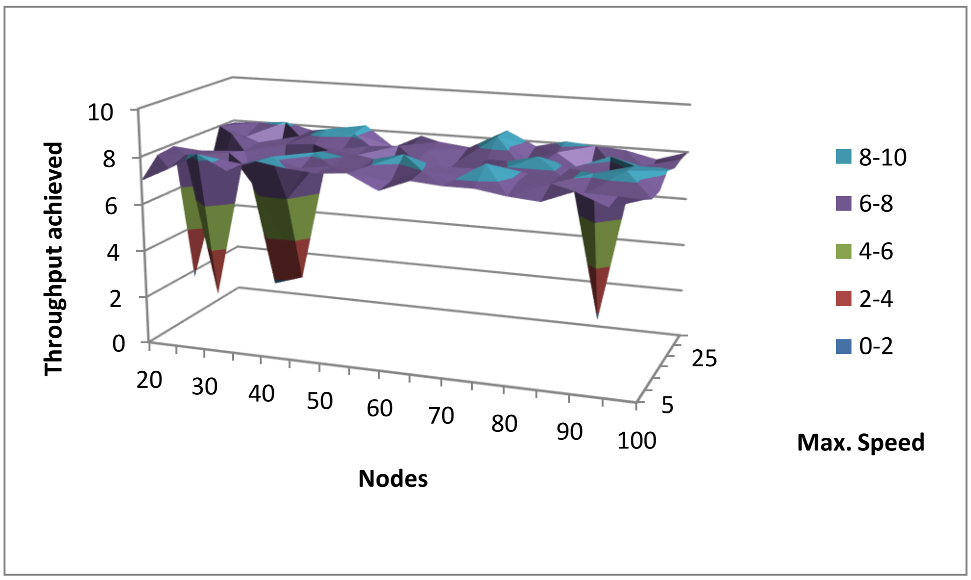

Fig 8: Throughput achieved by using DSR protocol for Random Waypoint model

Though the throughput graphs are similar, there are scenarios where only a specific protocol is favoured. The following table shows the need for a switch while applying Random Waypoint mobility model. The values represent the percentage of scenarios where that specific protocol is a better choice.

Factors | Protocols	AODV	DSR	Either
Energy consumed	56.3	43.7	0.0

Throughput achieved	33.61	23.53	42.86
Packets lost	28.57	62.18	9.24
Packet Delivery ratio	27.73	31.93	40.34

Table 2: Summarization of all the graphs for Random Waypoint model

C. Effect of node density and node mobility on various metrics in Manhattan Grid mobility model

Manhattan Grid mobility model gives us a perspective of cities with perpendicular roads. Hence, in this model, the nodes move only vertically and horizontally.

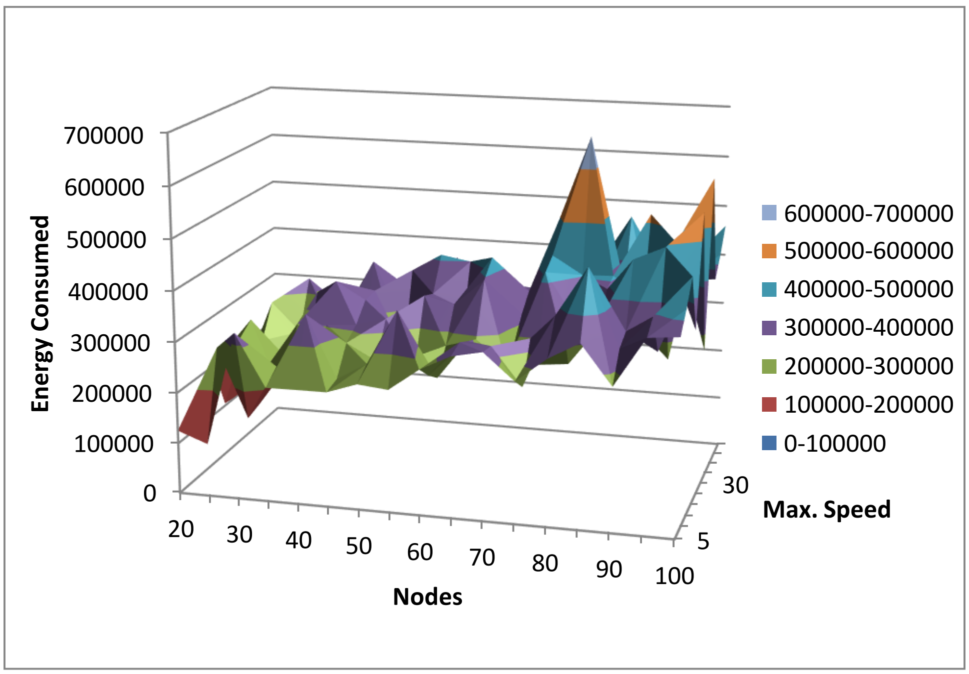

Fig 9: Energy consumed in using AODV protocol for Manhattan Grid model

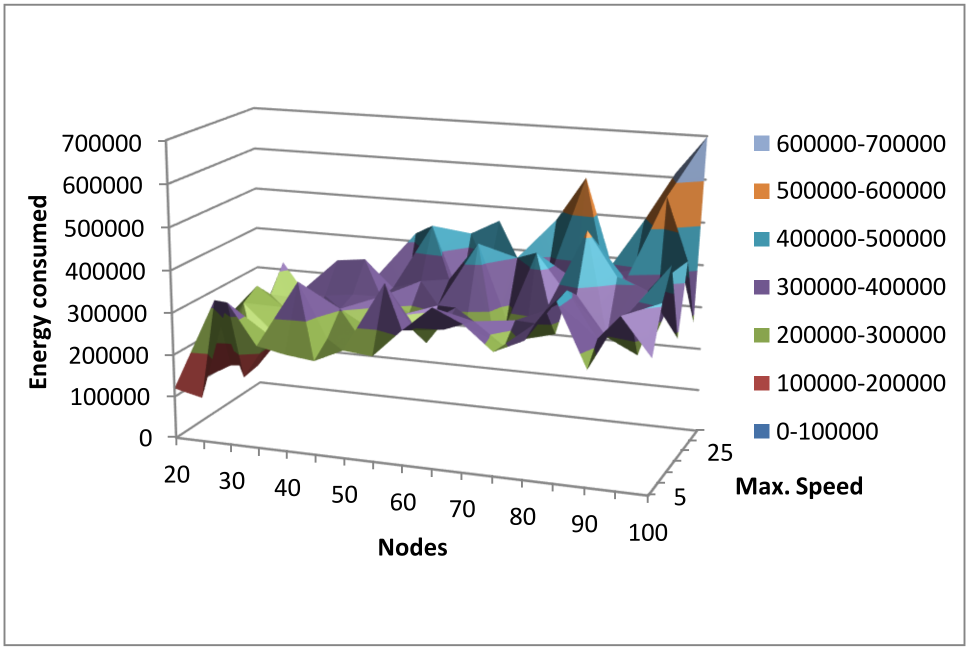

Fig 10: Energy consumed in using DSR protocol for Manhattan Grid model

From the above energy based graphs it is visible that there are major differences in the way in which the two protocols handle the scenarios and that there is no clear favorite.

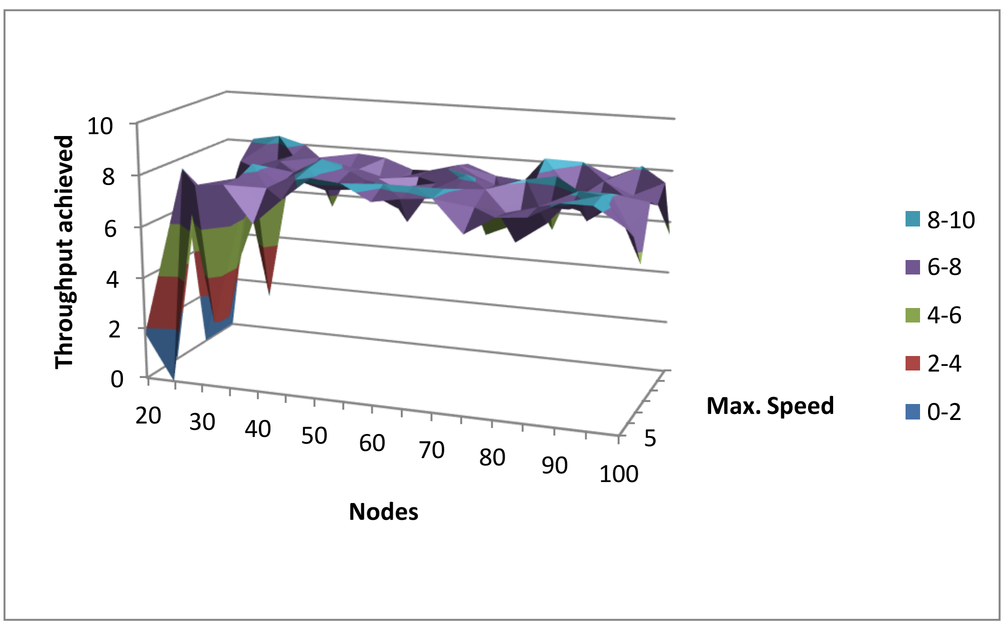

Fig 11: Throughput consumed in using AODV protocol for Manhattan Grid model

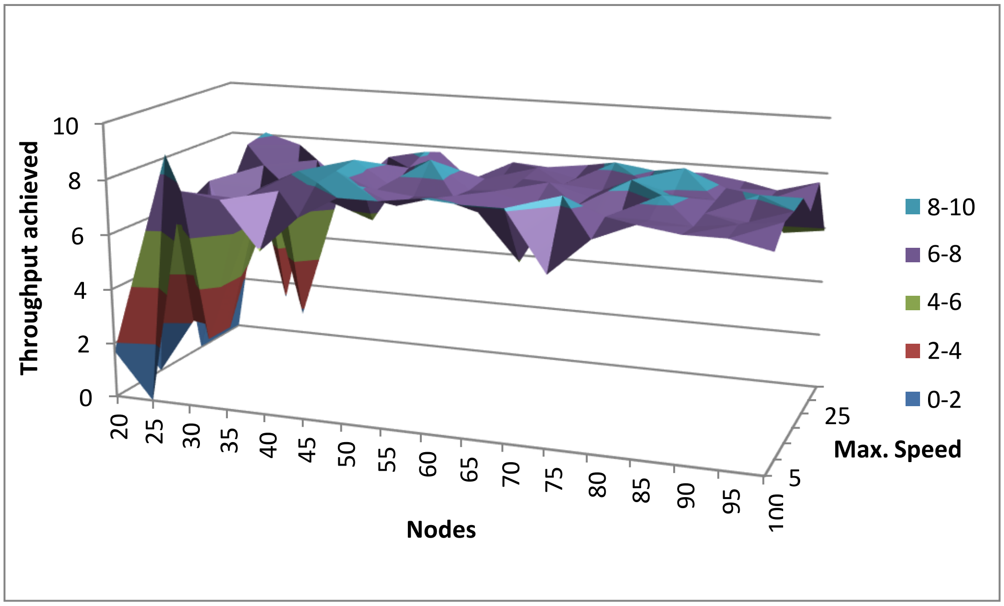

Fig 12: Throughput consumed in using DSR protocol for Manhattan Grid model

As in the energy based graphs, no single protocol can be favored over the other on the basis of throughput in this mobility model.

The following table gives the favourability (%) that each metric shows towards the protocols.

Factors | Protocols	AODV	DSR	Either
Energy consumed	34.45	65.55	0.0
Throughput achieved	10.08	8.41	81.51
Packets lost	25.21	64.71	10.08
Packet Delivery ratio	8.41	10.08	81.51

Table 3: Summarization of all the graphs for Manhattan Grid model

An application that uses a city environment may wish to either conserve energy or achieve throughput or require precise packet delivery. Thus depending on the metric's priority the decision algorithm can be adapted and thus an appropriate protocol can be chosen.

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