International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 4 (2015) pp. 10633-10645

http://www.ripublication.com

# Cluster Based Data Transfer Strategy For Multihop Layered Wireless Sensor Network

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## Abstract

The paper attempts to draft an energy efficient cluster based mechanism to route the data in a multihop architecture of a layered Wireless Sensor Network (WSN). The philosophy of data transfer fosters an exhilarating influence on the emergence of a renewed communication technology to facilitate an increase in the network lifetime. The approach interleaves the theory of a cluster in the formulation of an Ad-hoc On demand Distance Vector (AODV) routing pattern to extradite the scalability of the network. The cluster based Ad-hoc On demand Distance Vector (CAODV) scheme strives to reach enlarged dimensions in the heterogeneous environment and comply the needs of the growing traffic. The function of a cluster head (CH) reinforces strength in an effort to reduce the energy consumption and realize a passage for the safe delivery of the information. It includes the simulation results obtained from a NS2 platform to exhibit the merits of the design expressed in terms of the performance indices and carries through its suitability for use in the practical world.

**Keywords:** wireless sensor network, layered approach, cluster, multihop routing, energy efficiency, on-demand routing.

## Introduction

Wireless Sensor Networks (WSNs) continue to emerge as an innovative technology and spread across a wide range of areas that include healthcare systems, military surveillance, robotic exploration and environmental monitoring [1]. The traditional architectures consist of densely deployed nodes and the primary task renders to process messages from the region covered by sensor nodes. The rapid advances in the field of communication technology enable the use of miniature sensors and the small size favors to effectively manage the sensors energy consumption in order to extend their lifespan.

The philosophy of traffic flow in view of the increasing data transfers showcases a rise in the latency and leads to an explosion of the routing tables. The routing patterns with hierarchical topology allow the reduction in the number of transmitted messages throughout the network, and thus reduce the energy consumption [2], [3], However the transmission of information to the destination through a single-hop becomes difficult when the size of the network turns out to be large [4]. The caste lays further emphasis to explore avenues and arrive at options for a safe uninterrupted flow of data between the destined nodes.

The nodes in sensor networks usually experience limited energy resources and throw a restriction on the types of deployable routing mechanisms. The sensor networks therefore appear to evince interest in the creation of a layered architecture to offer a sense of flexibility for the transfer of data to different destinations. The theory owes to group the network nodes with the same hop-count to form each layer as seen from Fig.1and relay the packets to the destination into different layers. In other words the structure evolves with nodes that can reach the destination in one hop to be in the first layer, two hops in the second layer and the sequence realizes the complete configuration of what terms to be a multi-hop infrastructure network.

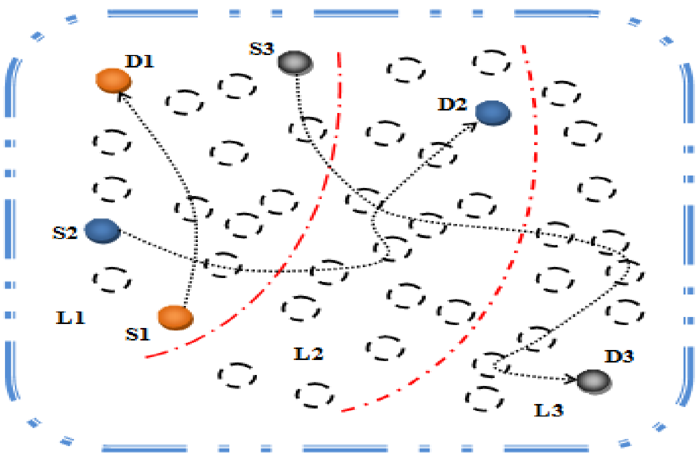


**Figure 1:** System Model

The need for efficient and flexible network access proliferate a focus on multihop wireless networks [5] and support the ad hoc nature of network to handle nodes randomly located with respect to each other. It forges to connect the nodes in the network using a wireless communication channel in the process of laying an ad hoc multihop wireless network. The routing methods in most cases depend on the hop count to decide the path for traversing the information from the source node to the end user. The hop count relates to the number of relaying nodes between the source and the destination unit in the network. It helps to identify issues like infinite loops and envisage in such cases to carry through longer distances.

The influence of link error rate on retransmission – aware metrics has been studied to decide on an efficient choice between a part with a large number of short distance hops and the other with a smaller number of long distance hops [6]. A cost function has been defined to capture the cumulative energy expended in reliable data transfer for both reliable and unreliable link layers. An interactive study of wireless link has been developed to provide an in depth analysis of Transfer Control Protocol (TCP) performance over wireless chains [7]. The methodology has been evaluated over the most frequently occurring chain type to reveal significant performance differences between chains that inherit the same hop count. A novel distributed multihop co-operative communication scheme has been proposed for WSN [8]. The simulation results have been shown to suit large scale network and dynamic environment. The tradeoff between lifetime and hop count of link disjoint, node disjoint and zone disjoint multi path route over a single minimum hop path has been analyzed for mobile ad hoc network (MANET) [9]. The results have been related to indicate with a number of zone disjoint path per multi path set turns out to be lower than the number of node link disjoint path available per multi path set.

A packet transmission scheme has been suggested to estimate the probabilistic delay and the network lifetime in a WSN [10]. A mobility data collection model has been developed for reducing the delay using Ad hoc On Demand Vector (AODV) protocol. A channelization strategy based on frequency division multiplexing (FDM) has been formulated to enable fast reliable and multihop data transmission with minimum overhead in WSN [11]. The theory has been extricated to eliminate intra path collision along multihop routing path and achieve a high data rate transmission. A new opportunistic real time routing method has been outlined to guarantee a delivery of data time constraint with efficient power consumption [12]. A relay node within the area of real time data delivery has been selected for the purpose of balancing the overall energy level. An energy aware approach for routing delay constrained data has been proposed through multihop packet relaying [13]. It has been tailored to minimize transmission energy and avail the use of weighted fair queuing to provide soft real time guarantee for data delivery. A dynamic routing layer has been thought of to allow the automatic change over between different routing method on the basis of query task [14]. The simulation results have been shown to be energy efficient for dynamic routing scheme over single routing method.

Inspite of consistent efforts to realize multi hop based routing, a different direction in this perspective appears imminent to explore alternatives and perceive enhancements over other data transfer patterns in terms of energy efficiency.

## Problem Description

The primary theory incites to form a layered network with widely different number of nodes distributed in each layer and articulate a passage for the transfer of packets through mobile intermediate centers. The exercise lays centered to examine the performance of a Cluster based Ad-hoc On demand Distance Vector (CAODV) routing pattern in the process of carrying the data between source and destination entities located either in the same or the other layers of the chosen configuration [15, 16]. The emphasis echoes to travel through with minimum energy loss and delay to ensure an increase in the life time for the network. The formulation envisages using the Network Simulator (NS2) to measure the metrics and foresee the possibility of large scale transmission in the same environment.

## Proposed Approach

The low-cost of the nodes facilitate to deploy a large number of nodes in a random fashion and serve to gather data for transmitting them to the destination, over a wireless channel. It attempts to process the data from all the nodes and analyzes them to draw inferences related to the activity in the area of interest. The receiver node or sink envisages the role of gateways to other networks, disseminate control information and extract data from the network.

The transfer of data necessitates forming routes and progresses to reconstruct in event-driven networks routes, when an event occurs due to the fact that constant updates become prohibitive in this scenario. However in light of the energy constraints along with a typical requirement for deployment of large number of sensor nodes, energy-awareness at the layers of the network enforces a challenge in routing the messages through the network.

The presence of either a half duplex or a full-duplex wireless transceiver in each sensor node accentuates to transmit and receive data within the network. Each node inherits a unique hard-coded ID to identify itself from its neighbors and the destination node. The embedded computational processor in the sensor node emulates the signal processing activity to suit the application needs. The data packets on account of the multi-hop nature of data communication go through a state of buffering in the sensor nodes before being made suitable for the bi-directional flow in the network.

The role of a clustered based data forwarding mechanism formulates to conceive an energy efficient methodology where the sensor nodes organize themselves into clusters, with each member node belongs to only one cluster. The data collected from sensors travel to the cluster head (CH) and thereafter reach the destination. The high density of sensor networks may lead to multiple adjacent sensors generating redundant sensed data and augur the need for eliminating data redundancy to reduce the communication load.

The exercise enters to form the clusters and each node based on the energy level decides whether to become a CH for the current round. It follows from a predetermined fraction of nodes and the threshold T(s), expressed as in Eqn.1

$$T(s) = \begin{cases} \dfrac{P_{opt}}{1-P_{opt}\times\left(r \bmod \left(1/P_{opt}\right)\right)} & if\ s \in G \\ 0, & \text{otherwise} \end{cases} \quad \text{---------} \quad (1)$$

Where $P_{opt}$ refers to the predetermined percentage of CHs, r the count of current round and G the set of sensor nodes, not part of the CHs in the last $1/P_{opt}$ rounds. The threshold fosters each node to be a CH at some round within 1/Popt rounds and may be after 1/Popt rounds, the nodes become once again eligible to become CHs.

The energy consumed by the radio in transmitting L bits data over a distance d is related using Eqn.2

$$E_{Tx}(L,d) = \begin{cases} L \times (E_{elec} + \epsilon_{fs} \times d^2), \ if\ d \le d_0 \\ L \times (E_{elec} + \epsilon_{mp} \times d^4), \ if\ d \ge d_0 \end{cases} \text{--------} \quad (2)$$

Where $E_{elec}$ accounts for the energy dissipated per bit to run the transmitter or the receiver circuit. The parameters $\epsilon_{fs}$ and $\epsilon_{mp}$ depend on the model of the transmitter amplifier. The destination assumes to be located inside the field and the distance of any node to its CH as ≤ d0.

The energy dissipated in the CH node during a round is thus written as in Eqn. 3:

$$E_{ch} = \left(\frac{n}{k} - 1\right) \times L \times E_{elec} + \frac{n}{k} \times L \times E_{DA} + L \times E_{elec} + L \times \epsilon_{fs} \times d_{BS}^2 \text{ --- } (3)$$

Where n the number of nodes, k relates to the number of clusters, $E_{DA}$ the processing cost of a bit report to the destination and $d_{BS}$ the average distance between a CH and the destination.

The energy used in a member node is given as in Eqn.4

$$E_{nonch} = L \times E_{elec} + L \times \epsilon_{fs} \times d_{CH}^2 \text{ --------} \quad (4)$$

Where $d_{CH}$ corners the average distance between a cluster member and its CH and M represents the size of the region, which is governed by the Eqn. 5

$$d_{CH}^2 = \int_0^{x_{max}} \int_0^{y_{max}} (x^2 + y^2) \times \rho(x,y)\, dx\, dy = \frac{M^2}{2\pi k} \text{ --------} \quad (5)$$

Where ρ(x, y) identifies the node distribution. The equations combine to yield the total energy dissipated in the WSN as expressed as in Eqn. 6

$$\left.\begin{aligned} E_t &= E_{ch} + E_{nonch} \\ E_t &= L \times (2 \times n \times E_{elec} + n \times E_{DA} + \epsilon_{fs} \times (K \times d_{BS}^2 + n \times d_{CH}^2)) \end{aligned}\right\} \text{ ---- } (6)$$

On differentiating $E_t$ with respect to k and equating to zero, the optimal number of clusters can be arrived at using Eqn. 7

$$k_{opt} = \sqrt{\frac{n}{2\pi}} \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}}} \frac{M}{d_{BS}^2} \text{ --------} \quad (7)$$

If the distance of a significant percentage of nodes to the destination accrues to be greater than $d_0$ then it can be written as in Eqn. 8

$$d_{BS}^2 = \int_A (x^2 + y^2) \times \frac{1}{A} = 0.765 \times \frac{M}{2} \text{ --------} \quad (8)$$

The optimal probability of a node to become a CH, $P_{opt}$, can be computed from Eqns. 7 and 8 as in Eqn. 9

$$P_{opt} = \frac{1}{0.765} \sqrt{\frac{2}{n\pi}} \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}}} \text{ --------} \quad (9)$$

The key factor in this proposition endeavors to interleave the concepts of a cluster in the periphery of AODV to encapsulate a different platform for the multi hop layered network. The benefits of optimality from the modeling clan cleave way to admonish a new perspective for delivering packets in the network with different hop counts. The strategy pulls up the node with the highest energy as the CH and translates a two stage process to collect the data and route it between the source and destination nodes. It gangs up with the subsequent choice of CHs to replenish the decrease in energy level and continue the sequence of transfer. The second phase realizes a search format to identify fresh routes and land at the destination in the vicinity of large neighborhoods.

## Simulation Results

The strategy reflects to examine the performance of a three layered architecture constituted with nodes of the same hop count in each layer in a space of 1000 m X 1000 m as seen in Fig.2. The methodology attempts to transfer data between three source nodes in the first layer and the three destination nodes located one in each layer. The procedure entertains to identify a high energy node as the CH from among the two hundred intermediate mobile nodes arranged in the form of several groups of clusters within the three layers.

The mechanism involves the role of NS2 platform to obtain the nature of variations of the performance indices for a data flow of 3000 Kbps over a specific time frame of two hundred seconds. The study owes to evaluate the relative merits of the transfer of information from the source to the user outfits spread across three layers through the use of CAODV routing scheme.

The metrics in line with Packets Received, Packet Loss, Throughput, Energy Expended and Routing Delay offer graded strengths as depicted using the NS2 graphs in Figs 3 through 7 to bring out the energy efficient characteristics of the formulation. The best values for the indices turn out when the message traverses from the source through the network in the first layer in view of the fact that it requires minimum hops to reach the destination.

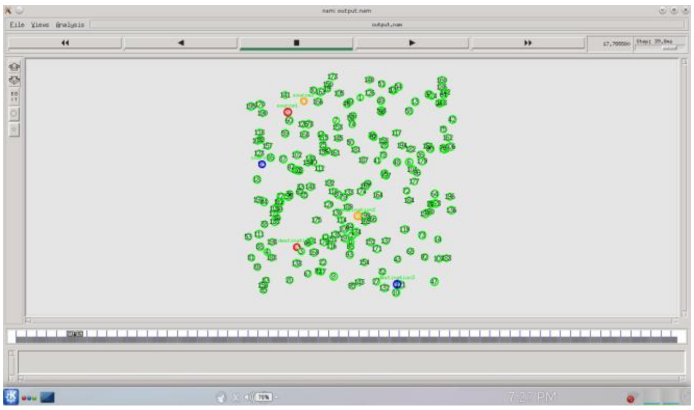

**Figure 2:** NS2 Network Model

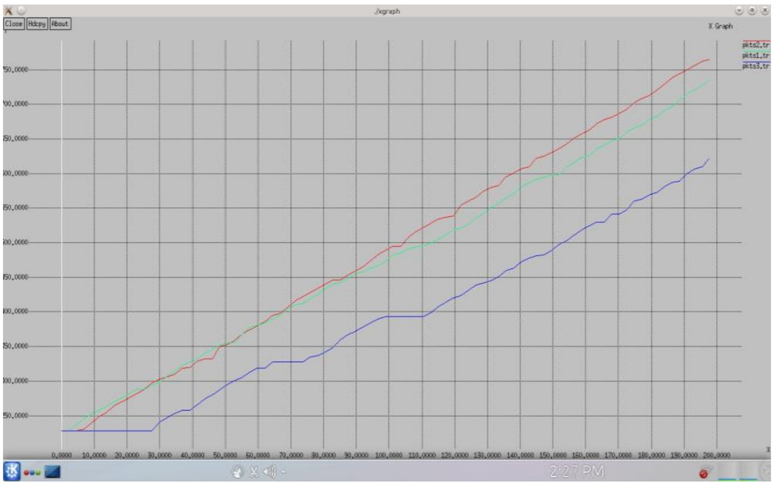

**Figure 3:** Packets Received vs Time

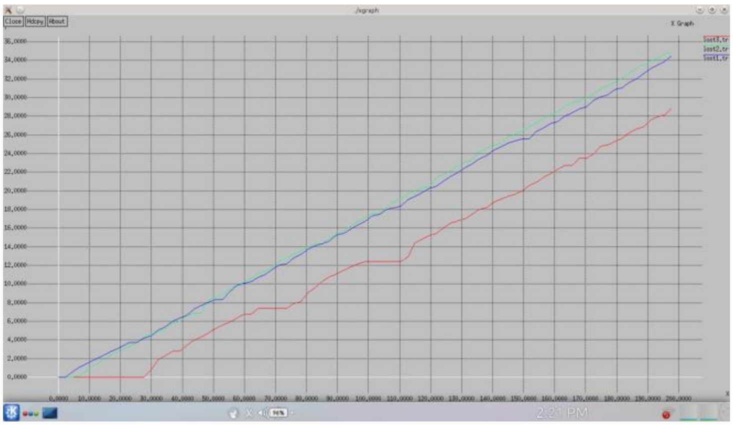

**Figure 4:** Packet Loss vs Time

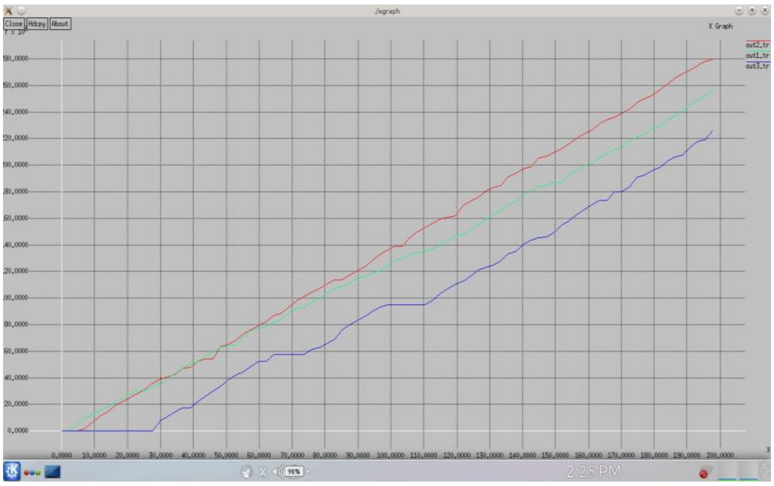

**Figure 5:** Throughput vs Time

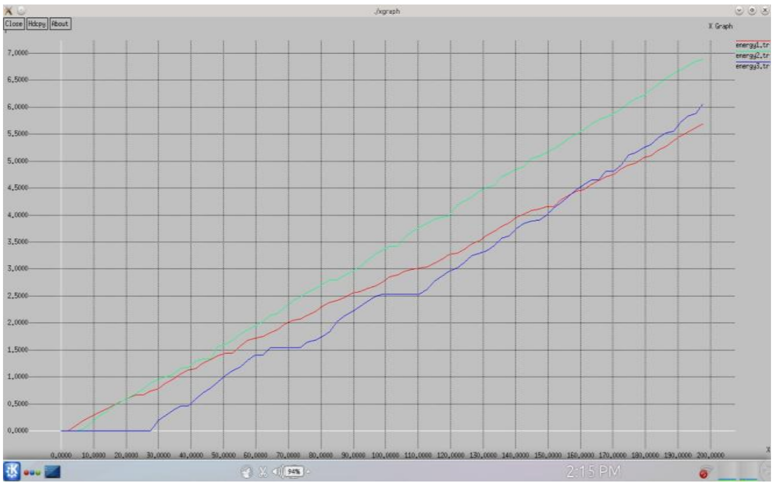

**Figure 6:** Energy Consumed vs Time

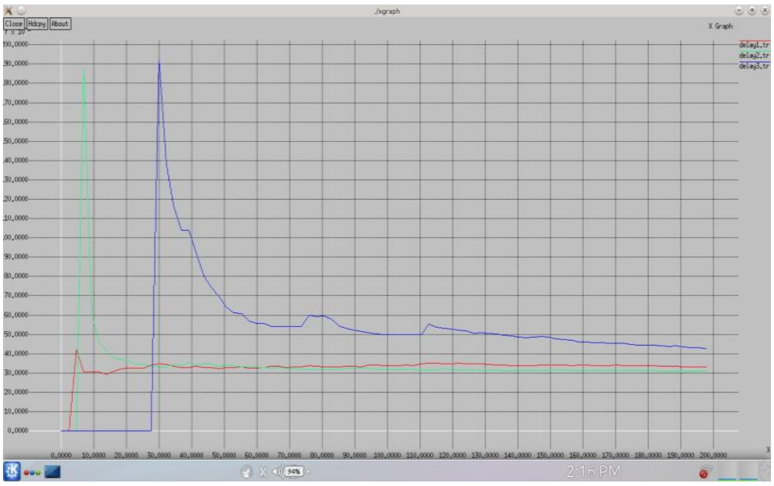

**Figure 7:** Routing Delay vs Time

The investigative process extends to emphasize the suitability of CAODV over similar other routing approaches through the transfer of packets of increasing sizes from the source to the first destination, which apparently cleaves to be most energy efficient. The bar charts in Figs.8 to 13 for the indices along with Energy x Delay establish the supremacy of the CAODV based data transfer in the sense it facilitates a superior performance in comparison with Original Ad-hoc On demand Distance Vector (OAODV) and Improved Ad-hoc On demand Distance Vector (IAODV) for packet sizes varying across 1000 and 5000 in the same interval of time. The results of Adaptive Cluster Based Routing Protocol (ACBRP) travel to validate the use of a clustered philosophy and incarnate the significance of a cluster based AODV.

The line graph for the network Packet Delivery Ratio (PDR) in Fig.14 further enumerates through a slower decline to carry forth the advantages of CAODV and drives to create a larger scope for the use of this routing method.

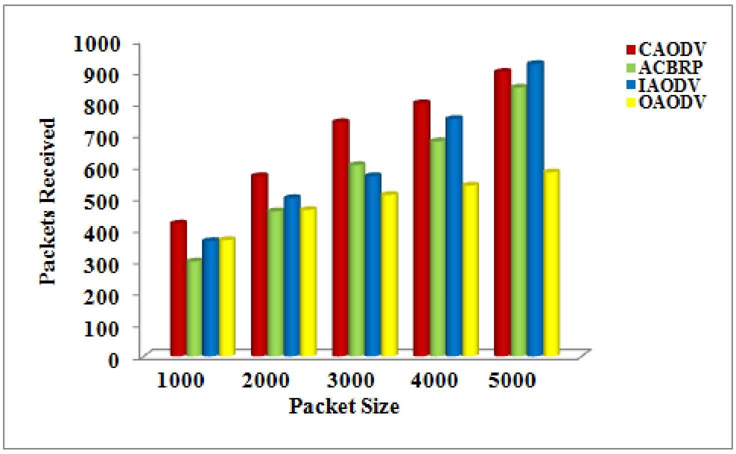


**Figure 8:** Packets Received vs Packet Sizes

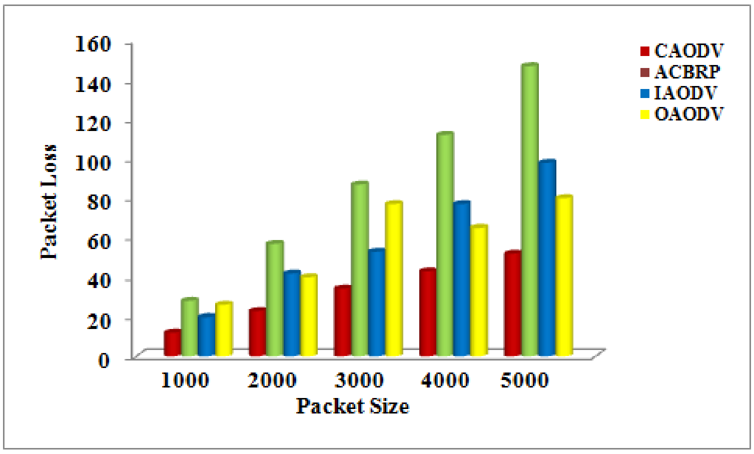


**Figure 9:** Packet Loss vs. Packet Sizes

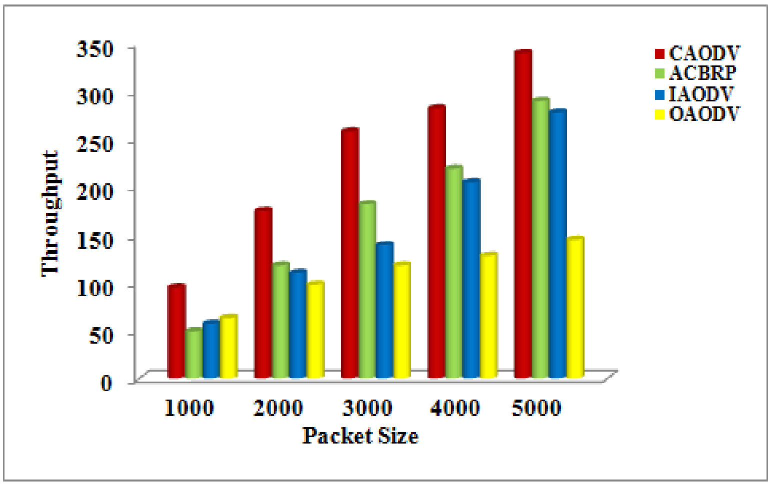


**Figure 10:** Throughput vs Packet Sizes

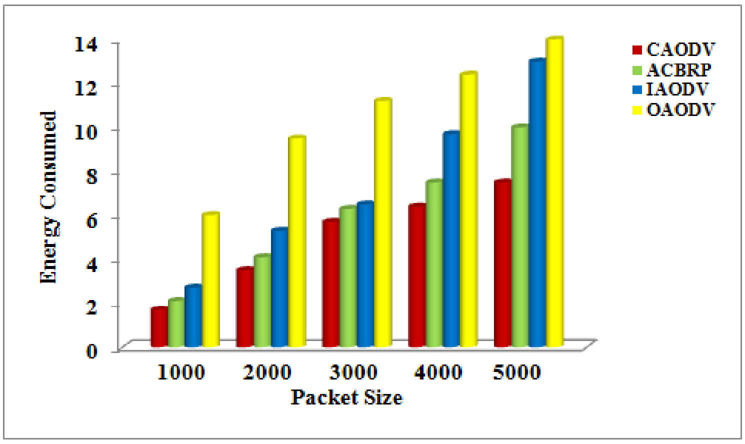


**Figure 11:** Energy Consumed vs Packet Sizes

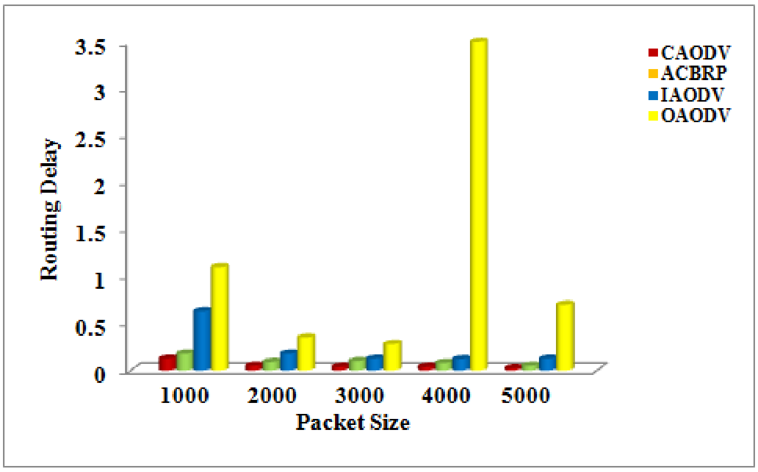


**Figure 12:** Routing Delay vs. Packet Sizes

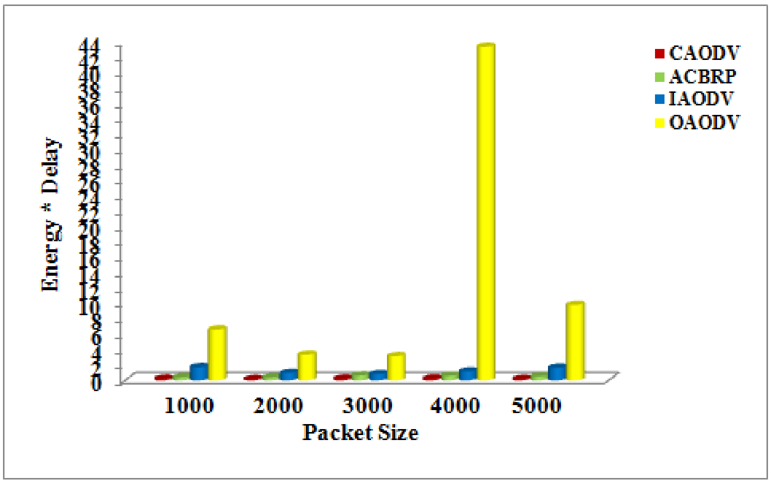


**Figure 13:** Energy * Delay vs. Packet Sizes

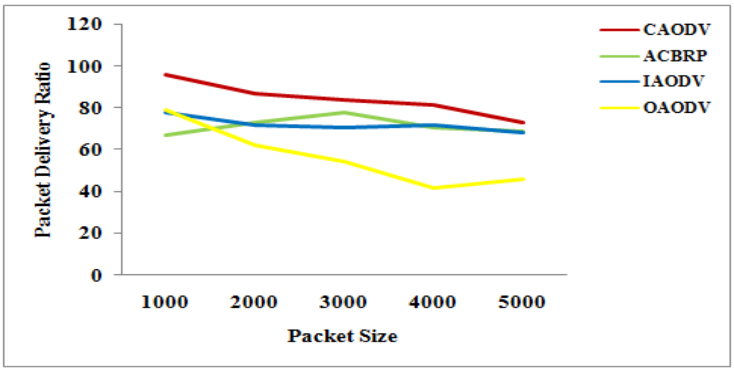


**Figure 14:** Packet Delivery Ratio vs Packet Sizes

## Conclusion

A WSN with different hop counts in each layer has been conceived to promote minimum hop routing of data between the layers. The principles of radio energy model has been sought to realize the flow of messages in the layered network. The passage of data has been articulated using the cluster concepts to corner the frontiers of energy efficient communication. The NS2 simulation results have been laid to eschew an enhanced performance for the lowest hop count destination. The relative merits have been elaborated through the best values for the indices accrued with the CAODV routing pattern. The ability of the algorithm to handle larger sized data with the same level of performance has been demonstrated. The fact it maintains a higher network PDR over other routing methods along with a possible increase in the network life time has been the strong reason to acclaim its influence in the world.

## Acknowledgements

The authors thank the authorities of Annamalai University for providing the necessary facilities in order to accomplish this piece of work.

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