

# GLOBAL JOURNAL

OF COMPUTER SCIENCE AND TECHNOLOGY: E

## Network, Web & Security

Cluster based Adhoc

An Energy Efficient Routing

Highlights

Pilot Approach under Parameter

Wireless Sensor Networks

Discovering Thoughts, Inventing Future

VOLUME 17 ISSUE 2 VERSION 1.0

© 2001-2017 by Global Journal of Computer Science and Technology, USA



GLOBAL JOURNAL OF COMPUTER SCIENCE AND TECHNOLOGY: E  
NETWORK, WEB & SECURITY

---

GLOBAL JOURNAL OF COMPUTER SCIENCE AND TECHNOLOGY: E  
NETWORK, WEB & SECURITY

---

VOLUME 17 ISSUE 2 (VER. 1.0)

OPEN ASSOCIATION OF RESEARCH SOCIETY



© Global Journal of Computer Science and Technology. 2017.

All rights reserved.

This is a special issue published in version 1.0 of "Global Journal of Computer Science and Technology" By Global Journals Inc.

All articles are open access articles distributed under "Global Journal of Computer Science and Technology"

Reading License, which permits restricted use. Entire contents are copyright by of "Global Journal of Computer Science and Technology" unless otherwise noted on specific articles.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without written permission.

The opinions and statements made in this book are those of the authors concerned. Ultraculture has not verified and neither confirms nor denies any of the foregoing and no warranty or fitness is implied.

Engage with the contents herein at your own risk.

The use of this journal, and the terms and conditions for our providing information, is governed by our Disclaimer, Terms and Conditions and Privacy Policy given on our website <http://globaljournals.us/terms-and-condition/menu-id-1463/>

By referring / using / reading / any type of association / referencing this journal, this signifies and you acknowledge that you have read them and that you accept and will be bound by the terms thereof.

All information, journals, this journal, activities undertaken, materials, services and our website, terms and conditions, privacy policy, and this journal is subject to change anytime without any prior notice.

Incorporation No.: 0423089  
License No.: 42125/022010/1186  
Registration No.: 430374  
Import-Export Code: 1109007027  
Employer Identification Number (EIN):  
USA Tax ID: 98-0673427

## Global Journals Inc.

(A Delaware USA Incorporation with "Good Standing"; Reg. Number: 0423089)

Sponsors: Open Association of Research Society  
Open Scientific Standards

### *Publisher's Headquarters office*

Global Journals® Headquarters  
945th Concord Streets,  
Framingham Massachusetts Pin: 01701,  
United States of America  
USA Toll Free: +001-888-839-7392  
USA Toll Free Fax: +001-888-839-7392

### *Offset Typesetting*

Global Journals Incorporated  
2nd, Lansdowne, Lansdowne Rd., Croydon-Surrey,  
Pin: CR9 2ER, United Kingdom

### *Packaging & Continental Dispatching*

Global Journals  
E-3130 Sudama Nagar, Near Gopur Square,  
Indore, M.P., Pin: 452009, India

### *Find a correspondence nodal officer near you*

To find nodal officer of your country, please email us at [local@globaljournals.org](mailto:local@globaljournals.org)

### *eContacts*

Press Inquiries: [press@globaljournals.org](mailto:press@globaljournals.org)  
Investor Inquiries: [investors@globaljournals.org](mailto:investors@globaljournals.org)  
Technical Support: [technology@globaljournals.org](mailto:technology@globaljournals.org)  
Media & Releases: [media@globaljournals.org](mailto:media@globaljournals.org)

### *Pricing (Including by Air Parcel Charges):*

*For Authors:*

22 USD (B/W) & 50 USD (Color)  
Yearly Subscription (Personal & Institutional):  
200 USD (B/W) & 250 USD (Color)

# EDITORIAL BOARD

GLOBAL JOURNAL OF COMPUTER SCIENCE AND TECHNOLOGY

*Dr. Corina Sas*

School of Computing and Communication  
Lancaster University Lancaster, UK

*Dr. Kassim Mwitondi*

M.Sc., PGCLT, Ph.D.  
Senior Lecturer Applied Statistics/Data Mining,  
Sheffield Hallam University, UK

*Dr. Yogita Bajpai*

M.Sc. (Computer Science), FICCT  
U.S.A.  
Email: [yogita@computerresearch.org](mailto:yogita@computerresearch.org)

*Dr. Diego Gonzalez-Aguilera*

Ph.D. in Photogrammetry and Computer Vision  
Head of the Cartographic and  
Land Engineering Department  
University of Salamanca  
Spain

*Alessandra Lumini*

Associate Researcher  
Department of Computer Science  
and Engineering  
University of Bologna Italy

*Dr. Osman Balci, Professor*

Department of Computer Science  
Virginia Tech, Virginia University  
Ph.D. and M.S. Syracuse University, Syracuse, New York  
M.S. and B.S. Bogazici University, Istanbul, Turkey  
Web: [manta.cs.vt.edu/balci](http://manta.cs.vt.edu/balci)

*Dr. Kurt Maly*

Ph.D. in Computer Networks, New York University,  
Department of Computer Science  
Old Dominion University, Norfolk, Virginia

*Dr. Stefano Berretti*

Ph.D. in Computer Engineering and Telecommunications,  
University of Firenze  
Professor Department of Information Engineering,  
University of Firenze, Italy

*Dr. Federico Tamarin*

Ph.D., Computer Engineering and Networks Group,  
Institute of Electronics, Italy  
Department of Information Engineering of the  
University of Padova, Italy

*Dr. Aziz M. Barbar, Ph.D.*

IEEE Senior Member  
Chairperson, Department of Computer Science  
AUST - American University of Science & Technology  
Alfred Naccash Avenue – Ashrafieh

*Dr. Anis Bey*

Dept. of Comput. Sci.,  
Badji Mokhtar-Annaba Univ.,  
Annaba, Algeria

*Er. Pritesh Rajvaidya*

Computer Science Department  
California State University  
BE (Computer Science), FICCT  
Technical Dean, US  
Email: pritesh@computerresearch.org,  
deanusa@globaljournals.org

*Er. Suyog Dixit*

(M.Tech), BE (HONS. in CSE), FICCT  
SAP Certified Consultant  
CEO at IOSRD, Ph.DGAOR OSS  
Technical Dean, Global Journals Inc.(US)  
Website: [www.suyogdixit.com](http://www.suyogdixit.com)  
Email: [suyog@suyogdixit.com](mailto:suyog@suyogdixit.com),  
[deanind@globaljournals.org](mailto:deanind@globaljournals.org)

*Dr. Chutisant Kerdvibulvech*

Dept. of Inf.& Commun. Technol.,  
Rangsit University  
Pathum Thani, Thailand  
Chulalongkorn University Ph.D. Thailand  
Keio University, Tokyo, Japan

*Dr. Abdurrahman Arslanyilmaz*

Computer Science & Information Systems Department  
Youngstown State University  
Ph.D., Texas A&M University  
University of Missouri, Columbia  
Gazi University, Turkey  
Web: [cis.ysu.edu/~aarslanyilmaz/professional\\_web](http://cis.ysu.edu/~aarslanyilmaz/professional_web)

*Dr. Sotiris Kotsiantis*

Ph.D. in Computer Science, University of Patras, Greece  
Department of Mathematics, University of Patras, Greece

## CONTENTS OF THE ISSUE

---

- i. Copyright Notice
  - ii. Editorial Board Members
  - iii. Chief Author and Dean
  - iv. Contents of the Issue
- 
1. Cluster based Multicast Adhoc on Demand Routing Protocol for Increasing Link Stability in Manets. **1-13**
  2. Risk Sensitive Filter for MIMO-OFDM System Channel Estimation using Combined Orthogonal Pilot Approach under Parameter Uncertainty. **15-20**
  3. An Energy Efficient Routing based on Route Segmentation in Mobile Ad Hoc Network. **21-27**
  4. Dynamic and Channel Adaptive Error Control Scheme in Wireless Sensor Networks. **29-40**
  5. Energy Efficient Weighted Clustering Algorithm in Wireless Sensor Networks. **41-49**
  6. Formal Verification and Validates the Mobile Nodes using NNDRP. **51-58**
  7. Node. Js Challenges in Implementation. **59-69**
  8. Secure and Economical Cost Aware Routing Protocol for Wireless Sensor Networks. **71-77**
- 
- v. Fellows
  - vi. Auxiliary Memberships
  - vii. Process of Submission of Research Paper
  - viii. Preferred Author Guidelines
  - ix. Index



## Cluster based Multicast Adhoc on Demand Routing Protocol for Increasing Link Stability in Manets

By M. Vijayalakshmi & Dr. D. Sreenivasa Rao

*G.Narayanamma Institute of Technology and Science*

**Abstract-** The critical issues faced in the MANET energy consumption, QoS (Quality of Services), exposure to attacks, link stability. Link stability is much essential to be discussed for improving communication. 'Link Stability' is significant because radio links are generally varied due to node mobility. This instability leads to increased rerouting which further escalates routing overhead. One way of reducing routing overhead is to use multicasting instead of unicast routing. Multicast Routing Protocol transmits data concurrently to a group of destination nodes to achieve better resource utilization. This paper present a multicasting routing protocol Link Stability based Multicast Adhoc on demand routing protocol (LSMAODV) that uses received signal strength as a metric to estimate link stability and node stability. The comparison between AODV, MAODV and LSMAODV is measured for link and node stability. In this paper, three clusters are created and one node from each cluster is selected as cluster head based on the packet priority. This paper aims to find the link with high probability of longer lifetime between the nodes.

**Keywords:** link stability, node stability; multicast routing; mobile adhoc network.

**GJCST-E Classification:** F.2.2, C.2.2



*Strictly as per the compliance and regulations of:*





# Cluster based Multicast Adhoc on Demand Routing Protocol for Increasing Link Stability in Manets

M. Vijayalakshmi <sup>α</sup> & Dr. D. Sreenivasa Rao <sup>σ</sup>

**Abstract-** The critical issues faced in the MANET energy consumption, QoS (Quality of Services), exposure to attacks, link stability. Link stability is much essential to be discussed for improving communication. 'Link Stability' is significant because radio links are generally varied due to node mobility. This instability leads to increased rerouting which further escalates routing overhead. One way of reducing routing overhead is to use multicasting instead of unicast routing. Multicast Routing Protocol transmits data concurrently to a group of destination nodes to achieve better resource utilization. This paper present a multicasting routing protocol Link Stability based Multicast Adhoc on demand routing protocol (LSMAODV) that uses received signal strength as a metric to estimate link stability and node stability. The comparison between AODV, MAODV and LSMAODV is measured for link and node stability. In this paper, three clusters are created and one node from each cluster is selected as cluster head based on the packet priority. This paper aims to find the link with high probability of longer lifetime between the nodes. The simulation are carried out and compared the result of the proposed routing protocol (LSMAODV) based on minimum hop count. Analysis of simulation results show improvement of various routing performance metrics such as routing overhead and packet drop ratio.

**Keywords:** link stability, node stability; multicast routing; mobile adhoc network.

## I. INTRODUCTION

Mobile Adhoc networks (MANET) are collections of wireless mobile devices, which can communicate with each other without any infrastructure support. It is denoted as self-configured and self-maintained network. Every node in MANET acts as both the host and a router and it communicate with each other without the support of any fixed centralized control. In MANET, the mobile nodes are interconnected by multi-hop wireless links in a dispersed manner [1]. The design of MANET routing protocol vary from wired network routing protocol; since a MANET is categorized by node mobility, node link unreliability, limited energy, limited bandwidth, high error rates, and security risk. The essential characteristics needed to design a routing protocol are dynamic topology, limited bandwidth,

battery, CPU resources and multi-hop communication. There are many routing protocols projected for MANET. Based on the principles of routing, the protocols can be classified either proactive or reactive. Proactive routing protocols use to communicate regularly and update routes for every pair of nodes at every time of period. Every mobile node will operate as a sender, receiver or an intermediate node of the data in the system. Thus system will create the awareness towards the findings to deliver an outstanding merits and flexibility related to bandwidth spatial reuse, intrinsic fault tolerance and low-cost fast distribution [2]. In the network, the each node receives the information from the packet and updates their interpretation by applying a shortest-path algorithm to find the next hop node to reach the endpoint.

The main principle of a MANET routing protocol develop a competent route between the communicating nodes to reach the end point. Thus, the message will deliver on time with less number of packets drops providing stable connectivity with less routing overheads. MANET routing protocol is generally classified into two types. They are table-driven and source-initiated [3]. Table-driven routing protocol sustain with one or more tables at each node to save routing information. This protocol is used when there is a change in network topology in order to propagate the updates throughout the network to maintain a reliable network. Existing table-driven routing protocols include the following routing methods such as DSDV (Destination Sequenced Distance Vector) [4], CGSR (Cluster head Gateway Switch Routing) [5], and WRP (Wireless Routing Protocol) [6]. Source-initiated routing protocols are used when a source node requests for a route. This protocol process is inspected with only the possible routes. For example, source-initiated protocols contain AODV (Ad Hoc on Demand Distance Vector) [7], DSR (Dynamic Source Routing) [8], TORA (Temporally Ordered Routing Algorithm) [9], ABR (Associativity Based Routing) and SSR (Signal Stability Routing) [10], etc.

Link stability rely on wireless link features such as link failures, packet loss rate, channel sensing rate, channel fading rate, bit error rate, band width fluctuations and environmental effects. The wireless channel variation due to the packet loss resulting in link failures and reduces link reliability. Thus, the failure in channel sensing and channel fading increase the errors that

Author <sup>α</sup>: GNITS, JNTUCEH, Hyderabad, India.

e-mail: mvlakshmi\_gnits@yahoo.co.in

Author <sup>σ</sup>: Professor, JNTUCEH, Hyderabad, India.

e-mail: dsraoece@gmail.com

trigger large dissimilarity in the existing bandwidth. The existing communication systems use checksum and sequence numbering for controlling the errors and some of them use positive recovery of packet retransmission. If checksum technique is not performed in the system then it affects the system performance. Similarly, Route stability relies on the performance of source, destination and intermediate nodes and the wireless channel connecting end-to-end route. When the lifespan of a route decreases, then the probability of end-to-end delivery can be improved with alternate routes between source and destination. Finally, to develop the route stability, there is a necessity to improve the constructed mesh based and multipath routing techniques.

The stability based routing protocols are intended to choose the stable route for passing through the stable links. These link stability and route stability protocols increases the lifetime of routing and the packet delivery. These protocols are compared with the shortest path routing protocols. Since mobile networks are very unstable links and the stability of routes becomes a main objective in the development of a mobile routing protocol. Communication links in Adhoc network are fundamentally unreliable because of their medium characteristics and varying internode distances due to node mobility. This leads to disconnection and result in reconfiguration of communication links. Each reconfiguration needs initiation of route discovery process and is expensive. Reconfiguration also expose to resource-constrained network as mobile devices that constitute MANET have limited resources in terms of computing power, memory, transmission power, and battery life.

A major challenge of MANET is to implement QoS to prevention of attacks, reduction in energy consumption, incorporating fault-tolerance and delay of nodes [12]. The primary objective of this paper is to improve QoS by improving the Priority based Adhoc on Demand Routing Protocol (PAODV) and thus increase the route stability through proper selection of links that are likely to be more stable. Some of the applications of MANET are rescue operations in military battlefield, disaster relief efforts, and audio and video conferencing. This applications needs support of survivable, reliable and efficient communication. Hence, this paper focus on developing a clustering based Priority Adhoc on demand routing protocol for increasing link stability and node stability in MANET.

## II. LITERATURE SURVEY

Currently, there are several new multicast routing protocols are estimate to achieve efficient multicasting in MANET. Some of the routing protocols are Multicast Adhoc On-Demand Vector (MAODV), Adhoc Multicast Routing protocol Utilizing Increasing ID Numbers (AMRIS), Core Assisted Mesh Protocol (CAMP), Location Guided Tree (LGT), Lightweight Adaptive Multicast (LAM), and Differential Destination Multicast (DDM). The

above protocols are mainly based on the features of distance vector routing or link-state routing with some benefits to help the routing process in definite ways [13]. Many multicast routing protocols reviewed in [2] which were scheduled to enhance QoS broadly and their behavior were assessed in terms of latency, packet loss ratio, jitter etc. Similarly, the performance in Ad-hoc networks was reviewed in [14]. Collision is a major problem since it results in packet drops, extensive delay of data and queuing of packets. So, the performance of Ad-hoc networks also reduces adversely. Hence, this paper proposed the model framework with the Enhanced Cluster head Gateway Switch Routing Protocol (ECGSR) with the origin of Ad-hoc On-demand Distance Vector Routing (AODV) based technique collision evading. A new AODV routing protocol was presented in [15], to enhance the stable link. In this paper the parameters are used for the establishment of Quality of Service (QoS) by node stability, load stability and least residual distance in order to select the link to the endpoint. The result showed that the proposed protocol enhanced the performance. Thus, the proposed work did not measure the power of the received signal at the endpoint though moving over the route.

Similarly, [16] examined an innovative Enhanced Adhoc On-demand Distance Vector (E-AODV) protocol which is related to AODV. AODV can be modified with reduced end to end delay with enriched packet distribution ratio. The ad hoc networks mainly select AODV protocols as it can deliver low routing overhead with high performance. His study proved that QoS in the MANET has no universally predefined parameters. But it was commonly a well-defined group of service quality which has the necessity to be achieved by the network while transferring a packet stream from a transmitter to its receiver end. The researchers also described that QoS is associated with certain parameters such as throughput, delay, and drop of packets. This would be established and approved by the mark of end user. QoS model also described an architecture that delivered the possible best facility.

Cluster Based Routing Protocol is intended to use in mobile ad hoc network (MANET). In this study, the mobile nodes of the Adhoc network is separated into a number of overlying or disjoints 2-hop distance clusters by the protocol in a dispersed manner [17]. Among the clusters, a cluster head is selected to maintain the information of all the cluster members. By this cluster participation, the information from Inter-cluster routes are projected dynamically and kept at each cluster head. Thus, by using this clustering technique, the flooding traffic between the data communication and the route discovery is competently minimized by the protocol and speeds up this process as well. The MANET network has two main protocols that are Tree-based protocols and mesh based protocols. MAODV and ODMRP (On-Demand Multicast Routing Protocol) are two popular

multicast routing protocols for tree-based and mesh based protocols, respectively.

The performance comparison and study of multicast protocols was reported by [18] which affords a vision into the functionality and presentation. Similarly, [3] justified MAODV as an on-demand routing protocol that determined the route only when a node has something to send. It is a hard state usage of protocol. This study revealed that if a member node of a multicast group needs to terminate its group membership, it must give a request for termination but, when a mobile node wants to join a multicast group or send a message but not having a route to the group, a Route Request (RREQ) was originated. All the nodes that are members of a multicast group and the non-member nodes that are not members of the group but their position are very critical for forwarding the multicast information that compose the tree structure. Every multicast group is recognized by a unique address and group sequence numbers for tracing the newness of the group situation.

In other study [19] examined an ant metaphor in dynamic routing for MANET, where ants spread the gathered data to nearest sources. Thus the dispersed routing system for motor vehicles that direct them through the city using the shortest way in time and the account of load is described. Similarly, a routing protocol based on swarm intelligence by using ants was reported by [20] where ants use heuristics to find the routes in multi-hop ad hoc networks. The other efficient hybrid multicast routing protocol suitable for high mobility applications was presented by [21] that addresses the scalability issue of ODMRP protocol. The data forwarding path and join query forwarding path were separate in this protocol. A routing protocol for MANET named as terminates routing, which has the purpose for keeping the assistance of scalability by considering the location-based routing, irregular topology and node mobility. A Mobility Prediction Aided Dynamic Multicast Routing (MPADMR) algorithm was proposed by [22]. Hence, this algorithm contains two steps, the construction of link lifetime constrained minimum hop count multicast tree and the dynamic multicast tree maintenance procedure.

The other study proved by [23] described multicast protocols performance characterization over a wide range of MANET situations. The performance of mesh and tree-based multicast routing schemes which related to flooding are evaluated and recommend by the protocols which is suitable for specific MANET situations. New algorithm for online multicast routing in ad hoc networks was proposed in [24]. A two level management approach for efficient constructing and maintaining a QoS routing path in ad hoc wireless networks was proposed in [25]. This scheme considerably reduced the quantity of control packets. So, for implementing real-time multicast services, degree constrained QoS aware routing algorithm was given by [26]. This scheme increased the overall performance of application-layer

multicast services. Hence, this study proposed the new algorithm to find the clustering based Priority Adhoc on demand routing protocol for increasing link stability and node stability in MANET.

Similarly, the researches [29] established a Quality of Service (QoS) involved multi-cast routing protocol to select reliable neighbor nodes, which is named as QMRPRNS. Compared to other protocols this protocol have better reliability pair factor, hence it is preferable for reliable data transmission. QMRPRNS protocols select the route to transfer the data with more stability, reduced transmission delay. Further, it requires less time to data transmission, and the node failure probability is less due to QMRPRNS reliability pair factoring scheme. Moreover, these nodes have high reliability pair factor and associated with threshold reliability pair factor were designated for data transmission.

### III. EXISTING PROTOCOLS

To increase the performance of the MANET, many researchers mainly suggest their view on the route discovery. In MANET the AODV routing protocol is mostly used for path discovery. The AODV routing protocol which creates less reactive routing protocol is used to determine the route after accepting the route request (RREQ) and the communication from the sender node. In this protocol, the route failure in the network was projected by sending the Route Error (RERR) indication message to the source node and it is achieved by the AODV protocol. Then the AODV resends the information's to the receiving node. In MANET system, MAODV is used to multicast the data packets. This multicast protocol creates the multicast group by developing the multicast tree. MAODV is the most effective protocol used for multicasting to provide service quality. The main drawbacks of MAODV and the chief principle of the group is it continuously send the multiple messages even if there is no transmitter, because of which the next sender will get delay and the controversy will be large in MAODV [27]. Metric based enhancement to AODV protocol [12] suggested reducing the link failure by picking the best link. Hence, this protocol accepts the route constancy to reach the endpoints. In order to avoid the overload of the messages due to traffic, the EM-AODV routing protocol supported various links as well as path to the endpoint. When compared with the AODV this protocol provides enhanced performance [28]. The major drawback of reactive routing protocol is the respective route detection methods were not considered with loss of route reply message during data communication which indicates the drop of network efficiency. Hence, [29] QMRPRNS: QoS based multicast routing protocol scheme only used to select reliable neighboring nodes for data transmission.



#### IV. PROPOSED METHODOLOGY

In this section, Link Stability Based Priority Multicast Adhoc on Demand Routing Protocol (LS PMAODV) using reliable neighboring nodes selection scheme has been proposed.

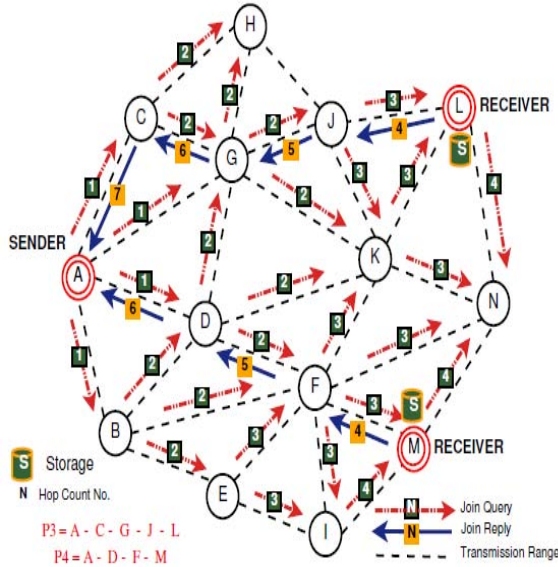


Figure 1: Flow diagram of LS PMAODV

The study deployed few mobile nodes randomly in a specific region which are associated with some initial energy. Here a reliability pair factor (F th RP) = 2.8 is taken as a threshold value. However, in general the value of (F th RP) is application dependent and fixed by the system administrator. Since multicast routing in MANET for a group communication is needed to establish a reliable communication links among the neighbouring nodes.

So in order to overcome the limitations of the MAODV multicast routing protocol, this paper presents a Link Stability based Priority Multicast Adhoc on demand routing protocol. The proposed protocol is processed in several phases such as basic idea formulation, route discovery mechanism, route reply process and route maintenance process.

##### a) Proposed Link Stability Based Priority Multicast Adhoc On Demand Routing Protocol

The flow of LS PMAODV protocol is illustrated in Figure 1. In this topology there is one sender, two receivers M and L (denoted by double ring). In LS PMAODV, forwarding nodes use the shortest path between multicast group members. Red arrow indicates 'JOIN Query' and blue arrow indicates 'JOIN Reply'. Weight on an arrow indicates hop count value for respective link. A link marked with both red and blue arrow is part of a path which returns back to source. Information about other possible paths is not discarded and is used to establish links in event of disconnections

induced by mobility. For example, in Figure 1, route (P3)  $A \rightarrow C \rightarrow G \rightarrow J \rightarrow L$  is established as soon as (P4)  $A \rightarrow D \rightarrow F \rightarrow M$  is disrupted because of movement of J. As a result, this mesh structure is more resilient to tree-like topology as there is no requirement to reconfigure the entire route in change of node position.

According to LS PMAODV protocol, minimum hop count is utilized to determine the paths between source and destination nodes. Figure 1 shows paths between source A and destinations L and M is P3 and P4 that obtained from LS PMAODV protocol using minimum hop count while P3 and P4 are shown in Figure 1 using signal strength of nodes. Path P3 has changed from path P4 due to less signal strength of node A as compare to C. But in Path P4 doesn't change to P3 because it's already getting best signal strength.

##### b) Link Stability

Fluctuating link stability induced by mobility and/or medium characteristics in wireless network impacts network performance. Efficiency of a dynamic routing protocol can be characterized by its ability to deal with link unreliability and routing overhead in terms of computation and reconfiguration/ rerouting (Torkestani, 2011).

Using link stability as a basis for routing decision can lead to protocol being,

- **Energy Efficient:** low communication and computation overhead as less number of link breaks reduces number of re-routings.
- **Resilient to Mobility:** links are selected to resist connectivity breaks for longer periods in events of node movements
- **Stable:** same path is sustained for longer duration reducing overhead on routing tables. Link stability can be estimated using parameters such as (1) Signal to interference plus noise ratio, (2) Energy, (3) Link Delay and (4) Bit Error Rate. If node has more energy, it is likely to remain alive for a longer duration and its transmission range is higher.

Less the link delay, smaller is the distance and hence more probability of link remaining intact. Smaller BER means higher bandwidth and better quality of link.

##### c) Mathematical modeling of the proposed system

Link Stability is given by,

$$LS_{i,j} = \frac{v_2 - DSS_{i,j}}{v_2 - v_1} \quad (1)$$

Where, DSS is the differential signal strength. It is computed as follows.

$$DSS_{i,j} = SS_{cur,i,j} - SS_{new,i,j} \quad (2)$$

Where, SS represents Signal Strength at nodes in the interval i and j.

A path between source and destination is given as

$$P(s,d) = (s, e(s,x), x, e(x,y), y, \dots, e(z,d), d) \quad (3)$$

The feasible path is represented by,

$$P(s,d) = P0, P1, \dots, Pn \quad (4)$$

Here, P is define as the path stability, by the product of link stability of its edges as follows,

$$Stability(P) = \prod_{e \in P} LS(e) \quad (5)$$

Where, LS is the Link Stability.

#### d) Algorithm of proposed protocol

In this section the algorithms for link stability discovery process and Link stability maintained process are provided.

##### i. Algorithm 1 (Link stability discovery process)

Link stability is estimated for every link routing from source to destination. For the selection of the next hop in establishing a route, link stability is estimated by computing Proposed Link Stability based Priority Multicast Adhoc on demand routing protocol in shortest path process.

1. Begin
2. Initialize  $F_{RP}^{th} = 2.8$ ,  $RQ = \{S_{addr}, MC_{addr}, \dots\}$  and other fields of the request packet at S.
3. S broadcast the (RQ) packet to its adjacent nodes those are coming in its transmission range.
4. For every packet request (RQ) packet attained at its neighboring node do
5. If there is no neighbor of a particular node which broadcast the packet
6. Go to step 17.
7. Else
8. If  $F_{RP}^{th}(\text{Rec node}) < F_{RP}^{th}$  value then
9. Discard the packet
10. Else
11. Store the request (RQ) packet at received node header and broadcast further across the network.
12. Repeat step 3-13 until destination nodes received the request (RQ) packets.
13. End if
14. End for
15. End

##### ii. Algorithm 2 (Link stability maintained process)

1. Begin
2. If a node  $N_i$  send a request (RQ) packet to the node  $N_j$  however, the node  $N_j$  go out from the transmission range of the node  $N_i$  (i.e.) there is no channel exist between the these two nodes then
3. At this stage the node  $N_i$  saves the current data packet in its multicast routing information table (MRIT)
4. After channel break down node  $N_{i-1}$  to repair the path.

5. If the node  $N_i$  received the route repair reply (RR\_REP) packet return from node  $N_{i-1}$  within a fixed timeout ( $T_{timeout}$ ). Then
6. The node  $N_i$  is ready to send a request packet (RQ) to node  $N_j$ .
7. Else
8. The node  $N_i$  send a route error (RE) packet to source node S to restart the routing discovery process
9. End if
10. End if
11. End

## V. RESULTS AND DISCUSSION

The parameters used in stimulation, are shown in Table I.

Table 1: Simulation Scenario

Parameters	Values
No of nodes	60
Number of clusters	3
Network size	1000 × 1000 m <sup>2</sup>
Node placement	Random
Node mobility	Mobility
MAC layer protocol	IEEE 802.11
Simulation time	100sec
Initial energy	100j

The proposed LS PMAODV protocol and the technique is implemented using Network Simulator 2 (NS-2) software. Generally, NS-2 is the most standard nonspecific network simulator which supports a wide range of protocols in all layers. It uses OTcl as configuration and script interface. NS-2 is the paradigm of reusability. The network size of the proposed simulation model in terrain area is 100 m x 100 m using Adhoc On-Demand Distance Vector (AODV) routing protocol for monitoring the important parameters like Packet Delivery Ratio (PDR), end-to-end Delay, energy consumption, network life time, computation overhead, connectivity, link stability and throughput. The parameters used in stimulation, which are shown in Table 1.

#### a) Packet delivery ratio

Packet Delivery Ratio is defined as the ratio of aggregate number of data packet that is successfully delivered to the aggregate number of data packet sent. Fig.2 shows the packet delivery ratio for different number of nodes. It is clearly evident the proposed approach achieves high packet delivery ratio than other protocols. Fig.3 shows the packet delivery ratio for varied speed. The proposed protocol LS PMAODV has high packet delivery ratio when compared to other protocols.



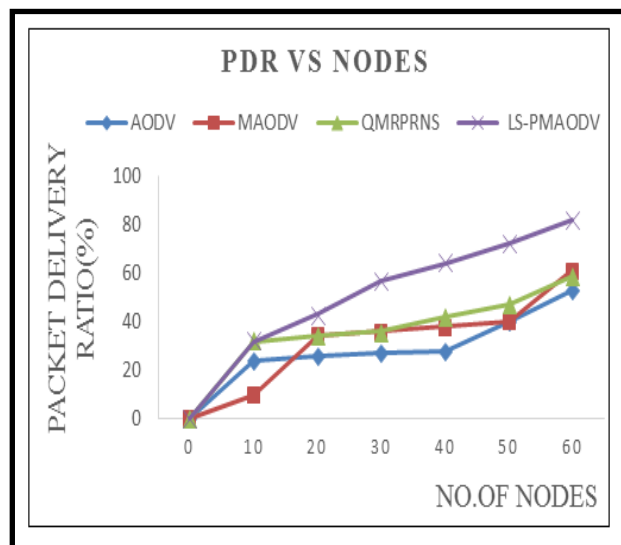


Figure 2: Packet Delivery Ratio Vs Node

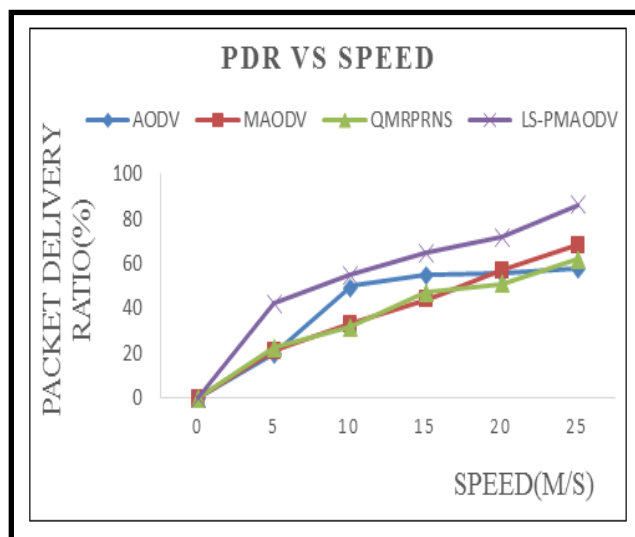


Figure 3: Packet Delivery Ratio Vs Speed

#### b) End-to-End Delay

End-to-End Delay of data packets is calculated as the time it takes to transmit data packets from the source to the destination. Low end-to-end delay is preferred for better application execution. Fig.4 shows the end-to-end delay for different number of nodes. It is clearly evident the proposed approach provides less end-to-end delay than other protocols. From Fig 5, it is obvious that the LS PMAODV has lower end-to-end delay for different node speed. Furthermore, LS PMAODV achieves lower end-to-end delay than AODV, MAODV and QMRPRNS.

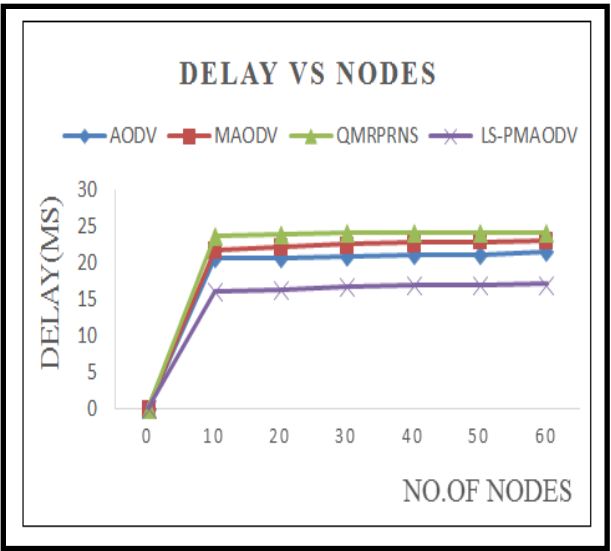


Figure 4: End-to-End Delay Vs Node

c) Energy Consumption

The energy consumption is the total of utilized energy of the considerable number of nodes in the system, where the energy is utilized due to transmitting ( $P_t$ ), reception ( $P_r$ ), and initialization ( $P_i$ ). Accepting every transmission expends a vitality unit, the aggregate energy utilization is proportional to the aggregate number of parcels sent in the system.

Fig.6 shows the energy consumption for different number of nodes. It is clearly evident the proposed approach has less energy consumption than other protocols. From Fig 7, it is obvious that the LS PMAODV has less energy consumption for different speed when compared to other existing protocols.

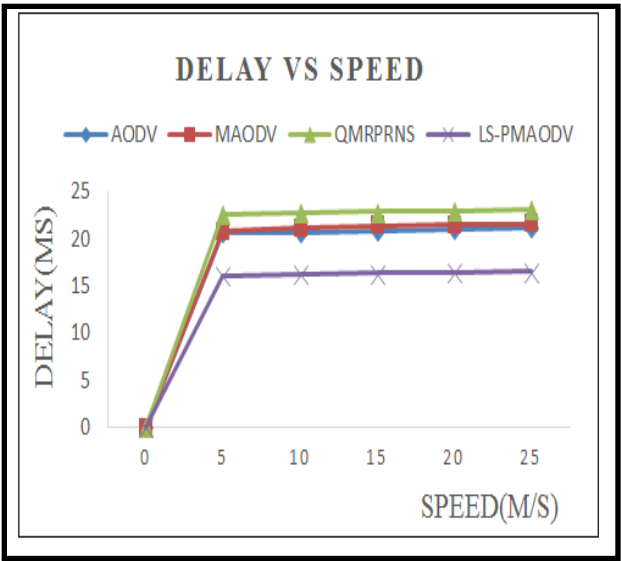


Figure 5: End-to-End Delay Vs Speed

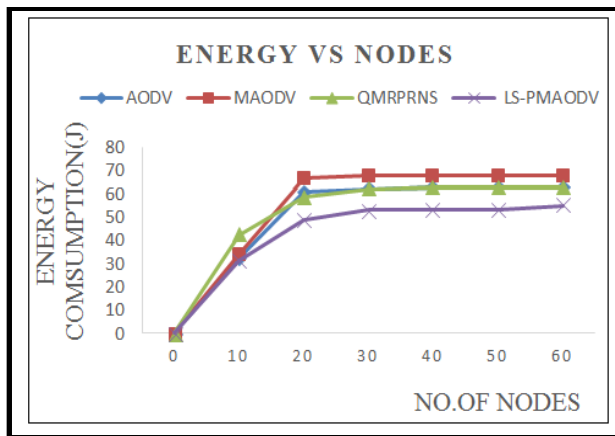


Figure 6: Energy Consumption Vs Node

#### d) Network lifetime

Network lifetimes determine the interval between the start of a packet transmission of the network till the first node fails due to battery depletion. Fig. 8 depicts the lifetime of nodes for different number of nodes. It is

obvious that the proposed method results in longer node life time when compare to other existing methods. Fig. 9 depicts lifetime of nodes for different speed. It reveals that LS PMAODV increases the node lifetime than other methods.

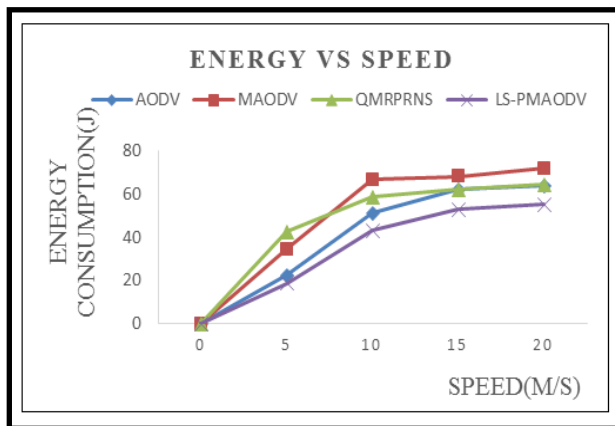


Figure 7: Energy Consumption Vs Speed

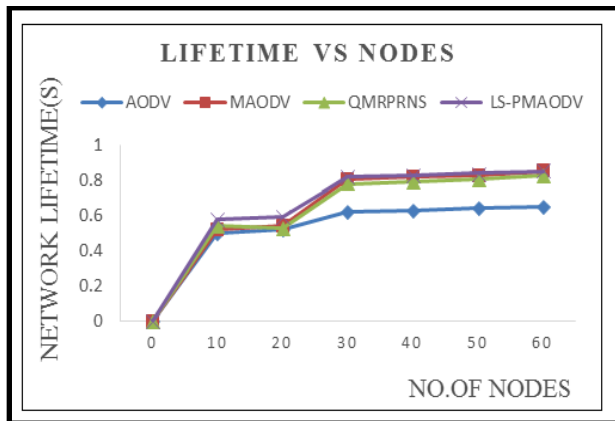


Figure 8: Network Lifetime Vs Node

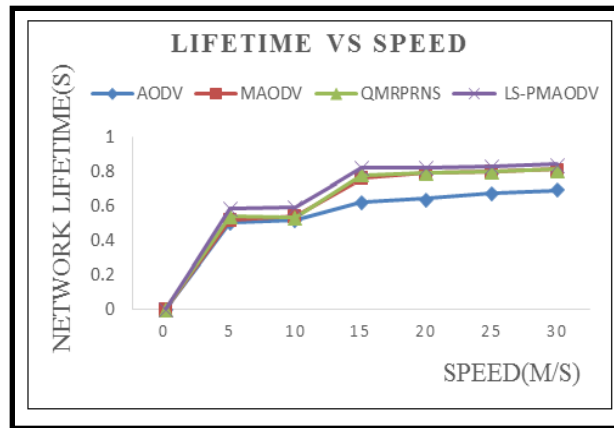


Figure 9: Network Lifetime Vs Speed

#### e) Computation overhead

Computation Overhead is the combination of excess or indirect computation time, memory and bandwidth. The main problem of wireless network is reliability and traffic overhead. Overhead is also the combination of excess or indirect computation time, memory, and bandwidth.

Fig. 10 shows the computation overhead for different number of nodes. It is clearly evident the proposed approach has less computation overhead than other protocols. From Fig 11, it is clear that the LS PMAODV has less computation overhead for different node speed when compared to other existing protocols.

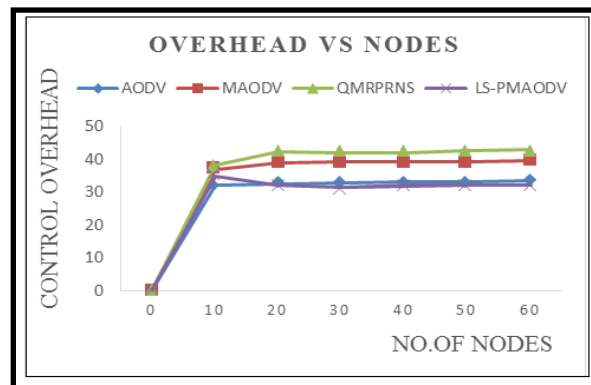


Figure 10: Computation Overhead Vs Node

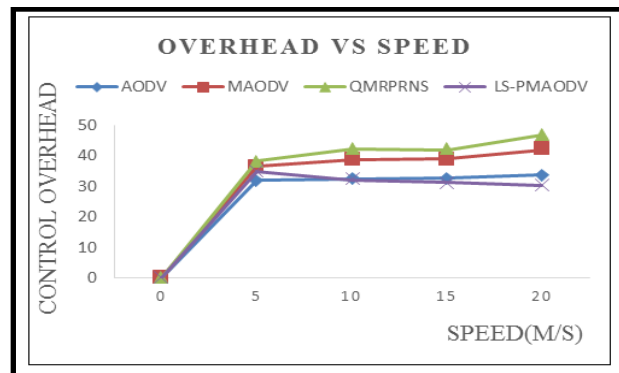


Figure 11: Computation Overhead Vs Speed

#### f) Connectivity

Connectivity plays the main role, which have the ability to report information to the fusion center, even though it has the critical for sensing the coverage. A wireless sensor network (WSN) is a network comprises

of enough space for distributing the autonomous devices using sensors to screen the physical or environmental conditions. A WSN framework combines to form a portal that gives remote network which acts a backbone to the wired world and conveyed hubs.

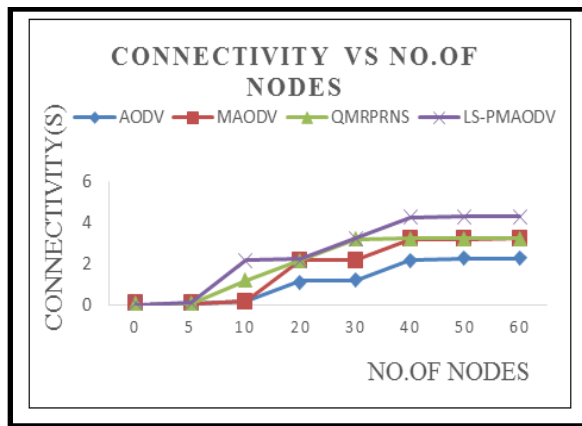


Figure 12: Connectivity Vs Node

Fig. 12 shows the connectivity for different number of nodes. It is evident the proposed approach provide high connectivity than other protocols. From Fig

13, it is clear that the LS PMAODV has high connectivity for different node speed when compared to other existing protocols.

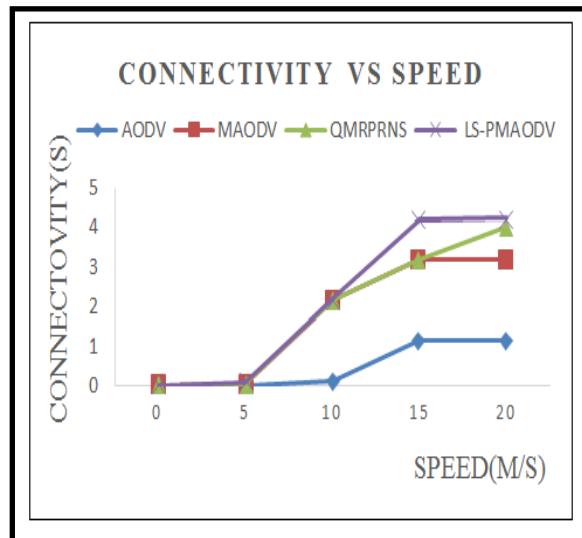


Figure 13: Connectivity Vs Speed

#### g) Link Stability

Link Stability is a statistical-based approach has been adopted in order to discriminate among several links which are more stable for some periods of time without exactly predicting the residual link lifetime of each link. Thus, to enable mobile devices to make smart decisions in connection to the stability, a practical method is used, based exclusively on observations related to the link, in previous time instants. As a result, this analysis produces an evaluation of the link residual lifetime of the link, since the stability of a link is given by its probability of persisting for a certain time span. Fig 14 and 15 shows the number of nodes vs. link stability and speed vs. link stability respectively.



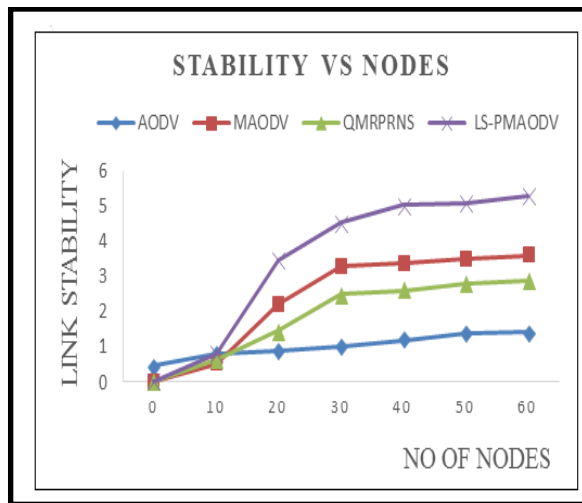


Figure 14: Link stability Vs Node

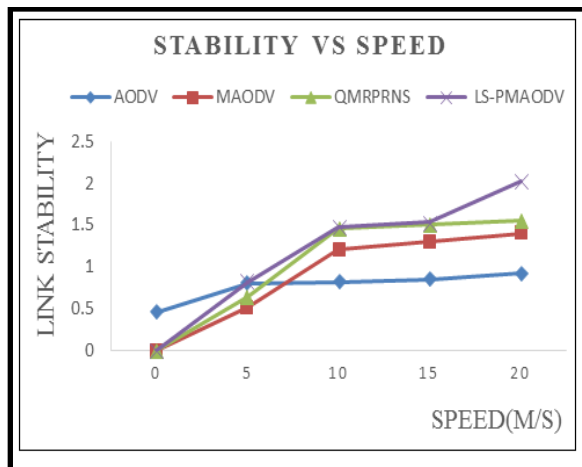


Figure 15: Link stability Vs.Speed

It is clearly evident that LS PMAODV provides high link stability than AODV, MAODV and QMRPRNS.

#### h) Throughput

In data transmission, network throughput is the amount of data transmitted successfully from sender node to receiver node in a given time period and typically

measured in bits per second (bps), megabits per second (Mbps) or Gigabits per second (Gbps). Fig 16 and 17 shows the throughput achieved for different number of nodes and different speed respectively. From Fig 17 and 18, the throughput for LS PMAODV is greater than other protocols.

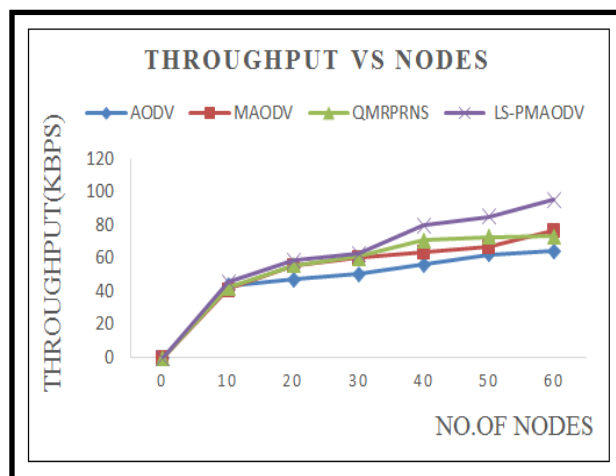


Figure 16:Throughput Vs Node

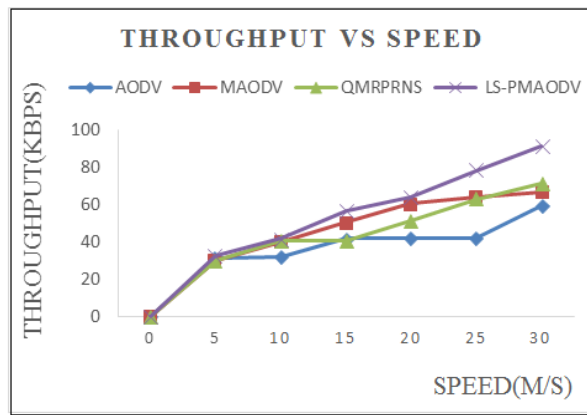


Figure 17: Throughput Vs Speed

## VI. CONCLUSIONS

This research paper describes the link stability based priority multicast Adhoc and demand distance vector routing protocol to enhance the route discovery of nodes which is stable of MANET. The proposed LSMAODV protocol is implemented using Network Simulator 2 (NS-2). The support level of predictable performance for network system is decreased the delay and to enhance the efficiency. The QoS metrics such as delay, energy consumption, an end to end latency, loss, overhead are minimized and PDR, throughput are enhanced using the proposed protocol compared to the existing AODV and MAODV routing protocols. The clustering arrangement stores the energy of the cluster member nodes. Hence, the proposed method is enormously energy efficient which is linked to the AODV and MAODV algorithm in achieving high QoS in MANET.

## REFERENCES RÉFÉRENCES REFERENCIAS

1. Layuan, L., Chunlin, L., A QoS multicast routing protocol for clustering mobile ad hoc networks, Computer Communications, (2007), 30(7), 1641-1654.
2. Sutariya, D., Kamboj, P., A Survey of QOS Multicast Routing Protocol for MANET, (2013), 73(10), 3589-3599.
3. Royer, E.M and Chai-Keong Toh. A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks. IEEE Personal Communications, pp. 46-55, April 1999.
4. Perkins, C.E., Bhagwat, P., Highly dynamic Destination Sequenced Distance-Vector routing (DSDV) for mobile computers, in: T. Imielinski, H. Korth (Eds.), Proceedings of SIGCOMM'94 Conference on Communications Architectures, Protocol and Applications, ACM, London, UK, 1994, pp. 234-244.
5. Chiang, C.C., Routing in clustered multihop mobile wireless networks with fading channel, in: T.S. Chua, H.K. Pung, T.L. Kunii (Eds.), Proceedings of the IEEE Singapore International Conference on Networks, Springer, Singapore, 1997, pp. 197-211.
6. Shree, M., Garcia-Luna-Aceves, J.J., An efficient routing protocol for wireless networks, ACM Mobile Networks and Application Journal 1 (1996) 183-197.
7. Perkins, C., Ad hoc On-Demand Distance Vector (AODV) routing, RFC3561[S], 2003, <http://www.ietf.org/rfc/rfc3561.txt>.
8. Johnson, D.B., Maltz, D.A., Hu, Y.C., The dynamic source routing protocol for mobile ad hoc networks, Internet Draft, draft-ietfmanet-dsr-10.txt, 2004.
9. Park, V.D., Corson, M.S., Temporally ordered routing algorithm (TORA) version 1: functional specification, Internet Draft, draft-ietfmanet-tora-spec-00.txt, November 1997.
10. Dube, R., Rais, C.D., Wang, K., Tripathi, S.K., Signal stability based adaptive routing for ad hoc mobile networks, IEEE Personal Communications 4 (1997) 36-45.
11. Charles. Wireless access technology - WiFi and WiMAX. Available at: <http://network.chinabyte.com/222/12223722.shtml> (Accessed: 5 July 2014) 2011.
12. Huang, Z.C., Shen, C.C., A comparison study of omnidirectional and directional MAC protocol for ad-hoc networks, IEEE Global Telecommunications Conference (2002) 57-61.
13. Chen, X., Wu, J., Multicasting techniques in mobile ad-hoc networks, The Handbook of Ad-hoc Wireless Networks (2003) 25-40.
14. Devarajan, K., Padmathilagam, V, An Enhanced Cluster Gateway Switch Routing Protocol (ECGSR) for Congestion Control using AODV Algorithm in MANET, International Journal of Computer Applications, (2015), 123(3).
15. De, M.C.C., Gossain, H., Agrawal, D.P., Multicast over wireless mobile ad-hoc networks: present and future directions, IEEE Network, (2003), 5259.
16. Vinay., P. Viradia, Improved AODV Routing Protocol for MANET, Journal of Engineering Research and Applications, (2014), ISSN: 2248-9622, Vol. 4, Issue 1 (Version 3), pp. 368-374.

17. Phate, N., Saxena, M., Rizvi, M. A., High temperature fiber optic laser-induced breakdown spectroscopy sensor for analysis of molten alloy constituents, Minimizing congestion and improved QoS of AODV using clustering in mobile ad hoc network, (2014), (pp. 1-5).
18. Rango, F. De.; Fazio, P.; (2012); Link Stability and Energy Aware Routing Protocol in Distributed Wireless Networks, IEEE Trans. on Parallel and Distributed systems, 23: 713-726.
19. Rajashekhar Biradar, Sunilkumar Manvi, and Mylara Reddy. Link stability based multicast routing scheme in MANET. Computer Networks. 54(7): 1183-1196, 2010.
20. Geunes, M., U. Sorges, U., I. Bouazizi, I., Ant-colony based routing algorithm for manets, in: ICPP workshop on Ad Hoc Networks (IWAHN 2002), August 2002, pp. 79–85.
21. Biswas, J., Barai, M., Nandy, S.K., Efficient hybrid multicast routing protocol for ad-hoc wireless networks, local computer networks, in: 29th Annual IEEE International Conference on November 2004, pp. 180–187.
22. Rong B, Amoussou G, Dziong Z, Kadoch M, Ahmed KE. Mobility prediction aided dynamic multicast routing in MANET. In: Proceedings of the IEEE/ Sarnoff symposium on advances in wired and wireless communication, Princeton, NJ, 2005. p. 21–4.
23. Viswanath K, Obraczka K, Tsudik G. Exploring mesh and tree-based multicast routing protocols for MANETs. IEEE Transactions on Mobile Computing 2006;5(1): 28–42.
24. Jiang, S., He, D., Rao, J., A prediction-based link availability estimation for routing metrics in MANETs, IEEE/ACM Transactions on Networking 13 (2005) 1302–1312.
25. Cheng H, Cao J, Wang X. A fast and efficient multicast algorithm for QoS group communications in heterogeneous network. Elsevier, Computer Communications 2007; 30: 2225–35.
26. Ramanathan, R., Hain, R., An ad hoc wireless testbed for scalable, adaptive QoS support, Wireless Communications and Networking Conference, (2000), (Vol. 3, pp. 998-1002).
27. Sedrati, M., Bilami, A., Benmohamed, M., M-AODV: AODV variant to Improve Quality of Service in MANETs, arXiv preprint arXiv, (2011), 1104.1186.
28. Lakshmi, S. M., Sikamani, K. T., Energy-aware multicast opportunistic routing protocol (Eamor) to optimize lifetime of MANET, In Current Trends in Engineering and Technology (ICCTET), International Conference, (2013), (pp. 210-212).
29. Yadav, A. K., & Tripathi, S. (2016). Qmrprns: Design of qos multicast routing protocol using reliable node selection scheme for manets. Peer-to-Peer Networking and Applications, 1-13.





This page is intentionally left blank



GLOBAL JOURNAL OF COMPUTER SCIENCE AND TECHNOLOGY: E  
NETWORK, WEB & SECURITY  
Volume 17 Issue 2 Version 1.0 Year 2017  
Type: Double Blind Peer Reviewed International Research Journal  
Publisher: Global Journals Inc. (USA)  
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

# Risk Sensitive Filter for MIMO-OFDM System Channel Estimation using Combined Orthogonal Pilot Approach under Parameter Uncertainty

By K. Rajendra Prasad, M. Srinivasan & T. Satya Savithri

*K L University*

**Abstract-** In this paper, risk-sensitive filter (RSF) based channel estimation has been proposed for MIMO-OFDM system. The uniqueness of the risk sensitive filter's performance in the presence of uncertainty is explored for channel estimation problem. In general, the channel estimation problem is formulated as the estimation of time varying coefficients of FIR filter. Estimation of channel is very critical task to recover the error free signal at the end of the receiver under the unknown statistics of the channel. Several Kalman based algorithms are proposed for channel estimation in MIMO-OFDM system under different channel considerations using traditional pilot based estimation. Auto regressive (AR) model is used to formulate the parameters to be estimated. Unlike to the traditional pilot based approach, in this work combined orthogonal pilot aided (COPA) channel estimation is used to eliminate the same frequency interference created by the OFDM frequency among different transmit-receive antenna pairs.

**Keywords:** MIMO-OFDM, channel estimation, combined orthogonal pilots, kalman filter, risk sensitive filter, parameter uncertainty.

**GJCST-E Classification:** C.2.5, B.4.2



*Strictly as per the compliance and regulations of:*



RESEARCH | DIVERSITY | ETHICS



# Risk Sensitive Filter for MIMO-OFDM System Channel Estimation using Combined Orthogonal Pilot Approach under Parameter Uncertainty

K. Rajendra Prasad <sup>α</sup>, M. Srinivasan <sup>σ</sup> & T. Satya Savithri <sup>ρ</sup>

**Abstract-** In this paper, risk-sensitive filter (RSF) based channel estimation has been proposed for MIMO-OFDM system. The uniqueness of the risk sensitive filter's performance in the presence of uncertainty is explored for channel estimation problem. In general, the channel estimation problem is formulated as the estimation of time varying coefficients of FIR filter. Estimation of channel is very critical task to recover the error free signal at the end of the receiver under the unknown statistics of the channel. Several Kalman based algorithms are proposed for channel estimation in MIMO-OFDM system under different channel considerations using traditional pilot based estimation. Auto regressive (AR) model is used to formulate the parameters to be estimated. Unlike to the traditional pilot based approach, in this work combined orthogonal pilot aided (COPA) channel estimation is used to eliminate the same frequency interference created by the OFDM frequency among different transmit-receive antenna pairs. The results proved that proposed estimator is outperforming when compared with Kalman under uncertainty in parameter.

**Keywords:** MIMO-OFDM, channel estimation, combined orthogonal pilots, kalman filter, risk sensitive filter, parameter uncertainty.

## 1. INTRODUCTION

Multiple-Input Multiple-Output (MIMO) and Orthogonal Frequency Division Multiplexing (OFDM) combination will provide high data rates and mitigate the effects of the multipath delay in wireless communication[1]. The advantages originate from the multiple spatial channels, which are provided by the multiple antennas together with the scattering environment surrounding the transmitters and the receivers. As the wireless environment is time varying, channel estimation became as essential part of the receiver [2- 4]. The accurate estimation of the channel statistics will provide the better diversity gain and coherence detection and decoding.

Pilot aided channel estimation is proved as better approach to estimate the channel with more accuracy [13,14]. But it suffers interference created by the OFDM frequency among different transmit-receive antenna pairs. To overcome this Combining the design

of the joint orthogonal pilot for the MIMO-OFDM system has proposed in [15-17], which has designed the pilot data format maintaining the orthogonal property between different OFDM subcarriers of different transmitting-receiving antenna pair and same transmitting-receiving antenna pair, at the same time, the pilot symbols are inserted into the data frame at the transmitter according to the polygon form in the change of the OFDM subcarriers in transmitting-receiving antenna pair.

Most of the conventional methods work in a symbol-by-symbol scheme using the correlation of the channel only in the frequency domain i.e., the correlation between the sub-channels. More advanced algorithms are based on the Kalman Filter (KF), to also exploit the time- domain correlation [11,12]. KFs require a linear recursive state-space representation of the channel. However, the exact Clarke model does not admit such a representation. An approximation often used in the literature consists of approaching the fading process as auto-regressive [5,6]. Hence, a widely used channel approximation is based on a first-order Auto-Regressive model (AR), as recommended [5]. The KF appears to be convenient for the very high mobility case, which leads to quasi-optimal channel estimation. In the present study, we consider multi-path channel estimation in multi-carrier systems (i.e., OFDM systems). In this context, we are interested in evaluate the performance of KF and RSF under parameter uncertainty [26-29]. To do this, we use the least-square (LS) estimator at the pilots of current OFDM symbol. This first step explores the frequency-domain correlation of the channel and the knowledge of the delays to convert the primary observation at pilot frequencies.

This paper is organized as follows: Section II introduces the MIMO-OFDM system model, In Section III explored the arrangement of pilots in combined orthogonal scheme and its significance in estimation during the same frequency inference, Section IV discussion on time varying channel model and channel model with parameter uncertainty. Section V introduces the KF and RSF channel estimation methodology in parameter uncertainty.

Author <sup>α</sup>: Asst. Prof, Dept. of ECE, K L University, India.  
e-mail: krajendraec@gmail.com

Author <sup>σ</sup>: Post doc, Dept. of SRT Lulea University of Tech., Sweden.

Author <sup>ρ</sup>: Professor & HoD, Dept. of ECE, JNTU-Hyderabad, India.

## II. SYSTEM MODEL

Consider a MIMO system equipped with transmit antennas and receive antennas. The block

diagram of baseband MIMO-OFDM system is shown in Figure 1.

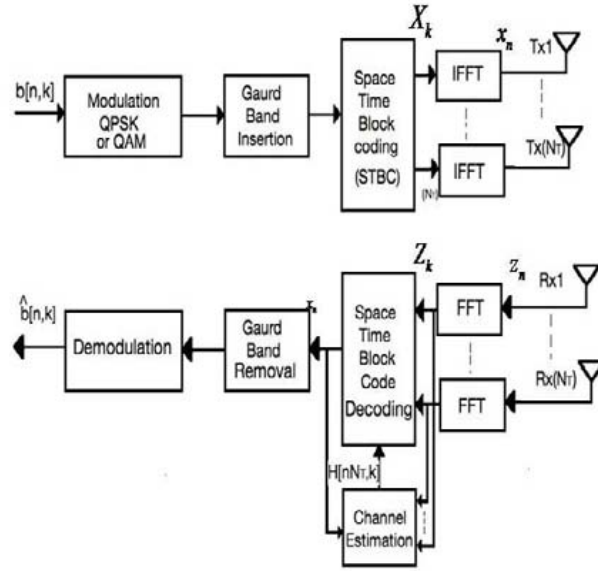


Figure 1: Block Diagram of MIMO-OFDM System

As Figure 1 shows, we use  $N_T$  transmit antennas,  $N_R$  receive antennas,  $n$  OFDM symbols and  $K$  subcarriers in a MIMO-OFDM system. The transmitted symbol vector is given as

$$x[n, k] = [x^{(1)}[n, k] \dots x^{(N_T)}[n, k]]^T$$

$$n \in \mathbb{Z}, k = 0 \dots K-1,$$

Where  $x^{(i)}[n, k]$  indicates the symbol transmitted at the symbol time  $n$ , subcarrier  $k$ , and antenna  $i$ . The  $n^{\text{th}}$  OFDM symbol  $X_n[m]$  can be acquired by performing an inverse fast discrete Fourier transform (IFFT) to the  $x[n, k]$  and inserting a CP of length  $L_{CP}$

$$X_n[m] = \begin{cases} \frac{1}{\sqrt{KN_T}} \sum_{k=0}^{K-1} x[n, k] e^{j2\pi mk/K}, m = -L_{CP} \dots K-1 \\ 0, \text{else} \end{cases} \quad (1)$$

Thus the duration of each OFDM symbol is  $cp$   $N = K + L_{CP}$ . The overall baseband transmitted signal is

$$X_n[m] = \sum_{n=-\infty}^{+\infty} x_n[m - nN] \quad (2)$$

The signal from each receiver is formed by the parameter matrix  $H[m, l]$  of the fading MIMO  $N_T \times N_R$  channel [11], the transmitted signal  $X_n[m]$ , and the noise  $\eta[m]$ .  $\eta[m]$  is stationary white Gaussian noise which distribution is expressed by  $N(0, \sigma_\eta^2)$ . The

receiver signal  $z[m]$  is demodulated by removing cyclic prefix and performing fast Fourier transform (FFT).

$$Z[n, k] = \frac{1}{\sqrt{K}} \sum_{m=0}^{K-1} z[nN + m] e^{-j2\pi km/K} \quad (3)$$

If  $N f_{Doppler} \ll 1$  and  $H[m, l] = h_l[n]$  (Here  $n=m$ ) varies negligibly within one OFDM symbol, the input/output relation can be expressed as below,

$$Z[n, k] = \hat{H}[n, k] x[n, k] + \hat{\eta}[n, k] \quad (4)$$

Here  $Z[n, k]$ ,  $\hat{H}[n, k]$  and  $\hat{\eta}[n, k]$  are all  $N_T \times N_R$  matrices, and  $x[n, k]$  is  $N_T \times N_R$  matrix.

## III. COMBINED ORTHOGONAL PILOT SCHEME

Use of pilot symbols for channel estimation introduces overhead and it is desirable to keep the number of pilot symbols as minimum as possible. The completely orthogonal pilot data symbol among the different subcarriers position of different transmitting receiving antenna pair [15, 17]. And the pilot data symbols are distributed in the entire time-frequency grid of the channel for each transmitting antenna of the OFDM transmitter, the pilot symbols are coded, so that the antenna is unique. The coded pilot symbol was inserted into the OFDM frame, in order to form the diamond grid, and the diamond grid used for different antenna will use the same frequency, but in the time domain will deviate a single symbol from each other.

At the OFDM receiver, the channel responses are estimated through the use of two dimensional

interpolations according to the diamond center symbol of each of the diamond grid and the estimated channel response in frequency domain is smoothed. The channel response of the rest symbols are estimated through the interpolation in the frequency domain. The arrangement of the pilot pattern is shown in the figure.2 [15].

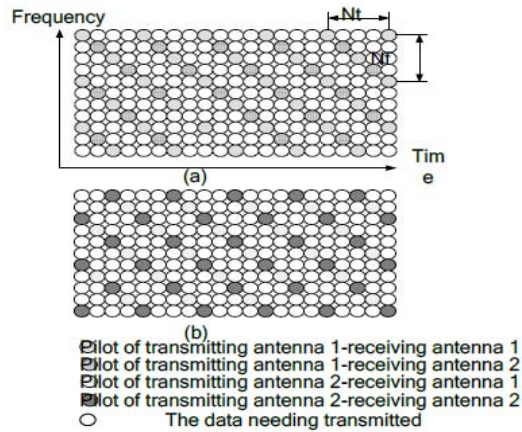


Figure 2: Pilot Arrangement in Combined Orthogonal Scheme

#### IV. TIME VARYING CHANNEL MODEL

##### a) Tapped delay line channel Model

A multiplicative channel model with an additive Gaussian white noise (AGWN) model is used sometimes it also refers as Gauss-Markov process represented [5] above as equation (2) i.e.

$$y(t, \tau) = \sum_r h_r(t) x(\tau - \tau_r) \quad (5)$$

The function  $y(t, \tau)$  in the above equation is just same as Finite Impulse Response (FIR) filter which has time-varying coefficients. In real world scenario there are many factors, as disturbance, affect the medium, which leads to model the system with additive noise and result the system model become (3) i.e.

$$z(t, \tau) = \sum_r h_r(t) x(\tau - \tau_r) + v(\tau) \quad (6)$$

To design effective communication, it is necessary to have good knowledge about these coefficients. There are too many parameters to estimate in (5). As observation samples are corrupted with noise, weights of samples will rapidly change from one to others. The weighted taped channel is modeled as Gauss-Markov model. The Gauss-Markov model will be used to fix the correlation between successive values of given taped weight in time.

In channel estimation, the state vector is given as

$$h[n] = Ah[n-1] + u[n] \quad (7)$$

where

$$h[n] = \begin{bmatrix} h_n[0] \\ h_n[1] \\ \vdots \\ h_n[p-1] \end{bmatrix} \quad A \text{ is a } p \times p \text{ matrix}$$

and  $u[n]$  is AWGN, with zero mean and variance  $Q$ . Standard assumption made that tap weights are joined Gaussian and uncorrelated with each other.

Measurement/observation model is written by rearranging (10)

$$z[n] = \begin{bmatrix} x[n] & x[n-1] & x[n-2] & \dots & x[n-p+1] \end{bmatrix} h[n] + w[n] \quad (8)$$

and it can be expressed as

$$z[n] = x[n]^T h[n] + w[n] \quad (9)$$

where  $w[n]$  is Gaussian white noise with variance  $R = \sigma^2$  and  $x(n)$  is known sequence, act as input to the channel.

##### b) Tapped delay line channel Model with uncertainty

In a circumstance, when there is uncertainty in the channel state vector, (7) may be written as

$$h[n] = Ah[n-1] + \Delta A + u[n] \quad (10)$$

where  $\Delta A$  is a constant which arises due to channel phase rotation during coding and it is considered as a parameter modeling uncertainty in matrix  $A$ . This model is similar to case of random walk process described in [7] and in state-space domain the model

#### V. CHANNEL ESTIMATION

##### a) Kalman based channel estimation

The Kalman filter is a mathematical method used to use observed values containing noise and other disturbances and produce values closer to true value and calculate value [21]. The basic operation done by the KF is to generate estimates of the true and calculated values, first by predicting a value, then calculating the uncertainty of the above value and finding an weighted average of both the predicted and the measured values [20]. Most weight is given to the value with least uncertainty. The result obtained the method gives estimates more closely to true values. It is a recursive predictive filter based on the use of state space techniques and recursive algorithms. It demands

the description of the dynamical problem in a state-space form which includes a system model and an observation model which is considered only for linear systems. Kalman filter is a recursive minimum mean square error (MMSE) estimator and it provides optimal estimation solution for linear and unbiased process with additive white noise. There is enough literature on KF, for example [5,21].

The implementation of KF for channel estimation problem given in above subsection is given in detail as follow steps [29].

Filter initialization

$$\hat{h}[n-1|n-1] = \mu_h \text{ and } P[n-1|n-1] = C_h \quad (11)$$

Prior state estimation

$$\hat{h}[n|n-1] = A\hat{h}[n-1|n-1] \quad (12)$$

Prior estimate error covariance

$$P[n|n-1] = AP[n-1|n-1]A^T + Q \quad (13)$$

Kalman Filter gain

$$K[n] = P[n|n-1]V[n](V[n]^T P[n|n-1]V[n] + (R))^{-1} \quad (14)$$

Posterior state estimate

$$\hat{h}[n|n] = \hat{h}[n|n-1] + K[n](x[n] - V[n]^T \hat{h}[n|n-1]) \quad (15)$$

Posterior estimate error covariance

$$P[n|n] = (I - K[n]V[n]^T)P[n|n-1] \quad (16)$$

b) *Proposed Risk Sensitive Filter approach*

A RSF which is recursively update a posteriori state and estimate error covariance as given in [23] is used here for fading channel estimation. Implementation of fading channel estimation using RSF is follows:

For linear system, the posteriori state estimate  $\hat{h}$  of  $h$  at  $k^{\text{th}}$  time is obtained by the risk sensitive approach such that

$$\hat{h} \in \arg \min E[\exp \theta \{ \sum_{m=0}^{k-1} l(h_m, \hat{h}_m) + l(h_k, \hat{h}) \} | x[n]] \quad (17)$$

Here,  $\theta$  is a tuning parameter, known as risk factor or risk parameter, the function  $l(h, \hat{h})$  is defined as

$$l(h, \hat{h}) = \frac{1}{2} (h - \hat{h})^T (h - \hat{h}) \quad (18)$$

$$x[n] = \{x[1], \dots, x[n]\} \quad (19)$$

(Notation T denotes transpose)

This is strictly filtering problems. For more details readers can refer [23-26].

As [25], the posteriori state estimation is given as

$$\hat{h}[n|n] = A\hat{h}[n-1|n-1] + P[n|n]V[n]^T R^{-1} (x[n] - V[n]^T A\hat{h}[n-1|n-1]) \quad (20)$$

Posteriori estimation error covariance is given as

$$P[n|n]^{-1} = \left[ A(P[n-1|n-1]^{-1} - \emptyset I)^{-1} A^T + Q \right]^{-1} + V[n]R^{-1}V[n]^T \quad (21)$$

## VI. SIMULATION RESULTS

The simulation parameters are as follows. The FFT size,  $N$ , is 64. The data symbol  $X_k$  is based on QPSK. The channel  $h_n$  is the Rayleigh fading channel which has two paths. The space-time coding scheme is Alamouti's STBC with  $\frac{1}{2}$  rate and the decoding scheme used is Maximum likelihood (ML) technique with only linear processing. The number of OFDM symbols considered here are 8. The initial values of the for the KF are as follows:  $0 \text{ } h = [0 \ 0]^T$ ,  $0 \text{ } P = 100 \text{ } I$ ,  $0 \text{ } S = 0 \text{ } I$ ,  $0 \text{ } q = [0 \ 0]^T$ , and  $0 \text{ } a = 1$ . The comparison factor, MSE, is obtained after 100 independent trials. The linear interpolator is used as we considered slow fading channel. In contrast, the proposed RSF algorithm works well in parameter uncertainty conditions and usual performance and close to KF in absence of parameter uncertainty [22]. Although this paper focuses mainly on channel estimation under parameter uncertainty.

The graphs are plotted for Error Rate versus SNR and Mean Square Error versus SNR by taking 2x2 MIMO-OFDM systems. Performance is compared in the aspect of mean square error (MSE) LS, KF and RSF under uncertainty with 0.5 and the Bit error rate (BER) shown in Figure.3 and Figure.4 respectively.



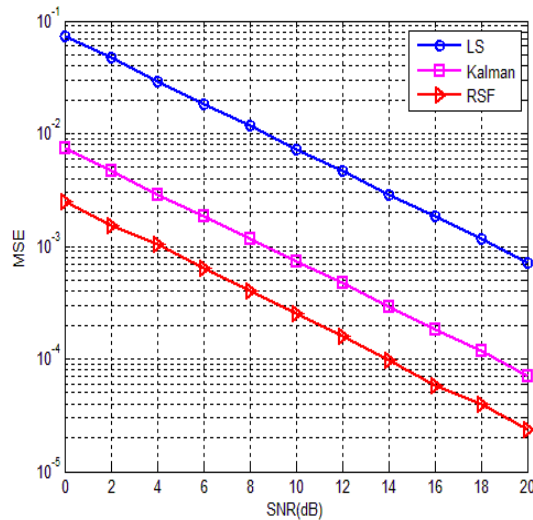


Figure 3: MSE vs SNR for LS, KF and RSF

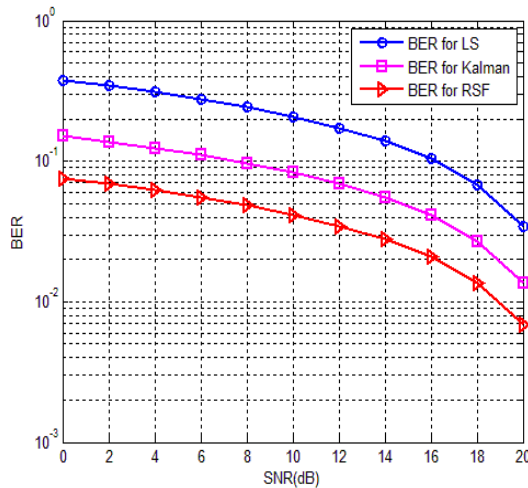


Figure 4: BER vs SNR for LS, KF and RSF

## REFERENCES RÉFÉRENCES REFERENCIAS

- Ahmad R. S. Bahai, Burton R. Saltzberg, Mustafa Ergen, (2004). "Multicarrier Digital Communications: theory and application of OFDM", *Springer, Second Edition*.
- Mehmet Kemal Ozdemir, logus Huseyin arslan, (2007). "Channel estimation for wireless OFDM systems", *IEEE Communications Surveys & Tutorials*.
- Won-Gyu Song and Jong-Tae Lim (2006). "Channel Estimation and Signal Detection for MIMO-OFDM with Time Varying Channels" *IEEE communications letters*, vol. 10.
- Ezio Biglieri, John Proakis, Shlomo Shamai, (1998). "Fading Channel: Information-Theoretic and Communication Aspect," *IEEE trans. on information theory*, vol.44.
- Steven M.Key, (1993). *Fundamental of Statistical Signal Processing: Estimation Theory*, pages: 452-456, *Prentice Hall, NJ*.
- Kareem E. Baddour, Norman C. Beaulieu, (2001). Autoregressive Model for Fading Channel Simulation, *IEEE Global Telecommunication Conference*, vol.2 pp:1187-1192,
- Ali Jamoos, Ahmad Abdo, Hanna Abdel Nour, Eric Grive, (2010). "Two Cross-Coupled  $H_\infty$  Filters for Fading Channel Estimation in OFDM Systems" *Novel Algorithms and Techniques in Telecommunications and Networking*, pp 349-353, Springer, Netherlands,
- Huaqiang Shu, Laurent Ros, and Eric Pierre Simon (2014). "Simplified Random-Walk-Model-Based Kalman Filter for Slow to Moderate Fading Channel Estimation in OFDM Systems" *IEEE transactions on signal processing*, vol. 62, no. 15.
- Hye Mi Park and Jae Hong Lee (2006). "Estimation of Time-Variant Channels for OFDM Systems Using Kalman and Wiener Filters, *Vehicular Technology Conference*.
- Hussein Hijazi, Eric Pierre Simon, Martine Li'enard and Laurent Ros (2010). "Channel Estimation for MIMO-OFDM Systems in Fast Time-Varying Environments" *4th International Symposium on Communications, Control and Signal Processing (ISCCSP2010)*.
- Bor-Sen Chen, Chang-Yi Yang, and Wei-Ji Liao, (2012). "Robust Fast Time-Varying Multipath Fading Channel Estimation and Equalization for MIMO-OFDM Systems via a Fuzzy Method," *IEEE Transactions on Vehicular Technology*, Vol. 61.
- Xuewu Dai, Wuxiong Zhang, Jing Xu, John E Mitchell and Yang Yang, (2012). "Kalman interpolation filter for channel estimation of LTE downlink in high-mobility environments," *EURASIP Journal on Wireless Communications and Networking*.
- Sinem Coleri, Mustafa Ergen, Anuj Puri, and Ahmad Bahai, (2002). "Channel Estimation Techniques Based on Pilot Arrangement in OFDM Systems," *IEEE Trans. on Broadcasting*, Vol.48.
- Ye (Geoffrey) Li, (2000). "Pilot-Symbol-Aided Channel Estimation for OFDM in Wireless Systems" *IEEE transactions on vehicular technology*, Vol. 49.
- Gunther Auer, (2012). "3D MIMO-OFDM Channel Estimation" *IEEE transactions on communications*, vol. 60.
- Shuichi Ohno, Emmanuel Manasseh, Masayoshi Nakamoto (2011). "Preamble and pilot symbol design for channel estimation in OFDM systems with null subcarriers" *EURASIP Journal on Wireless Communications and Networking*.
- Wang Liping (2014). "Channel Estimation and Combining Orthogonal Pilot Design in MIMO-OFDM System" *Journal of Networks*, VOL. 9.
- Jun Cai, Xuemin Shen, Jon W. Mark, (2004). "Robust Channel Estimation for OFDM Wireless



- Communication Systems—An  $H_\infty$  Approach”, *IEEE Trans. on Wireless Communication*, Vol. 3.
19. Alper T. Erdogan, Babak Hassibi, Thomas Kailath, (2000). “on  $H_\infty$  equalization of communication channels”, *IEEE transactions on signal Processing*, Vol.48.
20. M.J.Omidi, M.Pasupathy, P.G.Gulak, (1999). “Joint Data and Kalman Estimation for Rayleigh fading Channel,” *Wireless personal communication*, Vo.10, pp:319-339, 1999.
21. Robert Grover Brown, Patrick Y.C. Hwang, (1997). *Introduction to Random Signal and Applied Kalman Filtering*, 3<sup>rd</sup> Ed, John Wiley & Sons.
22. R.N. Banavar, J. L. Speyer (1998). “Properties of Risk sensitive filters/Estimators” *IEE Proc.-Control Theory Appl.*, Vol. 145.
23. Rene K. Boel, Matthew R. James, Ian R. Peterson, (2002). “Robustness and risk sensitive filtering,” *IEEE Transactions on Automatic Control*, Vol.47.
24. U. Uguner, F. Gustafsson, (2008). “Risk sensitive particle filter for mitigating sample impoverishment,” *IEEE Transactions on signal processing*, Vol.56.
25. Fan Wang, Venkataramanan Balakrishnan,(2003). “Robust Steady-State Filtering for Systems With Deterministic and Stochastic Uncertainties,” *IEEE Trans. On Signal Processing*, Vol. 51.
26. H. Zhang, L. Xie, and Y. C. Soh, (2003). “Risk-sensitive filtering, prediction and smoothing for discrete-time singular systems,” *Automatica*, vol. 39.
27. M.Jayakumar, R.N.Banavar, (1998). “Risk Sensitive Filters for Recursive Estimation of Motion from Images,” *IEEE Trans. of Pattern and Machine Intelligence*, Vol.20.
28. Jasan Ford,(1999). “Risk Sensitive Filtering and Parameter Estimation,” *Technical Report DSTO-TR-0764, DSTO Aeronautical and Maritime Research Laboratory, Melbourne, Australia*.
29. K.Rajendra Prasad, M.Srinivasan, T.Satya Savithri (2014). “Robust Fading Channel Estimation under Parameter and Process Noise Uncertainty with Risk Sensitive Filter and Its comparison with CRLB” *WSEAS transactions on communications*, Volume 13.



# An Energy Efficient Routing based on Route Segmentation in Mobile Ad Hoc Network

By M. Sunitha, Podili. V. S. Srinivas & Temberveni Venugopal

*CVR College of Engineering*

**Abstract-** Mobile Ad hoc networks based communication is one of an essential form of today's technologies which is highly effective in an emergency need. The feature of infrastructure independence makes it highly useful and versatile all kind of wireless communications needs. But the insufficiency of resources availability degrades its performance and stability of the network. Energy is the vital resource in MANET, as it makes a node to live and retain in-network for longer, which provide better network stability, scalability, and throughput. In this paper, we propose an energy efficient routing based on route segmentation mechanism (EER-RS) for energy saving in the high scalable network. It presents a lightweight route segments energy prediction algorithm to predicts the optimal energy efficiency path for data routing. We evaluate this mechanism in a high scalable network and the obtained results show an improvisation with 40 to 60 percent less energy consumption than traditional AODV and other compared protocol.

**Keywords:** AD hoc network, energy efficiency, route segmentation, scalability.

**GJCST-E Classification:** C.2.2, F.2.2



*Strictly as per the compliance and regulations of:*



RESEARCH | DIVERSITY | ETHICS

# An Energy Efficient Routing based on Route Segmentation in Mobile Ad Hoc Network

M. Sunitha <sup>α</sup>, Podili. V. S. Srinivas <sup>σ</sup> & Temberveni Venugopal <sup>ρ</sup>

**Abstract-** Mobile Ad hoc networks based communication is one of an essential form of today's technologies which is highly effective in an emergency need. The feature of infrastructure independence makes it highly useful and versatile all kind of wireless communications needs. But the insufficiency of resources availability degrades its performance and stability of the network. Energy is the vital resource in MANET, as it makes a node to live and retain in-network for longer, which provide better network stability, scalability, and throughput. In this paper, we propose an energy efficient routing based on route segmentation mechanism (EER-RS) for energy saving in the high scalable network. It presents a lightweight route segments energy prediction algorithm to predicts the optimal energy efficiency path for data routing. We evaluate this mechanism in a high scalable network and the obtained results show an improvisation with 40 to 60 percent less energy consumption than traditional AODV and other compared protocol.

**Keywords:** AD hoc network, energy efficiency, route segmentation, scalability.

## 1. INTRODUCTION

In the today's activities, rapid utilization of wireless communication is common. The availability of service like Wi-Fi, hotspots in public places makes it more efficient and scalable. These services are well stabilized for a fixed infrastructure based networks but in the case of a mobile ad hoc network (MANET), it is highly unstable due to its frequent changing network topology and absence of infrastructure. In MANET each node operates as routers to forward packets to other mobiles nodes which are in their transmission range. It creates a good amount of overload over the nodes and high and quicker energy loss. In a practical scenario, the batteries can be recharged or replaced but quicker exhaustion may lead to network partitioning due to poor connectivity range. To ensure a better energy efficient routing new routing mechanism is needed in a scalable environment.

MANET is a very dynamic and uncertain environment due to "frequent topology", "data traffic load", "bandwidth" and "energy resources" change often.

*Author α:* Department of Computer Science and Engg, CVR College of Engineering Hyderabad, Telangana-501510, India.  
e-mail: palemonisunitha@gmail.com

*Author σ:* Department of Computer Science and Engg, J.B Institute of Engineering and Technology, Hyderabad, Telangana-500075, India.  
e-mail: pvssrinivas@ieee.org

*Author ρ:* Department of Computer Science and Engg, JNTUHCES, Sultanpur, Medak, Telangana-502293, India.  
e-mail: t\_vgopal@rediffmail.com

On the other hand, possible routing information is undecided and deficient because of MANET dynamic and distributed organization. To make certain high-quality network performance, the routing protocol have to need to modify the routing strategy dynamically to account the transform in network situations. That is, the routing protocol for the MANET must adapt for different contexts such as mobility, traffic, energy utilization [1], [2], [3].

Routing at all times been one of MANET's key challenges and has become difficult as the size of the network grows. Various routing protocols for MANET have been proposed in [4], [5], [6], [7] and these protocols can be classified into dissimilar type according to diverse standard. Routing protocols can be cluster into "proactive" and "reactive" protocols if they are categorized in a manner that corresponds to network topology changes. The reactive routing protocol works well on small networks with hundreds of nodes. However, as the network develops due to "routing overhead" and "high energy consumption" its performance degrades rapidly. "Clusterhead-Gateway Switch Routing" (CGSR) [12] is a proactive routing protocol that separates the network into segments that are in rounded areas with a predefined number of hops. Later the network is partitioned into segments, the local route maintenance does without affects the adjacent segment, but the other segments are not affected. Therefore, scalability is achieved.

However, as the network develops, the path among the source and target node happen to longer. When a route is interrupted because of "node mobility" or "node failure", reactive routing protocols such as "DSR" and "AODV" normally reject the main complete route and start one more route discovery to create a fresh route from the source to the target node. If the path is broken, only have some hops are usually corrupted, but the previous hops are not corrupted. Therefore, this methodology desecrates knowledge of the unique route and can result in considerable overhead and energy loss in discovering the new route.

In DSR, the source route transmits in data packets can source of considerable overhead in large networks with longer routes. The "Internet draft of DSR" [8] describes that DSR is appropriate for "MANET up to 200 nodes". In "DSR" [8] and "AODV" [9], if a path is lost due to "node mobility or node failure", then the failure path is deleted and a new path is found from the source

to the target node. The "Scalability" and "performance" issues can arise in large networks. To defeat this problem in this paper, we propose an energy efficient routing solution based on route segment to support high scalability routing through effectively managing the energy consumption in route segments for active routes from source to the target node.

The following paper organized as follows. Related works are discussed in section-2, the proposed energy efficient routing based on route segment is presented in section-3, the experimental work and result in the analysis is presented in section-5 and section-6 presents the conclusion of the paper.

## II. RELATED WORKS

This section illustrates the main tasks associated with energy efficient routing in MANET. Developing energy efficient routes is a challenge in mobile ad-hoc networks. The existence of an active route depends on the lifetime of each individual node in that route. If all nodes in the path die due to energy shortage, the path between all target node pairs is considered an invalid path [17]. To overcome the problem, the routing protocol must recognize the "residual energy". Making sure of the proper use of network resources throughout routing is a difficult assignment which needs to address [11], [13], [21].

Much research has been completed in the previous years, and the authors have attempted to extend an energy-efficient path based on "load balancing" [14], [15], [16], [27]. To enhance network life span, a "cross-layer load balancing algorithm" for DSR (CLB-DSR) has been proposed to stabilize the load among the "data link layer" and "the network layer". "CLB-DSR" can exchange information among this layer to properly handle the load, thus minimizing network energy consumption [25], [26].

The author [18] tailored the original DSR protocol and proposed a "Power-Aware Dynamic Source Routing" approach. When the energy level of a node exceeds a predefined threshold, the node broadcasts an individual packet. These packets notify the neighbouring nodes that the initiating node is not competent of sending any new request messages for the lack of outstanding energy. Therefore, the neighbouring node does not forward the message to this node. The difficulty with this protocol is that the broadcast of this particular control packet gets through a large quantity of energy from the mobile node. In addition, the overhead of the network enhances as more nodes attempt to deliver such control packets over time.

J. Zhu et. al. [10] proposed an important proposal to create an "energy-efficient routing protocol" for mobile ad hoc networks known as "PEER". However, without watchful intend, energy efficient routing protocols can outperform conventional routing

protocols. In particular, energy-efficient routing protocols can result in significantly advanced control overhead and path setup delays as evidenced by simulation and can get through additional energy than a typical routing protocol in a mobile environment. The new link cost model allows for more accurate tracking of energy consumption and path maintenance issues related to path navigation and minimum energy routing protocols. "PEER protocol" with fast and small overhead path search and proficient path maintenance plan to reduce energy consumption in particular in a mobile environment.

J.E. Garcia et. al. [28] proposed ED-DSR is an energy-dependent DSR algorithm that prevents nodes from sharply dropping battery power consumption. ED-DSR provides better power usage compared to LEAR and MDR [7]. ED-DSR avoids the use of low-powered nodes and the outstanding energy information of the nodes is useful for path finding. The remaining battery power of every node is calculated by itself, and if it is higher than a certain threshold, the node cannot contribute in the routing activity. Otherwise, the node delays the rebroadcast of the "route request message" by a phase that is in reverse proportional to the expected duration.

Y. chen et. al. [29] proposed ECAODV, an "energy efficient routing protocol" that takes into relation the compactness of nodes affecting "energy consumption", valuable flooding mechanisms related to node steadiness and node remaining energy. "ALMEL-AODV" [30], "Alternate Link Maximum Energy Level The Ad-hoc On-Demand Distance Vector Routing Protocol" is also an enhancement of the existing "AODV routing" protocol. In this protocol, the residual energy sum of the nodes in the path acts as a metric for path selection. Highest energy path is opted for longer communication and network duration. The ESDSR ("Energy Saving Dynamic Source Routing") protocol is another modified DSR protocol for extending network life using two basic approaches to power consumption. One is the transmission power control method and the second is the load balancing method. The "Minimum Energy Dynamic Source Routing Protocol" (MEDSR) was one of the best attempts to make DSR an energy-aware routing protocol.

The above-mentioned routing protocols build up energy efficient routing in MANET using unexploited nodes with higher energy to balance the network load and thus reduce residual energy consumption [19], [20]. Finding high-energy nodes with "overhead" and "cross-layer load balancing" introduces an effective mechanism and necessitates additional overhead. Increasing the overhead of a critical baseline approach degrades network performance. To overwhelm this problem, we propose a mechanism to develop an energy efficient path among every source-target node pair that makes available a long life of network life by efficient and

effective use of node energy [22], [23]. Considering node energy and current queue state, the mechanism can apply "fuzzy-based rules" to expand the life of the node and develop a path that significantly improves network performance.

### III. ENERGY EFFICIENT ROUTING BASED ON ROUTE SEGMENTATION

The proposed energy efficient routing based on route segmentation (EER-RS) provides a scalable and energy saving routing model for MANETs. This maintains small route segments for the active routes. The functionality of route discovery of EER-RS is comparable to DSR where multiple routes are discovered to reach the target node, and the shortest and optimal route is used for routing. In the case of longer routing, the shortest route might have a few hops to reach the target node. These hops, when segmented into  $w$  node, makes  $v$  route segments. The process of construction segmentation is described below.

#### a) Route Segmentation Mechanism

The intention of segmenting route is to make EER-RS scale for the bigger network. The distribution of network in MANET is into regions based on the node ranges as shown in Fig.1. The two highlighted node in the figure makes a 2-hop segment. One can decide the number of hops based on the route hops length.

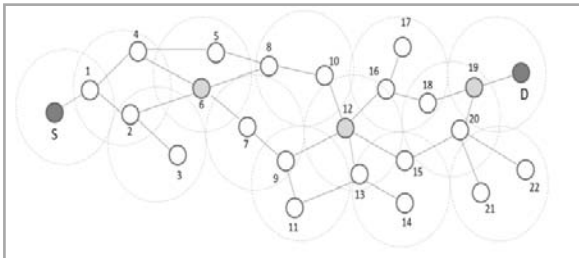


Figure 1: A general network with regions and 1-hop nodes

Let's consider a route discovery process of node S, identifies two prominent routes to reach D as shown below.

Route 1: S→1→4→6→8→10→12→16→18→19→D

Route 2: S→1→2→6→7→9→12→15→20→19→D

If the segment length,  $w=2$ , then each route will be divided  $w$  segments having a segment head which maintain the segment path to reach segment end node as shown in Table-1.

Table 1: Node Segment routes

S	6	12	19
1→4→6	8→10→12	16→18→19	D
1→2→6	7→9→12	15→20→19	

The advantage of these route segment supports in low energy utilization in maintenance in case of broken links. It can be present locally at the stage of a segment. Fixing a failure route within a segment broadens the life span of the route and accumulate energy through minimizing frequent route discoveries process. Thus, this mechanism will substantially help in reducing the routing overhead and energy consumption and improve the performance. Even varying segment length, we can support the adaptive routing scheme, which will be important for MANETs. Utilizing these segments we compute the minimum energy required to route data over it which will save the energy further.

#### b) Energy Saving Mechanism

Even though segmenting route save quite an amount of energy through minimizing routing overhead, but is essential to route data in an energy efficient route. As mention in Table-1 that each node in a route maintains its own segment path, eventually identifying the best energy sufficient path for routing can make the segment life longer and throughput efficiency can be achieved. To compute the energy level of each segment path we enhance the algorithm CMMBCR [24] ("Conditional Min-max Battery Capacity Routing") which recognize the routes that have an adequate left over energy of a battery and then choose the routes with lowest total transmission power.

Let's represent a routing structure by a graph  $V = (N, E)$ , where,  $N$  is "the set of nodes" and  $E$  is "the set of communication edges".

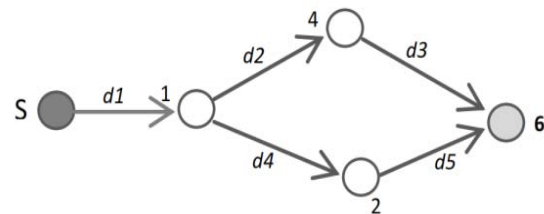


Figure 2: A graph model of node S to reach Node-6

Based on fig.2, the node S has to send a packet to N6, which has two paths to reach and the energy needed to send a message to each hopping node is directly comparative to the square of its distance. If the first path distance,  $p1$  have a distance is,  $p1=(d1+d2+d3)$  then the energy required for transmitting is,  $e1=(p1)^2$ . Since, node S also have another path for transmitting and its distance is,  $p2=(d1+d4+d5)$ , and its energy required is,  $e2=(p2)^2$ . In this case, if  $e1 \geq e2$  then, S transmit data through  $p2$  instead of  $p1$  to save energy.

The minimum energy,  $B$  required between nodes S to next node  $n$  to send the message can be computed using the equation-1 as follows,

$$B_{S \rightarrow n} = \tau d_{S,n}^{\alpha} \quad (1)$$



where,  $\tau d_{s,n}^{\delta}$  is compute the required energy transmission between two nodes, and  $\delta$  will be link loss exponent having minimum 2 and maximum 4, i.e.,  $2 \leq \delta \leq 4$ , it depends based on the communication medium feature[15]. In such case the total transmitting energy required by node S to transmit to N6 is given by,

$$B_{(S \rightarrow N1 \rightarrow N4 \rightarrow N6)} = B_{(S \rightarrow N1)} + B_{(N1 \rightarrow N4)} + B_{(N4 \rightarrow N6)} + (l \times \beta) \quad (2)$$

where,  $\beta$  is a constant amount of energy consumed by a receiver node, and  $l$  is the segment length excluding segment start and end node. A periodically monitoring of the node energy will be made after a configured time  $t$ , for each segment nodes to compute the remaining energy,  $B_{N1}(t)$  using the equation-3 as follows.

$$B_{N1}(t) = B_{N1} - (B_{Tx} + B_{Rx} + B_{Idle}) \quad (3)$$

where,

$B_{N1}$  - is the current battery energy status,

$B_{Tx}$  - total energy being consumed for transmitting packets,

$B_{Rx}$  - total energy being consumed for receiving packets,

$B_{Idle}$  - total energy being consumed being idle.

Using equation-2 and 3 we can compute required energy and available energy in the path segment based on this we can select the energy efficient segment to save the energy and route for longer.

#### c) EER-RS Based Routing Mechanism

In EER-RS, the nodes in the primarily discovered path are selected as segment end point based on the configured segment length. The advantage of the proposal is that when a node-link fails or a routing node moves out it does not discard the entire path, only the segment has to discover a new path to reach segment end. This provides a clear energy saving and low overhead performance. Based on functionality it routes the data packets in energy efficient route as described in Alogorithm-1 below.

---

#### **Algorithm-1: EER-RS Based Routing Algorithm**

---

##### **Inputs:**

$W(n) \rightarrow$  number of segments for nodes  $n$ .  
 $d_s \rightarrow$  segment end node.

//-- Before forwarding the packets

A source node S forwards a request packet

**for** each node  $n \neq d_s$  that have received Request packet **do**

    Compute remaining energy  $B_n(t)$ ;

$B_n(t) = B_n - (B_{Tx} + B_{Rx} + B_{Idle})$ ;

$B_n = B_n(t)$ ;

    Node  $n$  send a reply packet with  $B_n$ ;

**for end;**

//-- On receiving Reply packets

**for** each segment path  $p_i$  **do**

**for** each node  $n$  to destination node  $d_s$  **do**

        Compute energy efficient path,  $E(p_i)$ ,

$E(p_i) = \sum B_n$ ;

**for end;**

**for end;**

    Select the path having maximum  $E(p_i)$ ;

---

In the next section, we evaluate this work with varying different scale nodes.

## IV. EXPERIMENT EVALUATION

### a) Simulation Setup

We perform at widespread simulations to estimate the performance of EER-RS and contest with "DSR" [8], "AODV"[9] and "PEER"[10]. The simulation was executed over a scalable simulation background for wireless network structures. Traffic will be "constant bit rate" (CBR). The source and destinations of each "CBR

flow" arbitrarily opt for but not the same. Every flow does not transform the source and target node during the life span of the simulation execution. Every source transmits data packets at the rate of "4pkts/sec" having size "512bytes" each. A "random waypoint" mobility model is utilized with variation speed from "0 - 10 m/s" having a pause time of "30 seconds".

**Table 2:** Configuration Network Size and Nodes

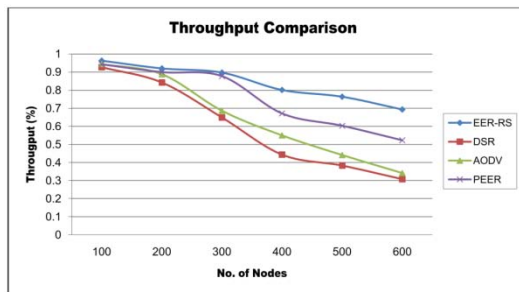
Network Size	Nodes
1000 m × 1000 m	100
1200 m × 1200 m	200
1300 m × 1300 m	300
1400 m × 1000 m	400
1500 m × 1500 m	500
1600 m × 1600 m	600

We perform six nodes sets simulations to assessment the performance of EER-RS varying the terrain area and nodes as shown in Table-2. The performance of EER-RS being studied with the varying number of nodes from "100 nodes to 500 nodes". The dimension and the area were certain so that the node compactness was remain something like invariable, which would appropriately imitate the scalability of routing protocols. For every performance measure, we calculated the results of EER-RS with "DSR", "AODV" and "PEER". The computed results are shown in below section.

#### b) Result and Analysis

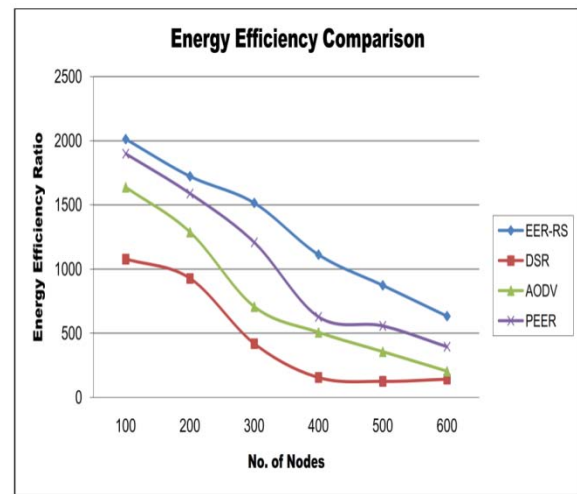
The simulation being performed with different nodes variation to assessment the performance of EER-RS in compared to DSR, AODV and PEER with respect to throughput, energy efficiency and routing overhead.

- **Throughput:** The throughput is measured based on the ratio of "the number of packets produced by the source" versus "the number of packets being delivered at the target node". The obtained results in Fig.3 shows the throughput comparison between DSR, AODV, PEER and EER-RS.

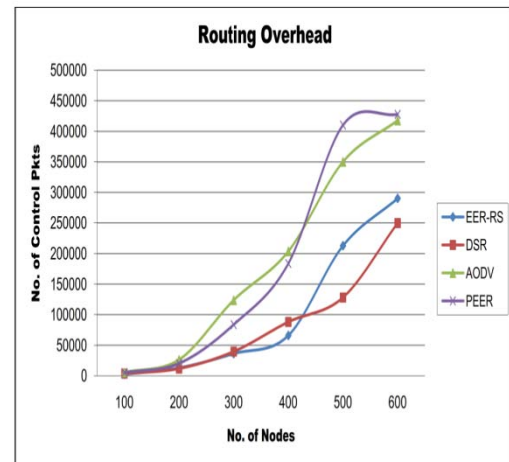
**Figure 3:** Throughput Comparison

- **Energy Efficiency:** It is defined as "total number of packets transmitted" / "total energy consumed". The higher the PE the better the energy efficiency will be considered. The comparison result is shown in Fig.4.

$$P_E = \frac{\sum(\text{REQ}_{Tx} + \text{REP}_{Tx} + \text{RERR}_{Tx} + \text{CTR}_{Tx} + \text{DP}_{Tx})}{\text{Total Energy Consumption}}$$

**Figure 4:** Energy Efficiency Comparison

- **Routing Overhead:** The "total number of control packets" being generated all through the simulation time. The comparison result is shown in Fig.5.

**Figure 5:** Routing Overhead Comparison

The main intention of the projected work is to reduce energy consumption and routing overhead, and also improve throughput. Fig.3 presents a promising improvement in throughput in compare to DSR, AODV, and PEER. The analysis shows that DSR and AODV cannot extend to networks away from a few hundred nodes but PEER shows a good performance up to certain scale but it also degrades with high number nodes. The EER-RS achieve nearly 20% better throughput in compare to PEER and nearly 40% in compare to DSR and AODV.

Fig.4 presents energy efficiency comparison between DSR, AODV, PEER and EER-RS. With increased number of nodes all shows falling off the efficiency, where DSR shows the lowest efficiency in comparing others. EER-RS shows an average of 20% efficiency improvisation in compare to others due to route segment based routing mechanism. Fig.5 presents routing overhead of EER-RS in compare with



DSR, AODV, and PEER, which shows drastically reduced since of the use of the segmented routing. But in the case of link loss between segment the node attained an additional overhead to rebuild the segment link. This creates a high routing overhead in compare to DSR, which can be crucial for EER-RS in the case of scale to large MANETs.

## V. CONCLUSION

In this work, we point an attention on improvising the energy efficiency routing for a reactive routing protocol. The approach presents three mechanism to describe the functionality of the proposal. It initially discusses the mechanism and its advantage of route segment creation. It divides a primarily discovered route to few hop segments to minimize the routing overhead and energy consumption. Next, we discuss the mechanism for energy saving routing in a route segment and compute the energy required between two nodes for data transmission based on hops distance and node battery energy status. Based on the computed energy level we find the energy efficient route between segment start and end node. This contributes an energy saving and longer lifetime of the node and network with low overhead. An experiment evaluation in varying number of nodes shows promising improvisation in throughput and energy efficiency with low overhead. In future, it can be evaluated in different mobility scenarios and also in traffic load which causes frequent link loss and congestion.

## REFERENCES RÉFÉRENCES REFERENCIAS

1. D. Choudhury, D. Kar, K. Roy Biswas, H. Nath Saha, Energy efficient routing in mobile ad-hoc networks, IEEE Computing and Communication (IEMCON), 2015.
2. R. Alubady, M. Al-Samman, A. Habbal, S. Hassan, S. Arif, Performance Analysis of Reactive and Proactive Routing Protocols in MANET, ARPN journal of engineering and applied sciences, vol. 10, no. 3, pp. 1819-6608, February 2015.
3. S. Sarkar, R., A secure and energy-efficient stochastic multipath routing for self-organized mobile ad hoc networks, Elsevier Ad Hoc Networks Vol-37, 209–227, 2016.
4. Meng, Yuan, Feng & Tan, Power adjusting algorithm: A new cross - layer power saving mechanism for mobile ad - hoc networks, Journal of Computer Science and Technology, vol. 28, no. 1, pp. 42 - 53, 2013.
5. M. I Channa , A. H Jalbani , P. K. Harani, A Survey of Power Aware Routing Schemes for Mobile Ad Hoc Networks, International Journal of Computer Applications 58(11):48-50, November 2012.
6. A. Sadat et. al, Reliable and energy efficient backup clustering scheme for wireless sensor networks, In Proc. of the International Conf. on Information Networking South Korea, 2010.
7. S. Gopinath, N. Sureshkumar, et. al, Energy Efficient Routing Protocol for MANET, IJCSI International Journal of Computer Science Issues, vol. 9, no. 2, March 2012.
8. D.B. Johnson, D.A. Maltz, and Y.-C. Hu, The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks (DSR), Internet draft, draft-ietf-manet-dsr-09.txt, Apr. 2003.
9. C.E. Perkins, E.M. Belding-Royer, and I.D. Chakeres, Ad Hoc On-Demand Distance Vector (AODV) Routing, IETF Internet draft, Oct. 2003.
10. Jinhua Z. and Xin Wang, Model and Protocol for Energy-Efficient Routing over Mobile Ad Hoc Networks, IEEE Transactions on Mobile Computing, Vol. 10, NO. 11, Nov. 2011.
11. S. Chettibi and S. Chikhi, Dynamic fuzzy logic and reinforcement learning for adaptive energy efficient routing in mobile ad-hoc network, Elsevier Applied Soft Computing, Vol-38, 321–328, 2016.
12. C.-C. Chiang, H.-K. Wu, W. Liu, and M. Gerla, Routing in Clustered Multihop Mobile Wireless Networks with Fading Channel, Proc. Singapore Int'l Conf. Networks (SICON'97), pp. 197-211, Apr. 1997.
13. Wei Sun, Z. Yang, X. Zhang, Yunhao Liu, Energy-Efficient Neighbor Discovery in Mobile Ad Hoc and Wireless Sensor Networks: A Survey, IEEE Communications Surveys & Tutorials, Vol. 16, No. 3, 2014.
14. R. Singh and S. Gupta, EE-AODV: Energy Efficient AODV routing protocol by Optimizing route selection process, International Journal of Research in Computer and Comm. Technology, vol. 3, no. 1, January 2014.
15. Q. Cui et al., Optimal Energy-Efficient Relay Deployment for the Bidirectional Relay Transmission Schemes, IEEE Trans. Veh. Technology, vol. 63, no. 6, pp. 2625-2641, July 2014.
16. Y. Li et al., Multiple mobile data offloading through disruption tolerant networks, IEEE Transaction Mobile Computing, vol. 13, no. 7, pp. 1579–1596, Jul. 2013.
17. D. Chen, H. Ji and X. Li, An Energy-Efficient Distributed Relay Selection and Power Allocation Optimization Scheme over Wireless Cooperative Networks, IEEE Int. Conf. Commun., Kyoto, Japan, June 5-9, pp. 1-5, 2011.
18. H. Jun, M. H. Ammar, M. D. Corner, and E. W. Zegura, Hierarchical power management in disruption tolerant networks using traffic-aware optimization, Elsevier Computer Commun., vol. 32, no. 16, pp. 1710– 1723, 2009.
19. K. Sreekanth and S. Sarfaraj, A survey on neighbor discovery in asynchronous wireless sensor network, Int. J. of Advanced Research in Computer Science

- and Software Engineering, vol. 2, no. 9, pp. 265–269, 2012.
20. J. He, S. Ji, Y. Pan, and Y. Li, Reliable and energy efficient target coverage for wireless sensor networks, *Tsinghua Science and Technology*, vol. 16, no. 5, pp. 464–474, 2011.
  21. G.Y. Li et al., Energy-Efficient Wireless Communications: Tutorial, Survey, and Open Issues, *IEEE Wireless Commun.*, vol. 18, no. 6, pp. 28–35, Dec. 2011.
  22. Y. Tao and Wei Luo, Modified Energy-Aware DSR Routing for Ad hoc Network, *International Conference on Wireless Communications, Networking and Mobile Computing*, 2007. *WiCom*, pp: 1601–1603, 2007.
  23. Saurabh J, S. Trivedi, V. Shah, Energy Efficient Ad-hoc on-demand Distance Vector Routing Protocol (EE-AODV) for Mobile Ad-hoc Network, *International Journal of Innovative Research & Development*, Vol 3 Issue 4, April 2014.
  24. C.K. Toh, H. Cobb, and D. Scott, Performance Evaluation of Battery-Life-Aware Routing Schemes for Wireless Ad Hoc Networks, *Proc. IEEE Int'l Conf. Comm. (ICC '01)*, June 2001.
  25. Yu Wang, Xiang-Yang Li, Wen-Zhan Song, Minsu Huang, and Teresa A. Dahlberg, Energy-Efficient Localized Routing in Random Multihop Wireless Networks, *IEEE Transactions On Parallel And Distributed Systems*, Vol. 22, No. 8, August 2011.
  26. J. Zhu, C. Qiao, and X. Wang, On Accurate Energy Consumption Model for Wireless Ad-Hoc Networks, *IEEE Trans. Wireless Comm.*, vol. 5, no. 11, pp. 3077–3086, Nov. 2006.
  27. M.R. Pearlman, Z.J. Haas, P. Sholander, and S.S. Tabrizi, On the Impact of Alternate Path Routing for Load Balancing in Mobile Ad Hoc Networks, *Proc. MobiHoc '00*, pp. 3–10, 2000.
  28. J.E. Garcia, A. Kallel, K. Kyamakya, K. Jobmann, J.-C. Cano and P. Manzoni, A Novel DSR-based Energy-efficient Routing Algorithm for Mobile Ad-hoc Networks, *IEEE in vehicular technology conference*, 2003.
  29. Yonghui chen, C. zhang and Z. liu, Energy Efficient Routing Protocol Based on Energy of node and Stability of Topology, In 3<sup>rd</sup> International conference on Information and computing 2010.
  30. Tai Hieng Tie, Chong Eng Tan and Sei Ping Lau, Alternate Link Maximum Energy Level Ad-hoc Distance Vector Scheme for Energy Efficient Ad-hoc Networks Routing, In *International Conference on Computer and Comm. Eng. (ICCCE 2010)*, Malaysia, 11–13 may, 2010.



This page is intentionally left blank



GLOBAL JOURNAL OF COMPUTER SCIENCE AND TECHNOLOGY: E  
NETWORK, WEB & SECURITY  
Volume 17 Issue 2 Version 1.0 Year 2017  
Type: Double Blind Peer Reviewed International Research Journal  
Publisher: Global Journals Inc. (USA)  
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

# Dynamic and Channel Adaptive Error Control Scheme in Wireless Sensor Networks

By Mallanagouda Patil & Rajashekhar C. Biradar

*Reva University*

**Abstract-** The application of wireless technology is increasingly influencing the deployment of sensor networks at low cost and maintainance in all walks of life. Poor channel conditions, severe power constraints, fading, interference and the low power communication requirements magnify the need for energy efficient and preferably cross layer error control schemes in Wireless Sensor Networks (WSNs). The main goal of error control mechanisms in WSNs is to reduce the energy expenditure while taking care of reliable and fast delivery of the sensed data. In this paper, we propose a 'Dynamic and Channel Adaptive Error Control Scheme in Wireless Sensor Networks' (DCAECS) that estimates the channel errors and controls errors dynamically based on channel characteristics and noise power observed at the receiver. This motivates the error control strategy to vary as the channel conditions change in terms of noise level. In this paper, we have come up with the models for both the error and channel estimation. Analysis and simulation results for various message sizes and error conditions show that there is an improvement in terms of throughput, BER and the probability of retransmission as compared to 'ARQ Scheme With Adaptive Error Control' (ASAEC).

**Keywords:** ARQ, BER, error control, energy efficiency.

**GJCST-E Classification:** B.4.2, C.2.5



*Strictly as per the compliance and regulations of:*



# Dynamic and Channel Adaptive Error Control Scheme in Wireless Sensor Networks

Mallanagouda Patil <sup>α</sup> & Rajashekhar C. Biradar <sup>σ</sup>

**Abstract-** The application of wireless technology is increasingly influencing the deployment of sensor networks at low cost and maintainance in all walks of life. Poor channel conditions, severe power constraints, fading, interference and the low power communication requirements magnify the need for energy efficient and preferably cross layer error control schemes in Wireless Sensor Networks (WSNs). The main goal of error control mechanisms in WSNs is to reduce the energy expenditure while taking care of reliable and fast delivery of the sensed data. In this paper, we propose a 'Dynamic and Channel Adaptive Error Control Scheme in Wireless Sensor Networks' (DCAECS) that estimates the channel errors and controls errors dynamically based on channel characteristics and noise power observed at the receiver. This motivates the error control strategy to vary as the channel conditions change in terms of noise level. In this paper, we have come up with the models for both the error and channel estimation. Analysis and simulation results for various message sizes and error conditions show that there is an improvement in terms of throughput, BER and the probability of retransmission as compared to 'ARQ Scheme With Adaptive Error Control' (ASAECS).

**Keywords:** ARQ, BER, error control, energy efficiency.

## 1. INTRODUCTION

Because of a high bit error rate (BER) in wireless link due to attenuation, multipath fading and noise, data can be corrupted during transmission. To handle the errors, reduce energy consumption (especially in case of retransmissions) and to maintain the required quality of service (QoS), an impressive and efficient error control scheme is necessary. The system with error control scheme provides better BER performance relative to others for the same signal to noise ratio (SNR). The goal of an error control system is to determine the perfect output parameters (e.g. retransmission limit) given the input parameters (e.g. BER). The error control mechanisms should trade off complexity, buffering requirements and energy requirements (taking into account the required energy for both processing and communication) for the throughput and delay. However, it is usually impossible to provide a very high degree of error correction as some left over errors pass through [1].

Generally, the wireless channel is considered to be such that the samples of an additive noise are added to the modulated symbols and these noise samples are

not related to the source. This model is comparatively straightforward to prove mathematically and comprises additive white Gaussian noise (AWGN) channels, flat Rayleigh fading channels and binary symmetric channels (BSC). In classical error correction and control (ECC) theory, the combination of modulation, noisy medium and demodulation is modeled as a discrete memoryless channel such as BSC that recognizes only a finite number of distinct signals. It is called memoryless because the probability of an error is assumed to be unrelated to all the occurrences of earlier errors. The binary transmission over an AWGN channel is modeled as BSC. The BSC channel is symmetric because the probability of receiving 1 when 0 is sent (i.e.  $P(1 | 0)$ ) is same as the probability of receiving 0 when 1 is sent (i.e.  $P(0 | 1)$ ). The BSC is defined by the parameter  $P_e$ , the probability of error where  $P(0 | 1) = P(1 | 0) = P_e$  and  $P(0 | 0) = P(1 | 1) = 1 - P_e$ . Error control system should balance among the added redundancy, BER and the energy expenditure. However, error control is not a layer centric issue and can be conceived in any layer of the protocol stack. As retransmissions and coding consume significant amount of energy, it is essential to go for energy efficient error control schemes at the same time maintaining the required QoS. In WSNs, sensor nodes are essentially battery-powered and should operate without being attended for a relatively long time. In such cases, it is very difficult and even impossible to change or recharge batteries of sensor nodes [2].

Error control in WSN can broadly be achieved by Automatic Repeat Request (ARQ), Forward Error Correction (FEC), or a mixture of both i.e Hybrid ARQ (HARQ). In ARQ, if the packet is erroneous or lost, it is retransmitted until it is received to be error free. The error detection is usually realized through a cyclic redundancy check (CRC) code before retransmission. ARQ mechanism is used in both data link and higher layers (such as transport and application layers). The ARQ scheme uses positive acknowledgment (ACK) or negative acknowledgment (NACK) for expected or unexpected reception respectively. The transmitter would retransmit if it has not collected ACK within expiry time [3]. ARQ handles the issue of duplicate packets by maintaining sequence numbers for each packet. While ARQ is a straightforward applicable mechanism to avoid packet errors, it has noticeable limitations such as the retransmissions (that lead to an increase in energy

**Author α:** Department of CSE, BNM Institute of Technology Bangalore-560 070, India. e-mail: mail mp2004@yahoo.com

**Author σ:** School of ECE, Reva University Bangalore-560 064, India. e-mail: raj.biradar@revainstitution.org



expenditure) and delay that are unacceptable for the time critical applications. ARQ schemes are typically used in data networks where reliability of received packet is of foremost relevance than latency. ARQ is occasionally used with Global System for Mobile (GSM) communication to ensure data integrity. Although, ARQ provides an unfailing transmissions, it would be costly in poor channels where retransmissions cannot be avoided. FEC performs better in this case, but the extra bits prove to be expensive even when channel conditions are better. Redundancy is defined as the ratio of redundant bits to data bits i.e.  $r/d$  where  $r$  is the number of redundant bits and  $d$  is the number of data bits. HARQ schemes exploit the advantages of both FEC and ARQ [4] where sender transmits an encoded packet which is retransmitted if the destination was unable to correct errors.

ARQ scheme can be used to provide with an assured QoS by persistent retransmissions until the data is successfully delivered. However, the performance of ARQ is closely associated with the channel conditions and probability of collisions. If the medium is in good condition and fairly loaded, then the retransmissions are rarely needed and ARQ can improve successful data delivery ratio. On the other hand, the delay, packet drop ratio and energy expenditure per successfully transmitted packet can rise to an unacceptable levels, especially for bound real delay time applications [5]. The idea behind the FEC mechanism is to avoid retransmission of the entire data packet in case of partial errors by including some extra bits in the packet. At the destination, this redundancy is then used to recover from errors. FEC is useful for one way channels where receiver does not have the privilege to request retransmission if an error was detected. FEC codes can be preferred for delay-sensitive traffic in WSNs. Also, the FEC coding algorithm must be simple and featherweight since sensor nodes are armed with very low clock rate processors [5]. In FEC, the energy required for encoding is negligible compared to that for decoding. The main limitation of FEC is the cost of extra bits that increase the packet size. Additionally FEC brings up encoding and decoding costs. Therefore FEC is mainly used in situations where retransmissions are comparatively expensive. Both ARQ and FEC are probabilistic ways and there is no deterministic way to guarantee the reliable transmission. ARQ is better for small frames and FEC for larger frames.

#### a) *Related Works*

Many researchers tried to resolve the issues at physical and MAC layers in WSNs in the past. The work proposed in [6] compares and analyzes energy models and modulation schemes in WSNs. The metrics used in performance evaluation are energy consumption, throughput, average jitter and end to end delay. Both Mica-mote and Mica-Z energy models perform better

with Amplitude Shift Keying (ASK) and Quadrature Phase Shift Keying (QPSK) but Binary Phase Shift Keying (BPSK) requires higher energy. The choice of modulation / demodulation techniques, filtering techniques, and frequency bands equally affect the energy consumption in WSNs. In the work [7], the researchers estimate the expected duration in which the quality of a specific link remains stable using the conditional distribution function of SNR of the received acknowledgment packets. This approach resulted in high packet delivery compared with the case where packets were transmitted without the knowledge of link quality fluctuations.

The researchers in [8], discuss the limitations of applying FEC codes in industrial WSNs based on the lack of access to the PHY layer, the limited memory resource and the delay requirements. In order to examine the likeliness of employing FEC codes in existing wireless sensor nodes, the researchers benchmark different types of FEC codes with the software implementation in terms of memory consumption and processing time. Evaluation results exhibit that low density parity check (LDPC) and Turbo codes as the state of the art FEC codes and are overwhelming to the wireless sensor nodes and fail to fulfill both memory and timing requirements. Repetition and Hamming codes can be considered due to the simplicity, but still not able to give the most satisfying performance. The RS (15, 11) code is the most suitable FEC code among all the candidates with decent memory footprint and fast processing time.

The work proposed in [9], does a comprehensive performance evaluation of ARQ, FEC, Erasure Coding (EC), linklayer hybrid FEC/ARQ, and cross-layer hybrid error control schemes over Wireless Multimedia Sensor Network (WMSNs) is performed. Performance metrics such as energy efficiency, frame Peak Signal-to-Noise Ratio (PSNR), frame loss rate, cumulative jitter, and delay-constrained PSNR are investigated. The results of analysis show how wireless channel errors can affect the performance of multimedia sensor networks and how different error control scenarios can be effective for those networks. The results also provide the required insights for efficient design of error control protocols in multimedia communications over WSNs.

In [10], the researchers proposed an analytical energy efficiency model using adaptive error correction code (AECC) in wireless sensor networks in fading environments. To adapt energy efficiency of sensor node to channel variations, the packet length is tuned at the data link layer. The analysis is based on Mica2 sensor node where a look-up table of distance and correction code is adaptive installed in the node. Based on channel conditions, the sender can adjust the adequate BCH code required for the next transmission. The numerical results show that the AECC scheme can



greatly improve the energy efficiency for the lengthy and under different message sizes over Rayleigh fading channel.

The researchers in [11], analyze FEC code based on CRC and adaptive Multiple Input Multiple Output (MIMO) approach. The mathematical analysis and simulation results show that the proposed transmission control scheme performs better in terms of throughput, reliability, latency and energy efficiency compared to the FEC and MIMO approaches considered alone. In [12], the researchers have focussed on the energy efficiency of particular error control codes (ECC) in WSNs with the outcome that coding saves energy for short distances, but larger packet size results into stretched radio on time. Only the energy spent in encoding and decoding schemes is acknowledged. The researchers in [13], check out the energy spent for three different ECCs but only for precise platforms. Researchers in [14], have tried to resolve some of the MAC layer issues based on the combination of parameters such as message length, node energy and number of requests. Results analysis shows an improved performance in energy efficiency, optimal message length and throughput.

The work mentioned in [15] presents an analysis of error control schemes in WSNs where ARQ, FEC, and HARQ are contrasted in terms of energy expenditure, delay, and packet error rate (PER). Here, the researchers proposed a technique called hop length expansion, where the reduced PER could be ventured by providing lengthy hops leading to fewer hops for a transmitted packet to reach its destination. In turn fewer hops would lead to increased energy efficiency and lower delay. But the lengthy hops affect the transmission power of radio.

In [16], researchers analyse convolutional codes and consider the cost of decoder at the destination side and not the sum of computation cost, that rises with bigger packets in terms of energy expenditure. Researchers in their work [17] prove mathematically and from the simulation results that the energy skilfulness of ARQ scheme does not rely on the no of retransmissions. Researchers in [18], study Turbo codes in WSN and use parallel concatenated convolutional code circuit for encoding at source while the repetitious decoding is performed at the sink. Simulation tests performed for various SNRs, show progress in bit error rate and frame error rate.

In [19], researchers correlate energy expenditure and error correction capacity of Reed-Solomon, and Hermitian codes. They inspect encoding in the initial node and competent decoding at the destination to conserve energy at relay nodes. The work proposed in [20] discusses convolution codes with changing rates to evaluate their energy expenditure in slow Rayleigh fading medium. Larger length of code incomparably reduces transmit power but the

consumption of energy also increases exponentially with the increase in constraint length of the code. Encoding consumes slight amount of energy while decoding consumes significant amount of energy. In [21], different error control techniques are considered, but the investigation is focused on the question of optimal packet size for WSNs.

In [22], the researchers applied the double binary convolutional turbo code to the 21451-5 architecture. To reduce the computational load in the turbo code decoder, a low complexity decoding solution has been proposed. At BER of  $10^{-5}$ , noise power of the proposed decoding scheme is reduced compared to the Log-MAP algorithm. The complexity of the compare, the shifting and the addition operations have reduced by 15.8%, 86.84% and 73.7% respectively. The proposed solution is a suitable error correction scheme with low decoding complexity that can be adopted.

We observe that all the research works mentioned above concentrate mainly on error control schemes for a fixed and static environment and do not consider the varying channel error conditions. Therefore, we propose a channel adaptive error control scheme based on the changing channel conditions with respect to noise and error rate. Our approach is compared with 'ARQ Scheme With Adaptive Error Control' (ASAEC) [23] that discusses about an adaptive ARQ scheme as the channel state varies.

#### b) *Our Contributions*

In our previous work, 'Priority based Slot Allocation for media access in Wireless Sensor Networks' (PSAWSN), the probability based priority scheme is used to allocate slots to competing nodes [24]. Limitations of this work are: 1) PSAWSN does not handle the dynamic and variable slot allocation based on the varying requirements from the nodes. 2) Error and flow control are not taken into account. 3) Effect of channel conditions on transmission quality, is not handled. To overcome some of these limitations, we propose a Dynamic and Channel Adaptive Error Control Scheme in Wireless Sensor Networks () that estimates the channel condition and controls the errors dynamically based on channel errors and noise power observed at the receiver. This allows error control strategy to vary depending on the channel conditions. Models have been designed for both the error and channel estimation. Analysis and simulation results for various message sizes and error conditions show that there is a performance improvement in terms of throughput and probability of retransmission compared to ASAEC.

#### c) *Channel adaptive model using Markov chain*

A larger BER in the channel can lead to a high retransmission rate costing additional energy consumption. On the other hand, even for good channel conditions, the retransmission rate increases

tremendously if there are more number of receivers. Choosing a fixed error control scheme may result in wastage of bandwidth during the normal behavior of the channel. That means the channel adaptive scheme that changes operating modes based on the error conditions and estimated noise in the channel, is required. Channel adaptive means formulating the error control strategies based on the error conditions prevailing in the channel.

The channel adaptive error control schemes are required for reliable transmission and maintenance of the given QoS requirements. These error control schemes need to estimate the channel conditions in order to adjust the parameters dynamically based on the optimization criteria. The Markov chain can be used to estimate the wireless channel error conditions as the use of such a model lies on its ability to capture the burstiness of the error process as well as to predict the future states of the channel based on its present state. That means, in order to track channel variations closely, reliable estimation of the channel state information should be carried out before applying the error correction mechanisms. The noise in the channel is measured in terms of signal to noise ratio (SNR) and through the estimated SNR of the channel, the required BER can be computed.

Usually, the received signal can no longer be modeled as a deterministic signal in white Gaussian noise (WGN). Instead, it should be considered as a function of either the state of a Markov chain or of its state transition probability with known parameters observed in the WGN. Markov chain is a special kind of stochastic process where the outcome of an experiment depends only on the present state not on the preceding states. Markov chain is defined as the process with

discrete set of states and can be observed when it passes through a BSC. It is a stochastic model describing the sequence of possible events in which the outcome of a given experiment can affect the outcome of the next experiment. In other words, future is independent of the past given the present. Apart from digital communications, Markov chain finds its applications in detection problems where the observed signal is a function of the states or transitions of a Markov chain.

As shown in the figure 1, channel condition is estimated and the derived BER is divided into three ranges: lower, middle and higher. Depending on the BER range, error control scheme uses three modes to handle the errors. All the three modes are detailed in the figure. We have assumed low range of BER is from  $10^{-9}$  to  $10^{-12}$ , mid range from  $10^{-6}$  to  $10^{-8}$  and high range from  $10^{-3}$  to  $10^{-5}$ . For the low range, simple error control scheme without retransmission is used. For the middle range, error control scheme with retransmission is employed and for the high range, the error control is left to the upper layer. As BER depends on the SNR, its requirement is different for different services and systems. For instance, wireless link BER is less than  $10^{-6}$  while optical BER is less than  $10^{-12}$ . On optical fiber link, the average BER is approximately  $10^{-9}$  where as on a coaxial cable, the probability of bit errors is around  $10^{-6}$ . For a switched telephone line, these numbers are even higher between  $10^{-4}$  and  $10^{-5}$ . Digitized voice can tolerate bit errors as high as 1 bit per thousand bits sent i.e  $10^{-3}$ . Computer data requires a BER of  $10^{-6}$  to  $10^{-12}$  (i.e. 1 per million to 1 per trillion) depending on the content.

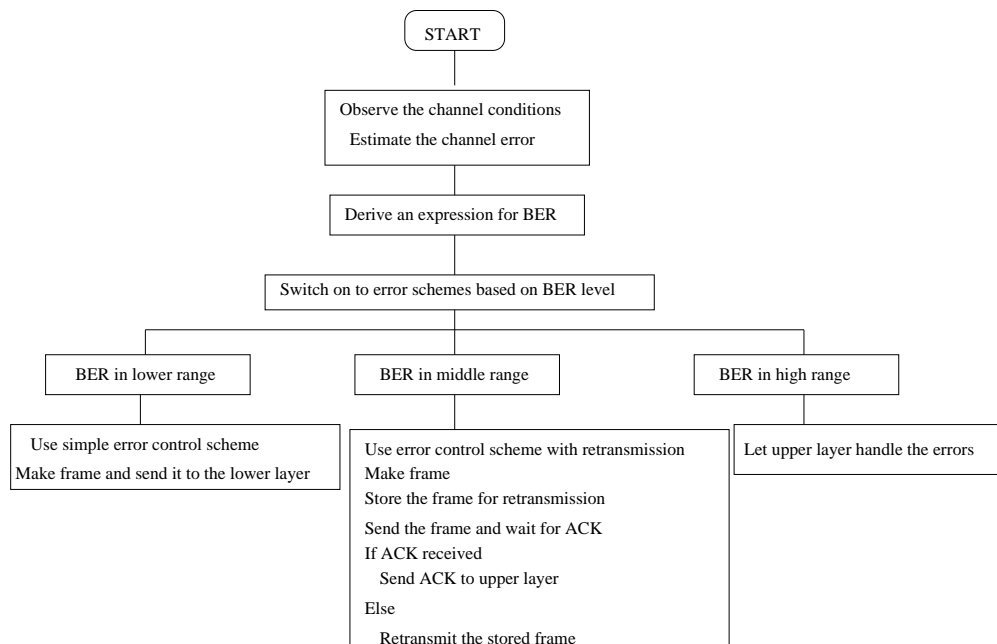


Figure 1: Channel adaptive error control scheme

i. *Markov chain model*

The Markov process starts in one of the states and moves successively from one state to another where each move is called a step. If the system currently in state  $S_i$ , moves to state  $S_j$  at the next step with a probability  $P_{ij}$ , then this probability does not depend on the states the system was in before the current state. The probability  $P_{ij}$  is called the transition probability. As shown in the figure 2, the probability  $p_j(n) = P(X_n = j)$  is

the probability of the system to reach state  $j$  in  $n$  steps. Similarly, the probability  $p_{ij}(m+n)$  is the probability of going from state  $i$  to  $j$  in  $(m+n)$  steps and is expressed in equation 1

$$p_{ij}(m+n) = \sum_{k=1}^s p_{ik}(m)p_{kj}(n) \quad (1)$$

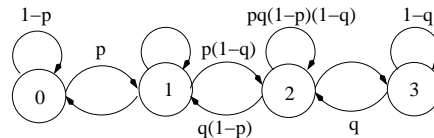


Figure 2: Markov chain with transition probabilities

where  $s$  is the number of states in the Markov chain and  $p$  is the transition probability from current to next state where as  $(1-p)$  is the probability to remain in the same state. Using these transition probabilities, one can establish an asymptotic formula for the capacity of a BSC as the noise parameter tends to zero. To capture the bursty nature of wireless networks, Markov chains have been extensively used to model the error sequences generated by a wireless channel where a

BSC is associated with each state. The Markov chain provides a good approximation of the error process in fading channels. Here, the Markov state and transition probabilities between the states are assumed. As shown in the figure 3, the probability  $p_j(n) = P(X_n = j)$  is the probability of the system to reach state  $j$  in  $n$  steps. For instance,  $p_2(1) = P(X_1 = 2)$  is the probability to reach state 2 from state 1 in one step.

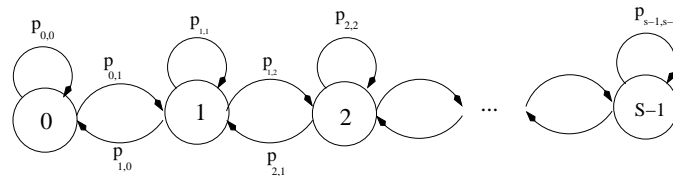


Figure 3: Markov chain representation of errors

The channel states associated with consecutive symbols are assumed to be the neighboring states for a slow fading channel where the SNR varies slowly as the symbol interval  $T$  increases. Each state describes the SNR level received as the interval  $T$  increases. In order to estimate the errors, we need to find out the expression for BER in terms of SNR using the standard deviation and mean. To estimate the BER, the system should move from one state to another in both the directions from good to bad and vice versa. The type of random noise in a communication system that determines the BER of a circuit is the thermal noise which can well be described by additive white Gaussian (AWG) noise across a narrow frequency band. Even though it is possible to have other types of noise from the interfering signals that combine with thermal noise in the final BER, the type of noise addressed here is purely Gaussian.

Because of the AWGN assumption, each noise source can be described by a single temperature. These temperatures are additive in nature so that the total noise energy,  $N_{total}$  in the system can be expressed as in the equation 2

$$N_{total} = C_b \times T_{total} \quad (2)$$

where  $C_b$  is Boltzmann's constant and  $T_{total}$  is the system noise temperature in Kelvin. Note that  $T_{total}$  is the sum of all the individual noise temperatures in the system normalized by the previous gains in the system. The Gaussian distribution provides with the probability to detect an observed value given the mean and the standard deviation of the measurement. To know the probability of a signal being misinterpreted (or in error) by the system, one just needs to know the number of standard deviations that is added or subtracted from the average signal level so that the signal can cross the threshold value. Then this number of standard deviations is related to the probability,  $(P)$  of an error occurring, using the Gaussian function as shown in equation 3

$$P = C \times Q(x) \quad (3)$$

where  $C$  is a constant that depends on the modulation and coding techniques used,  $x$  is the number of standard deviations of the detection level away from the mean signal level, and  $Q(x)$  (called the  $Q$  function) is the tail probability of the standard Normal distribution. In other words,  $Q(x)$  is the probability that a normal (Gaussian) random variable obtains a value larger than  $x$  standard deviations above the mean. This function is

used to evaluate the error probability of transmission systems that are affected by the AWGN.  $Q(x)$  is defined in terms of error function (er f) in equation 4

$$Q(x) = \frac{1}{2}[1 - \text{erf}(x/\sqrt{2})] \quad (4)$$

where the error function, er f is expressed as in the equation 5

$$\text{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt \quad (5)$$

The er f (x) also called the Normal distribution or the Gaussian error function is a special function of sigmoid shape that occurs in probability, statistics, and partial differential equations describing the diffusion. It is the cumulative distribution function (cdf) of Normal distribution with mean =0 and standard deviation =1. The signal Energy per bit divided by the Spectral noise density (Eb/N0) within the frequency band of measurement time (the time period of the bit), is a function of x. This ratio can be expressed as: Eb/N0 = Bx2 where B is a constant that depends on the modulation and coding schemes used.

The probability of bit error is proportional to er f c(Eb/N0) where erfc is a complementary error function defined as (1-er f). As the argument of er f c() increases, the probability of error also increases. Thus it is very important to have either high Eb or low N0 for good quality reception. Hence Eb/N0 is of the great importance and all BER and Symbol Error Rate (SER) curves are plotted against Eb/N0 for different forms of modulations such as BPSK, QPSK, and QAM, etc. These curves show the best performance that can be achieved across a digital link with a given amount of RF power and noise level in the system. Here, we have assumed BPSK modulation as it is the most robust of all the PSKs since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision. Since the number of bits for BPSK modulation is always one, the notations symbol energy (Es) and bit energy (Eb) can be used interchangeably.

For BPSK, since Es=Eb, the probability of symbol error (Ps) and the probability of bit error (Pb) are the same. Therefore, expressing the Pb and Ps in terms of Q function and er f c, we will get the equation 6.

$$P_b = P_s = Q[\sqrt{2E_b/N_0}] = \frac{1}{2}\text{erfc}[\sqrt{(E_b/N_0)}] \quad (6)$$

It can be easily recognized that Pb is the BER or equivalently the SER for the optimum BPSK modulator. This is the best possible error performance that any BPSK modulator-demodulator can achieve in the presence of AWGN.

Let  $0 = \text{SNRF}_0 < \text{SNRF}_1 < \text{SNRF}_2 < \dots < \text{SNRF}_n - 1 = \infty$  be the thresholds of the received SNR or fading at the states  $S_0, S_1, S_2 \dots S_{n-1}$ . The channel is said to be in the state S where  $S \in 0, 1, 2, 3, \dots, S-1$  if the

received SNR is in the interval SNRFs and SNRFs+1. Associated with each state, there is a BSC with along with respective error probability. The Rayleigh fading results in exponentially distributed distortion of the received signal (SNRF) and the probability density function (pdf) of the SNRF, i.e. F(SNRF) which is given in the equation 7

$$F(\text{SNRF}) = \frac{1}{\text{SNRF}} \exp[-\text{SNRF}/\text{SNRF}] \quad (7)$$

where SNRF is the average received SNR or fading and  $\text{SNRF} > 0$ . Assuming BPSK modulation, the expression for SNRF is given in the equation 8

$$\text{SNRF} = a^2 \times \text{SNR} \quad (8)$$

where a is the magnitude of the fading coefficient or amplitude. By using Q, a and SNR, the expression for BER is given in the equation 9

$$\text{BER} = Q \times \sqrt{a^2 \times \text{SNR}} = Q \times \sqrt{\text{SNRF}} \quad (9)$$

To find the average BER, we need to compute the average with respect to the distribution of a i.e.  $F_A(a) = 2ae^{-a^2}$  where  $F_A(a)$  is the analytical pdf of the fading amplitude. Therefore, the average BER over the limits 0 to  $\infty$ , can be expressed as given in the equation 10

$$\text{BER} = \int_0^\infty Q \times \sqrt{a^2 \times \text{SNR}} \times F_A(a) da \quad (10)$$

After solving the equation 10, we will get an expression for the average BER in terms of SNR as shown in the equation 11

$$\text{BER} = \frac{1}{2}[1 - \sqrt{\text{SNR}/(2 + \text{SNR})}] \quad (11)$$

The detailed procedure for the derivation of BER for BPSK, is given in the algorithm 1. Next subsection describes the BER error model by using the Binomial distribution.

## ii. Error Model

The number of errors in a message of length n bits, confirm to the Binomial distribution with n Bernoulli trials and probability of success as the BER (note that an error is being treated here as 'success'). So the errors in the communication networks (BER) can be modeled by using the Binomial distribution. The Binomial distribution models the number of 'successes' in a number of independent Bernoulli trials where each trial occurs with one of two outcomes: success or failure. The Binomial distribution is best suitable to model the BER as the number of bit errors can be represented by the number of successes. Similarly the number of bits in the codeword can be represented by the number of Bernoulli trials conducted. Thus, the number of bit errors in the codeword can be modeled as the events that are 'successes' and the other correctly received bits (in the codeword) as 'failures'. The number

of bits in the codeword can be considered as the the number of Bernoulli trials that can be either success (errors) or failure (without errors). In general, we can write the formula for finding the probability of getting k number of errors out of n total bits of data sent as shown in equation 12.

$$P_{tot} = \binom{n}{k} [BER^k (1 - BER)^{n-k}] \quad (12)$$

As shown within the square brackets in equation 12, there is a computation of probability of occurrence of exactly k bit errors in an n bit codeword. This means that we want the probability of getting k errors with (n-k) bits (received without errors) because the probability of getting an error is actually one minus the probability of getting no error. The  $\binom{n}{k}$  part is the Binomial coefficient that indicates the total number of possible ways by which one can get k errors out of n bits of the codeword.

For a BSC channel with bit error probability BER, the packet error rate (PER) is given by equation 13

$$PER = 1 - (1 - BER)^L \quad (13)$$

where L is the message length in bits. The probability that m out of n packets need retransmission is expressed in the equation 14

$$P_{RTx} = \binom{n}{m} [PER^m (1 - PER)^{n-m}] \quad (14)$$

#### d) Algorithms

Algorithm 1 explains the steps involved in estimating the channel condition in terms of errors and derives an expression for BER. Based on the level of this BER, appropriate operating modes become active to control the errors. These operating modes are detailed in the algorithm 2. The algorithm 3 details the steps at the receiver after receiving the frame from the sender.

---

#### Algorithm 1 Channel Error Estimation Algorithm

---

- 1: Use Markov model to estimate SNR and BER at each state of the system.
  - 2: **for** each  $S_i$  in steps of 1 **AND**  $i = 0, i \leq n$  **do**
  - 3: Received Power at each state =  $|h^2| \times T_p$  where h is fading coefficient and  $T_p$  is the transmit power.
  - 4: Fading Coefficient  $h = ae^{\phi}$  and  $|h| = a$  where 'a' is the magnitude of fading coefficient h.
  - 5: Received Power at each state =  $a^2 P$  where 'a' is the magnitude of fading coefficient and P is the received power.
  - 6: Received SNR or fading,  $SNR_F = a^2 P / \sigma^2 = a^2 SNR$
  - 7: Average BER =  $\int_0^\infty Q \times \sqrt{a^2 \times SNR} \times F_A(a) da$  where Q(x) is the tail integration of normal Gaussian distribution i.e  $Q(x) = \int_x^\infty \frac{1}{\sqrt{2\pi}} e^{-x^2/2} dx$ .
  - 8:  $F_A = 2ae^{-a^2}$  is the probability density function of 'a'.
  - 9: Solve the equation in step 7 to derive an expression for BER.
  - 10:  $BER = \frac{1}{2} [1 - \sqrt{SNR/(2 + SNR)}]$
  - 11: Calculate the SNR value for each state.
  - 12: Calculate the BER value by using the corresponding SNR.
  - 13: **end for**
  - 14: Compare the calculated BER with the predefined range.
  - 15: **if**  $10^{-9} \geq BER \geq 10^{-12}$  **then**
  - 16: Use simple error control scheme without retransmission.
  - 17: **else**
  - 18: **if**  $10^{-6} \geq BER \geq 10^{-8}$  **then**
  - 19: Use error control scheme with retransmission.
  - 20: **else**
  - 21: **if**  $10^{-3} \geq BER \geq 10^{-5}$  **then**
  - 22: Request Upper layers to handle the errors
  - 23: **end if**
  - 24: **end if**
  - 25: **end if**
-



**Algorithm 2** Sender algorithm

---

```

1: while TRUE do
2:   if (RequestToSendFromUpperLayer) then
3:     Collect data packet from the upper layers.
4:     Estimate the error in the channel using algorithm 1
5:     Depending on the BER estimated, Use one of the three methods.
6:     if  $10^{-9} \geq BER \geq 10^{-12}$  then
7:       Use simple error control scheme without retransmission.
8:       Use simple code to make the frame = d + k where d represents data bits and k the redundant bits.
9:       Send the frame.
10:    else
11:      if  $10^{-6} \geq BER \geq 10^{-8}$  then
12:        Use error control scheme with retransmission.
13:        Store the frame in the buffer for retransmission.
14:        Start the timer for retransmission.
15:        Send the frame and wait for ACK from the receiver.
16:        if (ACKArrivalNotificationFromReceiver) then
17:          Receive the ACK frame and send it to upper layer.
18:        else
19:          Retransmit the frame.
20:        end if
21:      else
22:        if  $10^{-3} \geq BER \geq 10^{-5}$  then
23:          Request Upper layers to handle the errors
24:        end if
25:      end if
26:    end if
27:  end if
28: end while

```

---

**Algorithm 3** Receiver algorithm

---

```

1: Input: Frame received from the sender.
2: while TRUE do
3:   if (FrameArrivalNotificationFromSender) then
4:     Receive the frame.
5:     if Are there redundant bits in the received frame then
6:       Decode the frame.
7:       Separate redundant bits (n-d) from the frame
8:       Calculate the redundant bits.
9:       Compare the received bits with the calculated bits.
10:      Accept the frame if the codewords match else Reject the frame.
11:    else
12:      if Check whether the frame is damaged or lost then
13:        Accept the frame and send it to upper layer.
14:      else
15:        Prepare the NACK and send it to the sender.
16:      end if
17:    end if
18:  end if
19: end while

```

---

## II. SIMULATION PARAMETERS

The proposed scheme is simulated using the following simulation inputs in C language. Message length ranging from  $L = 7$  to 300 bits, bandwidth = 300kbps, BER in the range  $10^{-1}$  to  $10^{-3}$ . Number of

standard deviations, x values in the range 0 to 4 and the SNR values in the range 0 to 10. The following performance parameters are assessed.

- *Throughput*: Throughput is expressed in terms of BER as shown in the equation 15



$$Thr = \frac{K}{L} \times R(1 - BER)^L \quad (15)$$

where L is the frame size in bits and K is the payload part (excluding redundant bits) of L and R is the transmission rate.

- **Bit error rate:** Bit error rate is the number of bit errors divided by the total number of transferred bits often expressed as a percentage. It is computed using the estimated SNR and is defined in equation 11
- **Probability of errors:** It is defined as the probability with which the errors occur given the noise in the transmission medium and is expressed in equation 12
- **Probability of retransmission:** This is the probability of occurrence of retransmission in case of frame is lost or corrupted and is given in the equation 14.

### III. RESULTS

Simulation results of the scheme using DCAECS are analyzed and compared with ASAECS in this section.

#### a) Analysis of Gaussian error function

The graph in figure 4 shows the behavior of erf (x) as the values of x, the number of standard deviations vary. Note that erf (0)=0, and erf (∞)=1. The error function gets progressively better with larger values of x. Initially when x increases the error function (erf (x)) also increases. At some particular point, erf (x) touches the value 1 and remains constant there after.

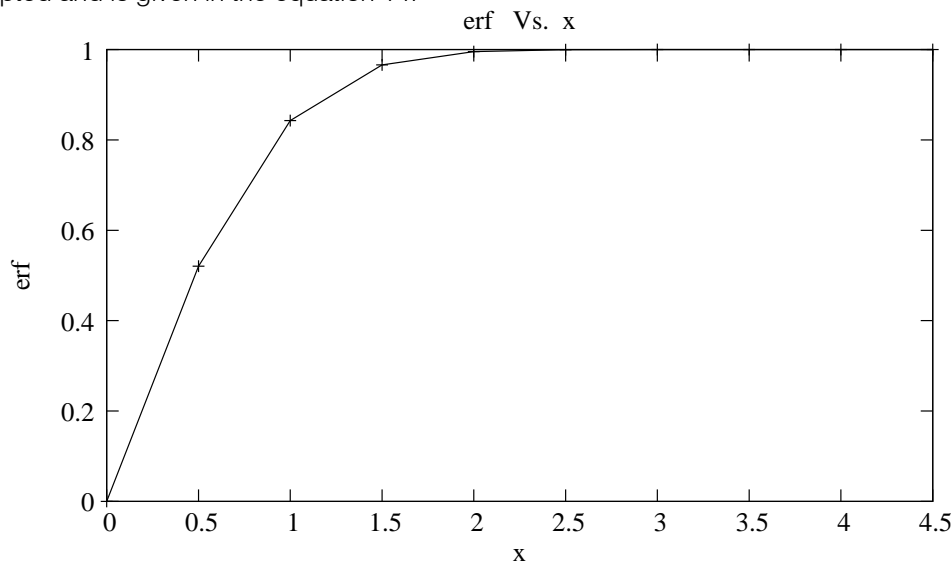


Figure 4: Plot for error function

#### b) Analysis of BER

The graph in figure 5 shows BER Vs SNR. As shown in the graph, when SNR increases, BER keeps on decreasing because the noise level in the channel decreases. Increase in SNR decreases BER and increase in data rate increases BER.

Similarly an increase in bandwidth allows an increase in data rate. This behaviour of BER is not handled in ASAECS.

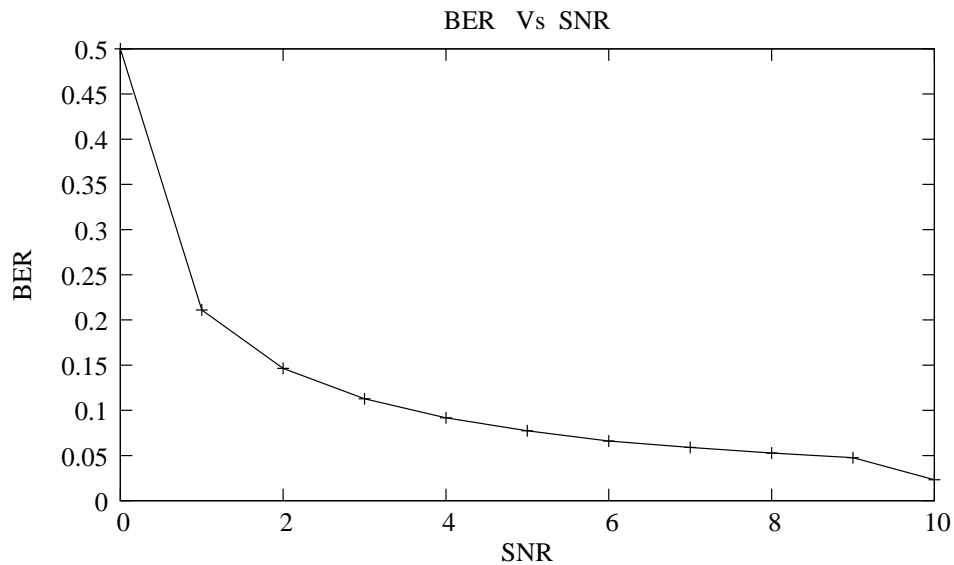


Figure 5: BER Vs. SNR for BPSK

#### c) Analysis of Throughput

As shown in the figure 6, the throughput fluctuates for various SNR values for a fixed number of frame lengths. However the throughput increases as the SNR increases. This is because, as the SNR increases, the number of errors in the frame decreases thereby

increasing the number of frames delivered thus increasing the throughput. The throughput is slightly more for DCAECS compared to ASAEC since in the case of ASAEC, the throughput increases with SNR slowly. In case of DCAECS, the throughput increases fast with various SNR values.

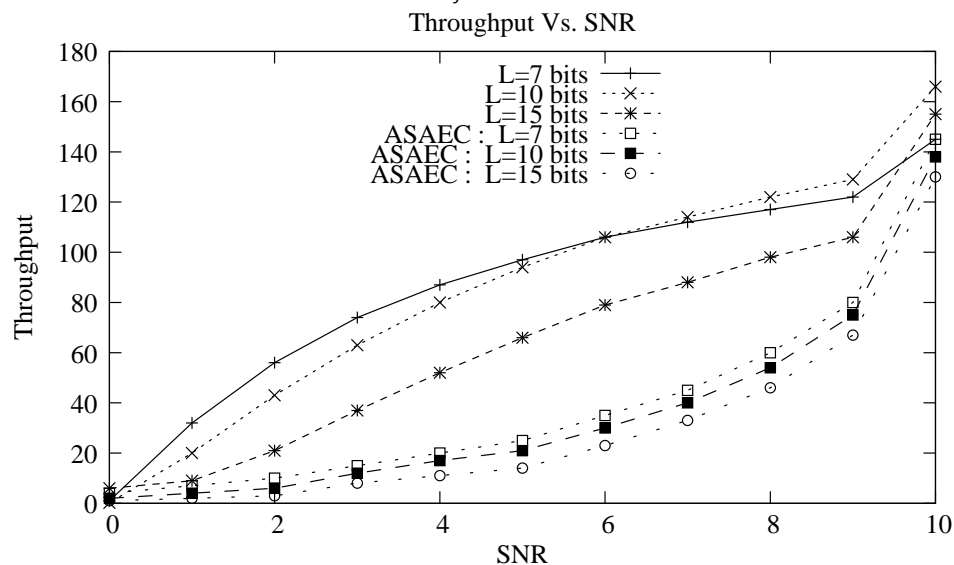


Figure 6: Throughput Vs. SNR

#### d) Analysis of Probability of Errors

In figure 7, probability of errors is plotted against the number of errors for different frame lengths (10, 20 and 30 bits). As shown in the graph, the probability of errors decreases as the number of errors increase. For all the three frame lengths, the probability of error decreases fast initially, then remains almost constant as the number of errors increase. This shows that for larger frame lengths, the probability of errors decreases tremendously. In ASAEC, the conductance of probability of errors against the number of errors for various message lengths is not taken care.

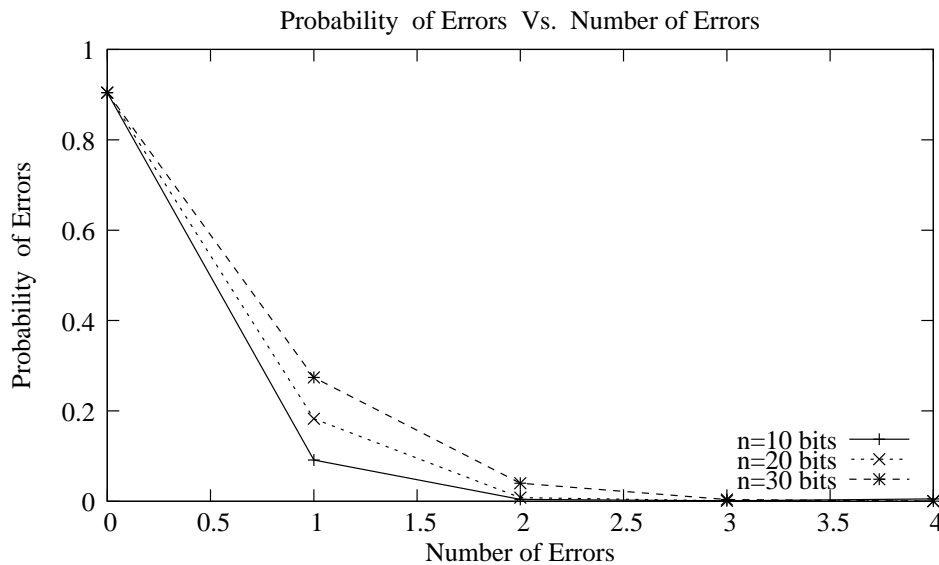


Figure 7: Probability of Errors Vs. Number of Errors for different message lengths

#### e) Analysis of Retransmissions

Although ASAECS speaks about ARQ, it does not analyze the probability of retransmissions where as DCAECS discusses about probability retransmission for different frame lengths. As shown in the graph in figure 8, the probability of retransmission is PRTx is

plotted against frame lengths for different values of BER. As the frame length increases, the PRTx also increases slowly and remains constant at some point ( $L = 200$ bits). This plot indicates that PRTx initially increases and later remains stable as the frame length increases.

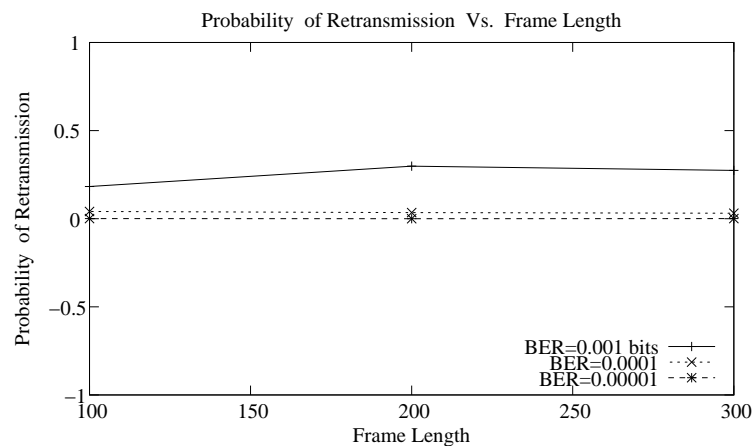


Figure 8: Probability of Retransmission Vs. Frame lengths for different BERs

## IV. CONCLUSION

In this paper, we have proposed a 'Dynamic and Channel Adaptive Error Control Scheme in Wireless Sensor Networks' (DCAECS) that estimates the channel state and controls the errors dynamically based on channel conditions and noise power observed. This allows error control strategy to vary as the channel conditions vary. Models have been designed for both the error and channel estimation where the expression for BER is derived. Error control strategy is formulated based on the observed BER levels. Simulation analysis has been done for BER, throughput, probability of retransmission, probability of errors and Gaussian error function. Results for throughput, BER and probability of retransmission show an improved performance over ASAECS.

## V. ACKNOWLEDGEMENT

Authors would like to thank Visvesvaraya Technological University (VTU), Karnataka, INDIA, for sponsoring the part of the project under VTU Research Scheme, grant no. VTU/Aca/2011-12/A-9/753, Dated: 5th May 2012.

## REFERENCES RÉFÉRENCES REFERENCIAS

1. Oskar Eriksson, "Error Control in Wireless Sensor Networks - A Process Control Perspective", 2011.
2. M. Patil, R. C. Biradar, "A Survey on Routing Protocols in Wireless Sensor Networks", IEEE International Conference on Networks, (ICON2012), Singapore, 2012, pp. 86-91.

3. Havinga P, Smit G, Bos M, "Energy Efficient Wireless ATM design", *Journal on Mobile Networks and Applications*, 2000, Vol. 5, No 2.
4. Vuran, Akyildiz, "Error Control in Wireless Sensor Networks: A Cross Layer Analysis", *IEEE/ACM Transactions on Networking*, 2011.
5. Aykut Yigitel, Ozlem Durmaz Incel, Cem Ersoy, "QoS-aware MAC protocols for Wireless Sensor Networks: A Survey", [www.elsevier.com/locate/comnet](http://www.elsevier.com/locate/comnet), 2011.
6. Sarvesh Kumar Singh, and Rajeev Paulus, "Analysis of Energy Model and QoS in Wireless Sensor Networks under different modulation schemes", *IEEE International Conference for Convergence of Technology*, 2014, pp. 1-5.
7. Jianjun Wen, Zeeshan Ansar, Waltenegus Dargie, "A link quality estimation model for energy-efficient wireless sensor networks", *IEEE International Conference on Communications (ICC)*, 2015, pp. 6694-6700.
8. Yonas Hagos, Kan Yu at el, "Implementation and Evaluation of Error Control Schemes in Industrial Wireless Sensor Networks", *IEEE*, 2011.
9. Yousof Naderi, Hamid R. Rabiee, Mohammad Khansari, "Error Control for Multimedia Communications in Wireless Sensor Networks: A comparative performance analysis", [www.elsevier.com/locate/adhoc](http://www.elsevier.com/locate/adhoc), 2012.
10. Ghaida A. Al-Suhail, Khalid W. Louis, Turki Y. Abdallah, "Energy Efficiency Analysis of Adaptive Error Correction in Wireless Sensor Networks", *International Journal of Computer Science Issues*, 2012, Vol. 9, Issue. 4, No. 2.
11. Yong Jin, Feng Li, Ya Fan, "Reliable Transmission Control Scheme Based on FEC Sensing and Adaptive MIMO for Mobile Internet of Things", *Journal of Communications*, 2014, Vol. 9, No. 12.
12. Howard, Schlegel, Iniewski, "Error Control Coding in Low-Power Wireless Sensor Networks: When is ECC Energy- Efficient", *EURASIP Journal on Wireless Communications and Networking*, 2006, pp. 1-14.
13. Balakrishnan, Yang, Jiang, and Kim, "Performance Analysis of Error Control Codes for Wireless Sensor Networks" *International Conference on Information Technology*, 2007, pp. 876-879.
14. M. Patil, R. C. Biradar, "Media Access Control in Wireless Sensor Networks using Priority Index", *Indonesian Journal of Electrical Engineering and Computer Science*, 2017, Vol. 5, No. 2, pp. 416-426.
15. Akyildiz, Vuran, "Error Control in Wireless Sensor Networks", *John Wiley and Sons Ltd*, 2010.
16. Shih, Cho, Lee, Calhoun, Chandrakasan, "Design Considerations for Energy Efficient Radios in Wireless Microsensor Networks", *Journal of VLSI Signal Processing*, 2004, Vol. 37, pp. 77-94.
17. Z. Tian, D.F. Yuan, Liang, 2008 "Energy Efficiency Analysis of Error Control Schemes in Wireless Sensor Networks", *IEEE International conference*, 2008, pp. 6-11.
18. Nashat Abughalieh, Kris Steenhaut, Ann Nowe, "Low Power Channel Coding for Wireless Sensor Networks", *17<sup>th</sup> IEEE Symposium on Communications and Vehicular Technology*, 2010.
19. Shraddha Srivastava, Christian Spagnol, "Analysis of a set of Error Correcting Schemes in multi-hop Wireless Sensor Networks", *IEEE*, 2009.
20. E. Shih, A. Chandrakasan, "Physical layer driven Protocol and Algorithm design for Energy Efficient Wireless Sensor Networks", 2001.
21. Sankarasubramaniam, Akyildiz, "Energy efficiency based Packet size Optimization in WSNs", *IEEE*, 2003, pp. 1-8.
22. Ming Zhan, Jun Wu, Zhong Zhi Zhang, "Low Complexity Error Correction for ISO/IEC/IEEE 21451-5 Sensor and Actuator Networks", *IEEE Sensors Journal*, 2015, Vol. 15, No. 5.
23. Hlaing Minn, Vijay K. Bhargava, "ARQ Scheme With Adaptive Error Control", *IEEE International conference*, 2001, Vol. 50, No. 6.
24. M. Patil, R. C Biradar, "Priority based Slot Allocation for Media Access in WSNs", *IEEE, ICERECT*, 2015, pp. 98-103.



GLOBAL JOURNAL OF COMPUTER SCIENCE AND TECHNOLOGY: E  
NETWORK, WEB & SECURITY  
Volume 17 Issue 2 Version 1.0 Year 2017  
Type: Double Blind Peer Reviewed International Research Journal  
Publisher: Global Journals Inc. (USA)  
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

# Energy Efficient Weighted Clustering Algorithm in Wireless Sensor Networks

By Mallanagouda Patil & Rajashekhar C. Biradar

*Reva University*

**Abstract-** With the advancement in communication and internet technologies, recently there have been many research efforts in the area of Wireless Sensor Networks (WSNs) to conserve energy. Clustering mechanisms have been applied to WSNs to enhance the network performance while reducing the necessary energy consumption. The goal of Weighted Clustering Algorithm (WCA) is to determine the cluster heads dynamically based on a combined weight metric that includes one or more parameters such as node degree, distances with respect to a nodes neighbors, node speed and the time spent as a cluster head. In this work, we have proposed a refined and improved version of WCA known as Energy Efficient Weighted Clustering Algorithm (EEWCA) to prolong the network lifetime by reducing energy consumption. EEWCA is designed and simulated with additional constraint on energy for the selection of cluster heads. Both the WCA and EEWCA schemes have been simulated using MATLAB. The proposed EEWCA behaves better than WCA for longer system lifetime.

**Keywords:** WSN; MANETS; energy efficiency; cluster.

**GJCST-E Classification:** I.4.8, C.2.1



*Strictly as per the compliance and regulations of:*





# Energy Efficient Weighted Clustering Algorithm in Wireless Sensor Networks

Mallanagouda Patil <sup>α</sup> & Rajashekhar C. Biradar <sup>σ</sup>

**Abstract-** With the advancement in communication and internet technologies, recently there have been many research efforts in the area of Wireless Sensor Networks (WSNs) to conserve energy. Clustering mechanisms have been applied to WSNs to enhance the network performance while reducing the necessary energy consumption. The goal of Weighted Clustering Algorithm (WCA) is to determine the cluster heads dynamically based on a combined weight metric that includes one or more parameters such as node degree, distances with respect to a nodes neighbors, node speed and the time spent as a cluster head. In this work, we have proposed a refined and improved version of WCA known as Energy Efficient Weighted Clustering Algorithm (EEWCA) to prolong the network lifetime by reducing energy consumption. EEWCA is designed and simulated with additional constraint on energy for the selection of cluster heads. Both the WCA and EEWCA schemes have been simulated using MATLAB. The proposed EEWCA behaves better than WCA for longer system lifetime. The proposed work is simulated and performance is tested for number of clusters and average execution time. Simulation results show that the EEWCA outperforms WCA in terms of both the number of clusters formed and the execution time.

**Keywords:** WSN; MANETS; energy efficiency; cluster.

## 1. INTRODUCTION

With the popularity of cell phones and smart devices, computing devices have become cheaper, mobile and more distributed in daily life. Wireless Sensor Network (WSN) is a collection of sensor nodes organized into a co-operative network to accomplish a common task. Each sensor node consists of a processing capability, multiple types of memory (program, data or flash memories), RF transceiver, and a power source. In addition, the nodes accommodate sensors and actuators [1]. WSNs have been widely considered as one of the most important technologies for the twenty first century [2]. Enabled by recent advances in microelectronic mechanical systems (MEMS) and wireless communication technologies, tiny, cheap and smart sensors deployed in a physical area and networked through wireless links and the Internet; provide unprecedented opportunities for a variety of civilian and military applications, for example, environmental monitoring, battle field surveillance and industry process control [3]. After the initial deployment, sensor nodes communicate and self organize into an

appropriate network often with multihop connections among sensor nodes. In most cases, it is very difficult and even impossible to change or recharge batteries for the sensor nodes. Distinguished from traditional wireless communication networks, WSNs have unique characteristics for example, denser level of node deployment, higher unreliability of sensor nodes, and severe energy, computation, and storage constraints [4] that present many new challenges in the applications of WSNs. In the past decade, WSNs have received tremendous attention from both academia and industry all over the world. It is envisioned that in the near future WSNs will be widely used in various civilian and military fields, and revolutionize the way we live, work and interact with the physical world [5]. The next section describes unique characteristics of WSNs.

Equipped with sensors, embedded microprocessors and radio transceivers, the sensor nodes have not only sensing capability but also data processing and communication capabilities [6]. Compared with traditional wireless communication networks such as cellular systems and MANETs, WSNs have unique characteristics and constraints that are listed below [7]. Sensor nodes are usually densely deployed in the field of interest. Thus, the data sensed by multiple sensor nodes has a certain level of redundancy [8]. Sensor nodes are usually deployed in harsh or hostile environments and the network operation is autonomous. As a result, the network undergoes frequent topology change and it is prone to physical damages or failures [3]. The following section briefs the hierarchical structure and clustering in WSNs.

### a) Hierarchical structure and clustering in Wireless Sensor Networks

In a hierarchical network shown in figure 1, sensor nodes can be organized into clusters, where the cluster members send their data to the cluster heads that serve as relays for transmitting data to the sink. The collaboration among sensor nodes is very important in WSNs for two reasons: 1. Data collected from multiple sensor nodes can offer valuable inference about the system under study. 2. The collaboration among sensor nodes can provide trade-offs between communication cost and computation energy. Since it is likely that the data acquired from one sensor node are highly correlated with the data from its neighbors, data aggregation can reduce the redundant information

Author <sup>α</sup>: Dept. of CSE, BNM IT, Bangalore-560070, India.  
e-mail: mailmb@gmail.com

Author <sup>σ</sup>: School of ECE, Reva Univ, Bangalore-560064, India.  
e-mail: raj.biradar@revainstitution.org

transmitted in the network. It is well known fact that the energy consumed for transferring one bit of data can be used to perform a large number of arithmetic operations in a sensor processor [9]. When the base station is far away, there are significant advantages in using local data aggregation instead of direct communication. Clustering aggregates nodes into groups and facilitates practical deployment and operation of WSNs. Traditional (i.e. flat) routing and data dissemination protocols for

WSNs may not be optimal in terms of energy consumption. The primary idea in clustering is to group nodes around a cluster head responsible for state maintenance and inter-cluster connectivity.

A node with lower energy can be used to perform the sensing task and send the sensed data to its cluster head at short distance, while a node with higher energy can be selected as a cluster head to process the data

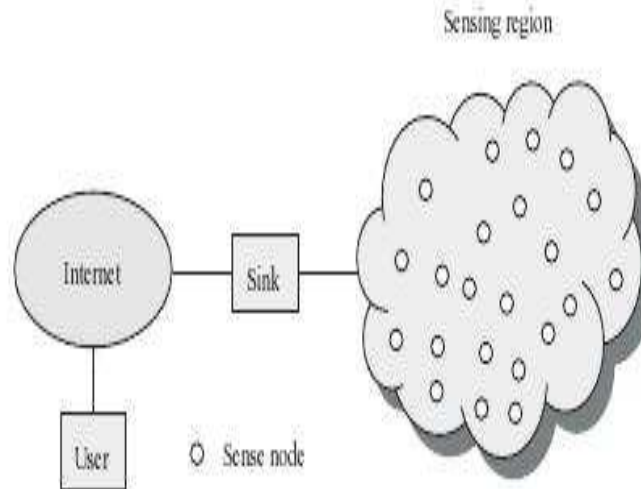


Figure 1: General Architecture of WSN

from its cluster members and transmit the processed data to sink. This process cannot only reduce the energy consumption for communication, but also balance traffic load and improve scalability when the network size grows. Moreover, data aggregation can be performed at cluster heads to reduce the amount of data transmitted to the sink and improve the energy efficiency of the network [10]. The major problem with clustering is how to select the cluster heads and organize the clusters [11]. Even routing mechanisms have been applied to sensor networks with hierarchical structures to enhance the network performance while reducing the necessary energy consumption [12]. In this context, there are many clustering strategies proposed in the literature. Next section highlights some of the important works carried out in this domain.

## II. RELATED WORKS

In Highest Connectivity Cluster Algorithm [13], the node with the highest connectivity (connected to the most number of nodes) is elected cluster head, but in the case of a tie, the node with the lowest ID prevails. Mobility Based Metric for Clustering [14] proposes a local mobility metric such that mobile nodes with low speed relative to their neighbors have the chance to become cluster heads. By calculating the variance of a mobile node's speed relative to each of its neighbors, the aggregate local speed of a mobile node is estimated. A low variance value indicates that this mobile node is relatively less mobile to its neighbors. Consequently, mobile nodes with low variance values in

their neighborhoods are chosen as clusterhead. Thus, a selected clusterhead can normally promise the low mobility with respect to its member nodes. However, if mobile nodes move randomly the performance may reduce. Clustering for energy conservation [15] assumes two node as master and slave. A slave node must be connected to one master node only and there is no direct connection between slave nodes. Each master node can establish a cluster based on connections to slave nodes. The drawback of this scheme are paging process before each round of communication consumes a large amount of energy. Master node election is not adaptive and the method of selecting the master node is not specified. In vote based clustering algorithm [16], researchers consider neighbor's number and remaining battery time of each mobile node. The basic concept is the Hello message, which is transmitted in the shared channel. Making use of node location and power information, this work proposes voting concept which is weighted sum of number of valid neighbors. The next section highlights the contribution of our work.

### a) Our Contributions

The goal of Weighted Clustering Algorithm (WCA) [17] is to determine the cluster heads dynamically in Mobile Adhoc Networks (MANETs). The Cluster heads are selected based on a combined weight metric that includes one or more parameters such as node degree, distances with respect to a nodes neighbours, node speed, and the time spent as a

cluster head. Wireless sensor networks are however little different from traditional wireless networks due to energy constraints. Besides in WSNs, prolonging network lifetime is an important issue. WCA cannot be applied directly to wireless sensor networks as it does not consider the energy constraint prevalent in WSNs. To have an improvement over WCA, we have proposed "Energy Efficient Weighted Clustering Algorithm (EEWCA)" that enhances network lifetime by reducing energy consumption. In EEWCA, we have considered an additional constraint on energy over WCA for the selection of cluster heads and to form clusters in WSNs. Both the WCA and EEWCA algorithms have been simulated using MATLAB. The proposed EEWCA behaves better than WCA in WSNs for longer system lifetime. The proposed work is simulated and performance is tested for the reduced number of clusters and reduced average execution time. The simulation results show that the EEWCA outperforms WCA in terms of number of clusters and execution time. The next part of this work describes the steps involved in WCA and EEWCA.

### III. ALGORITHMS

The following subsections explain both the WCA and EEWCA algorithms in detail.

#### a) Weighted Clustering Algorithm

The Weighted Clustering Algorithm (WCA) proposed for selecting cluster heads in MANETs, is based on a combined weight metric that includes the node degree, distances with respect to a nodes neighbors, node speed, and the time spent as a cluster head [17]. Each node broadcasts its weight value to all

other nodes. A node is chosen to be a cluster head if its weight is the minimum among its neighbors; otherwise, it joins a neighboring cluster. Nodes in MANET can be modelled as a set of nodes and links, represented by a graph  $G = (V, E)$ , where  $V$  is the set of nodes and  $E$  is the set of links. In MANETs, the transmission radii of all the nodes are assumed to be the same [17]. The equation 1 is used to calculate the effective combined weight ( $W_v$ ) of a node  $v$  as a cluster head.

$$W_v = w_1 d_v + w_2 D_v + w_3 M_v + w_4 T_v \quad (1)$$

where  $v$  is the serial number (ID) of a mobile node,  $d_v$  is the degree difference of node  $v$ ,  $D_v$  is the sum of the distances between  $v$  and its neighbors,  $M_v$  is the average speed of node  $v$ ,  $T_v$  is the cumulative time in which node  $v$  has acted as cluster head, and  $W_i$  is the weighted coefficient for the  $i$ -th factor. The degree of a node  $v$  is the number of nodes within the transmission radius of  $v$  excluding itself. The  $d_v$  is the difference between the degree of a node  $v$  and a predefined degree  $M$  of an ideal node in a cluster.  $W_v$  is used to determine the goodness of a node as a cluster head. Lower the  $W_v$  value, better are the chances of node  $v$  to become cluster head.

- Input: A set of sensor nodes, each with the same transmission radius  $R_v$ , Individual cumulative time  $T_v$  and mobility speed  $M_v$ , the predefined ideal node number  $M$  in a cluster and the four coefficients  $w_1$  to  $w_4$ .
- Output: A set of clusters with cluster heads and its members.

#### Algorithm 1 Weighted Clustering Algorithm

1: Begin  
2: for Each sensor node do  
3: Find the neighbors  $N(v)$  by using the equation  
4: end for

$$N(v) = \{v' | \text{distance}(v, v') \leq R_v\} \quad (2)$$

5: Calculate the degree  $d_v$  of node  $v$  as the number of the neighbors of  $v$  that fall within its transmission radius  $R_v$ , not including itself

6: Compute the degree difference for each node  $v$  by using the equation

$$\delta_v = |d_v - M| \quad (3)$$

7: Compute the sum  $D_v$  of the distances between node  $v$  and all its neighbors by using the equation

$$D_v = \sum_{v' \in N(v)} \text{distance}(v, v') \quad (4)$$

8: Compute the running average of the speed for every node till current time  $T$  by using the following formula. This gives the measure of mobility and is denoted by  $M_v$

$$M_v = 1/T \sum \sqrt{(X_t - X_{t-1})^2 + (Y_t - Y_{t-1})^2} \quad (5)$$

9: Assume an appropriate value of cumulative time  $T_v$  for each sensor node. Cumulative time is the time in

which node  $v$  has acted as a cluster head. A larger  $T_v$  value with node  $v$  implies that it has spent more resources (for example energy).

10: Calculate the combined effective weight,  $W_v$  by using the equation

$$W_v = w_1\delta_v + w_2D_v + w_3M_v + w_4T_v \quad (6)$$

11: Select the node with a minimum  $W_v$  as the cluster head.

12: Eliminate the chosen cluster head and its neighbors (cluster members) from the set of original sensor nodes.

13: Repeat Steps 1 to 12 for the remaining nodes not yet selected as a cluster head or until each node is assigned to a cluster.

14: All the mobile nodes are grouped into several clusters and each cluster has its own cluster head.

15: End

Although the WCA based on weighted coefficients, performs better than the earlier algorithms proposed in the domain of MANETs, it cannot be straight away used for WSN applications. In this work, the WCA is modified such that it can be used in WSNs with their specific energy constraint considered. The next part of our work describes the proposed EEWCA which is an improved version of WCA that takes care of energy constraints in WSNs.

#### IV. ENERGY EFFICIENT WEIGHTED CLUSTERING ALGORITHM

The WCA algorithm was designed to select cluster heads dynamically in MANETs. It is not so appropriate to directly apply the WCA algorithm to WSNs since it does not take care of energy constraints and the transmission rate into consideration. In the real world, the assumption of homogeneous sensors may not be practical because sensing applications may require heterogeneous sensors in terms of their sensing and communication capabilities in order to enhance network reliability and extend network lifetime. Also, even if the sensors are equipped with identical hardware, they may not always have the same communication and sensing models. In fact, at the manufacturing stage, there is no guarantee that two sensors using the same platform have exactly the same physical properties. Heterogeneous nodes in WSNs can bring the benefits of reduced response time and increased life time. The proposed EEWCA has been worked out for heterogeneous WSNs to form clusters with the energy constraints being considered. In this algorithm, energy factor is added into the evaluation

formula such that the nodes chosen as cluster heads may have a better behavior in heterogeneous sensor networks than those without this additional factor. Equation 7 is used to calculate the effective combined weight ( $W_v$ ) of a node  $v$  as a cluster head.

$$W_v = w_1\delta_v + w_2D_v + w_3M_v + w_4T_v + W_5C_v \quad (7)$$

where  $W_v$  is used to determine the likeliness of a node as a cluster head. The lower the  $W_v$  value is, the better  $v$  acts as a cluster head.  $v$  is the serial number (ID) of a mobile node,  $\delta_v$  is the degree difference of node  $v$ ,  $D_v$  is the sum of the distances between  $v$  and all its neighbors,  $M_v$  is the running average of the speed of node  $v$ ,  $T_v$  is the cumulative time in which node  $v$  acted as a cluster head,  $w_i$  is the weighted coefficient for the  $i$ -th factor and  $C_v$  is a characteristic factor of each node and is defined by the following equation 8

$$C_v = r_v/E_v \quad (8)$$

Where  $r_v$  the transmission rate and  $E_v$  is the initial energy of node  $v$ . After a fixed interval of time, the proposed algorithm is then re-run again to find new cluster heads for the purpose of getting a longer system lifetime. The detailed procedure for the EEWCA is described as follows.

- Input: A set of sensor nodes, each with the same transmission radius  $R_v$ , individual cumulative time  $T_v$ , mobility speed  $M_v$ , transmission rate  $r_v$ , the initial energy  $E_v$ , the predefined ideal node number  $M$  in a cluster and the five weighted coefficients  $w_1$  to  $w_5$ .
- Output: A set of clusters with cluster heads and its members.

#### Algorithm 2 Energy Efficient Weighted Clustering Algorithm

- 1: Begin
- 2: for Each sensor node do
- 3: Find the neighbors  $N(v)$  by using the equation

$$N(v) = \{v' | distance(v, v') \leq R_v\} \quad (9)$$

- 4: end for
- 5: Calculate the degree  $d_v$  of node  $v$  as the number of the neighbors of  $v$  that fall within its transmission radius  $R_v$ , excluding itself.

6: Compute the degree difference for each node  $v$  by using the equation

$$\delta v = |dv - M| \quad (10)$$

7: Compute the sum  $Dv$  of the distances between node  $v$  and all its neighbors by using the equation

$$Dv = \sum_{v' \in N(v)} \text{distance}(v, v') \quad (11)$$

8: Compute the running average of the speed for every node till current time  $T$  by using the following formula. This gives the measure of mobility and is denoted by  $Mv$

$$Mv = 1/T \sum \sqrt{(X_t - X_{t-1}) + (Y_t - Y_{t-1})} \quad (12)$$

9: Assume an appropriate value of cumulative time  $Tv$  for each sensor node. Cumulative time is the time in which node  $v$  has acted as a cluster head. A larger  $Tv$  value with node  $v$  implies that it has spent more resources (for example energy).

10: Compute the characteristic factor  $Cv$  of every node by using the equation

$$Cv = rv/Ev \quad (13)$$

11: Calculate the combined effective weight,  $Wv$  by using the equation

$$Wv = w1\delta v + w2Dv + w3Mv + w4Tv + w5Cv \quad (14)$$

12: Select the node with a minimum  $Wv$  as the cluster head.

13: Eliminate the chosen cluster head and its neighbors (cluster members) from the set of original sensor nodes.

14: Repeat Steps 1 to 13 for the remaining nodes not yet selected as a cluster head or until each node is assigned to a cluster.

15: All the mobile nodes are grouped into several clusters and each cluster has its own cluster head.

16: End

## V. SIMULATION PARAMETERS

Both WCA and EEWCA have been simulated in MATLAB. There are totally fourteen mobile sensor nodes

loaded with their initial simulation parameters (or factors) as shown in figure 2. Where SN

SN	Position	Rv	Mv	Tv	Rt	E
1	(3,3)	5	2	1	5	7.5
2	(4,7)	5	2	2	6	7.2
3	(4,12)	5	1	4	6	6.6
4	(7,15)	5	1	6	4	8.4
5	(11,15)	5	2	0	5	10
6	(15,20)	5	3	2	4	7.6
7	(7,4)	5	4	1	4	9.6
8	(11,6)	5	1	1	5	9.0
9	(15,4)	5	1	7	5	8.5
10	(17,8)	5	0	5	6	9.6
11	(18,17)	5	2	2	4	9.6
12	(15,15)	5	1	0	5	8.0
13	(5,9)	5	3	1	6	8.8
14	(7,12)	5	2	0	5	8.3

Figure 2: Input Parameters for Simulation



represents the serial number of a sensor node, Position is the coordinate position(X,Y) of a sensor node,  $R_v$  represents the transmission radius of node  $v$ ,  $M_v$  is the running average speed of node  $v$ ,  $T_v$  represents the cumulative time,  $R_t$  is the transmission rate of node  $v$  and  $E_v$  represents the initial power on node  $v$ . The ideal degree of a node,  $M$  is set at 3 that means a cluster head can ideally handle 3 sensor nodes. The five coefficient values are set as follows:  $w_1=0.5$ ,  $w_2=0.1$ ,  $w_3=0.05$ ,  $w_4=0.05$  and  $w_5=0.3$  where the sum of these weights is equal to 1. For comparison, the same simulation parameters are run with WCA. The result analysis is done in the next part along with the effect of number of input parameters and the execution time on the number of clusters generated.

## VI. RESULTS ANALYSIS

There are two main parameters that have been used to evaluate the performance of EEWCA and WCA. These parameters are the number of input sensor nodes and execution time as described in the following sections.

- \* Number of nodes: When the simulation example (with 14 sensor nodes as input) is run with both EEWCA and WCA, the EEWCA performs better than WCA with less number of clusters formed as shown in the figure 3 as compared to figure 4

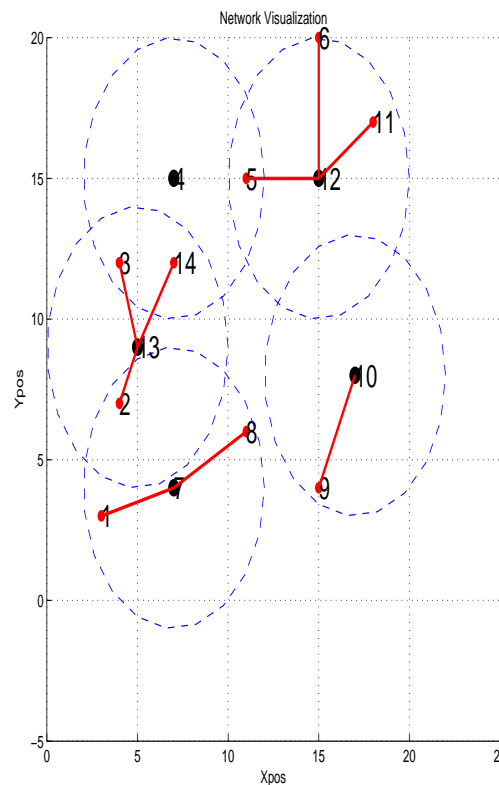


Figure 3: Clusters formed after simulating EEWCA

Thus EEWCA reduces the number of transmissions between the cluster heads and the base station. This reduces energy consumed in transmission of messages, thus prolonging the life time of a sensor network. The EEWCA and WCA are simulated with different number of input sensor nodes and the number of output clusters are noted down as shown in 5 and 6 respectively.

The graph 7 is drawn to compare the performance of both these algorithms with respect to the number of input sensor nodes against number of clusters formed. The graphs show that EEWCA forms less number of clusters compared to WCA for the same number of input sensor nodes.

- \* Execution time: While EEWCA and WCA are simulated for different number of input sensor nodes, the execution time in each of the cases is noted down. The following graph is drawn to plot execution times against number of inputs to compare the performance of both these algorithms. It is found that the average execution time of EEWCA is better compared to WCA. The execution times of both these algorithms for different number of input sensor nodes are listed in the figure 8.

## VII. CONCLUSION

In WSNs, power usage is an important factor for network lifetime. The proposed EEWCA is an improved

clustering algorithm based on the weighted clustering algorithm with a constraint of energy

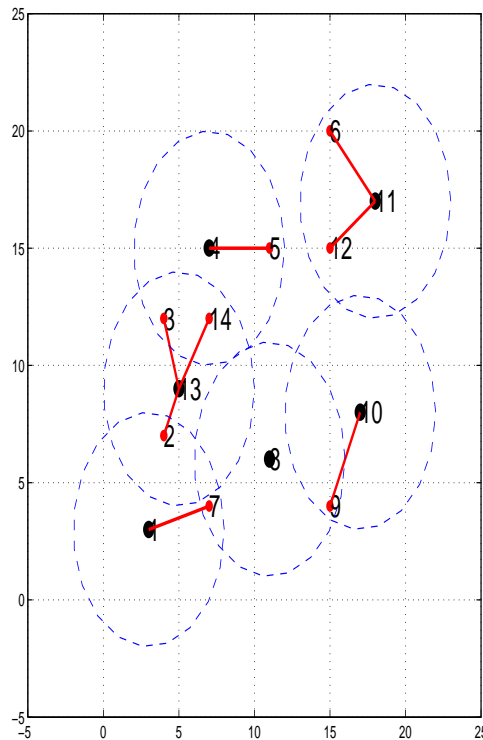


Figure 4: Clusters formed after simulating WCA

Number of sensor nodes (Input)	Number of clusters (Output)
8	4
12	4
14	5
16	6
18	8

Figure 5: Inputs and corresponding outputs of EEWCA

consumption for selection of cluster heads in mobile wireless sensor networks. The characteristics of sensor nodes including the power energy and the transmission rate are considered in the proposed algorithm. Experimental results have shown that the proposed algorithm behaves better than WCA on wireless sensor

networks for long system lifetime. The proposed algorithm reduces the number of

Number of sensor nodes (Input)	Number of clusters (Output)
8	5
12	6
14	6
16	7
18	9

Figure 6: Inputs and corresponding outputs of EEWCA

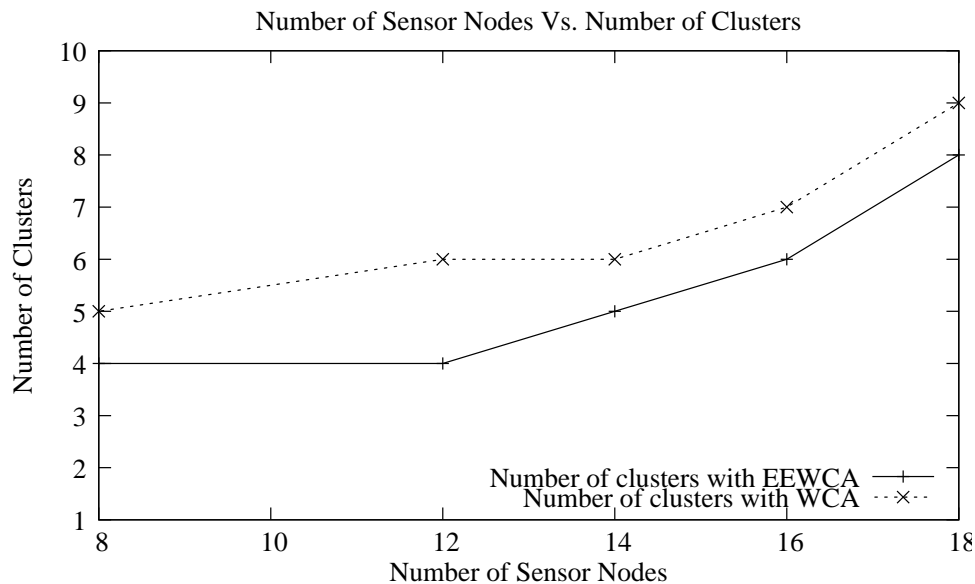


Figure 7: Performance of EEWCA and WCA

clusters compared to WCA for the same number of input sensor nodes. The average execution time of EEWCA is better than that of WCA when simulation runs are carried for different number input sensor nodes.

## REFERENCES RÉFÉRENCES REFERENCIAS

1. W. Heinzelman, A. Chandrakasan, H. Balakrishnan, Energy-efficient communication protocol for wireless sensor networks, in: Proceeding of the Hawaii International Conference System Sciences, Hawaii, January 2000
2. "21 ideas for the 21st century", Business Week, Aug. 30 1999, pp. 78-167.
3. C. Y. Chong and S. P. Kumar, "Sensor networks: Evolution, Opportunities, and Challenges, IEEE, vol. 91, no. 8, Aug. 2003, pp. 1247-1256.
4. I. F. Akyildiz, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks", IEEE Communications Magazine, vol. 40, no. 8, Aug. 2002, pp. 102-114.
5. D. Estrin, D. Culler, K. Pister, and G. Sukhatme, "Connecting the physical world with pervasive networks", IEEE Pervasive Computing, 2002, pp. 59-69.
6. "WIRELESS SENSOR NETWORKS, A Networking Perspective", Jun Zheng and Abbas Jamalipour, IEEE publications, 2009.
7. F. Zhao, L. Guibas, "Wireless Sensor Networks: An Information Processing Approach", Morgan Kaufmann Publishers, San Francisco, CA, 2014.
8. I. F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, "A survey on sensor networks", IEEE

- Communications Magazine, vol. 40, no. 8, Aug. 2002, pp. 102-114.
9. G. Pottie and W. Kaiser, "Wireless integrated sensor networks (WINS)", Communications of the ACM, vol. 43, no. 5, 2000, pp. 51-58.
  10. V. Mhatre and C. Rosenberg, "Design guidelines for wireless sensor networks: Communication, clustering and aggregation", Ad Hoc Networks, vol. 2, no. 1, Jan. 2004, pp. 45-63.
  11. R. Rajagopalan and P. Varshney, "Data aggregation techniques in sensor networks: A survey", IEEE Communications and Surveys and Tutorials, vol. 8, no. 4, 4th Quarter 2006, pp. 48-63.
  12. Mallanagouda Patil, R C Biradar, "A survey on routing protocols in Wireless Sensor Networks", IEEE, 2012, pp. 98-103.
  13. Chen, Nocetti, Gonzalez, Stojmenovic, "Connectivity based k-hop clustering in wireless networks", Proceedings of the 35th Annual Hawaii International Conference on System Sciences, 2002.
  14. Basu, Khan, "A Mobility Based Metric for Clustering in Mobile Adhoc Networks", IEEE, 2001, pp. 413-418.
  15. Ryu, Song, Cho, "New Clustering Schemes for Energy Conservation in two tiered Mobile Adhoc Networks", IEEE, vol. 3, 2001, pp. 862-866.
  16. Li, Zhang, Wang, "Vote Based Clustering Algorithm in Mobile Adhoc Networks", International Conference on Networking Technologies, 2004.
  17. M. Chatterjee, S. K. Das, and D. Turgut, "WCA: a weighted clustering algorithm for mobile ad hoc networks, Cluster Computing", vol. 5, no. 2, 2002, pp. 193-204.

Number of sensor nodes	Execution Time(Sec) (EEWCA)	Execution Time(Sec) (WCA)
8	0.309785	0.390993
12	0.284146	0.335276
14	0.314154	0.343704
16	0.309675	0.332417
18	0.340255	0.363349

Figure 8: Comparison of execution times of EEWCA and WCA



This page is intentionally left blank





GLOBAL JOURNAL OF COMPUTER SCIENCE AND TECHNOLOGY: E  
NETWORK, WEB & SECURITY  
Volume 17 Issue 2 Version 1.0 Year 2017  
Type: Double Blind Peer Reviewed International Research Journal  
Publisher: Global Journals Inc. (USA)  
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

# Formal Verification and Validates the Mobile Nodes using NNDRP

By Machha. Narender & Dr. R. P. Singh

*Sri Satya Sai University of Technology and Medical Sciences*

**Abstract-** Mobile ad-hoc networks are wireless networks and these are suitable for safety critical applications due to its ad-hoc behavior but attackers easily enter in to the network and they can access the network, so security is a crucial factor for any communication protocols, especially in mobile environment, so verifying the node that may be a malicious node or trustworthy node is a challenging task, but most of the researchers focused on the neighbor nodes distance only but they are not focused on security. This paper provides secure routing for MANET using NNDRP protocol, this protocol verify and validate the nodes with security measures.

**Keywords:** MANETS, validation, AODV, NTP, NNDRP.

**GJCST-E Classification:** C.1.3, C.1.4



*Strictly as per the compliance and regulations of:*



# Formal Verification and Validates the Mobile Nodes using NNDRP

Machha. Narender <sup>α</sup> & Dr. R. P. Singh <sup>σ</sup>

**Abstract-** Mobile ad-hoc networks are wireless networks and these are suitable for safety critical applications due to its ad-hoc behavior but attackers easily enter in to the network and they can access the network, so security is a crucial factor for any communication protocols, especially in mobile environment, so verifying the node that may be a malicious node or trustworthy node is a challenging task, but most of the researchers focused on the neighbor nodes distance only but they are not focused on security. This paper provides secure routing for MANET using NNDRP protocol, this protocol verify and validate the nodes with security measures.

**Keywords:** MANETS, validation, AODV, NTP, NNDRP.

## I. INTRODUCTION

Mobile Ad-hoc Networks (MANETS) are wireless mobile nodes that cooperatively form a network without underlying any infrastructure. It has become a hot topic in wireless network over the past years. The Mobile Ad-hoc Network (MANET) is a networking concept defines simple mechanism which enable mobile terminals to form a temporary fraternity without any planned coronation, or human interference.

Finding the node position is an important task in mobile networks, and it becomes particularly challenging in the presence of contestant aiming at harming the system. In these cases, we need solutions that let nodes correctly find their location in spite of attacks supplying the false location information, and verify the positions of their neighbors, so as to detect malicious nodes announcing false locations.

Mobile ad hoc network, where a prevalent infrastructure is not present, and the location data must be obtained through node-to-node communication only. Such a scenario is of particular interest, since it is open for malicious nodes to misuse or dislocate the location based services. For example, by advertising forged positions, adversaries could bias geographic routing or data gathering processes, attracting network traffic and eavesdropping or discarding. Similarly, counterfeit positions could grant adversaries unauthorized access to location-dependent services, let vehicles forfeit road tolls, disrupt vehicular traffic or endanger passengers and carriers. In this context, the challenge is to perform, in absence of trusted nodes, a fully-distributed.

**Author α:** Research Scholar, Sri Satya Sai University of Technology and Medical Sciences, Sehore, Madhya Pradesh, India.

e-mail: machha.narender@gmail.com

**Author σ:** Vice-Chancellor, Sri Satya Sai University of Technology and Medical Sciences, Sehore M.P. e-mail: rp.singh@gmail.com

Neighbor discovery is the process in which a node present in the network computes an identity and the total number of other nodes in its proximity. Many protocols consists fundamental building block including localization, routing, and group management. Time-based communications and many media access control mechanisms rely on meticulous neighbor information. Neighbor discovery is important to the proper functioning of wireless networks.

Neighbours are usually defined as nodes that lie within radio range of each other in the wireless network. Thus, neighbour discovery may be considered as the exploration of the volume of space or neighbourhood immediately surrounding a wireless node. Nodes found within the neighbourhood are neighbours and, depending on network configuration and topology, may cooperate in the performance of various tasks including communications, sensing and localization. However, wireless communications are prone to exploitation. Attackers have the freedom to do malicious activities ranging from simple denial of service to sophisticated deception. The correctness of node locations is thus an important task in mobile networks, and it becomes particularly challenging in the presence of adversaries target at harming the system. In these cases, we require solutions that let nodes (1) correctly establish their location in spite of attacks supplying not correct location information, and (2) verify the positions of their neighbours, so as to detect antipathetic nodes announcing false locations.

In this paper, NNDRP (Neighbour Node Discovery Routing Protocol) discovers the trusted neighbour node by AODV (Ad hoc on Demand Distance Vector) and NTP (Node Transition Probability), after finding the trusted node that can be validated by passing that node information to all its neighbour nodes to update their routing tables, then only easily to find the destination route from the source node.

## II. RELATED WORK

In this [2] paper, they presented a method which exploits Time-of-Flight distance bounding and node cooperation to mitigate the problems of the previous solutions. However, the cooperation is limited to couples of neighbor nodes, which renders the protocol ineffective against colluding attackers.

In this [1] paper, the new scheme is presented for neighbor position verification (NPV) protocol which

allows nodes to validate the neighbor nodes position based on local observations, this is done only by checking whether subsequent positions announced by one neighbor and draw a movement over time that is physically possible. The limitation of this method is an adversary can fool the protocol by simply announcing false positions that follow a realistic.

In this [3] paper, an impossibility proof showing that time-based protocols will not guarantee SND unless the environment is free of obstacles and the distance between neighbors is small.

In this[4] paper, each node transmits at randomly chosen times and discovers all its neighbors in a given time with high probability, each node transmits according to predetermined transmission schedule that allows to detect all its neighbors in a given time with its probability.

In this [5] paper, the algorithm used by Omni directional antenna is 1-way and the receiver will not send any acknowledgement after receiving the discovery message. The sender delivers the DISCOVER message to advertise itself. The receivers will discover one neighbor, if it receive the DISCOVER message

properly in the listen state, The Omni directional antennas have drawbacks like decreased gain, increased signal distraction, high bandwidth consumption, and increased noise. Directional antenna requires longer transmission range and high. They strongly reduce jamming susceptibility and signal interferences in unnecessary directions.

This [7] paper, AODV protocol finds the node in source-destination rout, but it cannot find the whether it is a trust node or malicious node.

### III. PROPOSED PROTOCOL

NNDRP (Neighbor Node Discovery Routing Protocol) finds the trust node with the help of AODV [7] (Ad hoc On Demand Distance Vector) and NTP [6] (Node Transition Probability) protocols, AODV protocol finds the neighbor node in the source to destination route, but that node can be verified by NTP protocol, whether it is a malicious node or trust node and it can be validated by sending trust information to all neighbor nodes to update in their routing table.

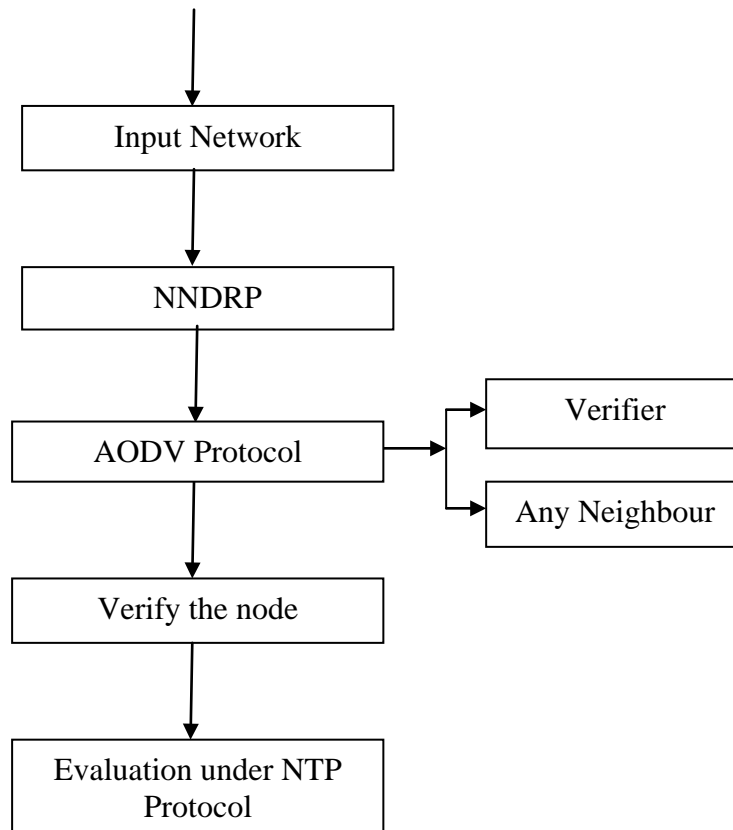


Figure 1: Proposed Architecture

AODV protocol sends a message to find a neighbour node, that message consists of route request (RREQ), route reply (RREP), route error (RERR) and for checking the link status (HELLO)

In a network, after finding a node in the source-destination route by AODV protocol, to find whether it is a trust node or malicious node, that can be found by NTP protocol, it determines the node based on the

probability, normally the nodes lie within the verifier node's proximity for longer time, thereby improving the stability of the node, so verifier uses less control packets to determine the route between two nodes. The proposed algorithm adapts quickly changes in routing when host movement is frequent. NTP based routing algorithm, which determines the route on replied information from a particular node replied and reply that same information to all of its neighbours. In this algorithm, verifier floods a control packet, if it does not have neighbour nodes information and has data to send. The verifier table is computed based on the received replies and we choose the node, which is replied with maximum replies for more times as neighbor. By choosing that neighbour node, route table is computed for the Source to Destination. We have assumed that a node within the other node's proximity then we can say i.e. a neighbor node,

When a node in a network receives a number of route requests that is greater than the threshold value by a specific source to a destination in a particular time interval  $T_{interval}$ , the node is declared as malicious and the message is sent to all the nodes in a network. If any node is generating the control packets more than the threshold value in a particular time interval  $T_{frequency}$ , this node service can be treated as denial of service. If the source does not receive any reply from the destination for a particular time interval  $T_{wait}$ , then that node can be treated as malicious node.

We can determine the crisp value for the different traffic range of the mobile nodes based up on the input parameters such as queue length (QL), data rate (DR), and item size (IS) for the Node Transition Probability protocol.

#### IV. TRAFFIC LEVELS

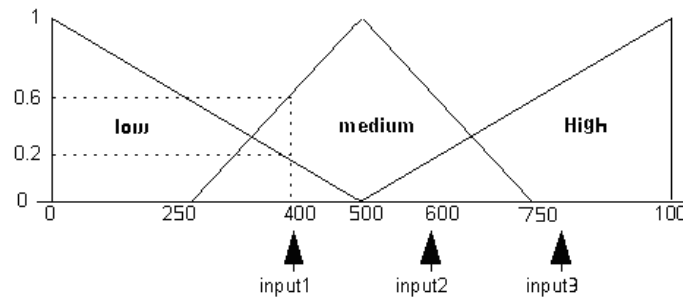


Figure 3: Three levels of input.

The above figure shows the three traffic levels based upon the input parameters after rule base is selected and sorted for various traffic levels.

input traffic level that is shown in table 1, 2 and 3 respectively.

##### a) Rule base

Rule base is designed for the fuzzy model as low-level, medium-level and high-level based on the

Low level:

Table1: Rule Base for low level range

Rules	Queue length	Data rate	Item size	Traffic range
Rule1	Low	Low	Low	Low
Rule2	Low	Low	High	Low
Rule3	Low	Low	Medium	Low
Rule4	Low	Medium	High	Low
Rule5	Low	High	Low	Low
Rule6	Low	Medium	Low	Low
Rule7	Low	High	Medium	Low
Rule8	High	Low	Low	Low
Rule9	Medium	Low	Low	Low

Medium level:

Table 2: Rule Base for Medium level range

Rules	Queue length	Data rate	Item size	Traffic range
Rule10	Medium	Medium	Medium	Medium
Rule11	Medium	Medium	Low	Medium
Rule12	Medium	Medium	High	Medium
Rule13	Medium	Low	High	Medium
Rule14	Medium	Low	Medium	Medium
Rule15	Medium	High	Medium	Medium
Rule16	Medium	High	Low	Medium
Rule17	Low	Medium	Medium	Medium
Rule18	High	Medium	Medium	Medium

High level:

Table 3: Rule Base for High level range

Rules	Queue length	Data rate	Item size	Traffic range
Rule19	High	High	High	High
Rule20	High	High	Low	High
Rule21	High	High	Medium	High
Rule22	High	Medium	Low	High
Rule23	High	Low	High	High
Rule24	High	Medium	High	High
Rule25	High	Low	Medium	High
Rule26	Low	High	High	High
Rule27	Medium	High	High	High

In order to find the crisp value, we have framed 27 rules based on the three input parameters QL, DR and IS. Now based upon the crisp value output, the threshold parameter associated with respect to the traffic pattern in any routing protocol can be changed to achieve desired flow control. In order to improve the Intrusion detection model and the intrusion response model crisp can be used to reduce the malicious node activity in the given 'MANET'. Packet size, queue length are selected for fuzzy parameters of the data packets, data rate, power margin of nodes, and mobility range of nodes etc., a rule base is generated based upon these parameters.

## V. INTRUSION DETECTION METHOD

A node sends an intrusion (or anomaly) status request to a neighboring node, and then each node (including the initiation node) propagates the intrusion or anomaly status information. Then each node verifies whether the majority of the received reports indicate an intrusion or anomaly; if yes, then it concludes that the network is under attack. Any node that detects an intrusion then initiates the response procedure throughout the network.

If any node identifies that another node is compromised, when its *malcount* exceeds the crisp value of the fuzzy approach (case-2) or threshold value as for (case-1) for allegedly compromised node. In such cases, it transmits this information to the entire network through a Mal packet. If other nodes also suspect that

the node which has been detected, is compromised, it reports its suspicious to the network through a ReMal packet.

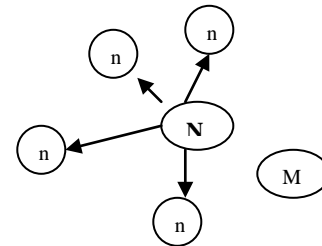


Figure 4: Mal packets generation

Audited data from other nodes cannot be trusted and should not be used because the compromised nodes can send false data. However, the compromised nodes have no chance to send reports of intrusion or anomaly because the intrusion response may result in their expulsion from the network. Therefore, unless the majority of the nodes are compromised, in this case one of the legitimate nodes will probably be able to detect the intrusion with strong evidence and will respond, the above scheme can detect intrusion even when the evidence at individual nodes is weak.

## VI. INTRUSION RESPONSE METHOD (IRM)

If two or more nodes report about a particular node, Purge packet is transmitted to isolated node in the network.



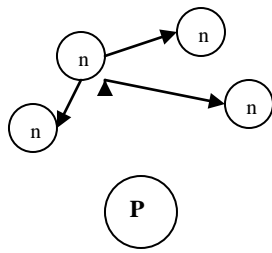


Figure 5: Purge packets transmission

All nodes look for a newer route through compromised node. All packets received from the compromised node are dropped. Any node that detects locally known intrusion or anomaly with strong evidence (i.e., the detection rule triggered has a very high accuracy rate), can determine independently that the network is under attack and can initiate the response. Purge packet is send to all the nodes in the network so that all nodes in that network becomes aware of the malicious or anomaly node and discards all the data packets and control packets from that node, through the purge packet all nodes change their rout table entry, purged node is detected from the neighbor node routing table and check the table for the neighbor nodes.

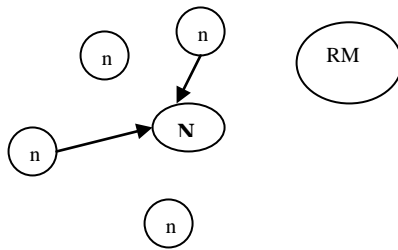


Figure 6: ReMal packets generation

## VII. IMPLEMENTATION

The proposed security measures were implemented using NS2 as the simulator. The implementation part consists of following steps:

### a) Creation of Malicious Nodes

Out of N nodes 30% of the nodes were made malicious in a network. In a network the nodes were selected randomly as malicious node, which generate more Route Requests (RR) than the normal value. Normally the nodes generate route requests for a proper rout is not known to the destination when data is present in their buffer. The randomly selected nodes were made to generate more number of route requests irrespective of their buffer data and for route discovery. Randomly each malicious node generates a variable number of route requests to another in the network. IDM and IRM operations are done cooperatively by a group of nodes when the confidence percentage level is very low. When the confidence level is very high the alleged node is directly purged from the network increasing the efficiency of the method and thereby decreasing the

time taken for the detection and response modules incorporated. Thus the malicious nodes are identified through the proposed security model.

### b) Method implementation

NS2 software is used to implement the method. The simulations were based on 1KM X 1KM area with 50 wireless nodes. The nodes move from a random starting point to a destination with a speed ranging from 0-20 m/sec, whenever destination is reached another destination be targeted after a pause time. The Intrusion detection and intrusion response methods are incorporated. Traffic sources are used Constant Bit Rate (CBR) with each data packet 512 bytes size, 15 nodes in the network were made malicious, sources and destinations were spread randomly across the network. The mobility model used random way in rectangular field. Duration of the simulation is 900 seconds. Separate simulation was performed for the malicious node creation in the network and after the implementation of the Intrusion Detection and Response methods.

### c) Performance scaling

#### i. Control overhead

The number of control packets transmitted for every data packet is noted, for routing each hop is treated as a packet. The following graph shows that the malicious nodes increase the routing load over the network as they generate the false route requests and thereby increasing the number of control packets for each data packet. After implementing the proposed security model, it considerably decreases the routing overhead by identifying the malicious nodes and eliminating them from the network and bringing the network near to normal through NTP protocol. The performance metrics of control Overhead Vs Pause Time is shown in the below figure.

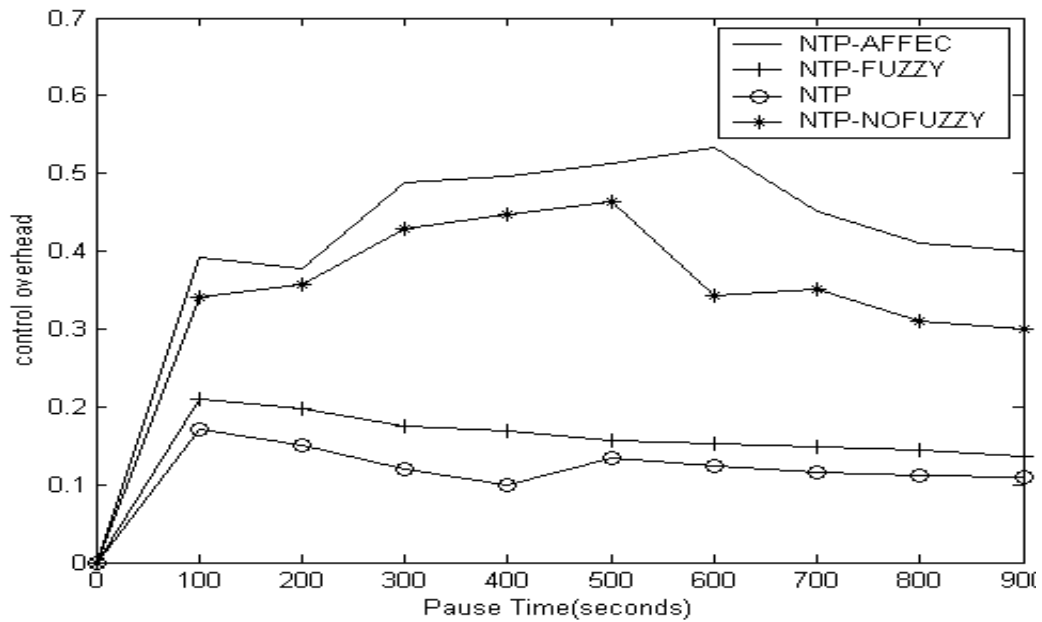


Figure 7: Control Overhead Vs Pause Time

### ii. Throughput

The ratio of CBR packets delivered to the generated is termed as throughput. For different pairs of the source and destination pair corresponding throughput is noted. The throughputs for the NTP

affected with malicious nodes are less when compared with ordinary NTP protocol. After incorporating the fuzzy approach the throughput is getting increased. The performance scaling of the throughput Vs Source-Destination Pair is shown in the figure 3.2.

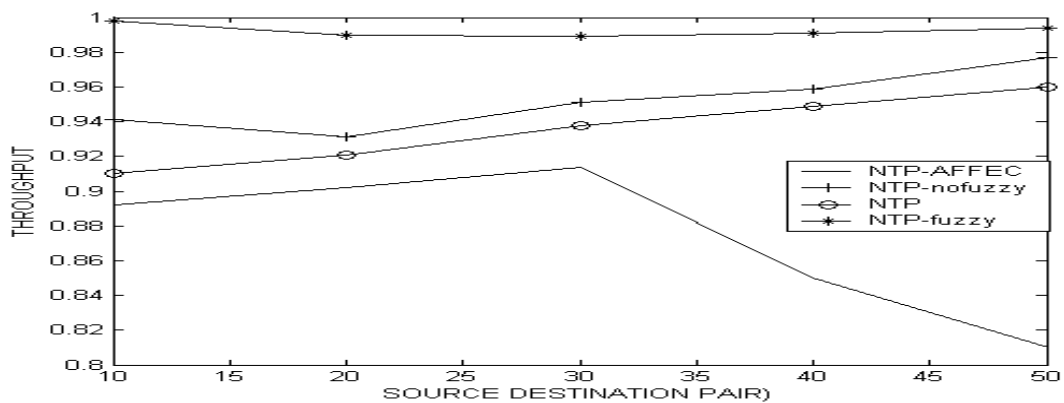


Figure 8: Throughput Vs Source-Destination Pair

### iii. Mobility

The graph is plotted for different mobility ranges. The system performance has been observed in the presence of malicious nodes. The performance of the system is enhanced due to the implemented model. In the simulation misbehaving node generates false route requests, so that node corresponding packet delivery decreases. The performance metrics of Packet delivery Vs Mobility is shown in the below figure.

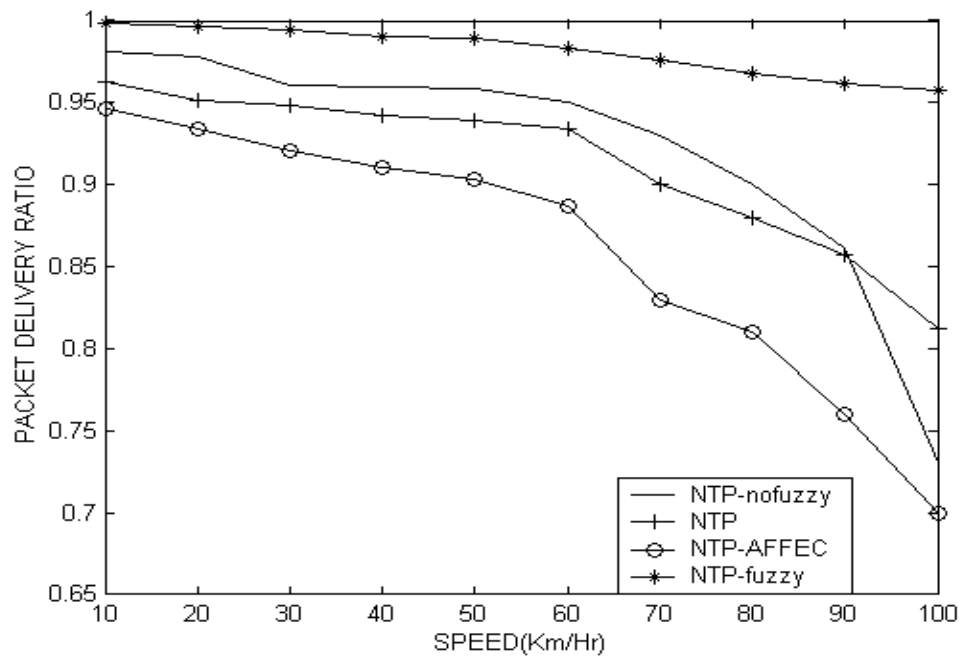


Figure 9: Packet Delivery Vs Mobility

#### iv. Delay Vs Pause Time

This is an average of delays incurred by all of the packets that are successfully transmitted. The below graph shows the malicious nodes in the network has meticulously increased end-to-end delay of the network

compared to the normal network as the nodes forward the false RRs to other nodes and thereby increasing the overall time to process the control packets. The performance metrics of delay Vs Pause Time is shown in the below figure.

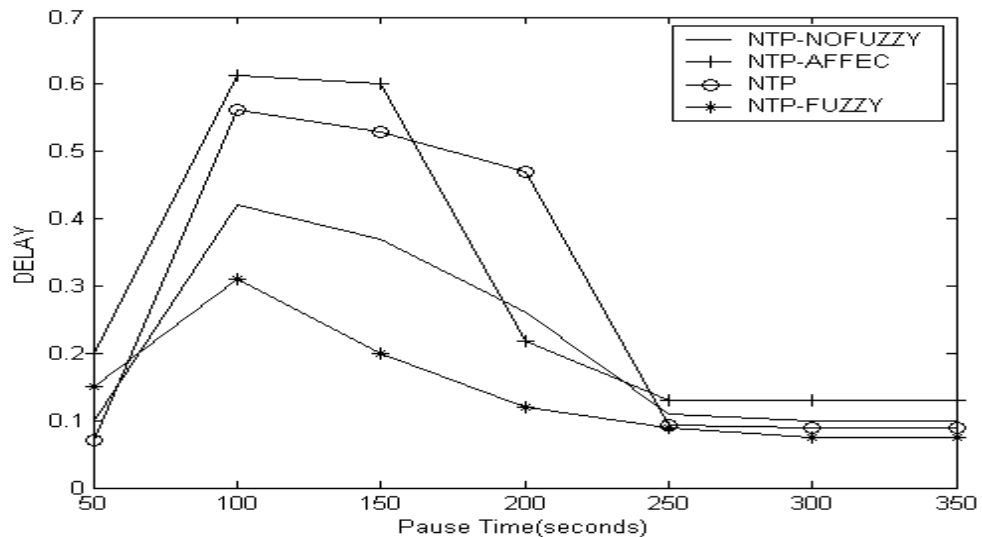


Figure 10: Delay Vs Pause Time

After incorporating the fuzzy security scheme the end-to-end delay is brought down to near normal network as intruder nodes were identified and their activities are restricted and intruder nodes are eliminated from the network.

eliminated the intruder nodes and has brought the network performance near to the normalcy. The performance characteristics of network depicted in the graphs prove this statement.

## VIII. CONCLUSION

The distributed false route request problem increases end-to-end delay, routing overhead, decreases the throughput and overall efficiency of the network. Our solution to this problem as successfully

## REFERENCES RÉFÉRENCES REFERENCIAS

1. T. Leinmuller, C. Maihofer, E. Schoch, F. Kargl, "Improved Security in Geographic Ad Hoc Routing through Autonomous Position Verification," *ACM VANET*, Los Angeles, CA, Sept. 2006

2. S. Capkun, L. Buttyan, and J. Hubaux, "SECTOR: secure tracking of node encounters in multi-hop wireless networks," in ACM Workshop on Security of Ad Hoc and Sensor Networks, 2003.
3. M. Poturalski, P. Papadimitratos, and J. Hubaux, "Secure neighbor discovery in wireless networks: formal investigation of possibility," in ACM Symposium on Information, Computer and Communications Security (ASIACCS), 2008.
4. Sudarshan Vasudevan, Micah Adler, Dennis Goessel, Fellow, IEEE, and Don Towsley, Fellow, IEEE, ACM, "Efficient Algorithms for Neighbor Discovery in Wireless Networks".
5. Zhen sheng Zhang and Bo Li, "Neighbor Discovery in Mobile Ad Hoc Self-Configuring Networks with Directional Antennas: Algorithms and Comparisons".
6. Sankararajan Radha and sethu shanmugavel "Implementation of Node Transition Probability Based Algorithm for MANET and performance analysis using different mobility models" IEEE Proc, VOL5, NO.3.sept2003
7. Sonali Bhargava, Dharma P. Agarwal "Security enhancement in AODV protocol for wireless Ad Hoc networks", IEEE 2001
8. Ross, Timothy. "Fuzzy Logic with Engineering Applications", Mc Graw-Hill, New York, NY, 1995.
9. Yongguang Zhang and Wenke Lee. " Intrusion detection in wireless ad hoc networks." In the 6<sup>th</sup> international conference in mobile computing and networking (MOBICOMM'00), pages 275-283, June 2000.
10. Sergio Marti, T.J. Giuli, Kevin Lai, and Mary Baker. "Mitigating routing misbehaviour in mobile ad hoc networks." In 6th International Conference on mobile computing and networking (MOBICOM'00), pages 255-265, August 2000.



## Node.js Challenges in Implementation

By Hezbullah Shah & Tariq Rahim Soomro

*SZABIST Dubai*

**Abstract-** Node.js gave rise to the Full Stack Developers who are now able to manage server and client side by their own. Node.js is fast and reliable for heavy files and heavy network load applications due to its event driven, non-blocking, and asynchronous approaches, where developers can also maintain a complete projects in single pages (SPA) and can use for IOT. The result of study concludes from a survey and from literature review the implementation areas and challenges of the Node.js. Lastly will provide suggestion on how to improve to overcome the challenges.

**Keywords:** *node.js, javascript, SPA, IOT.*

**GJCST-E Classification:** *1.2.4, 1.7.2*



*Strictly as per the compliance and regulations of:*





# Node.js Challenges in Implementation

Hezbollah Shah <sup>α</sup> & Tariq Rahim Soomro <sup>σ</sup>

**Abstract-** Node.js gave rise to the Full Stack Developers who are now able to manage server and client side by their own. Node.js is fast and reliable for heavy files and heavy network load applications due to its event driven, non-blocking, and asynchronous approaches, where developers can also maintain a complete projects in single pages (SPA) and can use for IOT. The result of study concludes from a survey and from literature review the implementation areas and challenges of the Node.js. Lastly will provide suggestion on how to improve to overcome the challenges.

**Keywords:** *node.js, javascript, SPA, IOT.*

## 1. INTRODUCTION

Web based applications are increasing its popularity as they become easier to develop, maintain and secure. Also they are easily reachable to the clients and does not require additional installations in most cases and are quickly customizable [1]. Web application is derived from web based system, which have additional functionality to execute business logic of an organization. These applications are totally web based instead of requiring to install a separate application on the operating system [2]. Google Docs, Web based retail stores, Google Maps, and the web based email applications are kind of Web applications [1][3].

The Web development industry will find two kinds of developers. i.e. Front-end developers and Back-end developers[3]. Front-end developers require

to have knowledge of HTML, CSS, and a programming language to add effects and more to the front – end i.e. JavaScript. They build the web sites display and effects which are shown to the clients by converting the designer's design [3]. Back-end Developers build the business logic behind any web application. The actions for instance adding and retrieving news highlights to and from a web applications, or sending email from a web based forms, or authenticating a visitors or clients credentials are all part of back-end developers. A back-end developers need to know languages like PHP, .NET, Java, and others [3][4]. Back-end developers should also have knowledge of databases like My SQL, Oracle, and SQL Server, or should hire or entrust a database administrator to work with the flow. A database administrator will take care of database server and ensure its smooth performance [5] [4].

Full stack developers are jack of all trades, and they are the one who do all. Mostly back-end developers are required to have skills of front-end developers and vice versa and have extra burden on them of learning additional skills set[4]. So it is clear that for a developer to become full stack, he have to have expertise in languages of three kinds, i.e. Client Side languages such as Java script along with HTML and CSS, Server Side Languages such as PHP, .NET, Java, Ruby, etc, and database expertise such as SQL Server, MySQL Server, and Oracle. As depicted in Figure 1.

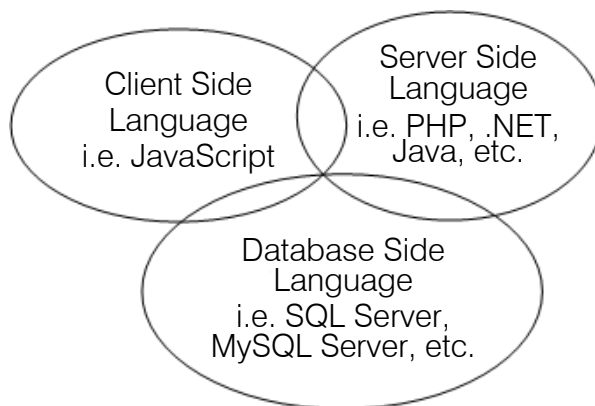


Figure 1: Full Stack Developer

Node.js is overriding the complication of learning multiple languages in the same time to become a Full Stack developer where a front-end developer who

is confident in JavaScript just requires to learn some additional Server Side Functions and he becomes a Back-end developer [6] [7]. Apart from this where Node.js is free, it is also used by thousands of developers around the globe [8]. While the web application demands performance and scalability, history have already adopted threading and events

Author <sup>α</sup> <sup>σ</sup>: Department of Computer Science, SZABIST Dubai Campus, UAE. e-mails: email@hezbollahshah.pk, tariq@szabist.ac.ae

either separately or its combination. But its daily internet traffic's increasing nature demand better and new solutions to improve the concurrent nature of the service. One solution is Node.js (which sometimes is also termed as Node [9]) which is a lightweight, and fulfills the demands through event-driven and non-blocking I/O model and server-side JavaScript [10][11]. Chrome's V8 JavaScript engine is the basis for Node.js as Node.js JavaScript runtime is built on it [11]. Written in C++, V8 is an open source from Google as a high performance JavaScript engine. Google have used V8 in Google Chrome browser, and is capable to run standalone and can also be embedded into C++ applications. It is capable to run on different versions of Windows, Mac OS, and Linux [12]. As Node.js is event-based and not thread-based, it is also capable of scaling to millions of connections concurrently, while using an event loop within a single thread and not making overhead of multiple threads. Node.js processes its I/O operations asynchronously and is widely misunderstood with AJAX. While Node.js and AJAX are considerably different [9].

#### a) Advantages of Node.js over others

Node.js is built from ground for the purpose of handling asynchronous I/O as it is built of JavaScript and JavaScript is built as event loop. Like the on click event for a button in client side JavaScript is and event loop. While other environments do have this feature, they have it with using third party libraries or are not built from ground for the same purpose like the Node.js and hence they are often slow, or lags and does not belongs as a standard feature to them. Some of the examples are Event Machine – built for Ruby, Twisted – licensed under open source MIT License, it is introduced for Python and is available since Python 2 onwards, and network framework library for Apache named as Apache MINA which is also called “Networking Socket Library” and is another example of providing event-driven and asynchronous limited to APIs only. Similarly Apache AsyncWeb is built using Apache MINA and Perl's Any

Event. Similarly an edge of Node.js over others will be that it will be capable of handling multiple request while it will act like a client towards the third party services by executing only a single thread. Other languages in this regard will block the processing until the remote server responds first for their initial request as a result they will be requiring multiple threading for executions. Comparatively in Node, all what you will use is asynchronous as it will become quite hard if you are to write non-asynchronous code in it. Also Node.js will never force to buffer data before outputting while the others like Event Machine, forces buffering in many cases to buffer the data[7][6][13][14][15][16][17].

Being server side JavaScript, another admirable edge of Node.js over others is that a developer will be required to only have knowledge and experience of a single language i.e. JavaScript, no matter if he is developing client side scripts or scripts for server side. The developer is not required to swap his brain cycles from for one language at client side and then for another language at server side. Hence JavaScript end-to-end as depicted in the Figure 2. Here the database of JavaScript also store data like a JavaScript Object. Adding to this, it is also worth considering that Node.js is new and thus have benefit of taking precautions against the mistakes which other languages had come across in the past such as the mistake of backward compatibility[7][6]. Figures shows that about 47% of web surfers wants a website to be loaded within 2 seconds and a 3 second delay drops the customer satisfaction by 16% [18]. Here the Node.js leads as the interpreter of Node.js is smaller and fast compared to other languages like PHP. Here the server side apps are permanently kept ON unlike other languages where every initiation of the application will follow cycles consuming steps of for example loading configurations, followed database connectivity, acquire required information and finally render the markup language. Node.js on other hand reduces these steps by keeping an app permanently ON [19].

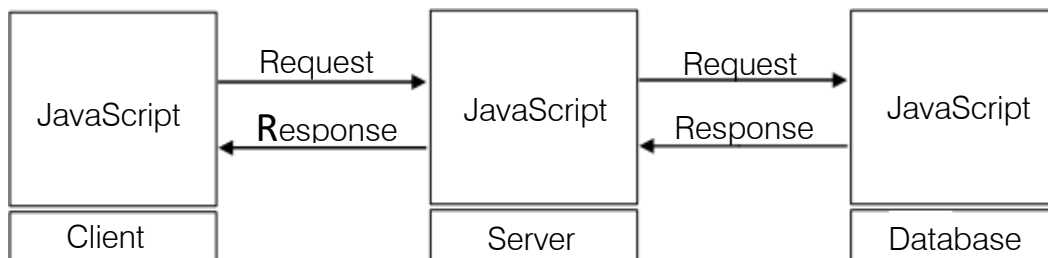


Figure 2: JavaScript end-to-end

#### b) Disadvantage of Node.js over others

A code in Node.js becomes fast growing, along with making it difficult to debug due to the fact that it is using event-driven/callback approach [7]. Big drawback currently is the unavailability of ready hosting for Node.js

environment. Complex topics of JavaScript language such as prototypical inheritance, anonymous function, callbacks make the language hard to learn, and thus becomes the choice to be learnt when one has mastered another easy language first [20]. Node.js is

not a mature language still and thus faces so much hesitation to get joined by expert programmers. Another issue is that being single-threaded, other requests are stopped if in case the CPU is occupied even for some parts of a second. And so the developers are also forced to think in asynchronous which is not easy to get used with [21] [22].

The scope of the study is to make struggles for exploring the implementations of Node.js and try to catch on how it can be made easy to implement for new comers specially. Also it tries to explore challenges to Node.js that why it is still not being very widely implemented and why new comers to Node.js are less? Efforts will be made to combine the ideas with real experiences and not suffice just theories. The study will be exploring the issues in the Node.js implementations and adoption if any and provide recommendations for those challenges. This study will make the reader interested in the adopting of Node.js as the features and possibilities of Node.js will be uncovered to the reader. The result of this study will help developers to find out reasons and methods to quickly adopt the Node.js and help Node.js become popular in the market similar to other top languages like .Net Languages and PHP. This paper is organized as follows, section 2 will explore the review of literature, section 3 will talk about material and methods used for this study and section 4 will depict the results and finally discussion and future work will be discussed.

## II. LITERATURE REVIEW

This section describes about the existing research on the Node.js as a server side language and areas where Node.js is implemented practically, along with having some general review about the same like History of Node, and some application areas of Node.js and is it efficient or not.

### a) *About JavaScript and Node.js*

The history of JavaScript dates back to the beginning of WWW and it started playing integral role in making the front ends of websites interactive. JavaScript introduced its concepts in AJAX in late 1990's which is again used to add real time like behavior to the web pages. Till this time the JavaScript was always believed to be a client side scripting language and that it has nothing to do with the server side programming. However by the development of server side JavaScript like Node.js, the concept changed and now the JavaScript is not only a client side scripting programming language, but also it is also capable of executing on server side. Node.js is one of the main competitor in the JavaScript on server-side era. Again it is important to mention that Node.js is different from JavaScript, while JavaScript is no doubt backbone of Node, Node.js is just build on top of JavaScript only and hence use the same language [9].

### b) *History and Evolution of Node.js*

The created Ryan Dahl was first motivated to build Node.js from a progress bar showing file upload at Flickr (a company of Yahoo dealing with pictures galleries [23]) where the browser was asking server again and again about how much size of file is being uploaded [24][25]. And on March, 2009 Node.js got its name for the first time and the package manager for it was also introduced in the same year in October and an early preview of npm (the Node.js Package Manager) was introduced. Later in the same year in November, the creator Ryan Dahl did the first talk about Node.js at JSConf 2009 where he talked about Node.js in detail. He explained how Node.js is event based, and works on callbacks where every function of I/O as receiving input from disk, network or any process, should use callback and the audience stoop up to applaud for his extra ordinary project. In 2010 Express framework was introduced towards Node.js [26][17]. The node.js was not available for Windows Environment until July 2011 when Microsoft partnered with Joyent for this purpose and support of even older version of Windows Server was added [27]. Later in end of 2014 some of the enthusiasts from Node.js team boycotted Node.js and created their own fork from Node.js naming it io.js or iojs. They boycotted as they were unhappy with the control of Joyent over the project [28]. The following year, both of them again seem to merge together as they both voted to form a neutral Foundation of Node.js and finally in the same year in September 2015 they merged back and their integrated community made amazingly progress in emerging a joined codebase[29][30].

### c) *Architecture of the Node.js Platform*

With the build of Node.js, the web servers got event driven programming. Which made the web server fast and in a language widely popular i.e. JavaScript, and this is also the reason that the entire web development community got access to Node.js within no time. In Node.js developers are not required to make use of threading while creating greatly scalable servers. Node.js uses a very easy event-driven model which uses the triggering of callback functions upon completion of a task or generation of error. Ryan Dahl created the Node.js behind the idea that other programming languages makes it difficult to program things to make them work concurrently[31][32].

### d) *Adoption of Node.js*

Node.js is adopted by giants such as PayPal, LinkedIn, Medium, and Netflix to mention among the many [33]. Face book adopted Node.js and it proved for them extremely proficient and then they adopted it for production [34]. Microsoft made a worthy change of making Node.js a part of the developer stack mainly since then developers can now use it on Azure platform also along others and is not restricted to only old

Operating Systems[35]. Walmart adopted end-to-end JavaScript by using Node.js believing that Node.js will be helping them to front their services which they are providing all over the world. They mentioned they adopted Node.js also because it is not just introducing

new thinking of how to build perfect software, but also great way to express the existing things in a new way [36]. According to the statistics by GitHub, JavaScript is the most popular language. The statistics graph is shown in Figure 3[37].

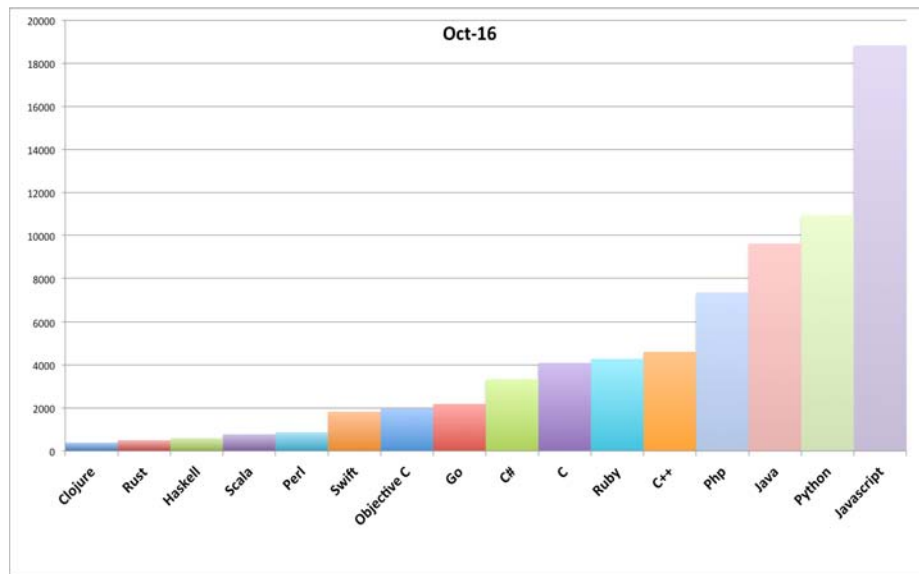


Figure 3: Javascript the most popular language[37]

#### e) Application of Node.js

Node.js was compared with PHP/Nginx for Performance and Scalability, where Node.js showed high performance and scalability compared to PHP/Nginx. The two researchers developed web application on Dijkstra Algorithm and simulated load of concurrent user requests using some load generators [38]. University of Notre Dame in [10] had a project report issued where the author performed tests between Node.js and Ruby's Event Machine and Apache's threading model, which measured request time over the number of cores. Node.js had again beaten the other two especially when the number of cores were increased. Node.js based DPWS – Devices Profile for Web Services (termed as Node. DPWS) was evaluated for performance and compared with alternative DPWS tools. The researcher concluded that Node.js based DPWS was easy to use as well as light weight. Node. DPWS had beaten even the most striking substitute of it in the field of IoT (Internet of Things) [39]. Node.js also plays important role in GIS field and a paper published in Journal of Korea Spatial Information Society used Node.js in Web GIS. They implemented Node map and concluded in their research that Internet GIS have its future bright in combination to the Node.js[40]. Another analysis study at [9] has shown that Node.js can be used to have complex real time applications and that these application can be served for millions of client connections. There is a web service named MAGI which is used in infrastructures of graphic processing unit (GPU) for the purpose of fast data analysis of Micro

RNA-seq. While MAGI is based on Node.js, it did addressed the limitation of other similar tools to not being able to handle large files, and a burdensome error prone steps. Also MAGI helped uncovered the delay in downstream analysis as the others are time consuming and solved the issue of others of not being able to provide statistical tests [41].

#### i. Single Page Applications

Single Page Applications or SPA is a term given to web based applications which does not cause a page to reload during use. While SPAs have history from quite a long time, and is based on Java, Flash and JavaScript. It is known that JavaScript does not require any third party client plugins like the former ones. And that is the reason that Node.js as it is based on JavaScript becomes successful in competing the others in SPAs [42].

#### ii. NodeOS

An operating system built on Java Script is Node OS. Its packages are managed by the package manager of Node.js which is npm hence any Node.js package is Node OS package. While packages in npm is about 300,000. NodeOS won the Spanish 9th National Free Software Championship in the category of the Systems and is also honorably Mentioned in its 10th edition [43] [44].

#### iii. PoisonTap

Poison Tap is built on Node.js to create backdoors even the locked computers. This USB just requires to be plugged to a running computer even if it



is locked. It then installs continuous backdoors which operates even if the USB is removed later and allows the intruder to access also the router along with the target network and cookies of the web browser [45]. When we asked the creator Samy Kamkar through email that why he choose Node.js for Poison Tap, he replied: "The browser based code must be in JavaScript, so it made sense to me to keep the backend in the same language".

#### iv. Node.js in IOT

Node.js is adopted by developers and researchers for IOT for the reasons that JavaScript fast and is familiar among the large number of web developers as they use it with HTML5 for programming front end User Interfaces, and important point is that JavaScript is best for embedded devices as its nature is to support asynchronous and event-driven functions. Also the programming model adopted by Node.js is a great fit for embedded devices as well as servers and the domain experts have already adopted Node.js for the purpose of IOT [46]. Microsoft have also adopted Node.js for IOT development in its developer resources [47].

### III. MATERIALS AND METHODS

This study gains knowledge from the Node.js domain experts through intensive literature review. This study also gains knowledge from a surveys conducted from the professional developers. The survey was created on Google forms and ran for 1 month from the following link:

- ✓ <https://docs.google.com/forms/d/e/1FAIpQLSc4Ghr oqubE5jQSnmPOXEWuXzD8lcpRCtFPbSfFYscszX SVg/viewform?hl=en>

The survey was targeted to the developers groups on the LinkedIn, Facebook and also shared with professional developers.

### IV. RESULTS AND FINDINGS

The Literature Review concluded that Node.js can be useful and should be implemented in any place

where there is processing of large files or requires large network load. Below are discussed some results in the same context. Due to Node.js a developer can easily become Full Stack Developer where he as a developer does not require separate colleagues for server side development and database development. Also the employers can reduce their cost by adopting Node.js as they will find a single developer taking care of performing all task at server side as well as at client side. Introduction of Node.js also introduced easy implementation Single Page Applications (SPA) where the web application developed in it are faster, as they use fewer resources of the server and fewer callbacks to the server while making the websites more interactive and user friendly[42]. The literature review also concluded that the field of Internet GIS have bright future in combination with Node.js. Also to mention, that Node.js is proven to be faster than other to process graphics processing. As there are benefits of the Node.js, there are large chances of misusing it and one such case is the release of PoisonTap USB which create backdoors to a computer and the network through any running computer even if it is password locked. Due to the increased use of JavaScript among the developers, such backdoor software are also part of life of developers.

As the study is also based on the quantitative research, because a survey was conducted, below are mentioned the results of the same. The online survey was sent to several Professionals through LinkedIn, Facebook, and Personal Networking. Total 93 responses were received. Among them 80 responses were useful for this study as they were developers and as this study is related to developers' community. Among the 80 developers (respondents) which were reached within a month, 16.2% did not know about Node.js. The rest 83.8% of the developers proceeded with the rest of the survey questions and they were 67 in count as shown in Figure 4.

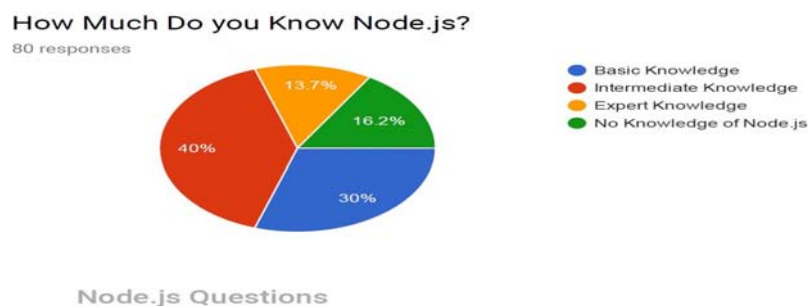


Figure 4: Awareness of Node.js

Regarding learning challenge; the respondents shows that is somehow hard to learn the Node.js as only 31.3% said it wasn't a challenge for them to learn

Node.js. 23.9% felt its learning as a challenge, 44.8% felt little bit the learning as a challenge as shown in Figure 5.

### Learning of JavaScript for Node.js was a challenge?

67 responses

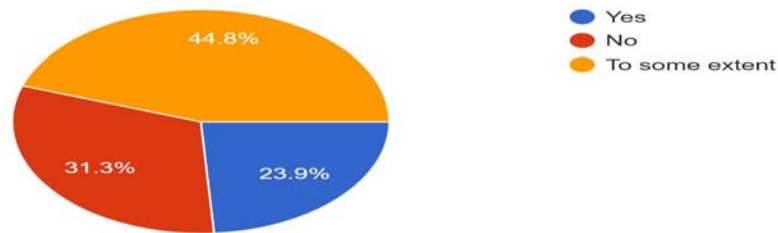


Figure 5: Learning JavaScript for Node.js

Regarding Database challenge; the survey concluded the results that as developers are familiar with the SQL databases, they find it difficult to adopt the

NoSQL databases as quickly as only 31.3% said that the NoSQL databases use and learning is not a challenge as shown in Figure 6.

### Learning and Using JavaScript Databases was a challenge?

67 responses

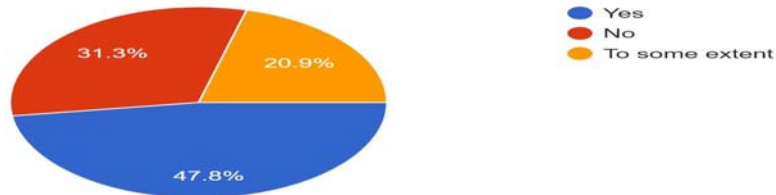


Figure 6: Use of NoSQL Databases

Regarding the Event-Driven feature challenge, the survey concluded that they felt difficulty with Event-Driven feature of Node.js as 40.3% did not considered it

as a challenge, the rest 25.4% felt it a challenge to some extent only, and the rest 34.3% said they felt it as a challenge as shown in Figure 7.

### Event Driven feature of Node.js was a challenge?

67 responses

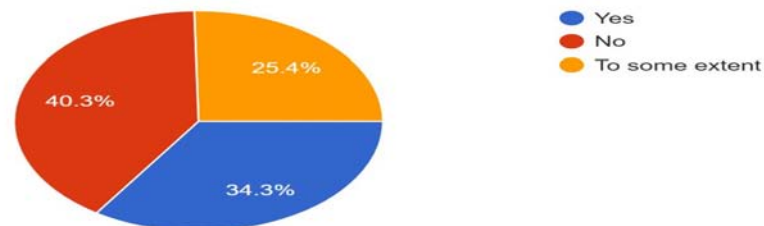


Figure 7: Event Driven feature of Node.js

Regarding Non-blocking feature challenge, the survey concluded this feature is a challenge to the developers. As the Figure 8 shows, only 41.8% did not feel it as a challenge while 31.3% see this feature as a

challenge, 26.9% see it as a challenge up to some extent only.



### Non-Blocking I/O feature of Node.js was a challenge?

67 responses

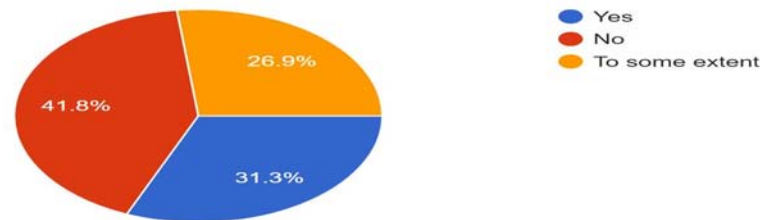


Figure 8: Non-Blocking I/O in Node.js

Regarding asynchronous feature challenge, the survey concluded this is not enjoyed by the developers as according to Figure 9 only 43.3% feel the feature

wonderful, 38.85 say that this feature is a challenge and 17.9% feel it as a challenge up to some extent only.

### Asynchronous Processing feature of Node.js was a challenge?

67 responses

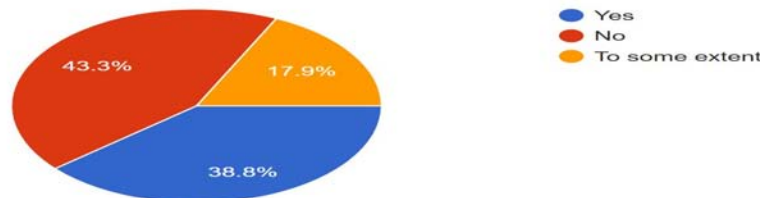


Figure 9: Asynchronous Processing in Node.js

Regarding the challenge of being familiar with other programming language; the survey concluded that the developers with hands on other languages also enjoys Node.js as according to the survey outcome shown in Figure 10 the respondents who are using other programming languages do not feel Node.js adoption

as a challenge by 50.7% and rest of 17.9% from the other programming languages felt Node.js adoption as a challenge to some extent. While only 31.3% feel it as a challenge if they are from other programming language environment.

### Hands on other environments (Like PHP, .Net, Ruby etc.) gave hard time to adapt Node.js?

67 responses

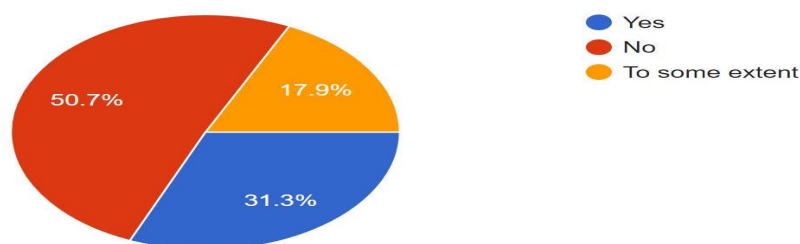


Figure 10: Developers from other programming languages

Regarding the challenge of configuring server for Node.js; 61.2% responded as they did not felt it as a challenge. Only 25.4% felt it as a challenge, while 13.4% felt setting up the server a challenge up to some extent

only. The result of survey to this opinion is shown in Figure 11.

### Setting up Hardware or Server was a Challenge

67 responses

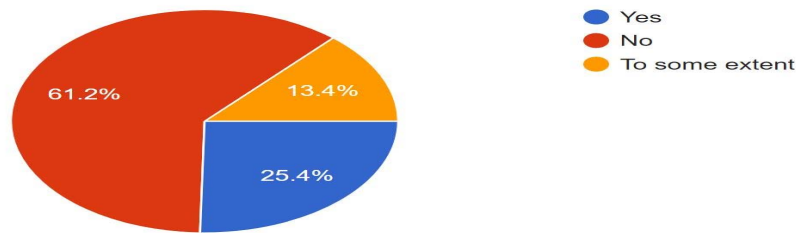


Figure 11: Setting up hardware for Node.js

Regarding the challenge of organizational decisions to adopt Node.js; according the Figure 12 from survey results, 47.8% said the reason to delay the

Node.js implantation is their organization's decision. 37.3% disagreed with it, while 14.9% respondents are not so sure about this question.

### Organization decision to replace existing technology was a hindrance in Implementation of Node.js?

67 responses

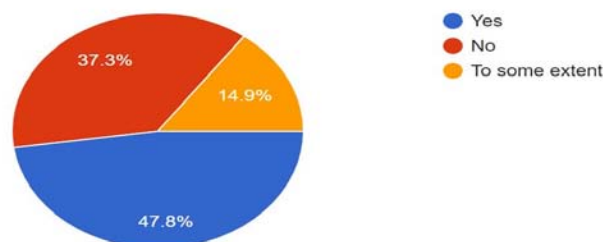


Figure 12: Organization decision to replace the current technology

The challenge of market awareness is also a factor in implementing the Node.js. This is shown from the Figure 13 as when asked from the online survey respondents about the market awareness factor, 44.8%

agreed to it as a challenge, 19.4% agreed it as a challenge up to some extent. While only 35.8% said it is not a challenge.

### Lack of Market Awareness caused a hindrance in implementing Node.js?

67 responses

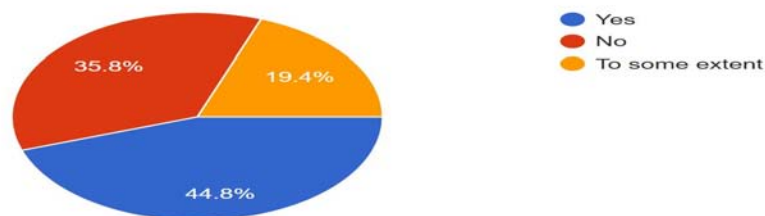


Figure 13: Lack of market awareness as a challenge to implementing Node.js

As a result of the survey conducted, the greatly liked feature (by about 50% developers) of the Node.js is the reality that the same consistent language is used on both the servers and the clients. While the other features like event-driven, non-blocking feature, and the

use of JavaScript is also liked by about 46% of developers. And some of them (which are 34.3%) also liked its ability to make itself best fit in IOT. This is shown in Figure 14

### What Do You Like About Node.js?

67 responses

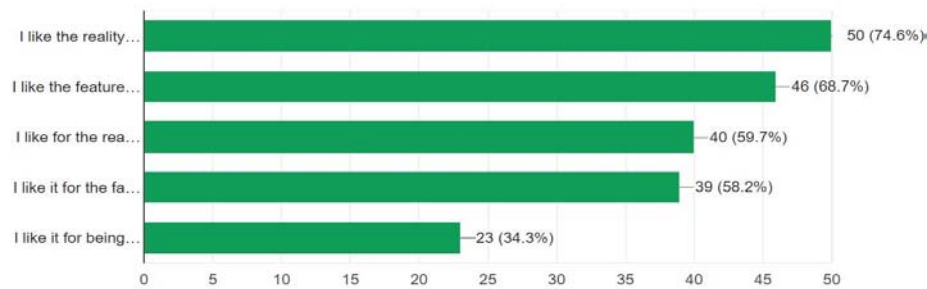


Figure 14: Greatly Liked Features of Node.js

## V. DISCUSSION AND FUTURE WORK

The study got the finding about the implementation of Node.js. Below is discussed the implementations positive findings as a result of literature review and the survey.

- ✓ The Node.js have made Full Stack Developers' job a dream come true. In absence of Node.js it was hard for a developer to learn several different languages and environments to manage the complete system at server side and client side.
- ✓ Organizations and developers can now with the invent of Node.js build highly load bearable and faster applications and by using Single Page Applications (SPA) now the server calls are reduced and the applications are more user friendly and faster.
- ✓ Node.js made it easy to achieve high load operations like graphic processing and Internet GIS very quicker, and it can be reliably used in every field where the files sizes are high or the network bandwidth is highly consumed. Node.js will make such operations faster and with less need of bandwidth.
- ✓ Community like its feature that the same language is also being used at server side while JavaScript is always been used at client side for ages.

Node.js have some challenges in context of its use in the community as well as its adoption by the developers and organizations over the existing programming technologies. No doubt that Node.js have great benefits, it have also some challenges to the community. One such challenge is the ability of misuse of the widely used language by developers. One enthusiast have made a backdoor software using Node.js on Raspberry Zero. It can create backdoors in the target computer and their network even if the computer is password locked. Although there are solutions from such backdoors but some seems impractical like totally blocking the USB ports, and closing the web browser every time the user leaves the computer. And other options are not implemented by

majority and mostly might not be aware of it like using secure layer on ones websites (https), and enabling secure flags on the cookies which common users might not know about it [45].

- ✓ There is a plus point but as understood from the survey conducted that the community feel it hard to learn JavaScript for Node.js
- ✓ Also the developers having knowledge of other programming languages have complications in adopting Node.js. Even the setting up of server for their programming work is not an obstacle. This is as concluded from the survey results.
- ✓ Another plus points were event-Driven Programming, Non-Blocking I/O, and asynchronous feature. But according the survey results is that the features like event-driven programming, Non-Blocking I/O, and Asynchronous processing is a hindrance.

As a result of the survey, a challenge comes to front is that most organizations are not ready to adopt the new technologies like Node.js over their existing ones like PHP, .Net, etc. Also there is a lack of market awareness which is causing a barrier to adopt Node.js for implementation. At a developer level, there is a challenge which is seen from the survey results that they are not feeling it easy to learn the database working and using of the JavaScript environment. And there also seems a lack of enough knowledge among the developers as from the survey results a reasonable respondents to the questions on the important features like event-driven, non-blocking I/O and asynchronous processing is making the decision about this.

The community can be taken to the Node.js by little efforts of trainings, and conducting workshops to introduce Node.js to new and existing programmers and explain to them the benefits of Node.js features like event-driven programming, non-blocking I/O, and asynchronous processing. The community need to be updated about the features of how Node.js is faster in performing network related tasks specially when it come to the challenge of handling large files over the network and handling multiple callbacks in the other languages

like PHP, .NET, etc, causing the server to overload or require more memory. Also organization should be briefed about the benefits of hiring Full Stack Developers based on Node.js and how they will cut costs related to server bandwidths and developers hiring and speed of the applications built over Node.js

## REFERENCES RÉFÉRENCES REFERENCIAS

1. "The benefits of web-based applications," [Online]. Available: <http://www.magicwebsolutions.co.uk/blog/the-benefits-of-web-basedapplications.htm>. [Accessed 25 November 2016].
2. Web Application Basics, Pearson Higher Education.
3. F. Bridge, "What Types of Developers Are There?," tree house, 24 June 2016. [Online]. Available: <http://blog.teamtreehouse.com/what-types-of-developer-are-there>. [Accessed 25 November 2016].
4. M. Wales, "Front-End vs Back-End vs Full Stack Developers," Udacity, 08 December 2014. [Online]. Available: <http://blog.udacity.com/2014/12/front-end-vs-back-end-vs-full-stack-web-developers.html>. [Accessed 25 November 2016].
5. J. Long, "I Don't Speak Your Language: Frontend vs. Backend," tree house, 25 September 2012. [Online]. Available: <http://blog.teamtreehouse.com/i-dont-speak-your-language-frontend-vs-backend>. [Accessed 25 November 2016].
6. A. Mardan, "PHP vs. Node.js," Programming Weblog, [Online]. Available: <http://webapplog.com/php-vs-node-js/>. [Accessed 28 January 2016].
7. J. Kaplan-Moss, "Quora," [Online]. Available: <https://www.quora.com/What-are-the-benefits-of-developing-in-Node-js-versus-Python>. [Accessed 29 June 2016].
8. "Node.js Tutorial," tutorials point, [Online]. Available: <https://www.tutorialspoint.com/nodejs/index.htm>. [Accessed 25 November 2016].
9. N. Chhetri, "A Comparative Analysis of Node.js (Server-Side JavaScript)," Culminating Projects in Computer Science and Information Technology., p. 5, 2016.
10. R. R. McCune, "Node.js Paradigms and Benchmarks," 2011.
11. Node.js, "Home page of Node.js," Joyent, 2016. [Online]. Available: <https://nodejs.org/en/>. [Accessed 01 May 2016].
12. G. Developers, "Chrome V8 | Google Developers," Google, [Online]. Available: <https://developers.google.com/v8/>. [Accessed 27 May 2016].
13. eventmachine, "GitHub, Inc," [Online]. Available: <https://github.com/eventmachine/eventmachine>. [Accessed 30 June 2016].
14. Twisted Matrix Labs, "Twisted Matrix Labs," [Online]. Available: <http://twistedmatrix.com/trac/>. [Accessed 30 June 2016].
15. The Apache Software Foundation, "Apache MINA," [Online]. Available: <http://mina.apache.org/>. [Accessed 30 June 2016].
16. The Apache Software Foundation, "Apache MINA," [Online]. Available: <http://mina.apache.org/async-web-project/index.html>. [Accessed 30 June 2016].
17. Ryan Dahl: Original Node.js presentation. [Film]. Youtube, 2012.
18. "How Loading Time Effects Your Bottom Line," Kissmetrics Blog, [Online]. Available: <https://blog.kissmetrics.com/loading-time/>. [Accessed 25 November 2016].
19. C. Buckler, "Site Point Smack Down: PHP vs Node.js," Site Point, [Online]. Available: <http://www.sitepoint.com/sitepoint-smackdown-php-vs-node-js/>. [Accessed 28 January 2016].
20. Firehose, "Firehose," Firehose Project, [Online]. Available: <http://blog.thefirehoseproject.com/posts/nodejs-vs-rails/>. [Accessed 30 June 2016].
21. "Quora," [Online]. Available: <https://www.quora.com/What-are-the-disadvantages-of-using-Node-js>. [Accessed 30 June 2016].
22. "Hashnode," Hashnode, [Online]. Available: <https://hashnode.com/post/what-are-the-actual-disadvantages-of-using-nodejs-ciibz8fd3017yj3xtxqz1r9hs>. [Accessed 30 June 2016].
23. Flickr, "Flickr, A Yahoo Company," Yahoo, [Online]. Available: <https://www.flickr.com>. [Accessed 18 November 2016].
24. A Harris, "The Birth of Node: Where Did it Come From? Creator Ryan Dahl Shares the History," silicon ANGLE, 01 April 2016. [Online]. Available: <http://siliconangle.com/blog/2013/04/01/the-birth-of-node-where-did-it-come-from-creator-ryan-dahl-shares-the-history/>. [Accessed 18 November 2016].
25. L. ORSINI, "What You Need To Know About Node.js," read write, 07 November 2013. [Online]. Available: <http://readwrite.com/2013/11/07/what-you-need-to-know-about-nodejs/>. [Accessed 2016 November 2016].
26. G. Nemeth, "Rising Stack Engineering," [Online]. Available: <https://blog.risingstack.com/history-of-node-js/>. [Accessed 27 October 2016].
27. R. Dahl, "Porting Node to Windows With Microsoft's Help," Node.js, 23 June 2011. [Online]. Available: <https://nodejs.org/en/blog/uncategorized/porting-node-to-windows-with-microsofts-help/>. [Accessed 18 November 2016].
28. P. Krill, "Q&A: Why io.js decided to fork Node.js," JAVAWORLD, 04 December 2014. [Online]. Available: <http://www.javaworld.com/article/2855639/open-source-tools/qanda-why-io-js-decided-to-fork-node-js.html>. [Accessed 18 November 2016].
29. "Node.js Foundation Advances Community Collaboration, Announces New Members and Ratified Technical Governance," The Linux Foundation, 15 June 2015. [Online]. Available:

- <https://www.linuxfoundation.org/newsmedia/announcements/2015/06/nodejs-foundation-advances-community-collaboration-announcesnew>. [Accessed 18 November 2016].
30. "Node.js Foundation Combines Node.js and io.js Into Single Codebase in New Release," Node.js, 14 September 2015. [Online]. Available: <https://nodejs.org/en/blog/announcements/foundation-v4-announce/>. [Accessed 18 November 2016].
31. A. Bretz and C. J. Ihrig, Full Stack Javascript Development With Mean.
32. G. Ornbo, Sams Teach Yourself Node.js in 24 Hours.
33. Li, "Architecture of Node.js' Internal Codebase," 04 June 2016. [Online]. Available: <https://arenli.com/architecture-of-node-js-internal-codebase-57cd8376b71f#.koh166uay>. [Accessed 18 November 2016].
34. J. Harrell, "Node.js at PayPal," PayPal Engineering, 22 November 2013. [Online]. Available: <https://www.paypal-engineering.com/2013/11/22/node-js-at-paypal/>. [Accessed 18 November 2016].
35. "How did Microsoft adopt Node.js as part of its developer stack?," Quora, [Online]. Available: <https://www.quora.com/How-did-Microsoft-adopt-Node-js-as-part-of-its-developer-stack>. [Accessed 18 November 2016].
36. J. O'DELL, "Why Walmart is using Node.js," VentureBeat, 24 January 2012. [Online]. Available: <http://venturebeat.com/2012/01/24/why-walmart-is-using-node-js/>. [Accessed 25 November 2016].
37. "GitHub Language Statistics," GitHub, November 2016. [Online]. Available: <https://github.com/emmanuel-keller/github-language-statistics> [Accessed 10 December 2016].
38. Y. Pandji D. and W. S. Raharjo, "Performance and Scalability analysis of Node.js and PHP/Nginx Web Application," INFORMATIKA, vol. 9, no. 2, pp. 117-124, 2013.
39. K. Fysarakis and D. Mylonakis, "Node.DPWS – High performance & scalable Web Services for the IoT," [Online]. Available: <https://arxiv.org/ftp/arxiv/papers/1503/1503.01398.pdf>. [Accessed 21 May 2016].
40. [S. H. Jun and K. T. Doh, "Design and Implementation of Web GIS Server Using Node.js," Journal of Korea Spatial Information Society, vol. 21, no. 3, pp. 45-53.
41. "MAGI: a Node.js web service for fast microRNA-Seq analysis in a GPU infrastructure," BIOINFORMATICS APPLICATIONS NOTE, vol. 30, no. 19, pp. 2826-2827, 6 June 2014.
42. M. S. Mikowski and J. C. Powell, Single Page Web Applications, MANNING PUBLICATIONS.
43. J. L. Combarro, "NodeOS: Light weight operating system using Node.js as userspace," [Online]. Available : <https://github.com/nodeos/nodeos>. [Accessed 16 September 2016].
44. npm, "Official Website of npm," npm, [Online]. Available: <https://www.npmjs.com/>. [Accessed 16 September 2016].
45. S. Kamkar, "Samy Kamkar," November 2016. [Online]. Available: <https://samy.pl/>. [Accessed 10 December 2016].
46. M. McCool, R. Peri and R. S. John, "Programming the Internet of Things Using Node.js and HTML 5," in O'Reilly Solid Conference, June 23, 2015.
47. Microsoft, "Developer resources," Microsoft, [Online]. Available: <https://developer.microsoft.com/enus/windows/iot/samples/expressnodejs>. [Accessed 10 December 2016].





This page is intentionally left blank





## Secure and Economical Cost Aware Routing Protocol for Wireless Sensor Networks

By Machha. Narender & R.P. Singh

*Sri Satya Sai University of Technology and Medical Sciences*

**Abstract-** The main objective of the paper is to supply security and to expand the network lifetime. The energy management domain is selected to reinforce the security system in wireless sensor networks. A typical wireless sensor network consists of many trivial and low-power sensors that sense radio frequencies to perform disseminate sensing tasks. These nodes typically have really restricted and non-replenish prepared energy resources, that produces energy and an important vogue issue for these networks. Routing is another really troublesome vogue issue for WSNs. Properly designed routing protocol not absolutely guarantees high message delivery relation and low energy consumption for message delivery, but in addition it should balance the full sensor network energy consumption, and thereby extend the sensor network fundamental measure. Throughout this paper, the tendency to confer Secure and Economical value Aware Secure Routing protocol for WSNs to balance the energy consumption and enhance the network fundamental measure.

**Keywords:** *wireless sensor network, security, energy efficiency, geo routing*

**GJCST-E Classification:** C.2.2, C.2.6



SECUREANDECONOMICCOSTAWAREROUTINGPROTOCOLFORWIRELESSSENSORNETWORKS

*Strictly as per the compliance and regulations of:*



RESEARCH | DIVERSITY | ETHICS

# Secure and Economical Cost Aware Routing Protocol for Wireless Sensor Networks

Machha. Narender <sup>α</sup> & R.P. Singh <sup>σ</sup>

**Abstract-** The main objective of the paper is to supply security and to expand the network lifetime. The energy management domain is selected to reinforce the security system in wireless sensor networks. A typical wireless sensor network consists of many trivial and low-power sensors that sense radio frequencies to perform disseminate sensing tasks. These nodes typically have really restricted and non-replenish prepared energy resources, that produces energy and an important vogue issue for these networks. Routing is another really troublesome vogue issue for WSNs. Properly designed routing protocol not absolutely guarantees high message delivery relation and low energy consumption for message delivery, but in addition it should balance the full sensor network energy consumption, and thereby extend the sensor network fundamental measure. Throughout this paper, the tendency to confer Secure and Economical value Aware Secure Routing protocol for WSNs to balance the energy consumption and enhance the network fundamental measure. Further the tendency to reinforce very cheap work to avoid the fake energy indicator nodes by victimizing the house parameters.

**Keywords:** wireless sensor network, security, energy efficiency, geo routing.

## 1. INTRODUCTION

Future sensor networks area unit is composed of Associate in nursing oversize category of closely packed sensor nodes. Each node inside the sensor network may embody one or further sensors, occasionally radio power, movable power gives presumptively localization hardware, sort of GPS (Global Positioning System) unit or a travel device. A key feature of such networks is that their nodes area unit unattended. Consequently, they have restricted and non-replicable energy resources. Therefore, energy efficiency could be a crucial vogue thought for these networks. Throughout this paper the tendency to review energy economical geographic packet forwarding techniques. Distributive knowledge in an area would be a really useful antique in many location aware systems, and notably detector networks. The region could also be expressed, as an example, by a tetragon in 2-space, therefore it satisfies the on prime of communication task, this question should be disseminated to the sensors inside the region, cost-effective because of publicize the geographic question to such a region is to leverage the

position info inside the question and to route the question on to the region instead of flooding it everywhere. Previous survey had done to route a packet geographically to a target area in Associate in assist ad-hoc networks. Detector networks believe wireless communication, that's naturally a medium and is further vulnerable to security attacks than its wired counterpart due to lack of a physical boundary. Inside the wireless detector domain, anyone with a suitable wireless receiver can oversee and interrupt the detector network communications. The adversaries may use valuable radio transceivers, powerful workstations, and move with the network from a distance since they don't seem to be restricted to exploitation detector network hardware, it's accomplishable for the adversaries confirm to spot, the message provide or maybe determine the availability location, though durable secret writing is employed. Source-location Privacy (SLP) could be a crucial security issue. Lack of SLP can reveal very important perception concerning the queue carried on the network and additionally the physical world entities. Whereas confidentiality of the message could also be ensured through content secret writing but it miles a lot of difficult to adequately address the SLP and protecting the SLP is toughest job in WSNs since the detector nodes embody exclusively cheap and low-power radio devices, and area unit designed to regulate unattended for long periods of some time. Battery recharging or replacement is additionally unfeasible or unacceptable. Computationally intensive crypto graphical algorithms, like public-key cryptosystems, and large scale broadcasting based protocols, are not acceptable for WSNs. To optimize the detector nodes, restrict the node capabilities and additionally applying specific nature of the WSNs. Traditionally, security desires for the foremost half overlooked, this leads to WSNs vulnerable from network security attacks. Considering the worst case, opponents are able to undiscovered and lead some wireless detector nodes, compromise the cryptographically keys, and reprogram the wireless detector nodes. Throughout this paper, the tendency to initial proposes some criteria to quantitatively live source-location knowledge discharge for routing-based SLP schemes. Through the projected live criteria, the tendency to area unit able to establish security vulnerabilities of some exiting SLP schemes. We tend to propose a subject matter which is able to provide every

**Author α:** Research Scholar, Sri Satya Sai University of Technology and Medical Sciences, Sehore, Madhya Pradesh, India.  
e-mail: machha.narender@gmail.com

**Author σ:** Vice-Chancellor, Sri Satya Sai University of Technology and Medical Sciences, Sehore M.P. e-mail: rp.singh@gmail.com

content confidentiality and SLP through a two-phase routing. Inside the initial routing section, the messages provide randomly selects Associate in nursing intermediate node inside the detector domain therefore transmits the message to the Randomly Selected Intermediate Node (RSIN), this section provides SLP with a high native degree. Inside the second routing section, the messages area unit routed to a hoop node where the messages area unit homogenized through a Network Mixing Ring (NMR). By integration of the nuclear magnetic resonance, we tend to area unit able to dramatically decrease the native degree and increase the SLP. Our simulation results demonstrate that the projected theme is improbably economical and may return through a high message delivery relation. We believe it is going to be used in many smart applications.

## II. RELATED WORK

The main idea of [1] authors approach was to eliminate the unidirectional link at the network layer and magnificence novel shake and channel reservation mechanisms at the medium-access management layer using topological knowledge collected inside the network layer. This paper absolute to get the unidirectional links and to avoid the transmissions supported unlike links but they have not considered dynamic nodes benefits. In [2] paper, author designed a cross layer framework that constructively improves the performance of the raincoat layer in power heterogeneous extempore networks. In addition, our approach seamlessly supports the identification and usage of unidirectional links at the routing layer. In [3] paper author thought of the periodic salutation sharing is to hunt out the unidirectional link. But this periodic sharing may even causes to overhead inside the network. In [4] paper, author planned to distribute the answer supported reducing the density of the network exploitation with a pair of mechanisms: bunch and adjustable transmission vary. By exploitation adjustable transmission varies; author in addition achieved another objective, energy economical vogue, as a by-product. In [5] paper, author's thought is bunch mechanism. The result of tightly coupled technique may increase the delay in information transmission and author presents ad-hoc on demand distance vector routing (AODV), a totally distinctive rule for the operation of such ad-hoc networks. Each mobile host operates as a specialized router, and routes unit obtained professional re natal (i.e., on-demand) with little or no reliance on periodic advertisements. AODV is on demand routing protocol that routes unit established on demand and destination sequence numbers unit accustomed notice the latest route to the destination. The affiliation setup delay could be a smaller quantity. The salutation messages supporting the routes maintenance and unit range-

limited, so those causes superfluous overhead inside the network but the intermediate nodes can lead to inconsistent routes if the availability sequence selection is very precious and additionally the intermediate nodes are stronger but not the latest destination sequence selection, thereby having stale entries. In [6] paper, authors present a mathematical framework for quantifying the overhead of proactive routing protocols in mobile ad hoc networks. They specialize in things where the nodes unit indiscriminately but the wireless transmissions could also be decoded faithfully and communication among nodes unit vary completely different. In [7] paper, authors present a general preview on different sources of energy consumption in wireless sensor networks, not on the routing. In [8] paper, authors concentrated on distance between nodes only not on security.

### a) Overview of Existing System

Several geographical routing protocols were planned in recent years for wireless detector networks. In geographical routing each node forwards messages to its neighboring nodes by supported computable value and learning value. The computable value considers every house to the destination and additionally remaining energy of the detector nodes. Location privacy is provided through broadcasting that mixes the valid messages with dummy messages, but exclusively consumes the detector energy but in addition can increase the network collisions and scale back the packet delivery relation.

### b) Proposed System

The energy consumption is severely disproportionate to the uniform energy preparation for the given configuration that greatly reduces the period of time of the detector networks. To resolve this drawback, we have an inclination to propose a secure and economical Cost-Aware Routing protocol which is able to address the energy balance and routing security at constant time in WSNs. In the proposed protocol each detector node needs to maintain the energy levels of its adjacent neighboring grids in addition to their relative locations, throughout this paper we'll specialize in a pair of routing strategies for message forwarding: shortest path message forwarding, and secure message forwarding through random walking to create routing path unpredictability for provide privacy and jam hindrance.

#### i. Route Discovery

Initially all nodes assortment contains data regarding neighbor nodes, the network monitors having the detailed data of neighbor nodes like routing table, It provides the nodes data to the route manager.

#### ii. Energy Updating

The mobile devices periodically share their unused energy to all the nodes per unit area

participating inside the network, this energy nodes will select the route i.e., reliable.

### iii. Calculating Hop-By-Hop Energy

When supply node sends a request, nodes can check the energy of all its one hop neighbor nodes. Then the node chooses succeeding node that one has high energy price. All the nodes do constant method.

### iv. Neighbor Node Processing

This module is split into 2 sub modules named as

1. Poll method and information method
2. Poll method–By exploitation this module the node will verify the neighbors.

### c) Data Process

In this sub module, the node ought to cross check the knowledge. A node must verify the other node, and then the champion checks the knowledge (which is collected from the neighbor). Throughout the checking methodology verifiers compares the house b/w each neighbor and the other. The distance is calculated in a pair of ways, i.e. during which

- Location based comparison
- Data transmitted speed comparison

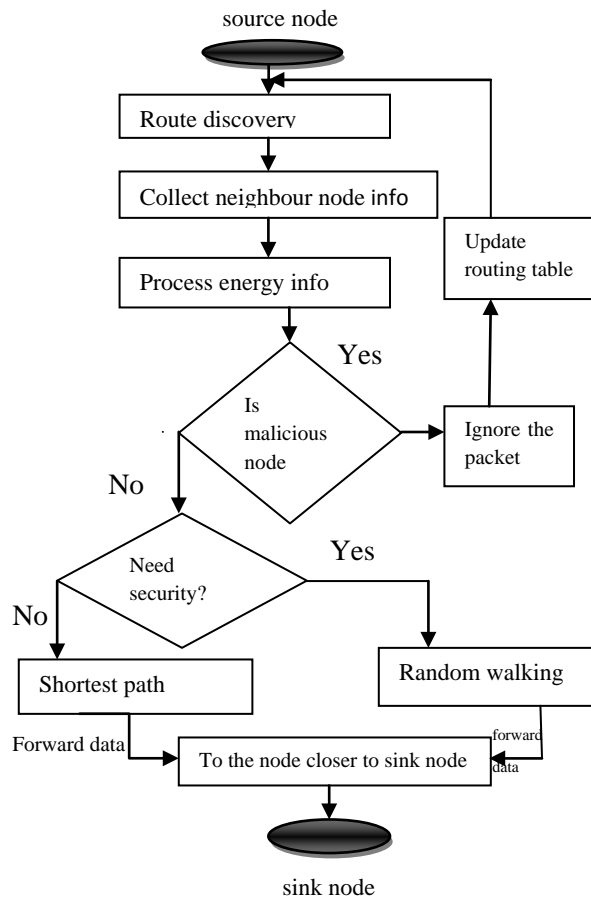
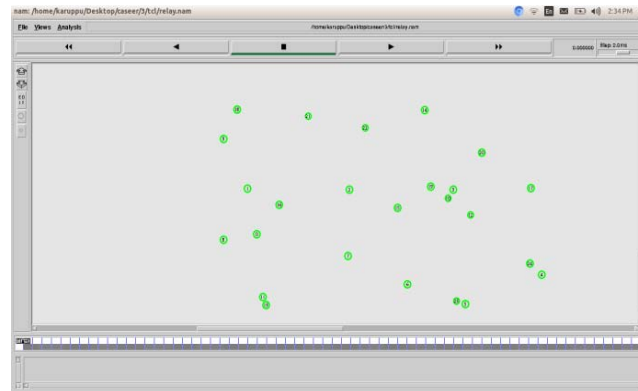


Fig.1: Activity of proposed model

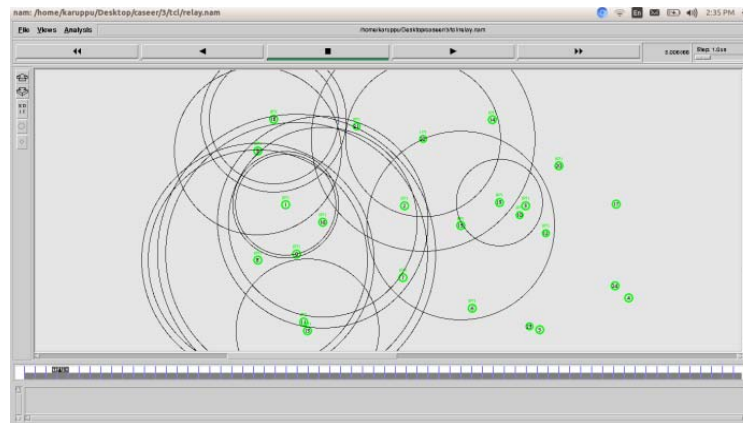
### III. RESULTS

Fig. 2 shows the network placement. The nodes are randomly deployed in the network with initial energy of 100 Joules.



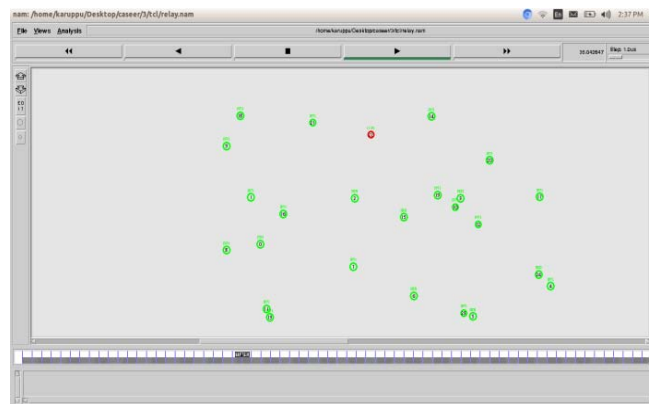
*Fig. 2:* Network placement

Fig.3 shows the results of route discovery through the broadcasting of route request and unicasting of route reply packets.



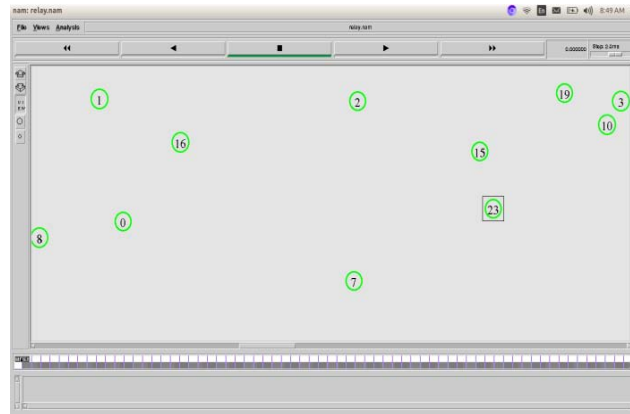
*Fig. 3:* Route discovery

Fig.4 shows the result of node failure. The node failure occurs when the energy of the particular node is drained out.

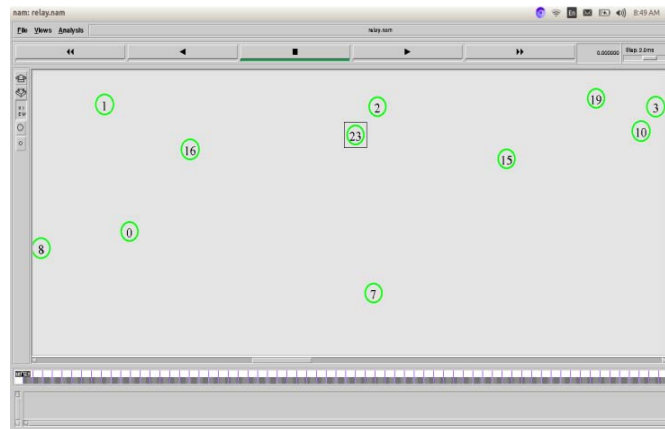


*Fig. 4:* Node failure

Fig.5 a and Fig.5b shows the attacker which is trying to track the source location.

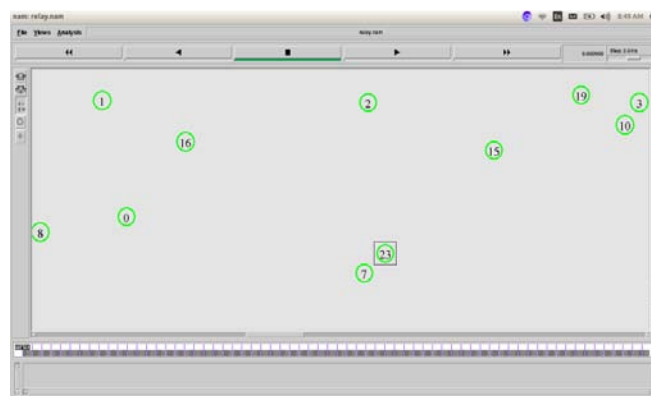


*Fig. 5 a:* Attacker movement



*Fig.5 b:* Attacker movement

Fig.6 shows the attacker fails to find the source location due to random selection of nodes in the network



*Fig. 6.:* Attacker fails to find the source



Fig.7 shows the comparison of energy efficiency in terms of the failure occurred at the particular time for existing, and proposed technique.

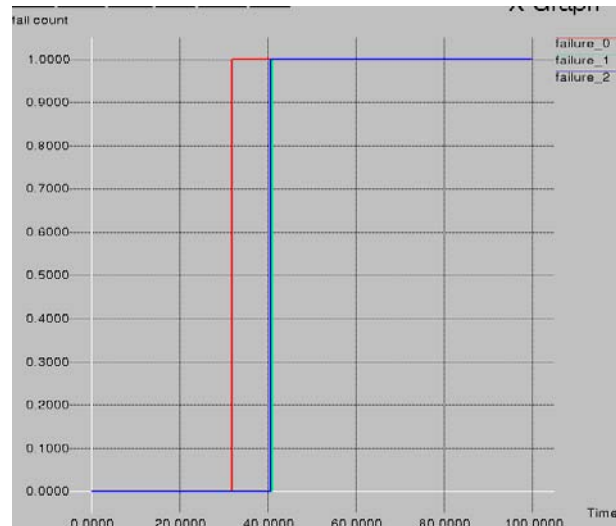


Fig.7: Energy efficiency graph

Packet delivery rate is defined as the rate at which the numbers of packets are delivered successfully.

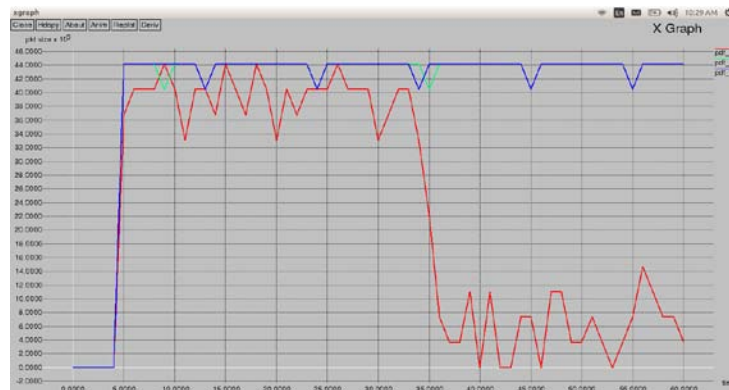


Fig. 8: Packet Delivery Rate

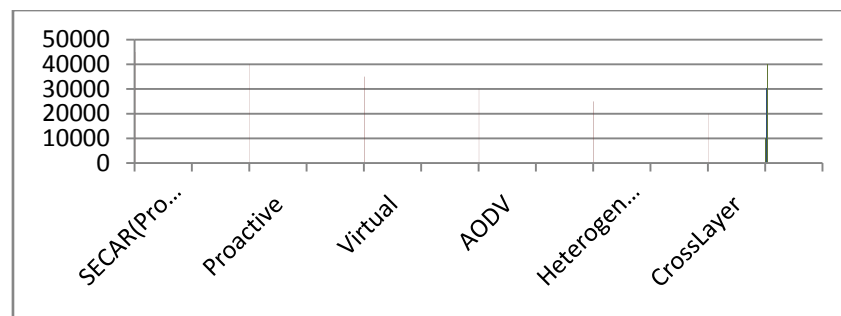


Fig. 9: Comparison of Protocols Life Time

#### IV. CONCLUSION

In this paper, the proposed routing protocol provides the security in message forwarding and also enhances the packet delivery rate and network lifetime.

The non uniform energy deployment scheme is implemented to extend the network lifetime and the fake energy sharing tracing technique is also introduced to find the malicious node present in the sensor network. The simulation results show that the lifetime of the

network and packet delivery rate is enhanced while increasing the secure routing.

## REFERENCES RÉFÉRENCES REFERENCIAS

1. Y. Huang, x. Yang, s. Yang, w. Yu, and x. Fu, "cross-layer approach asymmetry for wireless mesh access networks", March, 2011.
2. V. Shah, e. Gelal, and p. Krishnamurthy, "Handling asymmetry in power heterogeneous ad hoc networks: a cross layer approach", July, 2007.
3. J. Wu and f. Dai, "virtual backbone construction in MANET's using adjustable transmission ranges", September. 2006
4. Charles e. Perkins, Elizabeth m. Royer *Ad-hoc on-demand distance vector routin.*
5. Xiamen wu, hamid r. Sadjadpour and j.j.garcia-luna-aceves, *Routing overhead as a function of node mobility: modeling framework and implications on proactive routing.*
6. Kevin c. Lee, uichin lee and Mario gerla, *Survey of routing protocols in mobile ad-hoc network*
7. Mohamed El Fissaoui, Said Benkirane, Abderrahim Beni-Hssane, Mostafa Saadi,
8. *Scalability Aware Energy Consumption and Dissipation Models for Wireless Sensor Networks*, Vol.7, No.1, Pages:424-431, IJECE, ISSN:2088-8708, February, 2017.
9. Shivan Qasim Ameen, Ravie Chandren Muniyandi, *Improvement at Network Planning using Heuristic Algorithm to Minimize Cost of Distance between Nodes in Wireless Mesh Networks*, Vol.7, No.1, Pages:424-431, IJECE, ISSN:2088-8708, February, 2017.



# GLOBAL JOURNALS INC. (US) GUIDELINES HANDBOOK 2017

---

[WWW.GLOBALJOURNALS.ORG](http://WWW.GLOBALJOURNALS.ORG)

## FELLOWS

### FELLOW OF ASSOCIATION OF RESEARCH SOCIETY IN COMPUTING (FARSC)

Global Journals Incorporate (USA) is accredited by Open Association of Research Society (OARS), U.S.A and in turn, awards “FARSC” title to individuals. The 'FARSC' title is accorded to a selected professional after the approval of the Editor-in-Chief/Editorial Board Members/Dean.



- The “FARSC” is a dignified title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

FARSC accrediting is an honor. It authenticates your research activities. After recognition as FARSC, you can add 'FARSC' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, and Visiting Card etc.

*The following benefits can be availed by you only for next three years from the date of certification:*



FARSC designated members are entitled to avail a 40% discount while publishing their research papers (of a single author) with Global Journals Incorporation (USA), if the same is accepted by Editorial Board/Peer Reviewers. If you are a main author or co-author in case of multiple authors, you will be entitled to avail discount of 10%.

Once FARSC title is accorded, the Fellow is authorized to organize a symposium/seminar/conference on behalf of Global Journal Incorporation (USA). The Fellow can also participate in conference/seminar/symposium organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent.



You may join as member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. In addition, it is also desirable that you should organize seminar/symposium/conference at least once.

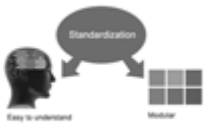
We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.





The FARSC can go through standards of OARS. You can also play vital role if you have any suggestions so that proper amendment can take place to improve the same for the benefit of entire research community.

As FARSC, you will be given a renowned, secure and free professional email address with 100 GB of space e.g. [johnhall@globaljournals.org](mailto:johnhall@globaljournals.org). This will include Webmail, Spam Assassin, Email Forwarders, Auto-Responders, Email Delivery Route tracing, etc.



The FARSC will be eligible for a free application of standardization of their researches. Standardization of research will be subject to acceptability within stipulated norms as the next step after publishing in a journal. We shall depute a team of specialized research professionals who will render their services for elevating your researches to next higher level, which is worldwide open standardization.

The FARSC member can apply for grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A. Once you are designated as FARSC, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria. After certification of all your credentials by OARS, they will be published on your Fellow Profile link on website <https://associationofresearch.org> which will be helpful to upgrade the dignity.



The FARSC members can avail the benefits of free research podcasting in Global Research Radio with their research documents. After publishing the work, (including published elsewhere worldwide with proper authorization) you can upload your research paper with your recorded voice or you can utilize chargeable services of our professional RJs to record your paper in their voice on request.

The FARSC member also entitled to get the benefits of free research podcasting of their research documents through video clips. We can also streamline your conference videos and display your slides/ online slides and online research video clips at reasonable charges, on request.





The FARSC is eligible to earn from sales proceeds of his/her researches/reference/review Books or literature, while publishing with Global Journals. The FARSC can decide whether he/she would like to publish his/her research in a closed manner. In this case, whenever readers purchase that individual research paper for reading, maximum 60% of its profit earned as royalty by Global Journals, will be credited to his/her bank account. The entire entitled amount will be credited to his/her bank account exceeding limit of minimum fixed balance. There is no minimum time limit for collection. The FARSC member can decide its price and we can help in making the right decision.

The FARSC member is eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get remuneration of 15% of author fees, taken from the author of a respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account.



## MEMBER OF ASSOCIATION OF RESEARCH SOCIETY IN COMPUTING (MARSC)

The ' MARSC ' title is accorded to a selected professional after the approval of the Editor-in-Chief / Editorial Board Members/Dean.

The "MARSC" is a dignified ornament which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., MARSC or William Walldroff, M.S., MARSC.



MARSC accrediting is an honor. It authenticates your research activities. After becoming MARSC, you can add 'MARSC' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and reputé to your name. You may use it on your professional Counseling Materials such as CV, Resume, Visiting Card and Name Plate etc.

*The following benefits can be availed by you only for next three years from the date of certification.*



MARSC designated members are entitled to avail a 25% discount while publishing their research papers (of a single author) in Global Journals Inc., if the same is accepted by our Editorial Board and Peer Reviewers. If you are a main author or co-author of a group of authors, you will get discount of 10%.

As MARSC, you will be given a renowned, secure and free professional email address with 30 GB of space e.g. [johnhall@globaljournals.org](mailto:johnhall@globaljournals.org). This will include Webmail, Spam Assassin, Email Forwarders, Auto-Responders, Email Delivery Route tracing, etc.







We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSC member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.



Once you are designated as MARSC, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.



## AUXILIARY MEMBERSHIPS

### Institutional Fellow of Open Association of Research Society (USA)-OARS (USA)

Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as “Institutional Fellow of Open Association of Research Society” (IFOARS).

The “FARSC” is a dignified title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.



The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as “Institutional Board of Open Association of Research Society”-(IBOARS).

*The Institute will be entitled to following benefits:*



The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA). The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.

The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.



The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of “Open Association of Research Society, U.S.A (OARS)” so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.



Journals Research  
inducing researches

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.



After nomination of your institution as “Institutional Fellow” and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.

The board can also take up the additional allied activities for betterment after our consultation.

### **The following entitlements are applicable to individual Fellows:**

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.



Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.



We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth \$ 2376 USD.

### **Other:**

**The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:**

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.



- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10% discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in-depth understanding of the application of suitable techniques to a particular area of research practice.

## Note :

//

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of “Difference of Opinion [if any]” among the Board members, our decision will be final and binding to everyone.

//

## PROCESS OF SUBMISSION OF RESEARCH PAPER

The Area or field of specialization may or may not be of any category as mentioned in 'Scope of Journal' menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as 'Knowledge Abstract' at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (\*.DOC,\*.DOCX).

The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

**(A) (I) First, register yourself using top right corner of Home page then Login. If you are already registered, then login using your username and password.**

**(II) Choose corresponding Journal.**

**(III) Click 'Submit Manuscript'. Fill required information and Upload the paper.**

**(B) If you are using Internet Explorer, then Direct Submission through Homepage is also available.**

**(C) If these two are not convenient, and then email the paper directly to dean@globaljournals.org.**

Offline Submission: Author can send the typed form of paper by Post. However, online submission should be preferred.



# PREFERRED AUTHOR GUIDELINES

## MANUSCRIPT STYLE INSTRUCTION (Must be strictly followed)

Page Size: 8.27" X 11"

- Left Margin: 0.65
- Right Margin: 0.65
- Top Margin: 0.75
- Bottom Margin: 0.75
- Font type of all text should be Swis 721 Lt BT.
- Paper Title should be of Font Size 24 with one Column section.
- Author Name in Font Size of 11 with one column as of Title.
- Abstract Font size of 9 Bold, "Abstract" word in Italic Bold.
- Main Text: Font size 10 with justified two columns section
- Two Column with Equal Column with of 3.38 and Gaping of .2
- First Character must be three lines Drop capped.
- Paragraph before Spacing of 1 pt and After of 0 pt.
- Line Spacing of 1 pt
- Large Images must be in One Column
- Numbering of First Main Headings (Heading 1) must be in Roman Letters, Capital Letter, and Font Size of 10.
- Numbering of Second Main Headings (Heading 2) must be in Alphabets, Italic, and Font Size of 10.

**You can use your own standard format also.**

### Author Guidelines:

1. General,
2. Ethical Guidelines,
3. Submission of Manuscripts,
4. Manuscript's Category,
5. Structure and Format of Manuscript,
6. After Acceptance.

### 1. GENERAL

Before submitting your research paper, one is advised to go through the details as mentioned in following heads. It will be beneficial, while peer reviewer justify your paper for publication.

### Scope

The Global Journals Inc. (US) welcome the submission of original paper, review paper, survey article relevant to the all the streams of Philosophy and knowledge. The Global Journals Inc. (US) is parental platform for Global Journal of Computer Science and Technology, Researches in Engineering, Medical Research, Science Frontier Research, Human Social Science, Management, and Business organization. The choice of specific field can be done otherwise as following in Abstracting and Indexing Page on this Website. As the all Global



Journals Inc. (US) are being abstracted and indexed (in process) by most of the reputed organizations. Topics of only narrow interest will not be accepted unless they have wider potential or consequences.

## 2. ETHICAL GUIDELINES

Authors should follow the ethical guidelines as mentioned below for publication of research paper and research activities.

Papers are accepted on strict understanding that the material in whole or in part has not been, nor is being, considered for publication elsewhere. If the paper once accepted by Global Journals Inc. (US) and Editorial Board, will become the copyright of the Global Journals Inc. (US).

**Authorship: The authors and coauthors should have active contribution to conception design, analysis and interpretation of findings. They should critically review the contents and drafting of the paper. All should approve the final version of the paper before submission**

The Global Journals Inc. (US) follows the definition of authorship set up by the Global Academy of Research and Development. According to the Global Academy of R&D authorship, criteria must be based on:

- 1) Substantial contributions to conception and acquisition of data, analysis and interpretation of the findings.
- 2) Drafting the paper and revising it critically regarding important academic content.
- 3) Final approval of the version of the paper to be published.

All authors should have been credited according to their appropriate contribution in research activity and preparing paper. Contributors who do not match the criteria as authors may be mentioned under Acknowledgement.

Acknowledgements: Contributors to the research other than authors credited should be mentioned under acknowledgement. The specifications of the source of funding for the research if appropriate can be included. Suppliers of resources may be mentioned along with address.

**Appeal of Decision: The Editorial Board's decision on publication of the paper is final and cannot be appealed elsewhere.**

**Permissions: It is the author's responsibility to have prior permission if all or parts of earlier published illustrations are used in this paper.**

Please mention proper reference and appropriate acknowledgements wherever expected.

If all or parts of previously published illustrations are used, permission must be taken from the copyright holder concerned. It is the author's responsibility to take these in writing.

Approval for reproduction/modification of any information (including figures and tables) published elsewhere must be obtained by the authors/copyright holders before submission of the manuscript. Contributors (Authors) are responsible for any copyright fee involved.

## 3. SUBMISSION OF MANUSCRIPTS

Manuscripts should be uploaded via this online submission page. The online submission is most efficient method for submission of papers, as it enables rapid distribution of manuscripts and consequently speeds up the review procedure. It also enables authors to know the status of their own manuscripts by emailing us. Complete instructions for submitting a paper is available below.

Manuscript submission is a systematic procedure and little preparation is required beyond having all parts of your manuscript in a given format and a computer with an Internet connection and a Web browser. Full help and instructions are provided on-screen. As an author, you will be prompted for login and manuscript details as Field of Paper and then to upload your manuscript file(s) according to the instructions.



To avoid postal delays, all transaction is preferred by e-mail. A finished manuscript submission is confirmed by e-mail immediately and your paper enters the editorial process with no postal delays. When a conclusion is made about the publication of your paper by our Editorial Board, revisions can be submitted online with the same procedure, with an occasion to view and respond to all comments.

Complete support for both authors and co-author is provided.

#### 4. MANUSCRIPT'S CATEGORY

Based on potential and nature, the manuscript can be categorized under the following heads:

Original research paper: Such papers are reports of high-level significant original research work.

Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications.

Research letters: The letters are small and concise comments on previously published matters.

#### 5. STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also. Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

**Papers:** These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

- (a) Title should be relevant and commensurate with the theme of the paper.
- (b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.
- (c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.
- (d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.
- (e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.
- (f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;
- (g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.
- (h) Brief Acknowledgements.
- (i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.



The Editorial Board reserves the right to make literary corrections and to make suggestions to improve brevity.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

## Format

*Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.*

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than  $1.4 \times 10^{-3} \text{ m}^3$ , or 4 mm somewhat than  $4 \times 10^{-3} \text{ m}$ . Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

## Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

**Title:** The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

*Abstract, used in Original Papers and Reviews:*

### Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

### Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art. A few tips for deciding as strategically as possible about keyword search:



- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

*Acknowledgements: Please make these as concise as possible.*

## References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

## Tables, Figures and Figure Legends

*Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.*

*Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.*

## Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

Color Charges: It is the rule of the Global Journals Inc. (US) for authors to pay the full cost for the reproduction of their color artwork. Hence, please note that, if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a color work agreement form before your paper can be published.



*Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.*

## **6. AFTER ACCEPTANCE**

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

### **6.1 Proof Corrections**

The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded

(Free of charge) from the following website:

[www.adobe.com/products/acrobat/readstep2.html](http://www.adobe.com/products/acrobat/readstep2.html). This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at [dean@globaljournals.org](mailto:dean@globaljournals.org) within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

### **6.2 Early View of Global Journals Inc. (US) (Publication Prior to Print)**

The Global Journals Inc. (US) are enclosed by our publishing's Early View service. Early View articles are complete full-text articles sent in advance of their publication. Early View articles are absolute and final. They have been completely reviewed, revised and edited for publication, and the authors' final corrections have been incorporated. Because they are in final form, no changes can be made after sending them. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the conventional way.

### **6.3 Author Services**

Online production tracking is available for your article through Author Services. Author Services enables authors to track their article - once it has been accepted - through the production process to publication online and in print. Authors can check the status of their articles online and choose to receive automated e-mails at key stages of production. The authors will receive an e-mail with a unique link that enables them to register and have their article automatically added to the system. Please ensure that a complete e-mail address is provided when submitting the manuscript.

### **6.4 Author Material Archive Policy**

Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

### **6.5 Offprint and Extra Copies**

A PDF offprint of the online-published article will be provided free of charge to the related author, and may be distributed according to the Publisher's terms and conditions. Additional paper offprint may be ordered by emailing us at: [editor@globaljournals.org](mailto:editor@globaljournals.org).

You must strictly follow above Author Guidelines before submitting your paper or else we will not at all be responsible for any corrections in future in any of the way.



Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

#### TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

**1. Choosing the topic:** In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

**2. Evaluators are human:** First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

**3. Think Like Evaluators:** If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

**4. Make blueprints of paper:** The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

**5. Ask your Guides:** If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

**6. Use of computer is recommended:** As you are doing research in the field of Computer Science, then this point is quite obvious.

**7. Use right software:** Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

**8. Use the Internet for help:** An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

**9. Use and get big pictures:** Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

**10. Bookmarks are useful:** When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

**11. Revise what you wrote:** When you write anything, always read it, summarize it and then finalize it.





**12. Make all efforts:** Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

**13. Have backups:** When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

**14. Produce good diagrams of your own:** Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

**15. Use of direct quotes:** When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

**16. Use proper verb tense:** Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

**17. Never use online paper:** If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

**18. Pick a good study spot:** To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

**19. Know what you know:** Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

**20. Use good quality grammar:** Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

**21. Arrangement of information:** Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

**22. Never start in last minute:** Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

**23. Multitasking in research is not good:** Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

**24. Never copy others' work:** Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

**25. Take proper rest and food:** No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

**26. Go for seminars:** Attend seminars if the topic is relevant to your research area. Utilize all your resources.



**27. Refresh your mind after intervals:** Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

**28. Make colleagues:** Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

**29. Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

**30. Think and then print:** When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

**31. Adding unnecessary information:** Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

**32. Never oversimplify everything:** To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

**33. Report concluded results:** Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

**34. After conclusion:** Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

## INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

### Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

### Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.



Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

### **General style:**

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

- Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

- Use standard writing style including articles ("a", "the," etc.)
- Keep on paying attention on the research topic of the paper
- Use paragraphs to split each significant point (excluding for the abstract)
- Align the primary line of each section
- Present your points in sound order
- Use present tense to report well accepted
- Use past tense to describe specific results
- Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives
- Shun use of extra pictures - include only those figures essential to presenting results

### **Title Page:**

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.



### Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript-- must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

### Approach:

- Single section, and succinct
- As an outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

### Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from an abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

### Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.



- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

#### **Procedures (Methods and Materials):**

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

#### **Materials:**

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

#### **Methods:**

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

#### **Approach:**

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

#### **What to keep away from**

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

#### **Results:**

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently. You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.



## Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

### What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

### Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

### Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

### Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

### Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- ~ Submit to generally acknowledged facts and main beliefs in present tense.





## THE ADMINISTRATION RULES

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

**Segment Draft and Final Research Paper:** You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.
- Do not give permission to anyone else to "PROOFREAD" your manuscript.
- **Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)**
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.



CRITERION FOR GRADING A RESEARCH PAPER (COMPILATION)  
BY GLOBAL JOURNALS INC. (US)

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

Topics	Grades		
	A-B	C-D	E-F
<b>Abstract</b>	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
<b>Introduction</b>	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
<b>Methods and Procedures</b>	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
<b>Result</b>	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
<b>Discussion</b>	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
<b>References</b>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



# INDEX

---

---

## *C*

Collision · 2  
Convolutional · 45

---

## *D*

Dendritic · 26

---

## *I*

Internode · 2

---

## *L*

Linklayer · 44

---

## *M*

Mitigating · 73

---

## *P*

Pervasive · 64  
Predictive · 18  
Probabilistic · 44  
Promiscuous · 29

---

## *R*

Redundancy · 44  
Regressive · 14  
Residual · 2, 10, 36

---

## *S*

Stochastic · 41, 46



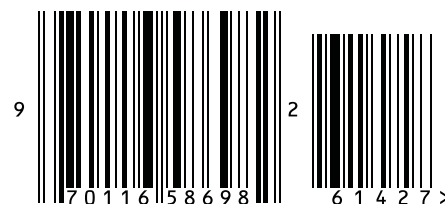
save our planet



# Global Journal of Computer Science and Technology

---

Visit us on the Web at [www.GlobalJournals.org](http://www.GlobalJournals.org) | [www.ComputerResearch.org](http://www.ComputerResearch.org)  
or email us at [helpdesk@globaljournals.org](mailto:helpdesk@globaljournals.org)



ISSN 9754350