Energy Aware Unequal Multi-hop Weighted Cluster Heterogeneous Routing Protocol for Wireless Sensor Network

Neetu Mehta, Arvind Kumar

Abstacrt:In the earlier systems middle hop nodes which works for each and every data transmission consumes maximum energy which repeatedly affects the life time of the wireless sensor network. Later the stability of cluster became a serious issue in WSNs. Minimum level of stability may leads to rapid failure of cluster head, high energy consumption which leads to re-clustering at the earlier stage. It will greatly affect the overall performance of the network. In order to improve the stability of the clusters a novel method is proposed namely, EAUM-WCH routing protocol (Energy Aware unequal Multi-hop Weighted Cluster Heterogeneous Routing). The important process which is present in this protocol was weighted unequal cluster head selection, data aggregation, and event-driven cluster head rotation. The act of this protocol is evaluated by using Network Simulation 2 (NS2). The results show that the produced cluster by using the protocol has longer lifetime and higher stability. Simulation results also prove that while comparing the proposed protocol with the earlier protocols such as LEACH, ECHERP and EEQR, the proposed EAUM-WCH protocol is more efficient in balancing the stability and consumption of energy in the network and improves the lifetime of the wireless sensor network.

Keyword–*Multi-hop Heterogeneous Wireless Sensor Network, Energy aware unequal weighted clustering, Data Aggregation, Energy consumption and Network stability.*

.

I. INTRODUCTION

Wireless sensor networks (WSNs) have established much attention all over the globe due to its sensing capability and stability. The Micro Electro Mechanical System (MEMS) [1] has introduced low powered compact sensor nodes. Those sensor nodes employed four basic sections, they are: sensing, processing, and then forwarding the information from one node to other neighbor node for future exploration process. The architecture of a low powered compact sensor node is shown in Fig. 1.

Low powered compact sensor nodes can be used to several kinds of different areas to sense the necessary information. WSNs have established well known techniques in many areas, which are probably health-care, industrial sector,
military applications, civil works, and transport systems [2]. These low powered nodes with compact sensing have resources in inadequate form. Battery power demand is high with some degree in scarce resources from designers of low powered compact sensing nodes, energy efficiency based designs of operating systems included radio modules, with transmission protocols for low powered compact nodes [3]. WSNs expansively worked with sensing of dissimilar kind of data. A variety of difficult and touch applications of the wireless sensor network as has been investigated in [4], demand from compact sensing nodes to support not only the concentration in efficiency of the network but also works to reduce the network delay. To achieve high quality of service, the energy and lifetime improvement in wireless sensor network has been concentrated as the core motivation for developing any transmission prototype. Various kinds of design patterns are developed according to the concept of energy conservation in WSN.

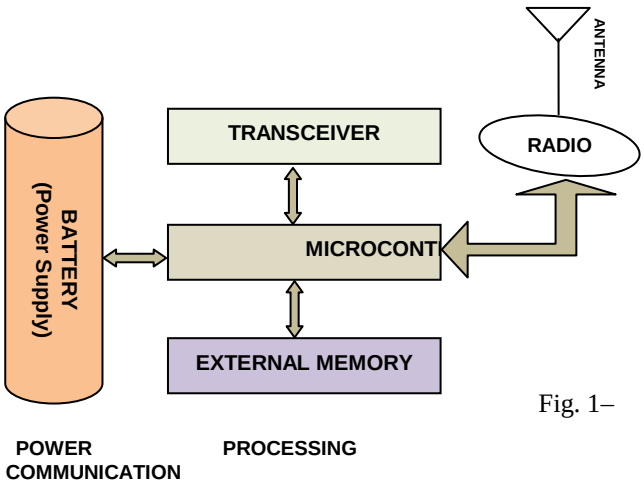

Fig. 1– A Simple node architecture

II. LITERATURE SURVEY

Energy efficient clustering routing protocols (EECRP) has received much concentration in wireless sensor network. In these protocols, the low

Revised Manuscript Received on April 06, 2019.

Neetu Mehta, Department of Computer Engg,, SRM University,Sonepat, Haryana,India
Arvind Kumar, Department of Computer Engg,, SRM University,Sonepat, Haryana,India

.

powered compact sensing nodes are separated into minor groups such as clusters. One among the nodes in a cluster network is elected with more responsibilities of data transmission than compared to other nodes. This unique node is termed as the Cluster Head (CH), and the other nodes in the cluster are referred to as cluster members. Cluster members transfer their information to the cluster head. Then, the CH performs the concept of data aggregation to collect the data from the cluster child and then forwards that data to the Base station (BS). Various kinds of energy efficiency based clustering prototypes have been investigated in the literature [5, 6, 7]. The following explains some energy aware clustering and Quality of service (QoS) aware routing prototypes, and also about their major contributions, and boundaries. The Equalized Cluster Head Election Routing Protocol (ECHERP) [8] is based on the method of balanced clustering. In the QHCR protocol, various linear systems are helped to develop the optimal clustering concepts. For improving the balanced cluster head election process the Gaussian problem solving approach (GPSA) is introduced. The ECHERP improvise a lifetime and stability of the network compared with other predictable clustering routing protocols of wireless sensor network. However, the major limitation of this protocol is, the behavior of this protocols are not supported for the real time traffic environment. The Quality of service oriented applications is not concentrated by the ECHERP protocol.

A heterogeneous multi-hop wireless sensor network based reinforced barrier-coverage approach (RBCA) has been proposed in [9]. In this protocol, the information linked to the diffusion from any of the intruder is transferred to the base station (BS) with less delay. Through the formation of base graph, a novel approach has been introduced to forward the delay sensitive traffic. Moreover, as compared to our proposed EAUM-WCH approach, this method does not consider the sensor nodes with energy fluctuating technique incorporated with it. The energy-efficient and QoS-aware routing (EEQR) [10] protocol concentrated on both issues (energy efficiency and Quality of service of the network).

In this protocol, traffic load of the network is the primary concentration on the basis of the content of traffic. A grouping of immovable and mobile sink is devised to provide multiple paths for real-time traffic environment. The end-to-end delay is reduced in great manner by providing primary attention for network traffic.This method improves the lifetime of the network and stability of homogeneous wireless sensor network. However, the energy efficient and quality of service aware protocol is limited by the concept that it does not concentrated on the heterogeneity of a network. The performance of the same protocol is reduces when it is directly applied to the heterogeneous network environment is used to ensure the QoS in wireless sensor network.

III. PROBLEM FORMULATION

Wireless sensor network has dependability for the energy consumption of the network during the process of communication in the network. During previous years, researches of these areas have shown enormous growth in diverse application which may acquire benefit by these technologies. These research efforts dealt with the examination of lifetime improvement of the network and reduction of energy consumption of the network during transmission and also to reduce the traffic.

The work presented here tries to improve the network lifetime through the implementation of a heterogeneous multi-hop routing with intelligently adjusted clustering protocol based on underlying remnant energy of the nodes [11]. This dynamically divides the network into underlying clusters. Through this a cluster head (CH) is chosen on the basis of weighted mean of their energies, the nodes will then be able to efficiently transmit packets among the CH which will be then relayed to the sink or base station (BS) by the latter, achieving a longer network life-cycle and less energy consumption.

A.Proposed work

In general, the Cluster is defined as the structure of the collection of nodes in the network. And the cluster head (CH) is called as head among the cluster members. The sensor network is separated into n number of clusters and each cluster is consists by one node, which is named as the cluster head (Fig. 2). The cluster head is able to get in touch with all child nodes in the cluster directly because they are all arranged in its transmission range.

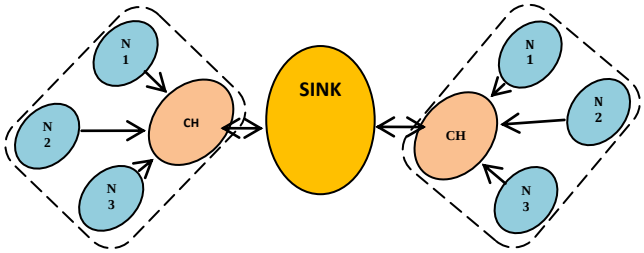

Fig. 2 - Cluster formation in WSNs. (*N= node, CH=cluster head*)

Though the LEACH protocol has been a method of choice for energy conservation in WSNs, but it faces few problem relating to the cluster heads that are selected randomly. The probable cluster heads that are formed in the LEACH protocol are unbiased and not distributed uniformly, which makes parts of network unapproachable. In the proposed work during the WSN initialization each node dynamically acquires an identification based on synchronized communication. Therefore, knows its role (communication node/source node) and neighbors (children, parent). The Fig. 3 shows the architecture flow of the proposed approach. The energy aware unequal weighted clustering method consists of four main divisions. They are: unequal weighted cluster head creation, cluster formation, data aggregation and the cluster rotation in the cluster. In the proposed protocol each and every link between the nodes consists of a separate weight-age. Final weights of the nodes in the network are

determined by using the initial weight calculation. The cluster head of the network is selected according to the final weights calculation it also decides the cluster child nodes of the cluster. Here the neighbor node features are helpful in measuring the final weight of each and every node and it is done by determination of link weights, while the earlier methods with asynchronous nodes limited this feature.

IV. METHODOLOGY OF EAUM-WCH ROUTING PROTOCOL

The main phases of the proposed energy aware unequal multi-hop weighted clustering method are Cluster building, Cluster maintenance and CH rotation. These are briefly discussed in the subsequent sections below.

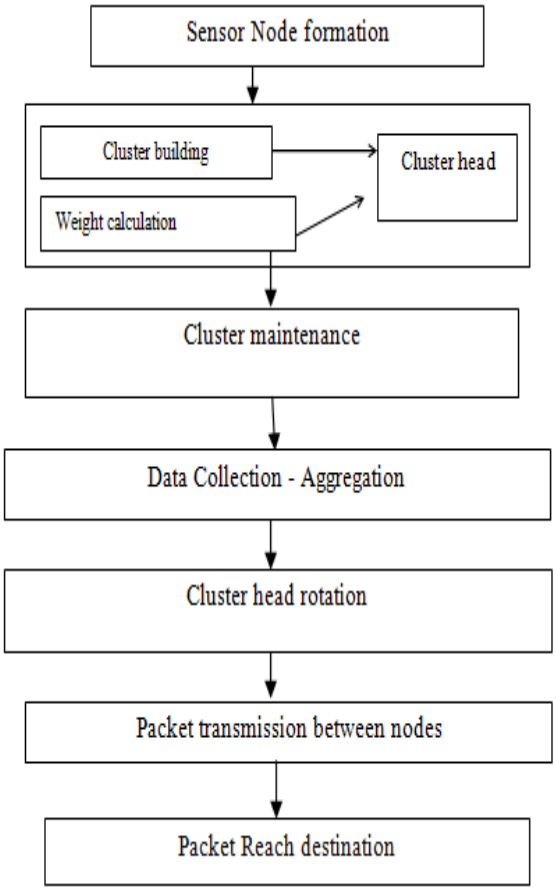

Fig. 3 - Proposed architecture for WSNs

A. Cluster Building

To perform the operation of building a cluster, the proposed protocol determines links by means of:
(i) Input link neighborhood,
(ii) Stability value of the each and every link calculation,
(iii) Linked nodes energy consumption values,
(iv) The linked nodes distance calculation.
Links weight is the major criteria to determine the nodes weight. Then, it is followed by the election of cluster head according to the weights and also elects the cluster child of the cluster.

B. Cluster Maintenance

This phase initiated instantaneously after the first cluster has been created. During the presence of certain problems this phase is activated. The problems are given below and the solutions are provided.
(1) Problem 1 - When the node is deviated from its cluster range: in this situation, the new cluster has to take care of the node. The node has to find the cluster head which is present inside the new coverage area and it has to transfer the information to the cluster head. Node should wait for the acceptance of the cluster head, then after the acceptance process, the cluster head sends the message to the new cluster member and declares its value. If the number of available cluster head in the nodes coverage area is more than one, then multiple cluster head will send the values to the new node. The cluster head which sends the highest value will be selected by the node and it will joins as cluster child to that cluster head.
(2) Problem 2 - Cluster head fails due to battery discharge: two ways are present to solve this issue. They are (a) those child nodes which are present in the failed cluster are considered as the new nodes and it has to follow the problem 1 process and it has to choose the new cluster head, (b) New cluster head can also be created among the nodes which are survived after the cluster head failure and invite the other nodes into the coverage area of the new cluster head.
(3) Problem 3 –Node members fails due to battery discharge: to solve this issue, from the cluster member list the dead node is removed. And to calculate the effectiveness of the other child nodes it send messages to all the nodes in the cluster and it helps also to calculate the other newly modified features of the child nodes.

C. Cluster head rotation

Cluster head consumed energy is comparatively higher than that of the cluster child nodes because it receives all the information from the cluster child nodes acts as a forwarder in the current cluster and also handle the operation of backbone network information forwarding process. During the absence of cluster head rotation process, there is a possibility of formation of energy whole in the network which can able to destroy local or entire network. Here control and packet transmission interference is concentrated when predictable regular replacement of the CH is applied to the network thus suggest the throughput of the network. In this condition,the cluster head rotation is the possible solution for the backbone networks and also less amount of energy is sufficient for this process. Here event based CH rotation method is proposed with the help of the following packet definitions.
Step 1 -CH rotationdata packet, including CH address.
Step 2 -CH rotation response information packet.
Step 3 -CH appointmentpacket, including CH address appointment.
Step 4 -CH lost contact data, when cluster nodes been unsuccessful to connect in the particular time period then the data packets are multicast to other cluster nodes.

V. PERFORMANCE

ANALYSIS

The proposed system performance analysis can be used in various factors like energy consumption, latency, throughput, delivery ratio of the packets, lifetime of networks and quality of service of the network. By using cooperative approach easily detect the node behavior also achieves less amount of energy consumption.

Here, U_m denotes the quality of the sensor node m with regards to the transmission of a new message. U_m is a time and energy reserve function of a node. U_m is calculated as follows:

$$U_m = w_1.U^m_{error} + w_2.U^m_{error} + (1-\sum_{i=1,2} w_i).U^m_{time'} \sum_{i=1,2} w_i \le 1$$

where, $Um = 1$ (for each messages),

$$U^m_{energy} = 1 - e^{\left[-10\frac{E}{E_{\max}}\right]}$$

$$U^m_{error} = \begin{cases} \dfrac{err^2}{(err_{threshold})^2} & err \le err_{threshold} \\ U_m = 1 \end{cases}$$

$$U^m_{time} = \begin{cases} 2.\dfrac{\Delta t}{\Delta T} & 0 \le \Delta t \le \dfrac{\Delta T}{2} \\ -2.\dfrac{\Delta t}{\Delta T} + 2 & \dfrac{\Delta T}{2} \le \Delta t \le \Delta T \end{cases}$$

where E is the current energy of node, the maximum energy that can be stored in node is E_{max}, err is the error induced in the measurements, whereas, $err_{threshold}$ denotes the maximum amount of errors that can be tolerated, Δt is the time of transmission of previous message and ΔT is time taken by the new message. The elements for time are used to avoid transmission of frequent messages one after other.

A. Network throughput

Throughput of the network is termed as the amount of information transmitted productively from one sender to the receiver in a given time interval. Pink line indicates proposed EAUM-WCH protocol, blueline indicate EEQR method, green line indicates ECHERP method and red line indicates LEACH method as shown in below Fig. 3.

B. Network Lifetime

Lifetime of the network is the transmission time period at which the node runs out of energy to transmit a packet from one place to another. Pink line indicates proposed EAUM-WCH protocol, blue line indicate EEQR method, green line indicates ECHERP method and red line indicates LEACH method as shown in below Fig. 4

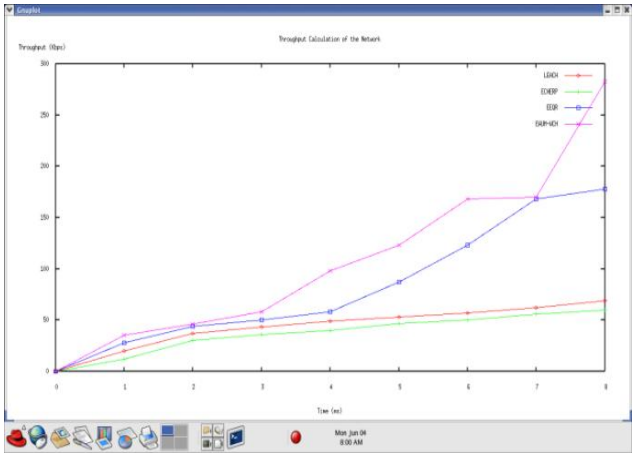

Fig. 3 - Throughput Comparison graph

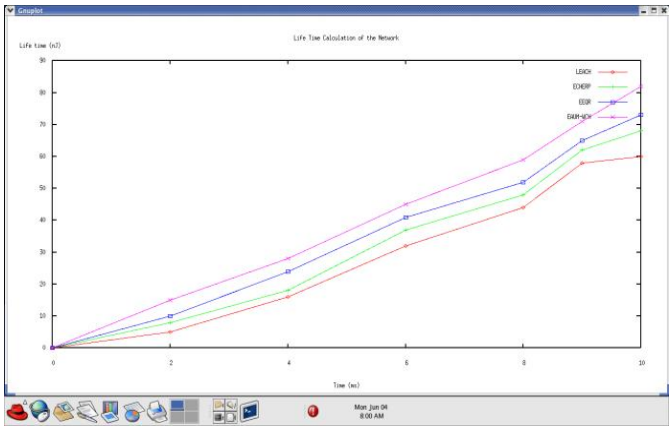

Fig. 4 - Network Lifetime graph

C. Energy consumption calculation of the network

Consumption of energy is the amount of energy used by the individual node that to be processed. Pink line indicates proposed EAUM-WCH protocol, blue line indicate EEQR method, green line indicates ECHERP method and red line indicates LEACH method as shown in below Fig. 5.

D. Packet Delivery Ratio of the network

Network Packet delivery ratio is defined as the ratio of amount of packets received by the destinations which is sent from the sources. Pink line indicates proposed EAUM-WCH protocol, blue line indicate EEQR method,
green line indicates ECHERP method and red line indicates LEACH method as shown in Fig. 6, below. The Table. 1 shows the performance analysis of energy aware unequal multi-hop weighted clustering method compared with other earlier methods such us LEACH, ECHERP and EEQR.

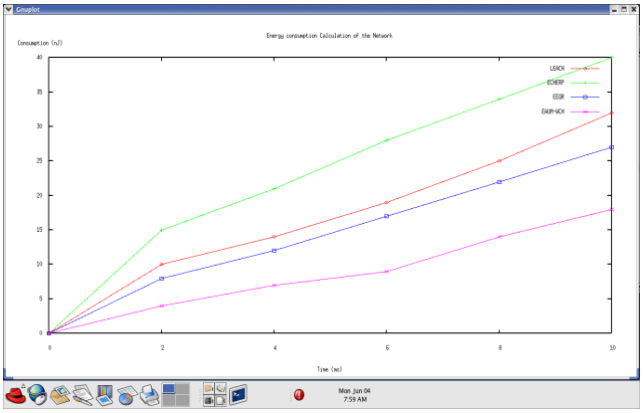

Fig. 5 - Energy Consumption graph

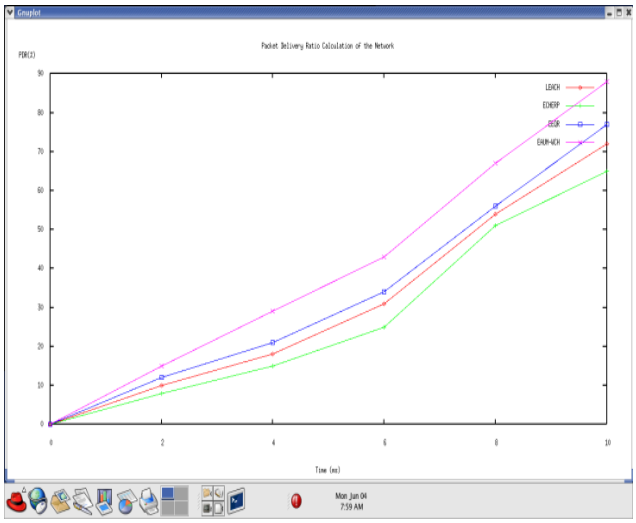

Fig. 6 - Packet Delivery Ratio graph

Table.1 comparison of methods

Parameters	LEACH	ECHERP	EEQR	EAUM-WCH
Throughput	69 (kbps)	60(kbps)	178(kbps)	283(kbps)
Network Lifetime	60 (J)	68 (J)	73 (J)	82 (J)
Energy consumption	40 (J)	32 (J)	27 (J)	18 (J)
Packet delivery ratio	65 %	72 %	77 %	88 %

VI. RESULTS

NS2 simulation results are obtained from experiment repeats for consistency, comparison of different architectures to the proposed WSN protocol. It was observed that the proposed model (EAUM-WCH) had a much better performance reliability compared to other protocols. As it can be seen (refer Table 1) that EAUM-WCH produces better results than other protocols in high throughput (283kbps), increased network lifetime (82 Joules), energy efficiency with low energy consumption and has a maximum packet delivery ratio of 88%.

VII. CONCLUSION

In WSNs, consumption of energy is influenced by several kinds of factors and also this is main reason for reducing the energy efficiency and also it affects the overall quality of service of the network. Many research people are working in this area to improve the performance of the network further with more energy efficient models. Basic understanding about the performance and working of the network is essential to carry out this process. The concept of advanced clustering method is a great tool to reduce the energy consumption and to increase the lifetime of the network. Our approach mainly concentrates in reducing the energy consumption. The parametric definitions such as probability, maximum energy of nodes and the accessibility of maximum connectivity determined intelligent CH selection. Results obtained from NS2 simulation show that the proposed EAUM-WCH has overall better performances and energy conservation than the compared topologies.

REFERENCES

1. Alessandro Sabato, Wireless MEMS-based accelerometer sensor boards for structural vibration monitoring IEEE Sensors Journal, 17(2), (2017) 226–235.
2. W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, An application-specific protocol architecture for wireless micro sensor networks, *IEEE Trans. Wireless Commun.*, vol. 1, no. 4, (Oct. 2002), pp. 660–670.
3. Jian Guo. An energy efficient node scheduling model for spatial temporal coverage optimization using 3 directional sensor networks. IEEE Access, 4, (2016), 4408–4419.
4. J.Y.Yu and P.H.J.Chong, A survey of clustering schemes for Mobile Ad Hoc Networks, Communications Surveys andTutorials, IEEE, vol.7, (2005), 32–48.
5. Georgios Z Papadopoulos, Julien Beaudaux, Antoine Gallais, Periklis Chatzimisios, and Thomas Noel. Toward a packet duplication control for opportunistic routing in wsns. In Global Communications Conference (GLOBECOM), (2014), 94–99.
6. Fco Javier,. A low energy and adaptive routing architecture for efficient field monitoring in heterogeneous wireless sensor networks. In High Performance Computing and Simulation (HPCS), 2011 International Conference on, (2011), 449–455.
7. M Arifuzzaman, OA Dobre, MH Ahmed, and Telex MN Ngatched. Joint routing and mac layer qos-aware protocol for wireless sensor networks. In IEEE Global Communications Conference (GLOBECOM), (2016), 1–6.
8. M Sivakumar and J Divakaran. Qos enhanced cluster routing protocol for wireless sensor networks. In Online International Conference on Green Engineering and Technologies (IC-GET), (2015), 1–5.
9. Adnan Ahmed, Pardeep Kumar, A secure and QoS aware routing protocol for wireless sensor network. In Internet Technology and Secured Transactions (ICITST), 2016 11th International Conference for, (2016), 313–317.
10. W. Zhang, L. Li, G. Han, and L. Zhang. E2hrc: An energy-efficient heterogeneous ring clustering routing protocol for wireless sensor networks. IEEE Access, (2017), 99.
11. Fawzy AE, Amer A, Shokair M, Saad W. Proposed intermittent cluster head selection scheme for efficient energy consumption in WSNs. In 34th National Radio Science Conference (NRSC), (2017), 275-283. doi: 10.1109_NRSC.2017.7893486

AUTHORS PROFILE

Neetu Mehta is B.E in computer science from Poona university and M.Tech from NIELIT. Her area of interest are sensor networks, Internet of Things and computer network

Publication

1."Advanced malicious detection using HMAC balanced load sub-cluster head selection" in Journal of Advanced research in dynamic and control systems

2."Heterogeneous Four Level Active Weighted Threshold Scheme" in International journal of technical innovation in modern Engg, & science

3."Protocols of Wireless Sensor Network: A Comparative Review" in IJTIMES

4." Enhanced network life using four-level heterogeneous clustering scheme" in International Journal of innovative research in computer and communication Engg.

Dr. Arvind Kumar(Assistant Professor in SRM University) has done B.Tech from UPTECH and M.Tech from Gautam Budha University.He finished his PHD programme from JJT University, Rajasthan.

His major research is in area of software Engg. and Computer Networks.

Publication

1. "Applying separation of concern for developing software using aspect oriented programming concepts" in Procedia Computer Science

2 ."A design based new reusable software process model for component based development environment" in Procedia Computer Science

3. "Reusable model with optimization factors for component based software development" in JARDCS

4."A new perspective of measuring the superegatory functionality in software components" in IJCTA

5."Advanced malicious detection using HMAC balanced load sub-cluster head selection"in Journal of Advanced research in dynamic and control systems

6.."Heterogeneous Four Level Active Weighted Threshold Scheme" in International journal of technical innovation in modern engg, & science

7."Protocols of Wireless Sensor Network: A Comparative Review " in IJTIMES

8."Challenges Faced during Software Component Selection "in International Journal of Computer Science and Engineering Research and Development (IJCSERD)

9. "Design New Component-Based Software Engineering Process to Produce Quality Product" in Research Way International Referred Online Research Journal

10".Slicing of Software Components Using Object Oriented Technique" in International Journal for Research in Applied science and Engineering Technology (IJRASET)

11. "Traffic Reduction Scheme for Pervasive Systems in MOM-based UPnP Networks" in International Journal of Computer & Mathematical Sciences (IJCMS)

12. "New Method to Analyze the Impacts on Reliability and Reusability in Component-Based Software development", IMS Manthan.

Membership

1.Member of International Association of Engineering (IAENG) with Membership Number: 109300

2.Member of International Association of Computer Science and Information Technology (IACSIT) with Membership Number: 80340823.

3.Member of Computer Science Teachers Association (CSTA) with Membership Number: 0467143

4.Member of Universal Association of Computer & Electronics Engineering with Membership Number: SM1004862

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication