A SURVEY ON: AN IMPROVED ENERGY EFFICIENT PROTOCOL FOR WIRELESS SENSOR NETWORKS

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Abstract

The wireless sensor networks have been experiencing exponential growth in the past decade. A wireless sensor network (WSN) provides low cost solutions and consists of several sensors distributed across a geographical area. In many commercial and industrial applications, it often needs to monitor and collect the information about the environment conditions (temperature, humidity, vibration, acceleration etc.) by using sensor networks. Recharging or replacing sensors batteries in a large geographical environment is not a feasible task. In this paper we have identified important issues pertaining to energy consumption of wireless sensor network (WSN). Also, we aim to resolve issues relating to excessive multi-hoping from one node to another and propose an addressing scheme refer to a node that can also be used for signal spreading and de-spreading and a protocol to minimize power usage. The proposed Improved Energy Efficient Communication Protocol (IEECP), comprises of moveable sinks and sensors node that can be randomly deployed in the network. Proposed protocol is compared with the two existing protocols namely Tree Routing (TR) and Enhanced Tree Routing (ETR). The simulation results show that the proposed protocol has the lowest hop-count compare to TR and ETR. And reduces hop-count, excessive multi-hoping and prevents flooding of path search messages in a dense sensor network, and thus saves energy of the sensor nodes.

Keywords: Wireless sensor network, Improved Energy Efficient Communication Protocol, Tree Routing, Extended Tree Routing, Non-Orthogonal Variable Spreading Factor Technique

1.Introduction

Wireless sensor network (WSN) has less bandwidth, short range and small data processing capability, while traditional networks have large range, more storage capacity and more data processing capability. A sensor network has slow processing devices. Now days a wide variety of applications make utilization of wireless sensor networks. Therefore, we need more efficient protocols and algorithms for routing, communication and data security. Main challenges of WSN are physical constraints, fault-tolerance, ad-hoc wireless deployment, scalability, QoS service, unattended operation, un-tethered and data Security. Physical constraint like battery power, storage and computational power are commonly known to a sensor network. Since sensors are supplied with the limited battery power, Hence, the energy consumption is main design constraint to a protocol and it depends on network size as well as routing algorithms. [1].

Due to physical constraints like physical damage or lack of power supply a sensor node may fail, so the protocol must accommodate changes like node failure, topology changes etc. [4]. The battery backup of sensor node is limited so network cycle as well as throughput of network is low [2]. Consumption of energy in WSN has been optimized by cross-layer design method, using this it is easily know about the network nodes, also cross-layer design method improves the network performance [3].

The deployment of sensors can vary from hundreds to thousands or to more, as per the application need. Thus, the protocols must be scalable enough to respond and operate with such large number of sensor nodes [5]. In some scenario, sensors once deployed can work for a longer time without any human intervention. Hence, the nodes themselves should be reconurable, adaptable to the new topology changes. The sensors have a fixed source of energy and have no external power supply; therefore, they must be optimally used for processing and communication. Since sensor networks work on low bandwidth, data security becomes a key issue in WSNs. Security in sensor networks must consider critical parameters for its design [2].

The energy consumption, QoS and overall performance of a routing protocol depends on the architectural model and design of the sensor network. Energy plays a vital role in designing a network infrastructure and route processing for data transmission. In a large sensor network, duplicate data generation by different sensor nodes is a common problem. The problem is resolved with the help of aggregation function [6].

The aggregation function eliminates duplicate data, by using functions such as min, max, suppression and average. As WSN are deployed in hostile areas such as battle fields, forests etc. The data collected is highly significant therefore; protection of the data is one of the major concerned. The communication protocols should incorporate security features for data transmission. Depending on the application type, the sensor network topology can be designed statically or dynamically [7].

The static architecture has a fix path from each sensor node to the sink node and thus consumes less energy, bandwidth etc. In deterministic approach, data routing, topology implementation and network management is easy and predictable, while in case of self-organizing sensor networks the sensor nodes themselves are responsible for topology management, data forwarding and network management [1]. Hence, the protocols implementation, to carry-out different tasks in the above two approaches are different.

Data Delivery models in WSN are demand driven. When a request is generated by a user it is processed instantly and result is produced. The power optimization in clustering approach aims to extend the clustered wireless network life time by making economical and efficient use of battery power supply [8]. Section 1, gives an introduction of WSN, purpose and significance of this research. Section 2, gives the related work study (literature survey) for various power optimization methods and energy efficient communication protocol. Section 3, discussed about proposed system model for power optimization. Section 4, gives information about topological structure, energy consumption model and data collection strategy for the protocol. A comparative analysis of the results of the proposed protocol (IEECP) and TR and ETR protocol has been discussed. Further, it is interpreted that the new protocol is superior to the existing protocol. In the last, Conclusion and future scope of the work is presented followed by reference made in the dissertation in presenting the clarity of the philosophy of the research

2.Related Work

The nodes in WSN dynamically self-organize their network topology based on varying network conditions, rather than having a preprogrammed network topology. Although, a WSN is having good characteristics, it has some limitations like the storage capacity, power consumption and limited processing. These limitations and the special architecture of sensor nodes lead to the development of energy efficient and secure communication protocols. Number of researchers have proposed different power saving strategies based on different approaches. The survey is broadly categorized in three areas i.e. power management based, cyclic approach and motion-based approach.

The cyclic approaches mainly focus on TDMA MAC, staggered wakeup pattern, scheduled rendezvous scheme, link scheduling, messaging and hybrid protocols. Cyclic approaches suggest that contention free slot allocation is desirable to eliminate collision and to save energy. Static to dynamic time stamping needs minimum efforts. Sensing the medium and availability of additional antenna are a sort of overhead to the sensor network. Further, energy efficient node addressing is essential in routing network traffic. It can further have divided into power management based and Topology based energy saving scheme.

The power management protocols deal with medium access control (MAC) and Sleep-Wake Up pattern. The major cyclic power management approaches are TDMA scheduling algorithm in WSN [9], Smallest collision free fixed time slot, minimize idle listening , LEMMA- an improved TDMA Approach [10], Contention Based MAC protocol CSMA [11], PAMAS (Power aware multi-access with signaling) protocol [12], Hybrid of TDMA and CSMA protocol [13], Quorum Based Asynchronous wakeup protocol [14], Asynchronous wakeup mechanisms gives information about forecasted energy [15,16], Flooding timestamp messages [17] and Link scheduling algorithm [18].

TDMA scheduling algorithm in WSN support collision free fixed time slot and minimize idle listening. LEMMA is an improved TDMA approach, it minimizes latency, In Contention Based MAC protocol CSMA, collision avoidance through channel listening.PAMAS (Power aware multi-access with signaling) protocol, uses two transceivers for messaging and controlling and avoid collision of data messages.Hybrid of TDMA and CSMA protocol, designed for one-hop neighbor, no consideration for topology change and synchronization.

In Quorum Based Asynchronous wakeup protocol, no guaranteed overlapped period in a cycle, include two steps wakeup prediction and neighbor discovery. In Asynchronous wakeup mechanisms, no need for slot assignment is required. Flooding timestamp compare Leader-timestamp and arrival-timestamps comparison and Link scheduling algorithm,provide slot length for all links.

Important features of cyclic approaches are smallest collision, free fixed time slot, minimize idle listening, minimize latency, collision avoidance through channel listening, nodes at different level of tree wake up different time, allow data aggregation, solar radiation as energy harvesting, time varying harvesting prediction model, lower average packet latency, fixed staggered scheme, use of spanning tree for time synchronization and node has wakeup schedule function, no need for slot assignment.

The major approaches based on network topology protocols are aggregation routing, enhanced tree routing, Connection Driven and location driven routing. In Aggregation Tree [19], root is sink and leaves are sensor nodes, it is a data gathering tree. An Aggregation Tree Protocol [19] follows a tree like structure for sink and sensor nodes deployment. Aggregation Tree is a data gathering tree that connects the base station node and all sensor nodes in a network. Root is the base station in the WSN and other nodes are located at the relaying or a leaf node. There can be more than one base station and each base station has its own tree.

Enhanced Tree Routing [20,43] avoids flooding network path search and use neighbor table to find shortest paths. An improvement to aggregation tree is Enhanced Tree Routing protocol, it avoids flooding, during searching the path, hence, save bandwidth and energy. A default tree routing (TR) protocol uses strict parent-child link for data forwarding. A tree-based topology is highly suitable for a moderate size network. The tree path from sensor node to the sink plays a critical role in energy consumption. Multi-hoping along a tree path is more energy efficient than single hopping.

Further, excessive multi-hopping in tree may cause early drain of energy of intermediate nodes in transferring its' own data and data forwarding. Connection Driven routing [22], elects coordinators for multi-hop routing and in location driven protocol [21], nodes are existing in two states active state and discovery state, root is selected based on rank-based election algorithm.

Data Oriented approaches works on data sensing impacts on sensor nodes. Major work in this area are adaptive sampling approach [23], it exploits temporal correlation between data. Adaptive sensing strategy [24], it exploits three approaches i.e. hierarchical sensing, adaptive sampling and model based active sensing. Model based data sampling [25], for prediction and uses computing model for sampling, Utility based sensing model [26], linear regression model is used to forecast sample. Hierarchical sampling [27], for low-power sensor and used for coarse-grain information, Probabilistic modeling [28] on data stream, uses two instance of model one at sink to answer query and other on source node to sense data, Correlation based scheme [29] uses dynamic estimation of frequency of signal and spatial correlation scheme [30,31] is back casting scheme, field need not to be sensed in uniform way.

Motion based approach were categories as mobile-sink and mobile-relay approach, in mobile-sink the sink node is moveable and can be repositioned to collect the data. In mobile-relay technique, data mule (Mobile Ubiquitous LAN Extension) is placed that reaches to every sensor nodes location to collect data. Major approach related to motion are discussed below.

In mobilizers approach [32] sensors are place to the device which are mobile like car, bus etc., a few nodes are mobile to keep connectivity using mobilizers, these sensorsare place to the device which are mobile like car, bus etc., a few nodes are mobile to keep connectivity.

In message ferrying approach [33], ferry moves and collect data. In data mule approach [35], mules are people, vehicle etc., and access points collects data from it and use short range radio for data transmission [34]. Mobile sink approach [36], uses linear programming technique for optimized sink placement.

Multiple mobile station approach [36], uses more than one mobile sink station. Distributed protocol [37], uses greedy maximum residual energy approach. Proximity selection based on high traffic rates, it considers mobility and routing together [38] and two-tier data dissemination approach [39] used for efficient data delivery to multiple mobile stations, it uses grid structure for forwarding the data.

The important issues identified in the literature survey are listed below:

- Transmission system in a sensor network consumes more power as compared to data processing.
- Excessive multi-hoping in dense sensor network causes early drain of energy for sensors near to the sink node.
- Mobility of devices makes significant effect on power consumption.
- Placing of mobile sink more than a specific number can increase cost of sensor network deployment.
- A scheme is needed to identify shortest path from source node to a sink node using neighbor table.
- MAC protocols like: ALOHA and CSMA sends a packet whenever they are generated, hence, causes lot of congestion.
- A systematic addressing scheme is needed to address a particular node in the network.

The critical issue is to manipulate mobility of devices energy efficiently. The move ability of the sink is limited to certain feasible sites. The feasible sites are those places that help in reducing excessive multi-hopping to minimum especially in tree-based sensor network.

3-Proposed Wireless Sensor Network Structure for power optimization

To obtain power optimization in wireless sensor network, we proposed a node-addressing scheme with reduced length. Availability of movable sinks are apart from fixed sink. The main sink node in tree network is fixed and other base stations are movable. The movable bases are located at feasible location from the fixed sink node.

The movable base station base stations are located at the centroid for each region. The architecture helps in reduction of excessive, parent-to-child multi-hoping in a dense sensor network. The sensors in this topology sense facts from the environment and forward it to nearby movable sink. The movable sink considerably having more energy than sensors, further forward collected data to the fixed fusion sink node as shown in ure 1. Movable sinks can only be placed at feasible location of the sensor network.

In proposed network structure shown in .1 to increase the life time of end devices (sensors), we propose to employ more than one base station in the network. In proposed network structure, there are more than one base station, because the sensor which are near to the sink node need to forward data coming from other nodes, in addition to delivering their own data. To share the medium with minimum interference the proposed MAC scheme is Non-Orthogonal Variable Spreading Factor Technique (NOVSF). The count of the movable base station in the network is determined by a special method called Non-Orthogonal Variable Spreading Factor Technique (NOVSF) [40,41].

shows a tree like architecture for NOVSF code with spreading factor 8. We have selected a Spreading Factor (SF-8) for analysis in a region of 500 x 500. The orthogonal codes generated by the fix base station, depending on the spreading factor, determine the size of the network. With SF-8 the network can have 8 unique addresses assigned to movable base stations. Movable sinks further use these codes to assign addresses to the sensor nodes to uniquely identify them on the network.

4- Improved Energy Efficient Communication Protocol(IEECP)

Researchers have proposed several communication protocols for energy efficient communication. The survey reported in section II, is broadly categorized in three areas: power management based, cyclic approach and motion-based approach. The aim of each approach is to save sensor's energy by implementing energy efficient addressing, topology creation, routing algorithms and data collection methods. As from literature survey, we have found that placing mobile sinks more than a specific number can reduce network performance as well as complexity of the network increases.

Therefore, we intend to introduce moveable sink in the region, the count of which is controlled by some mathematical formulation. Further we intend to propose an addressing scheme refer to a node, that can also be used for signal spreading and de-spreading. Thus, we have proposed in this paper a different energy efficient addressing scheme with minimum complexity, a network topology and energy efficient data collection method for tree-based sensor network. The proposed protocol (IEECP) follows the concept of tree routing protocols.

The scenario is based on the concept of inverted tree topology, where sink node is the root, movable sinks are the branches and sensors are the leaves of the tree. The movable sinks collect data from end node i.e. sensors and forward to fixed sink/root and can be repositioned at the feasible distance in a region where sensors are randomly deployed. A feasible distance is the center place where the hop-count of sensors to sink node can be reduced to minimum. As we know the transmission power is related to distance, as short distance consumes less power and large distance consumes more power for a single bit transmission. The objective of the proposed protocol is thus to reduce the distance between sensors and sinks by reducing multi-hopped links for certain distances.

Non-Orthogonal Vector Spreading Factor (NOVSF) technique is used for dynamic addressing with small address size. The technique makes use of orthogonal codes and movable sinks for data collection. The codes facilitate addressing and spreading of signal in a time-shared manner to provide data security and error correction mechanisms. The sensors have minimum overhead of path discovery when there is a change in the topology, otherwise they are assigned fixed time slots for data transmission without any data collision. The fixed sink node in this protocol generates the orthogonal codes and assigns them to the movable sink nodes. Movable sinks further use these codes for distribution among sensors in the region. Each movable sink is having a unique orthogonal code and can support up-to 128 sensors.

The detailed addressing scheme is NOVSF is shown in ure 2. Sensor Node Address Format is shown in . 3 and proposedaddressing scheme in movable base station is shown in table 1. Proposed Tree Structure is shown in . 1. In Basic Tree Structure [42] shown in ure 5, nodes are forward the packets to its parent or child, so it consumes less energy, no need of searching the path.

TR protocol is suitable for small network, it is complex and more energy consuming if we implement it in a large network. It works fast and efficiently when network size has no significance. By following the parent-child links it avoids flooding of synchronization message to the network hence, saves a lot of energy for WSNs but as the network grows, the hierarchy becomes large and complicated to handle. Moreover, the distance of the leaf node to the root node also increases causing large multi-hopping sequence to be followed. The problems identified in this protocol and removed in Enhanced Tree Routing (ETR) protocol.

In Enhance Tree Routing (ETR) [42] shown in ure 6, nodes are forward the packets to its parent or child, as well as neighbor node can provide a minimum path link and that neighbor is selected as the next hop for packet forwarding.

ETR protocol considers neighbor table for alternate path selection along with the traditional parent-child link. Though this causes the extra computation yet produces best shortest path from source to destination node. Moreover, it uses a fixed size, systematic addressing scheme for node address assignment. As the network density increases the possibilities of multiple shortest paths exist, hence, there are chances of frequent multi-hopping that leads to energy consumption for frequent short transmissions.

The ETR protocol uses a systematic node addressing scheme for sensor node identification. It also considers neighbor table containing the information available for the nearby neighbors. The decision for path selection is based on comparison of the distance as identified by TR protocol and path selected from neighbor table. ETR protocol uses a fixed size addressing scheme for node identification. Nodes in sensor network thus have an extra work of shortest path selection. The behavior of path selection in ETR in some of the cases is unpredictable. For a dense sensor network, the alternative path identification is a challenging and time-consuming task and consumes a lot of process cycle of sensors' processor and hence, energy. The frequent multi-hopping in ETR also causes more power consumption while forwarding data to the neighbor node.

The problem problems identified in TR and ETR is removed in Proposed Tree Routing (P Tree) protocol. PTR protocol uses a NOVSF addressing scheme for node identification. Proposed Tree Routing Protocol (IEECP) on the other hand also reduces the frequent multi-hopping by placing a movable sink to their nearest proximity of the sensor deployment.

5.Simulation Result

Results are obtained from simulation done in MATLAB. The snapshots of few network topologies in a region of 500 by 500 for the three protocols (TR, ETR and P Tree(IEECP)) for 50, 60 and 65 sensor nodes are shown in .7 to 12. The ures are self-explanatory to depict the topological structure of the three protocols. 7 and .12 shows that with increase in density the possibility of multi-hoping increases significantly and thus ETR become more complex and energy consuming. P Tree(IEECP) on the other hand helps in reducing the complexity of the network to minimum and that of excessive multi-hoping.

The dark blue lines in the above ures (TR-Topologies) shows the strict parent-child path as followed by the tree routing protocol for packet forwarding in the dynamic topology. A data packet can opt for single hopping or multi-hopping sequence to reach the sink node. The dark blue lines in the above ures (7 to 9) shows the strict parent-child path as followed by the tree routing protocol for packet forwarding in the dynamic topology and the red dotted lines are the alternative shortest path to reach sink nodes. A sensor sends data packets through the shortest possible path, if no path is identified the default path i.e. the traditional parent-child path as in TR is followed. A sensor node in ETR can adopt the shortest possible path by considering the neighbor table and can route a data packet to the sink node by following a sequence of multi-hops. However, it might be possible to forward the data packet to the destination by having only single or a few hops. ETR therefore, do not consider the probabilistic minimum path from source to sink to deliver data. In a dense network the excessive multi-hoping causes early drain of energy of intermediate sensor nodes that lies between sink node and the sensor node.

The dark blue line in the above . (13 to 15) connects the fixed sensor node to the movable sink station. The movable sink collects the sensed data from the environment through the sensor in the range using fixed time multiplexing technique and forwards the accumulated data to the fixed sink node. The hop counts as can be seen from the above topologies are found to be reduced significantly if we place movable sinks near to sensors density.

. 16 to 18 shows the hop count of TR, ETR and P Tree(IEECP) for 50, 60 and 65 nodes respectively. It is clear from the graphs that as the network density increases, more possibilities for multi-paths and hence, multi-hop routing increases. Therefore, TR become more complex in maintaining parent child links and ETR's computation for shortest path become typical and thus consume more power. P Tree(IEECP) comparatively consumes less power in finding paths and transmitting data to the sink node. It is evident from the three graphs that the P Tree(IEECP) protocol outperforms than the TR and ETR protocols and helps in reduction of excessive multi-hoping.

6.Conclusion& Future Scope

This paper deal with a new energy efficient communication protocol, a new energy efficient topology and data collection method. The main target of this paper is to optimize limited power supply to the sensor device and provide protocol to communicate data from sensor node. The proposed protocol (IEEECP) is based on tree topology concept, where the fixed sink is working as root of the tree, movable sinks are the branches of the tree and sensors are the leaves. By using NOVSF code, fixed sink node can identify its sender information.

Moreover, these codes further extended as addresses of the sensors nodes. Sensors in the network are free to send the sensed data to the movable sinks by using these addresses. Sensors forward sensed data to the nearby movable sink from which it has taken the address and specifically in the time slot assigned to it. Therefore, transmission energy is saved. Mobility of sink node supports dynamic topologies. Since spreading factor for network is fixed, the count of movable sink is also restricted. Proposed protocol (P Tree(IEECP)) is compared with the Tree Routing and Enhanced Tree Routing. Simulation results shows that the proposed protocol is more energy efficient than TR and ETR. It also reduces the frequent multi-hopping by placing a movable sink to their nearest proximity of the sensor deployment.

Wireless sensor networks are small, robust, scalable and cheap networks and are widely used in different areas of interest. Being small and powerful it has variety of rising application areas. Therefore, a continuous effort towards its growth and sustainability is required. Relating to it the future work identified as, finding the long lasting and self-generated power sources to the sensor network, applicability and manageability of the proposed protocol with the new areas, Finding and implementing the data security mechanisms to the sensor network by using proposed protocol.

References

1. H. F. Chan; and H. Rudolph (2015). New energy efficient routing algorithm for Wireless Sensor Network. *TENCON 2015 IEEE Region 10 Conference*, Macao, 2015, 1-5.
2. Huili Jia; XunliFan;KunLiu; and Yang Qian (2017). An Energy Efficiency Routing Algorithm for Wireless Sensor Network. *2017 IEEE International Conference on Computational Science and Engineering (CSE) and IEEE International Conference on Embedded and Ubiquitous Computing (EUC)*, Guangzhou, 2017, 735-739.
3. Yu, Jun; Zhang; andXueying (2015). A Cross-Layer Wireless Sensor Network Energy-Efficient Communication Protocol for Real-Time. *Journal of Sensors*, 2015(5), 1-13.
4. H. KIM (2008). Multiple Sink Positioning and Routing to Maximize the Lifetime of Sensor Networks. *IEICE Transactions on Communications*, volume 91(B), 3499-3506.
5. Vijayan, K; and ArunRaaza (2016). A Novel Cluster Arrangement Energy Efficient Routing Protocol for Wireless Sensor Networks. *Indian Journal of Science and Technology*, 9(2), 1-9.
6. Shinji Inoue;Noriyuki Masuda; and Yoshiaki Kakuda (2007). An Autonomous Method for Aggregating and Repairing Paths in Sensor Networks. *Eighth International Symposium on Autonomous Decentralized Systems (ISADS'07)*, Sedona, Arizona, USA, 526-533.
7. Basma M.Mohammad; El-Basioni;Sherine; M.Abd El-kader ; and Hussein S.Eissa (2012).Designing a local path repair algorithm for directed diffusion protocol. *Egyptian Informatics Journal*, 13, 155-169.
8. Arain;Qasim Ali; Uqaili; Muhammad Aslam;Deng; and Zhongliang (2017). Clustering Based Energy Efficient and Communication Protocol for Multiple Mix-Zones Over Road Networks. *Wireless Personal Communications*, 95, 411–428.
9. S. C. Ergen; and P. Varaiya (2010). TDMA scheduling algorithms for wireless sensor networks.*Springer Wireless Network*, 16(4), 985–997.
10. Mario Macedo;AntonioGrilo; and Mario Nunes(2009). Distributed Latency-Energy Minimization and interference avoidance in TDMA *Wireless Sensor Networks. Elsevier Journal on Computer Networks*, 53, 569–582.
11. Bashir Yahya; and Jalel Ben-Othman (2009). Towards a classification of energy aware MAC protocol for wireless sensor networks.*Wireless Communication and Mobile Computing*, 9, 1572–1607.
12. Singh S.; and Raghavendra C (1998). PAMAS: power aware multi-access protocol with signaling for ad hoc networks.*SIGCOMM Computer Communications Review*, 28(3), 5–26.
13. Ephremides; and O. Mowafi(1992).Analysis of a hybrid access scheme for buffered user probabilistic time division. *IEEE Transactions on Software Engineering*, 8 (1), 52–61.
14. J. R. Jiang; Y. C. Tsang; C.S. Hsu;and T. H. Lai (2003).Quorum-Based Asynchronous Power-Saving Protocols for IEEE 802.11 Ad-Hoc Networks. *Proceedings of the 2003 IEEE-International Conference on Parallel Processing (ICPP'03),* 257-264.
15. R. Zheng; J. Hou; and L. Sha (2003). Asynchronous wakeup for ad hoc networks. *Proceedings ACM Mobi Hoc*, USA, 35–45.
16. C. Vigorito;D.Ganesan;and A. Barto (2007).Adaptive Control of Duty-Cycling in Energy-Harvesting Wireless Sensor Networks. *Proceedings of IEEE Conference on Sensor, Mesh, and Ad Hoc Communications and Networks (SECON 2007)*, San Diego, 1-10.
17. M Maroti; B. Kusy;G. Simon; and A. Ledeczi(2004). The flooding time synchronization protocol. *Proceedings of*

ACM International Conference on Embedded Networked Sensor Systems, Maryland, USA, 39-49.

18. S. Cui; R. Madan; A. Goldsmith; and S. Lall (2005). Joint routing, Mac, and link layer optimization in sensor networks with energy constraints. *Proceedings of IEEE International Conference on Communications, ICC 2005*Seoul, Korea, 2, 725–729.
19. Kilhung Lee (2008). An Energy-Aware Aggregation Tree Scheme in Sensor Networks. International *Journal of Computer Science and Network Security,* 8 (5), 51-57.
20. WanzhiQiu;EfstratiosSkafidas; and Peng Hao(2009).Enhance tree routing for wireless sensor networks. *Ad-Hoc Networks, Elsevier*, 7, 638-650.
21. Y. Xu; J. Heidemann; and D. Estrin (2001). Geography-informed energy conservation for ad hoc.*Proceedings of ACM MobiCom*, Rome, 70–84.
22. S. Sharma (2008). Speed Aware Modified Span for Wireless Mobile Ad-hoc Networks. *Proceedings of Third International Conference on Digital Telecommunications IEEE Computer Society*, 53-58.
23. Jegadeesan,R.,Sankar Ram M.Naveen Kumar JAN 2013 "Less Cost Any Routing With Energy Cost Optimization" International Journal of Advanced Research in Computer Networking,Wireless and Mobile Communications.Volume-No.1: Page no: Issue-No.1 Impact Factor = 1.5
24. Jegadeesan,R.,Sankar Ram, R.Janakiraman *September-October* 2013"A Recent Approach to Organise Structured Data in Mobile Environment" R.Jegadeesan et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 4 (6) ,Page No. 848-852 ISSN: 0975-9646 Impact Factor:2.93
25. Jegadeesan,R., Sankar Ram October -2013 "ENROUTING TECHNICS USING DYNAMIC WIRELESS NETWORKS" International Journal of Asia Pacific Journal of Research Ph.D Research Scholar [1], Supervisor[2], VOL -3 Page No: Print-ISSN-2320-5504 impact factor 0.433
26. Jegadeesan,R., Sankar Ram, M.S.Tharani *(September-October, 2013)* "Enhancing File Security by Integrating Steganography Technique in Linux Kernel" Global journal of Engineering,Design & Technology *G.J. E.D.T., Vol. 2(5): Page No:9-14* ISSN: 2319 – 7293
27. Ramesh,R., Vinoth Kumar,R., and Jegadeesan,R., *January 2014* "NTH THIRD PARTY AUDITING FOR DATA INTEGRITY IN CLOUD" *Asia Pacific Journal of Research Vol: I Issue XIII, ISSN: 2320-5504, E-ISSN-2347-4793* Vol: I Issue XIII, Page No: Impact Factor:0.433
28. Vijayalakshmi, Balika J Chelliah and Jegadeesan,R., February-2014 "SUODY-Preserving Privacy in Sharing Data with Multi-Vendor for Dynamic Groups" Global journal of Engineering,Design & Technology. G.J. E.D.T.,Vol.3(1):43-47 (January-February, 2014) ISSN: 2319 –7293
29. Jegadeesan,R.,SankarRam,T.Karpagam March-2014 "Defending wireless network using Randomized Routing process" International Journal of Emerging Research in management and Technology
30. Jegadeesan,R.,T.Karpagam, Dr.N.Sankar Ram , "Defending Wireless Network using Randomized Routing Process" International journal of Emerging Research in management and Technology ISSN: 2278-9359 (Volume-3, Issue-3) . March 2014
31. Jegadeesan,R., Sankar Ram "Defending Wireless Sensor Network using Randomized Routing "International Journal of Advanced Research in Computer Science and Software Engineering Volume 5, Issue 9, September 2015 ISSN: 2277 128X Page | 934-938
32. Jegadeesan,R., Sankar Ram,N. "Energy-Efficient Wireless Network Communication with Priority Packet Based QoS Scheduling", Asian Journal of Information Technology(AJIT) 15(8): 1396-1404,2016 ISSN: 1682-3915,Medwell Journal,2016 (Annexure-I updated Journal 2016)
33. Jegadeesan,R.,Sankar Ram,N. "Energy Consumption Power Aware Data Delivery in Wireless Network", Circuits and Systems, Scientific Research Publisher,2016 (Annexure-I updated Journal 2016)
34. Jegadeesan,R., Sankar Ram , and J.Abirmi "Implementing Online Driving License Renewal by Integration of Web Orchestration and Web Choreogrphy" International journal of Advanced Research trends in Engineering and Technology (IJARTET) ISSN:2394-3785 (Volume-5, Issue-1, January 2018
35. Pooja,S., Jegadeesan,R., Pavithra,S., and Mounikasri,A., "Identification of Fake Channel Characteristics using Auxiliary Receiver in Wireless Trnsmission" International journal for Scientific Research and Development (IJSRD) ISSN (Online):2321-0613 (Volume-6, Issue-1, Page No. 607-613, April 2018
36. Sangeetha,R., Jegadeesan,R., Ramya,P., and Vennila.,G "Health Monitoring System Using Internet of Things" International journal of Engineering Research and Advanced Technology (IJERAT) ISSN :2454-6135 (Volume-4, Issue-3, Page No. 607-613, March 2018.