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Efficient Health Monitoring Networks Using Secured Energy Aware (SEA) Scheme

R. Sivaranjani, A.V. Senthil Kumar

Abstract: The volume of healthcare information is rapidly growing. Collecting and securing information gathered through a Wireless Sensor Network (WSN) is an open challenge. The integrity and confidentiality of the information is to be ensured, failing to do which will lead to fatal consequences. Further, conserving energy is a challenge in WSN. Hence, in this paper a Secured Energy Aware (SEA) scheme is proposed. Only authenticated nodes communicate to the Fusion Centres (FCs) which collect the data and forward to the Sink or other FCs, thus avoiding redundancy. The propounded scheme offers better results in contrast to the existing scheme in terms of Packet Delivery Ratio (PDR), Throughput, Residual Energy, Packet Loss Ratio (PLR) and Routing Overhead.

Keywords: **Security, Authentication, Residual Energy (RE)**

I. INTRODUCTION

Secured transmission of health data is the need of the hour. As major part of the population have developed enduring diseases including diabetes, heart problems, blood pressure etc., Efficient remote monitoring of patients is essential, thus enabling the physicians to detect health issues at the earliest. This could be possible by using sensors that involve low cost, power, computation and memory. Energy efficient, stringent and secured transfer of health information is an uphill task. Interception and modification of healthcare information should be dealt with as the universal systems using WSN should ensure confidentiality and integrity. The information should be available to appropriate healthcare providers, so that timely treatment is possible so as to ensure the proper treatment of the patient. If the healthcare information is corrupted, it would become life-threatening. Moreover, only authorized users should have access to the data.

II. WIRELESS SENSOR NETWORK (WSN)

The sensors in a WSN can be deployed at a lesser cost than the outmoded wired systems. The sensors are equipped with low-power transceivers that serve as an effective tool for collecting data. To preserve the cost effectiveness of WSNs, they are made of small batteries. This becomes a challenge as energy determines the lifetime of a network (Abbasi &Younis 2007; Boyinbode et al 2011). The transmission range and the data rate are reduced as the sensors with limited energy cannot communicate with sensors at a larger distance.

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Remote environments are to be monitored and the data from the individual sensors are forwarded to the Sink, thus enabling the end-user to have access to the data. Figure 1 shows a WSN model. Each sensor node includes three parts, namely

- A sensing subsystem that captures data from the real world
- A subsystem that processes local data and storage
- A subsystem that includes wireless communication to receive and transmit data

The following characteristics make WSN a standing technology.

- Easy deployment
- Capacity to manage node failures
- Ability to tackle communication failures
- Scalability
- Capability to perform energy harvesting
- Efficiency to cooperate with harsh environmental conditions

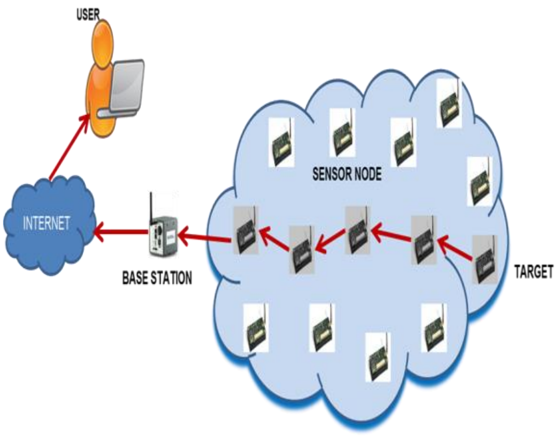

Figure Error! No text of specified style in document.**WSN Model**

Applications of WSN

The immense capacity of sensor network has enabled applications to connect the physical and the virtual worlds. WSN is an eminent technology that finds its applications in military surveillance, fire detection, border protection, environment and habitat monitoring, health care applications, weather monitoring, industrial process monitoring and control etc., These applications demand faster transmission and consumption of less energy as they are not battery powered. The communication and routing protocols are designed to manage these challenges.

Challenges in WSN

WSN faces many challenges due to limited resources (Li & Chong 2010; Chebrolu & Dhekne 2013). They are discussed below.

- **Energy conservation -** The first and foremost challenge of the WSN is the efficient use of energy in the sensors. The sensors come with small irreplaceable small capacity batteries. Hence, conserving power becomes mandatory. Energy efficient protocols are essential to establish communication in a WSN.
- **Application specific -** WSN has many applications due to its versatility to support even harsh environments. Networks are to be deployed to suit the application.
- **Self-Management** - The sensors are positioned in unreceptive environments where human intervention is impossible. Maintenance and repair of such nodes become impossible. They should be able to configure on their own being adaptive to failures and dynamic atmosphere.
- **Hostile environment -** The networks are deployed in harsh environments. So the protocols designed for the WSNs should be robust to failures to the possible extent.
- **Communication quality -** The quality of communication deteriorates with the nature of the surrounding environment.
- **Resource availability -** The sensor network offers better Quality of Service (QoS) even when the required resources are unavailable.
- **Design Constraints** - The sensors are tiny devices which are small in size and are cheap. They have less processing speed and memory capacity. As the batteries are also too small, the energy consumed by these devices should also be minimum.
- **Data aggregation -** Data obtained from sensors may be redundant. Data aggregation is performed to remove redundant data. The amount of transmissions conserves energy to a greater extent.
- **Scalability -** WSNs consist of thousands of sensors and new sensors can be added whenever needed.
- **Security -** The WSNs are deployed in sensitive areas like battlefields, disaster prone areas and forest areas where human intervention is challenging. The sensors carry sensitive and valuable information, the eavesdropping of which may lead to unanticipated results. As the sensors are exposed to malicious activities, security becomes a challenge.
- **Commercialization -** Many companies have started production of sensors, but the profit is less as the commercialization is very poor.
- **Topology** - The system topology constantly keeps changing due to energy-less dead nodes or inconsistent channel conditions. Hence, the protocols that are designed for WSNs must be capable of effectively managing the network topology.

The routing protocols designed for Ad-hoc networks do not suit WSNs due to their data centric nature and data redundancy in the network.

Communication Protocol in WSN

The communication protocol includes the following standard protocol layers to assist in packet switching(Sohraby et al 2007).The layered architecture is shown in Figure 1.2.

- **Application layer:** Diverse applications are included in this layer to support various sensing tasks.
- **Transport layer:** This layer addresses data communication, packet recovery, energy conservation and data flow. It also deals with congestion detection and mitigation. It also ensures reliable data flow.
- **Network layer:** This layer addresses the routing issues. This layer also deals with data aggregation and computational overheads.
- **Data link layer:** It deals with minimizing collision with broadcasts of other sensors. This layer considers transfer of data between physically connected nodes. It also deals with TDMA and CSMA/CA.
- **PHY Layer -** This layer deals with robust modulation, receiving techniques and transmission.

Multichip Communication in WSN

Sensors in a WSN support 2 types of communication namely, single and multi-hop communication.Sensors communicate with others directly only when they are within a short range. In single hop communication, sensors connectto the BS by forming a star topology. This is feasible only when the transmission range of the sensors covers the BS in a single hop.In WSNs, the power of radio transceivers consumed should be less. To establish communication with sensors that are not within the communication range, the sensors are made to communicate in a multi-hop fashion. The sensors detect events and forward data to a central location, wherein the parameters are assessed. In a multi-hop communication, the sensors form a mesh topology, where they not only send their captured data but also relay the data sent by other sensors. Sensors act as sources as well as routers, hence finding an optimized path to the BS is a challenge. As power conservation is important in a WSN, if the same paths are chosen for transmission, it will lead to energy depletion. Therefore, design of energy efficient routing algorithms is a hot area of research.

III. ENERGY HARVESTING IN WSN

As the sensor nodes are energy stringent, energy harvesting and minimization of energy have demanded much research interests. Extended use of sensors leads to energy depletion, which in turn, causes death and disconnection of the sensors from the network.

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The number of alive nodes and the connectivity of the network determine the lifetime of a network.The sensors replenishing energy from a source is called energy harvesting. Various energy sources are available Solar cell is the best technique, as it harvests energy from light

To deal with energy conservation and improve network lifetime, along with providing QoS in the network, following approaches are suggested by Yick et al (2008).

- Trusted wireless communication
- Smart placement of sensors to obtain suitable coverage, ensure security and better storage
- Data aggregation and compression

IV. SECURITY IN WSN

Many schemes proposed to ensure security fail to consider the malicious behaviour of nodes in a network. Finding and circumventing such malicious nodes in a network is a challenging task. Ensuring security in a network demands preserving the limited resources.

The intrusion detection system should dynamically monitor the events taking place in a network and identify the attacks if any. In general, the schemes that detect intrusions are categorized into the following.

- **Misuse intrusion detection schemes** - They match the observations with the signatures in the database.
- **Anomaly intrusion detection schemes** - They detect the abnormal behavior from the predefined normal profile.The security solutions are grouped into two main mechanisms.
- **Prevention based mechanisms -** They include both encryption and authentication algorithms. They sometimes fail to prevent both insider and outsider attacks.
- **Detection based mechanisms -** They are used when the preventive mechanisms fail to isolate the attacks. They protect the network from both insider and outsider attacks.

V. CLUSTERING IN WSN

The sensors are deployed in an ad-hoc fashion and organizing them into different structures demands much interest (Dechene et al 2007). The sensors are grouped into clusters, and each member can act as a member or a CH (Chinara & Rath 2009).

The computation cost is more when compared to that of transmitting a bit. The sensors that are organized as clusters do not communicate with the BS directly, but forward the sensed information to the CH, which in turn forwards the aggregated information to the processing centre, the BS. Thus, the amount of energy consumed for transmission is reduced to a greater extent (Kumar et al 2011; Bharti & Sharma 2013).Thus, clustering helps in extending the network lifetime.

A hierarchy of CHs reduce the transmission overhead, as each sensor do not send the data directly to the BS. The energy expended in increased number of transmissions as well as direct communication is reduced to a greater extent. The energy in a sensor is highly retained as they communicate with the next hop sensors.

Further, as the CH performs data aggregation, data redundancy is circumvented. This not only helps in conserving energy, but also in reusing the available bandwidth (Du et al 2008). The choice of the CH is a challenge that demands much attention.

Merits of Clustering

Clustering provides the following advantages.

- Transmission of aggregated information
- Lessened resource utilization
- Reduction in the number of alive nodes
- Energy conservation and efficient energy utilization
- Support versatile nodes
- Efficient reuse of resources

VI. ROUTING

Routing involves finding a path between the source and the destination, taking into account the available resources. The techniques available in the literature try to select minimum energy paths that consume the least energy. Choosing the path repeatedly leads to energy depletion in the network The paths may also become vulnerable to attacks. The routing protocol should ensure that the next hop sensors are chosen with equal probability, thus maintaining the connectivity of the network.

VII . RELATED WORK

Energy efficient clustering and routing algorithms are available in the literature.

Energy Efficient Clustering

Ye et al (2005) have proposed an Energy Efficient Cluster Scheme (EECS) that uses local radio communication to appoint CHs based on the remaining energy. It considers the trade-off between the energy consumed during communication between the sensors and the CHs, and between the CHs and the BS.

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Zhou et al (2007) have propounded an Energy Efficient Strong Head (EESH) clustering wherein their RE, degree, distance to their neighbours, along with the RE of their neighbours are considered. An iterative cost function is developed to elect the CH.

If the energy of the CH goes below the energy level of CH, the communication in a cluster is completely damaged, the reformation of which demands more energy. To deal with this issue, Deshpande & Patil (2013) have proposed a scheme with more than one CH in a cluster so as to improve the network lifetime. The CHs are made to play their role in rounds.

Mitton et al (2011) have come up with a self-stabilized clustering algorithm for a dynamic network that uses a Directed Acyclic Graph (DAG) to reduce the stabilization time.

Fuzzy based Schemes

Anno et al (2008) have designed a scheme based on fuzzy descriptors to select the CHs in environments with diverse characteristics. The sensors at close proximity to the BS die soon due to early depletion of energy, as more network traffic are relayed near the BS.

In addition to the RE, Bagci & Yazici (2010) have taken the distance of the sensor to the BS as the fuzzy descriptor. This leads to unbalanced clustering as the cluster sizes of the clusters near the BS reduce uncertainly.

Nayak & Devulapalli (2016) have propounded a technique to elect a Super-CH (SCH) from the CHs based on the fuzzy descriptors like RE, mobility of the BS and significance of the clusters. Based on the Fuzzy inference engine (Mamdani's rule), the CHs are appointed as the super-CHs.

Genetic Algorithm (GA) based Clustering

A Genetic Algorithm (GA) based scheme named Genetic Algorithm Based Energy Efficient Clusters (GABEEC) which resembles LEACH is proposed by Bayraklı & Erdogan (2012). GA maximizes the network lifetime, as the clusters are created and remain static in each round, though the CHs change dynamically.

7.1 Routing

In this section, various routing algorithms proposed for WSNs are discussed.

Energy Efficient Routing

Energy conservation is a challenge in wireless networks. Many routing algorithms are proposed to extend the lifetime of a network.

The energy aware routing algorithms proposed by Ganjali & Keshavarzian (2004) choose one of the multiple paths and hence incur more routing overhead, since routing information is exchanged periodically.

Zhu et al (2011) have proposed algorithms that select energy efficient paths. The sink node finds another path based on the global routing information. This is not securing as well as it may lead to network partitioning.

There are many works available in the literature that concentrate on energy efficient routing, but do not consider proportionate energy distribution (Zhu et al 2011; Zytoune & Aboutajdine 2010).

Zytoune & Aboutajdine (2010) have devised a central algorithm that is based on RE and energy to find the best routing path. The routing overhead increases as the universal routing information is necessary to find the optimal route. Liu et al (2012) have developed a cost function that finds an energy efficient path based on end-to-end energy and the RE.If the energy is not uniformly distributed, it leads to early depletion of energy. Bhattacharjee & Bandyopadhyay (2013) have computed the node costs based on the RE of nodes. An energy based routing algorithm is proposed to balance the data traffic and improve network lifetime. Distinct Energy Efficient Routing Trees (DEERTs) are designed at different intervals, and the routing tree is constructed based on the present network condition.

Cluster based Routing Algorithms

Cluster Based Routing for Mobile WSN (CBRMWSN) (Awwad et al 2011), a hierarchical protocol allocates transmission slots to the nodes that are not connected to a cluster. The node that moves away from a CH keeps transmitting to a CH before it connects to a new one. Mobility Based Clustering (MBC) is proposed by Deng et al (2011), in which, suitable metrics are derived from connection time, RE, CH degree and distance. Enhanced Cluster Based Routing for MWSNs (ECBR-MWSN) is proposed by Anitha & Kamalakkannan (2013) that selects CHs that are closer to the sink and that are with high RE.

Genetic Algorithm based Routing Algorithms

Bari et al (2009) have propounded a GA based routing scheme involving selection, crossover and mutation operations. Roulette-wheel is used for selecting individuals. The fitness function determines the network lifetime.

A Genetic Algorithm based Routing (GAR) (Gupta et al 2013) reduces energy by dropping the total distance. The distance is determined by the routing schedule based on the present network state.

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The computational efficiency of GA improves network lifetime, energy consumption and the distance traversed in each round. However, it is different from the work of Bari et al (2009).

Huruiala et al (2010) have presented a clustering and routing algorithm based on GA using a multi-objective function that chooses the optimal CH and minimizes the transmission distance. Chakra borty et al (2011) has designed a GA based protocol called GROUP, wherein a chain is formed to connect to the BS. To improve the network lifetime, individual sensors are involved in transmitting messages to the BS non-periodically based on their RE and location.

VIII. SECURED ROUTING

Healthcare information collected from various sensors is routed to the Sink through an energy efficient path. More amount of energy will be consumed, when the data from a sensor is forwarded directly to the Sink. Multihop communication conserves power. In addition, clustering conserves more power as redundant information is not forwarded beyond the Fusion Centre (FC). Thus, energy is conserved as the Routing overhead is reduced to a greater extent. Security at the FCs should be ensured. If the intruder takes hold of the FC, then all the information will be lost.

Data authentication stops unauthorized access to data in a network. Authentic nodes should be capable of detecting messages from unapproved nodes and discard them. In case of two-party communication, a secret key is shared between the source and the destination, based on which a Message Authentication Code (MAC) is determined. Correct MAC shows that it is sent by a genuine sender. On detecting an incorrect MAC, the report is dropped. Various techniques are propounded to deal with providing data assurance.

Information Assurance

The Fusion Centres (FCs) accumulate decisions and communicate directly with the Sink. OneFC sends the final result to the Sink. Unless all the sensors fail, this scheme assures guaranteed communication. However, accuracy becomes a question. Every FC must correctly accumulate the decisions. Further, fusion result should be an assured one. There are chances for some FCsto be compromised. Data may be sent by a malicious node. It is tedious to detect the anonymity of data at the Sink. If multiple data copies are sent to the Sink, power consumption increases. Hence in the proposed scheme, only the HASH VALUE is conveyed to the Sink. The Sinkand the FCs share private keys.

- FCs is selected at random for forwarding the HASH VALUE encrypted using the private key given by the Sink.
- The Sink decrypts it using the corresponding private key and broadcasts it after encrypting it using a common group key. It waits for negative votes from the FCs which reject the fusion result.
- The FCscompare the value received from the Sink and the value computed from the available data.
- The FCs send negative votes if the values do not match. The votes are encrypted using their private keys.
- If the number of negative votes is less, the Sink receives the data from the corresponding FC.

Credibility of the Proposed Mechanism

- In this novel mechanism, retransmissions are avoided until the FC that is selected is malicious. Random selection also assures security.
- AmalevolentFCcannot lead to dropping of data as sufficient number of negative votes will not be available.
- Use of Private keys avoids polling of negative votes.

IX. IMPLEMENTATION & RESULTS

The system is simulated using ns2. Sensors are organized as a tree rooted at a Sink. The non-leaf nodes perform data fusion on the data collected from sensors. Communication overhead is largely reduced.Figure 2 shows the Packet Delivery Ratio of the existing Direct Voting Scheme (DVS) and the proposed Secured Energy Aware (SEA) method.

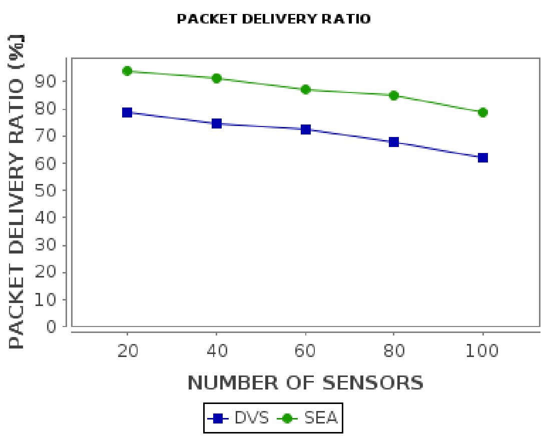

Figure 2: Packet Delivery Ratio

Figure 3 shows the Throughput of the existing DVS and the proposed SEA method.

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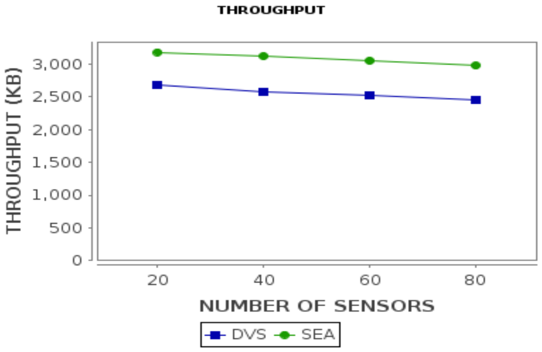

Figure 3: Throughput

Figure 4 shows the Residual Energy of the existing DVS and the proposed SEA method.

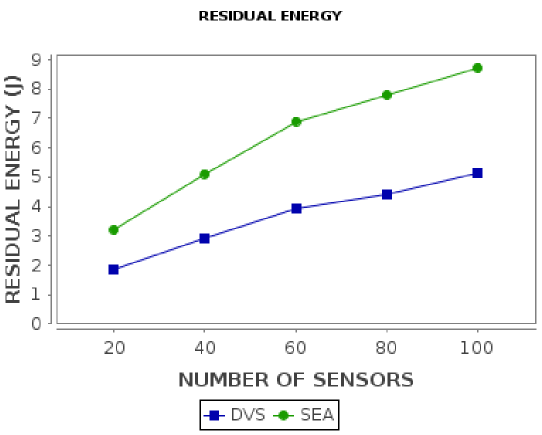

Figure 4: Residual Energy

Figure 5 shows the Routing Overhead of the existing DVS and the proposed SEA method.

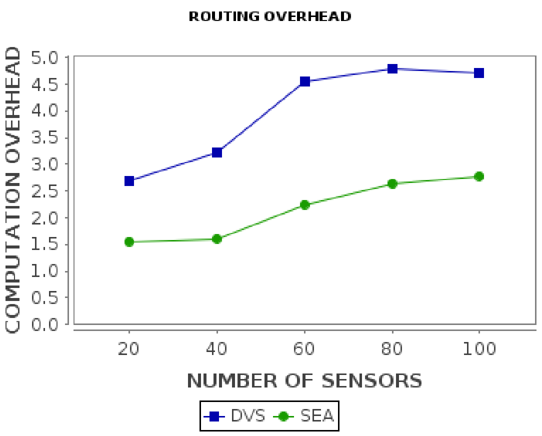

Figure 5: Routing Overhead

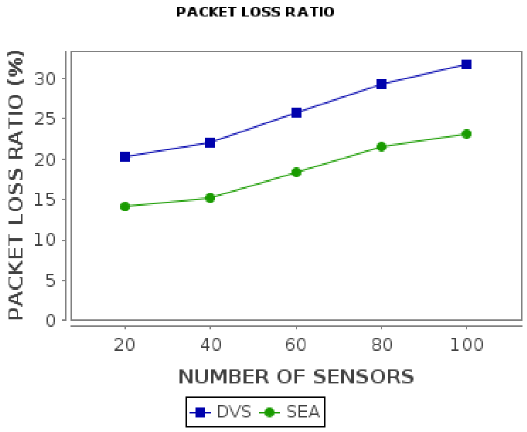

Figure 6: Packet Loss Ratio

Figure 6 shows the Packet Loss Ratio of the existing DVS and the proposed SEA method.

It is seen that the proposed SEA method involves less Routing overhead and yields better Packet Delivery Ratio, Throughput, Packet Loss Ratio with more Residual Energy.

X. CONCLUSION

In the proposed voting mechanism, the Sink collects the negative votes on the data directly from the witness (fusion) nodes and the fusion result from the randomly selected Fusion node, only when sufficient Anti-votes are not available. The proposed scheme is reliable involving less assurance overhead than the direct voting method. The initial phase results are exciting. The power consumption is very much reduced as the fusion result is transmitted as a HASH VALUE for validation by the Sink and approval by the witness nodes. The data is sent to the Sink, only on request.

REFERENCES

1. Abbasi, AA, & Younis, M 2007, 'A survey on clustering algorithms for wireless sensor networks', Journal of Computer Communications, vol. 30, no.14, pp. 2826-2841.
2. Anitha, RU, & Kamalakkannan, P 2013, 'Enhanced cluster based routing protocol for mobile nodes in wireless sensor network', Proceedings of the International Conference on Pattern Recognition, Information and Medical Engineering (PRIME), pp. 187 - 193.
3. Anno, J, Barolli, L, Durresi, A, Xhafa, F, & Koyama, A 2008, 'Performance evaluation of two fuzzy-based cluster head selection systems for wireless sensor networks', Journal of Mobile Information Systems, vol. 4, no. 4, pp. 297-312.
4. Awwad, SA, Ng, CK, Noordin, NK, & Rasid, MFA 2011, 'Cluster based routing protocol for mobile nodes in wireless sensor network', Journal of Wireless Personal Communications, vol. 61, no. 2, pp. 251-281.
5. Bagci, H, & Yazici, A 2010, 'An energy aware fuzzy unequal clustering algorithm for wireless sensor networks', Proceedings of the IEEE International Conference on Fuzzy Systems (FUZZ), pp. 1-8.
6. Bari, A, Wazed, S, Jaekel, A, & Bandyopadhyay, S 2009, 'A genetic algorithm based approach for energy efficient routing in two-tiered sensor networks', Journal of Ad Hoc Networks, vol. 7, no. 4, pp. 665-676.
7. Bayraklı, S, & Erdogan, SZ 2012, 'Genetic algorithm based energy efficient clusters (gabeec) in wireless sensor networks', Procedia Computer Science, vol. 10, pp. 247-254.

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8. Bharti, A, & Sharma, K 2013, 'Comparative Study of Clustering based Routing Protocols for Wireless Sensor Network', Journal of Computer Applications, vol. 66, no. 21.
9. Bhattacharjee, S, & Bandyopadhyay, S 2013, 'Lifetime maximizing dynamic energy efficient routing protocol for multi hop wireless networks', Journal of Simulation Modelling Practice and Theory, vol. 32, pp.15-29.
10. Boyinbode, O, Le, H, & Takizawa, M 2011, 'A survey on clustering algorithms for wireless sensor networks', Journal of Space-Based and Situated Computing, vol. 1, no. 2-3, pp. 130-136.
11. Chakra borty, A, Mitra, SK, & Naskar, MK 2011, 'A Genetic algorithm inspired routing protocol for wireless sensor networks', Journal of Computational Intelligence Theory and Practice, vol. 6, no. 1, pp. 1-8.
12. Chebrolu, K, & Dhekne, A 2013, 'Esense: Energy sensing-based cross-technology communication', IEEE Transactions on Mobile Computing, vol. 12, no.11, pp. 2303-2316.
13. Chinara, S, & Rath, SK 2009, 'A survey on one-hop clustering algorithms in mobile ad hoc networks', Journal of Network and Systems Management, vol. 17, no. 1-2, pp. 183-207.
14. Dechene, DJ, Jardali, AE & Sauer, MLA 2007, 'A Survey of Clustering Algorithms for Wireless Sensor Networks', Journal of Computer Communications.
15. Deng, S, Li, J, & Shen, L 2011, 'Mobility-based clustering protocol for wireless sensor networks with mobile nodes', Journal of IET Wireless Sensor Systems, vol. 1, no. 1, pp. 39-47.
16. Deshpande, VV, & Patil, ARB 2013, 'Energy efficient clustering in wireless sensor network using cluster of cluster heads', Proceedings of the tenth IEEE International Conference on Wireless and Optical Communications Networks (WOCN) , pp. 1-5.
17. Du, X, Xiao, Y, & Dai, F 2008, 'Increasing network lifetime by balancing node energy consumption in heterogeneous sensor networks', Journal of Wireless Communications and Mobile Computing, vol. 8, no. 1, pp. 125-136.
18. Gupta, SK, Kuila, P, & Jana, PK 2013, 'GAR: an energy efficient GA-based routing for wireless sensor networks', Proceedings of the International Conference on distributed computing and internet technology, Springer Berlin Heidelberg, pp. 267-277.
19. Huruială, PC, Urzică, A, & Gheorghe, L 2010, 'Hierarchical routing protocol based on evolutionary algorithms for wireless sensor networks', Proceedings of the ninth IEEE International Conference on RoEduNet, pp. 387-392.
20. Kumar, V, Jain, S, & Tiwari, S 2011, 'Energy efficient clustering algorithms in wireless sensor networks: A survey', Journal of Computer Science, vol.8, no. 5.
21. Li, XJ, & Chong, PHJ 2010, 'Performance analysis of multihop cellular network with fixed channel assignment', Journal of Wireless Networks, vol. 16, no. 2, pp. 511-526.
22. Liu, A, Ren, J, Li, X, Chen, Z, & Shen, XS 2012, 'Design principles and improvement of cost function based energy aware routing algorithms for wireless sensor networks', Journal of Computer Networks, vol. 56, no. 7, pp. 1951-1967.
23. Mitton, N, Sericola, B, Tixeuil, S, Fleury, E, & Lassous, IG 2011, 'Self-stabilization in Self-organized Wireless Multihop Networks?', Ad Hoc & Sensor Wireless Networks, vol. 11, no. 1-2, pp. 1-34.
24. Nayak, P, & Devulapalli, A 2016, 'A fuzzy logic-based clustering algorithm for WSN to extend the network lifetime', IEEE Journal on Sensors, vol. 16, no. 1, pp. 137-144.
25. Roundy, S, Rabaey, JM, &Wright, PK 2004, 'Energy Scavenging for Wireless Sensor Networks', Springer Verlag, LLC.
26. Sohraby, K, Minoli, D, & Znati, T 2007, 'Wireless sensor networks: technology, protocols, and applications', John Wiley & Sons, pp. 1-307.
27. Yick, J, Mukherjee, B, & Ghosal, D 2008, 'Wireless sensor network survey', Journal of Computer networks, vol. 52, no. 12, pp. 2292-2330.
28. Zhang, P, Sadler, CM, Lyon, SA, & Martonosi, M 2004, 'Hardware design experiences in ZebraNet', Proceedings of the second ACM International Conference on Embedded networked sensor systems, pp. 227-238.
29. Zhou, W, Chen, HM, & Zhang, XF 2007, 'An energy efficient strong head clustering algorithm for wireless sensor networks', Proceedings of the IEEE International Conference on Wireless Communications, Networking and Mobile Computing , pp. 2584-2587.
30. Zhu, YH, Wu, WD, & Leung, VC 2011, 'Energy-efficient tree-based message ferrying routing schemes for wireless sensor networks', Journal of Mobile Networks and Applications, vol. 16, no. 1, pp.58-70.

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