

A Survey on Secure and Energy Efficient Routing in Wireless Sensor Networks

R. Logeswari¹Mr.V.Manimaran²

¹PG Scholar, Department of Computer Science and Engineering,
Nandha Engineering College, Erode, Tamil Nadu

²Assistant Professor, Department of Computer Science and Engineering,
Nandha Engineering College, Erode, Tamil Nadu

ABSTRACT - This paper provides a survey on secure and energy efficient routing in wireless sensor networks. A Wireless Sensor Network (WSN) is composed of numerous number of nodes each of which comprises of sensing devices to collect data from environment. These sensing devices are furnished with processing unit to perform operations on data. In remote environment Sensing devices are deployed randomly, due to which battery charging or replacement is not considered practical. Clustering has been proven as one of the most important technique for reducing consumption of energy in the wireless sensor networks. Sensor nodes are always grouped into separate clusters. Wireless Sensor Network paid a large attention for their potential use in observing environment, health, military surveillance, home applications and many more. The design of sensor network is influenced by factors such as scalability, energy consumption, environment etc. and it depends on the application. Most of the energy is spent on communication purposes of the three activities: sensing, processing and communication. In WSN energy conservation is thus dominant factor. For proper delivery of packets routing strategy selections are very important. By designing protocols that requires less energy during communication ongoing research aims in extending networklifetime

Keywords: Network Security, Energy Efficiency, Survey, Cluster Approach

I. INTRODUCTION

Wireless Sensor Networks gained popularity as they can adapt to the changes in physical conditions such as temperature, pressure, pollution, and sound. They are developed mainly for military applications to make the communication efficient in harsh conditions. The sensors of such communication network have a transceiver, an antenna, a microcontroller and a battery to control its activity. The application areas of WSN are environment monitoring, entertainment, intelligent transportation, agricultural and industrial fields. The advantage of such structures is that they are flexible, suitable for isolated places such as mountain areas, seas, forest and rural areas. At any instance of time new devices can enter the network. The networks are mostly bounded by limited frequency range and power, as any node can enter any time for security issues as paving a way for attacker nodes to enter the network. To provide efficient energy routing and secure communication present literature use cluster head and encryption respectively. WSN is an emerging technology that has wide range of potential applications including environmental monitoring medical system, emergency applications (military) and robotic exploration. One of the most critical resources for WSN is Energy. Energy efficiency has become the most important aspect in the design of WSN protocol in order to increase the lifetime as long as possible. Optimization in the usage of energy at nodes is possible, by clustering the nodes.

To improve the lifetime and to minimize the energy utilization of the network, nodes are grouped into clusters. And a cluster head is selected based on different parameters such as distance, energy to transfer the information and group of nodes can communicate using these cluster heads. To encode the normal message in such a way that it should be decrypted to get back the original message by using encryption technique. Encryption process can be done by using the private key, that can provide the same

key for encryption and decryption and public key provides different keys for encryption and decryption.

The authorized user is provided with the key to access the original data and the unauthorized user cannot access it. However, cluster heads may not be appropriate as they are overloaded and should manage all the activities of the cluster in which it is present and security in such self-configured networks using encryption method may be problematic as the distribution of keys itself is a challenge.

II. LITERATURE SURVEY

Longteng Yi, Xiaojun Tong, Zhu Wang, Miao Zhang, Honghong Zhu, and Jing Liu [1] In this paper based on chaotic substitution box (s-box) a block encryption algorithm is proposed for basic security of wireless sensor networks (WSNs). In this paper, a new S-box based on the compound chaotic map, sinusoidal chaotic map, Baker map, and linear congruence generator. The limited computing power and communication capability of WSN are also considered in this paper in addition. Generating round subkeys and F function is constructed based on the S-box is one of the important method. The performance tests and extensive security show that the proposed encryption algorithm has high security and low resource consumption which is suitable for WSN.

Turki A. Alghamdi [2] Wireless sensor networks (WSNs) consist of autonomous sensor nodes, in adverse conditions that can predict the ambiance accordingly to transfer the data. However, in such networks limited energy and security issues restrict the efficient communication energy-based approaches using cluster heads and security is provided using encryption. However, due to the self-organized structure cluster head methodologies result in congestion, and security using encryption is difficult. Hence it degrades the performance of the network. In this paper, using the Dij-Huff Method secure and energy-efficient method of optimization is being proposed. The presented approach is validated by a simulator.

Xindi Wang, Qingfeng Zhou, and Jun Tong [3] One of the most important functions provided by wireless sensor networks (WSNs) is data aggregation. By encoding the raw sensed data using weight vectors the coding-based approaches can significantly reduce traffic quantity. Coding-based data aggregation protocol is used to construct a weight/measurement matrix for the application scenario. After constructing that, during the encoding process the sink node assigns the column of the matrix, that is treated as the weight vector, to each sensor node respectively. For a lively scenario the numbers of sensor nodes changes regularly, the existing move toward have to reconfigure the network by allocating the new weight vectors for all the existing nodes and regenerating the measurement matrix which causes a considerable energy consumption and that affects the regular monitoring tasks. To resolve this difficulty, a Vander monde matrix-based scalable data aggregation protocol (*VSDA*) is proposed, that protocol preserves the advantages of coding-based schemes and addresses the issues mentioned. In *VSDA* the original weight vectors owned by the original nodes do not need to regenerate the weight vectors entirely as new nodes join into the scaled-up network but add some new entries by itself. That outperforms the existing schemes by securing or saving the energy in network scaling-up. For that to quantify the data encoding process of *VSDA* a concise hardware framework, that provides a performance analysis process that is very closer to practical application. The numeric tests authenticate the presentation of *VSDA* compare with the obtainable scheme in several aspect, like the number of transmissions, energy consumption, and storage space that showing the outperformance of *VSDA* scheme.

Tayyab Khan, Karan Singh, Le Hoang Son, Mohamed Abdel-Basset, Hoang Viet Long, Satya P. Singh, Manisha Manjul [4] With the wide applications of Wireless sensor networks (WSNs) in various fields trust establishment among sensor nodes plays a vital requirement to improve security, as well as reliability and successful cooperation. The existing trust management approaches for large scale WSN

are failed due to their higher communication and low dependability and memory overheads (i.e. resource inefficient). In this paper, a novel and comprehensive trust estimation approach (LTS) is proposed for large scale WSN with reduced resource consumption that employs clustering to improve cooperation, as well as trustworthiness, and security by detecting malicious (faulty or selfish) sensor nodes. The future scheme (LTS) operate on two level they are, intra-cluster and inter-cluster along with dispersed and central approach to make precise trust choice of sensor nodes. LTS approach consists mainly of unique features at cluster head to obtain global feedback trust value like robust trust estimation function, attack resistant and efficient trust aggregation. Along with communication trust plays a significant role to cope with malicious nodes in data trust. In LTS approach, punishment and trust severity can be tuned due to the application requirement that makes it an innovative trust estimation approach. However, dishonest recommendations (outliers) are eliminated before aggregation at the base station by observing statistical dispersion. Theoretical and mathematical validation along with data trust and simulation results exhibit great performance of our proposed approach. In terms of trust evaluation cost, prevention, and detection of malicious nodes and mainly communication overhead.

Xiao Luo, Yanru Chen, Miao Li, Qian Luo, Kang Xue, Shijia Liu, And Liangyin Chen [5] As nodes' characteristics that the nodes are self-governed and as well as resource-limited, due to various attacks, wireless sensor networks (WSNs) face potential threats is wormhole attacks among which the most threatening attack is wormhole attack. Wormhole attack harshly impels WSNs and it is very hard to be detect, it causes incorrect routing in terms of data leakage, data dropping, and delayed delivery by private tunnels and damages to WSNs. However, due to the existing solutions are based on additional hardware, incur higher communication overhead, or it fails to give consideration to all types of wormhole attacks. This paper suggest a CREDND, a protocol for create a believable Neighbor Discovery against wormholes in WSN, that can detect not only external wormhole attacks through the hop difference between the own exclusive neighbors but also internal wormhole attacks through enabling the common neighbor nodes as witnesses to monitor. Whether the authentication packets are forwarded by the malicious nodes. CREDND is a extremely easy, limited to a small area protocol and wants no particular hardware, localization, or harmonization, and it improves the ability of wormhole defense attacks. The simulation results shows that CREDND outperforms in wormhole detection than are other than same types of solutions.

Anwar Ghani, Syed Husnain A. Naqvi, Muhammad U. Ilyas, Muhammad Khurram Khan, and Ali Hassan [6] In harsh or hostile environments, it is impossible to replace the power source of a sensor node in a WSN. The main solution is an energy efficient communication system. This paper provides an energy efficient system based on multipath collaborative communication that are having noise and fading. The collaborative communication exploits spatial diversity that is to achieve high gain in received power, low bit error rate (BER), and as well as high energy savings. Even if there received signals are always out-of-phase. The results show that the benefits are enhanced by the use of the multipath communication environment in combination with collaborative communication. For that the trade-off analysis message is flanked by power use and a broadcast distance, the multipath joint message is compared mainly with the single-input-single-output (SISO) system. Collaborative communication performs over the long distance and the SISO is suitable for short distances. The mainly proposed collaborative communication system can achieve 99% energy savings mainly in comparison to the SISO system.

Zahid Ullah, Imran Ahmed, Tamleek Ali, Naveed Ahmad, Fahim Niaz, And Yue Cao [7] Wireless body area network (WBAN) is one of the most specialized branches of WSN, that can draw attention from various fields of science. Important technologies of WBANs is routing technology. For most well-organized routing in WBANs, manifold network operation, like network constancy, throughput, energy

efficiency, end-to-end delay, and small packagereleaseratio that can be careful. This paper provides, a robust and efficient Energy Harvested-aware Routing protocol with main Clustering approach in Body area networks (EH-RCB). That is designed with the intention to stabilize the operation of WBANsby choosing the important forwarder node, which can be based on optimal calculated Cost Function (C.F). The cost function considersthe linkSNR,requiredtransmissionpower,andthe distancebetweennodes,andalsototalavailable energy, that the harvested energy and residual energy. At lengthimitation has been conducted, that can be support by NS-2 and C++ simulation tools to compare EH-RCB with existing protocols named DSCB, EERP, RE-ATTEMPT, and EECBSR.

Jiawei Tan, Wei Liu, Tian Wang, Shaobo Zhang, Anfeng Liu, Mande Xie' Ming Ma,MingZhao[8]Communication technology can enhance the user experience and can improve people'slifestyle.Duetothelimitation resources of WSN, the congestion occurswhen the node's traffic load exceeds that the available capacity. Congestion may cause serious problems such as high packet loss and low throughput, which is extremely important impact on the performance of WSNs. Totackle this problem, a differentiated rate control data collection (DRCDC) scheme is proposed mainly to avoidthe network congestion. dissimilar from preceding scheme, the DRCDC schemethat can mitigate the congestion mainly by intelligently plummeting the data that contain less in order, and maintain the distortion rate of information that are collected by the network is small. DRCDC mainly avoids as well as mitigates congestion on the spatial and temporal through information entropy theory. At the same time makes the information collected by the network has lowest distortion rate. (1) Congestion mitigation is spatial. There is spatial correlation between sensing data, henceinthecaseofcollectingacertainamount of data, some missing data in space can be recovered. Hence, in the DRCDC scheme, when overcrowding occurs, the amount of data transmit (forwarded) for nodes are crowded that will be abridged by an intelligent move toward, thereby able to mitigatecongestion.(2) Congestion mitigation is temporal. When congestion occurs, avoiding congestion to reduce the flow rate reducing the data collection of time slots containing small information that needs to transmit data, while minimizing data distortion rate of the network.

Majid Alotaibi [9] Wireless sensor networks (WSNs) consists mainly of small sensor nodes with minimum limited energy. That type of nodes have the ability to monitor the physical conditions and communicate information among with the nodes without the requirementofthephysicalmedium.WSNsare autonomous and are always distributedin space. the absence of central authority and random deployment of nodes in the network, WSN is always prone to security threats. Malicious attack is a well-known attack(such as compromised node imitating as one of the networknodes,misleadingothernodes).Inthis work, various methods are developed to overcome those mallicious attacks either by cryptographic approaches or mainly by time synchronization. These attack method may fail because of WSN autonomous structure. This paper proposes an efficient approach called Hamming residue method (HRM)that is presentedtomitigatethemaliciousattacks.The experimental results validate the bestpresented approach.

Feng Tian, Xin Chen, Shidong Liu, Kun Wang, Xu Yuan, and ZhenYang[10] Rapid innovations in the design of transceiverfor full duplex (FD) communications,themostimportantbenefitsof FD for single-hop wireless communications had been shown. In a multi-hop wireless network, the benefits of FD with powercontrol is to be disclose. The idea of Rapid innovations in the design of transceiver full duplex communication in multi hop wireless network is to investigate the energy efficiency (EE) and performance of FD scheduling. This paper, explores a FDon EE in multi-hop networks under the optimal scheduling through strict mathematical model, as well as formulation and proof. First, an EE model is constructed under FD schedulingwith power control in multi-hop wireless networks. By exploiting the reformulation linearization technique to reformulate and piece-wise linearization method to approximate,

then the nonlinear optimization problem for EE under FD is transformed into a linear one and solved with performance guarantee. The proposed optimization method need to achieve the optimal Energy Efficiency (EE) under Full Duplex(FD) with power control is mainly compared to duplex with power control is validated by the simulation result.

Yuxin Liu, Kaoru Ota, Kuan Zhang, Ming Ma, Naixue Xiong, Anfeng Liu, and Jun Long [11] Many sensors are used to monitor the smart grid. These sensors consume huge amounts of energy in the infrastructure of communication. The establishment of an energy-efficient medium access control (MAC) protocol for sensor nodes is always challenging. The Quorum-based MAC protocol can independently and adaptively schedule nodes' wake-up times and that can decrease idle listening and collisions, hence by increasing the network throughput and extending the network lifetime. A QTSAC-based MAC protocol that is mainly proposed for achieving delay and energy efficiency minimization for the wireless sensor networks (WSNs). The QTSAC-based MAC protocol has two main novelties: 1) It selects more Quorum time slots (QTSs) that is far from the sink according to energy consumption in WSNs mainly to decrease the network latency and 2) It allocates QTSs when data are transmitted to decrease the network latency. Experimental results indicate that the QTSAC protocol can improve network performance compared to existing Quorum-based MAC protocols.

Weidang Lu, Shanzhen Fang, Su Hu, Xin Liu, Bo Li, Zhenyu Na, and Yi Gong [12] In 5G wireless networks, the number of users and the system capacity will be significantly increased. The energy consumed for the communication will be increased, that can result in low system energy efficiency. Wireless information and power transfer (SWIPT) that can enable the user to perform energy harvesting from the radio-frequency signals that are parallel with the information decoding, which can be effectively improve the system energy efficiency. This paper, studies the energy efficiency optimization problem for orthogonal frequency-division multiplexing- based on 5G wireless networks with SWIPT. Subcarrier and power allocation are optimized to maximize the system energy efficiency for single and multiple user cases. Simulation results show that compared with other algorithms, our proposed algorithm can improve higher energy efficiency.

Lei Zhang, and Yu Wang [13] This paper comprises the off-line roadside unit (RSU) ON/OFF scheduling problem in a vehicular ad hoc network (VANET). The main problem as a mixed integer non-linear programming problem and that can propose a heuristic scheduling algorithm called Multi-Level Greedy (MLG) algorithm that is found a suboptimal approximation. In the MLG algorithm, the concepts of optimal service location and suboptimal service location is proposed. Then, the ON-OFF state matrix of RSUs is obtained. Simulation results show that the MLG algorithm can most significantly reduce the energy consumption of RSUs that are deployed and can provide a reference for energy efficient scheduling in VANETs.

Korhan Cengiz, and Tamer Dag [14] This paper, propose an energy-efficient multi-hop routing protocol for wireless sensor networks (WSNs). Nature of sensor nodes with the limited batteries and inefficient protocols are the main key limiting factors of sensor network lifetime. Aim is to provide a green routing protocol that is implemented in a wireless sensor network. Proposed protocol's most important achievement is the reduction of the excessive overhead that are seen in most of the routing protocols by employing fixed clustering and also reducing the number of cluster head changes. The analysis indicates that reduction that can significantly improve the lifetime as well as energy consumption in the sensor nodes that can be reduced through an energy-efficient protocol. The implementation of relay nodes allows the transmission of collected cluster data through inter cluster transmissions.

Jingjing Yan, Mengchu Zhou, and Zhijun Ding [15] In wireless sensor networks (WSNs), prolonging their lifetime is important due to a battery constraint. Energy-efficient routing techniques for WSNs play a major or vital role in doing so. This paper articulates the problem and classifies the problem as current routing protocols for WSNs and broadly classifies into two categories by their orientation either homogeneous or heterogeneous WSNs. Further they are classified into static and mobile ones. Overview of these protocols in each category is mainly by summarizing their characteristics, limitations, and applications. Some open issues in energy-efficient routing protocol design for WSNs are indicated finally.

Nami Susan Kurian [16] One of the most important resources for battery powered wireless sensor networks is Energy. The main challenging problem in WSN is energy efficiency. Low Energy Adaptive Clustering Hierarchy (LEACH) algorithm was used to make the system energy efficient. WSNs are influenced by the wide range of attacks due to its distributed nature. Byzantine attack is a most important serious menace to WSN, the adversary has full control over the genuine nodes resulting in harming the network resulting. After compromise requires either the help of a trusted third party (TTP) is by recovering privacy or access to high-quality cryptographic methods. This paper, proposed an energy efficient aggregation of data with high security by overcoming the issues of the byzantine attack using a new protocol called Trusted Third Party (TTP) protocol. The aggregation technique is done by using dividing the sensor nodes into clusters, in that each cluster consists of a cluster head called aggregator. The security over the transmission of data is made by overcoming the byzantine attack by a trusted third party (authentication node). The TTP protocol overcomes the problems discussed in this paper.

Hana Rhim, Karim Tamine, Ryma Abassi, Damien Sauveron and Sihem Guemara [17] Energy harvesting technologies are improving in WSN, the energy of sensors remains the scarce resource when designing routing protocols between sensor nodes and base station. In this paper MH-GEER protocol in wireless sensor network aims to distribute energy consumption mainly that takes place between clusters and its extend over networks' lifespans. MH-GEER technique it deals with node clustering and inter-cluster multi-hop routing selections. Routing phase builds a dynamic multi-hop path between the cluster heads and the base station. The main strategy is about exploring the energy levels in the network and using these to select next hop in intelligent way. The MH-GEER technique minimizes energy efficiency in distant clusters in a network shown by evaluation, thus by improving the network's lifetime and by stability compared with single-hop conventional LEACH protocol.

Movva Pavani and Polipalli Trinatha Rao [18] The primary challenge in the wireless sensor network (WSN) due to its resource limitations is Network lifetime maximization. E^2R^2 routing algorithm in WSN to minimize energy consumption it uses a hierarchical WSN. It can increase complexity, time consumption, and also energy consumption due to hierarchical model. To resolve the problems, this paper can propose a novel ring partitioned MAC (RP-MAC) protocol for energy-efficient WSN with mobile sink node. Energy efficiency can be achieved by following four phases: The first phase is the Clustering phase that is initiated by a weighted Voronoi diagram (WVD). By enabling novel RP-MAC scheduling in each cluster energy consumption due to idle listening is minimized. The main involvement of RP-MAC protocol achieves collision-free data transmission. A two-fold data aggregation (TFDA) scheme is for the data aggregation phase that is used to minimize energy consumption by reducing the number of transmissions. Routing phase it can support both intra-cluster routing and inter-cluster routing. For the intra-cluster routing, a hybrid chicken swarm optimization algorithm is mainly proposed. Proposed RP-MAC protocol minimizes energy consumption in all ways for improving network lifetime.

Danyang Qin, Songxiang Yang, Shuangjia, Yan Zhang, Jingya Ma, and Qun Ding [19] The serious impact of the typical network attacks caused by the limited energy and also caused on data

transmission by the poor deployment environment of WSN, as well as a trust-sensing- based secure routing mechanism (TSSRM) with the lightweight characteristics is the main aim. And the ability to simultaneously resist many common attacks is mainly proposed in this paper. The security route selection algorithm is optimized by taking trust degree and by taking QoS metrics into account at the sametime.

ZhiqiangLiu,BinLiu,andChangWen Chen [20] Wireless body area network (WBAN) has more attention to automatically and intelligently sense the health data. There are three main issues in the heterogeneous WBAN system: The dynamic link characteristics due to time-varying postures and also by environments; the high energy efficiency requirement can be made with considering the limited sensor battery; and The high quality-of- service (QoS) requirement can be made due to the importance of health data. To provide long service with the high quality, resource allocation scheme become sin-dispensable with considering all issues. A mix-cost parameter is mainly designed to evaluate the energy efficiency and QoS effectiveness, and also a resource allocation problem is formulated usually to minimize total mix-cost with optimizing the transmission rate, and the transmission power, and the allocated time slots for each sensor is discussed in this paper.

Palanisamy T, Krishnasamy KN [21] WSN can monitor and control the physical world through large number of small, low- priced sensor nodes. Sensed data communication through continuous data collection resulting in higher delay and energy consumption is the existing method on WSN. Bayes Node Energy and Polynomial Distribution (BNEPD) technique is introduced with energy aware routing in the wireless sensor network, To conquer the routing issue and reduce energy drain rate. The Bayes Node Energy Distribution can initially distributethe sensornodesthatcandetectanobjectofsimilar event (i.e., temperature, pressure, flow) into specific regions. The Polynomial Regression Function is applied mainly to target object of similar events that are considered for different sensors. The sensors are based on minimum and maximum value of object events. The object events are transferred to the sink node. The Poly Distribute algorithm effectively distributes the sensor nodes. The result shoes that experimental performance is evaluated using Dodgers Loop Sensor Data Set fromUCI repository.

III. COMPARATIVEANALYSIS

To the best of the knowledge, the work presented in this paper is the survey with the focus on the secure and energy-efficient routing in these distinct types of Wireless Sensor Networks. Furthermore, this work aims to provide the comparative analysis between various techniques and approaches.Inthissurveyvarioustechniques,mechanisms,andparametersareanalyzedforSecureand Energy Efficient Routing. Comparisons are listed in table3.1

| S.No | Title | Techniques and Mechanisms | Parameter Analysis | Tools | Future Work |
|------|---|--|------------------------------------|-------|--|
| 1. | A Novel Block Encryption Algorithm Based on Chaotic S-Box for Wireless Sensor Network | Novel Block Encryption Algorithm, chaotic substitution box (S-box) | Transfer Speed, Block Cipher | NS-2 | Study of key management technology: Guarantee security of the WSN data and security of the entire network. |
| 2. | Secure and Energy Efficient Path Optimization | Diji-Huff (DH) | Delay, Packet Loss Rate, Number of | NS-2 | Improve the lifespan of the Network |

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|----|---|--|--|---------------------------------------|---|
| | Technique in Wireless Sensor Networks Using DH Method | Method | Nodes, Hop Count | | |
| 3. | V-Matrix-Based Scalable Data Aggregation Scheme in WSN | VSDA Data Aggregation Protocol | Data Aggregation | NS-2 | Tackling channel noise, link failure and other effects from Hardware Circuit. |
| 4. | A Novel and Comprehensive Trust Estimation Clustering Based Approach for Large Scale Wireless Sensor Networks | Data and Communication Trust Management | Attack Mitigation | MATLAB | Detect and mitigate the on-off attack, DoS attacks and collusion attack. Examine the scalability and convergence rate of LTS. |
| 5. | CREDND: A Novel Secure Neighbor Discovery Algorithm for Wormhole Attack | Secure Neighbor Discovery Algorithm | Node Degree, Threshold | MATLAB with programming in C Language | Apply CREDND to more complex conditions. |
| 6. | Energy Efficiency in Multipath Rayleigh Faded Wireless Sensor Networks Using Collaborative Communication | Multipath Collaborative Communication | Noise and Fading, Off-the- shelf | Monte Carlosimulation in MATLAB | multipath collaborative communication may be investigated with imperfect frequency synchronization |
| 7. | Robust and EE Harvested-Aware Routing Protocol Withits Clustering Approach in Body Area Networks | Energy Harvested-Aware Routing Protocol | Packet Delivery Ratio, and Network Throughput. | NS-2 and C++ | Low bit error ratio with nodes cooperation for efficient routing. |
| 8. | An Efficient Information Maximization based Adaptive Congestion Control Scheme in Wireless Sensor Network | Congestion Control Scheme, Matrix Completion | Congestion Mitigation | OMNET++ | Reducing the average entropy of the matrix |
| 9. | Security to wireless | Hamming | Rival node, | NS-2 | |

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|-----|---|---|--|---|---|
| | sensor networks against malicious attacks using Hamming residue method | Residue Method, | Packet Delivery Ratio | | Increasing PDR against ON-OFF attacks, DOS attacks |
| 10. | On Full Duplex Scheduling for Energy Efficiency Maximization in Multi-Hop Wireless Networks | Full Duplex (FD) Communication, Energy Efficiency Maximization | Power Control, Reliability | MATLAB | Improve Efficient power consumption in FD scheduling without losing optimality and reliability. |
| 11. | QTSAC: An Energy-Efficient MAC Protocol for Delay Minimization in Wireless Sensor Networks | MAC Protocol Quorum Time Slot Condensing, | Network Latency, Lifetime. | OMNET++ | To improve the network performance efficiently using remaining energy. |
| 12. | Secrecy and Energy Efficiency Optimization in AN-Aided Distributed Antenna Systems Withits Energy Harvesting approach | Simultaneous Wireless Information and Power Transfer, Resource Allocation, Energy Efficiency. | Delay Latency, Throughput | NS-2 | To improve the insight into the effect of noise power on the system performance |
| 13. | Inter-Relationship Between Energy-Efficient Routing and Secure Communication in WSN | Energy-Efficient, Routing, Secure Communication, Sybil Attack. | Propagation Path Loss | MATLAB | The design thought of the algorithm in this paper can be used to provide a basis or reference for future studies. |
| 14. | Energy Aware Multi-Hop Routing Protocol for WSNs | Clustering Methods, Energy Efficiency, EAMR Protocol | Network Lifetime, Residual Energy, Sensor Node Density | NS-2 | Improve Efficient Power Consumption in Multi-Hop with Optimality |
| 15. | Recent Advances in Energy-Efficient Routing Protocols for Wireless Sensor Networks: A Review | Energy Efficient Routing Protocol | QoS, Hop Count, Delay Latency, Throughput | NS-2, MATLAB,J-SIM, CPLEX, SinAlgo, OPNET, Berkley mote | Strong need to create some benchmark problems to facilitate comparisons by simulation |

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|-----|---|--|---|--------|--|
| | | | | | |
| 16. | Energy Efficiency and Security Based Multi-hop Heterogeneous Trusted Third Party Protocol in WSN | Data Aggregation, Byzantine Attack, | Aggregation | NS-2 | To improve the energy, throughput and lifetime of the network. |
| 17. | A multi-hop graph-based approach for an energy efficient routing protocol in wireless sensor networks | Hierarchical Clustering, Load Balancing, Distributed Behavior, Ant Colony | Energy of a Sensor Node, Pheromone Value, Packet Size | MATLAB | complete this proposition by implementing the proposed protocol to evaluate its performance in large-scale networks. |
| 18. | Novel Two-Fold Data Aggregation and MAC Scheduling to Support Energy Efficient Routing in Wireless Sensor Network | Data Aggregation, MAC Protocol, Intra-Cluster Routing, Inter-Cluster Routing, Mobile Sink. | Packet Size, Packet Interval | NS-3 | future work to evaluate proposed work with large number of nodes in anyone of application scenario. |
| 19. | Research on Trust Sensing Based Secure Routing Mechanism for Wireless Sensor Network | Optimal Route, Security, QoS Metrics, Trust Degree. | Message Internal, Trust Degree, Packet Loss | NS-2 | Future research will design distributed intrusion detection system, which provide a new way for the research of trust degree and ubiquitous routing. |
| 20. | Buffer-Aware Resource Allocation Scheme With Energy Efficiency and QoS Effectiveness in Wireless Body Area Networks | Resource Allocation Scheme, Buffer-Aware Sensor State Evaluation Method | QoS Cost and Energy Cost. | MATLAB | To improve the optimal resource allocation problem with Ubiquitous routing |

IV. OPENISSUES

More studies about the secure and energy efficient routing of the latter are foreseen in order to meet diverse application requirements. As compared with static WSN's, routing protocols for mobile WSNs promise to bring more benefits to real-time delivery guarantee as well as high coverage, energy efficiency and energy balance but require high implementation and deployment cost.

4.1 WSN HardwareImplementation

To evaluate the performance of proposed protocols, simulation platform or software can be Tiny OS, OPNET, Java, J-Sim, MATLAB, CPLEX, Berkeley mote platform, SiNAlgo, OMNET++, Monte Carlo simulation and so on. Most of the implementations should be realized not only in simulations, but also on real WSNhardware.

4.2 New RoutingMetrics

Creating and using a reliable routing metric is important in routing design. It should measure routing overhead and routing capability from different aspects due to the diversity of WSNs. New routing metrics such as spatial reusability should be taken into consideration in order to increase the network throughputperformancewithaffordableenergy

5. CONCLUSION

This paper has presented awidespread and up to date survey on Secure and Energy Efficient Routing in WSN. This survey introduces the various Secure and Energy Efficient Routing in WSN. Wireless networks are posed to several issues and challenges due to limited energy and lack of security. In this paper,anenergyefficientandsimplemethodis discussed. Various routing protocols provide the guarantee secure and energy efficient communication. Routing protocols in wireless sensor networks have different requirements and challenges according to the network architectureanditsfieldofapplication.Wealso compare and highlight the techniques, parameters and tools used in the papers. Hence SecurityandEnergyefficiencycanbeachieved by various techniques and algorithms. The protocols overcome the problems of insecurity in data transmission and hence increasing the energy and various parameters. The protocol not only helps in secured transmission of data butalsohelpsinoptimizingtheusageofenergy in each node in a greaterextent.

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