A STUDY OF ENERGY-EFFICIENT LOAD-BALANCING MULTIPATH ROUTING SCHEME FOR WIRELESS SENSOR NETWORK

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Abstract: *Energy-efficient routing techniques for WSNs play a great role in doing so. In this work we articulate this problem and classify current routing protocols for WSNs into two categories according to their orientation toward either homogeneous or heterogeneous WSNs. They are further classified into static and mobile ones. We give an overview of theses protocols in each category by summarizing their characteristics, limitations and applications. Finally, some open issues in energy-efficient routing protocol design for WSNs are indicated. The ease of deployment of economic sensor networks has always been a boon to disaster management applications. However, their vulnerability to a number of security threats makes communication a challenging task. This paper proposes a new routing technique to prevent from both external threats and internal threats like hello flooding, eavesdropping and wormhole attack. In this approach one way hash chain is used to reduce the energy drainage. Level based event driven clustering also helps to save energy. The simulation results show that the proposed scheme extends network lifetime even when the cluster based wireless sensor network is under attack.*

Keywords: Energy-Efficient, Load-Balancing, Multipath Routing Scheme, Wireless Sensor Network, routing techniques

Introduction

In general, routing is performed for packet forwarding by using multi hops. It reduces the network life time because of involving multi hops to forward data. Therefore, efficient load balancing multipath routing is very much essential in WSN to achieve scalability and reliability. A novel Energy-aware Load-balancing multipath Routing Scheme (ELMRS) is proposed for WSN that used optimal double search mechanism to provide a reliable minimum energy cost routing. The proposed scheme is able to increase the network lifetime and find reliable and energy-efficient routes simultaneously. Optimal double search finds minimum energy cost routes, where the energy cost of packet forwarding from a node is a function of the remaining battery energy of the node, reliability of the physical link, and required energy for packet transmission. In this Paper, energy and path vacant ratio metrics are used to select optimal path from link disjoint multipath. Simulations demonstrate the performance of the proposed scheme and also reduce the overall energy consumption in the network by finding minimum energy cost routes.

Recent advances in micro-electro mechanical system (MEMS) technology have boosted the deployment of WSN. Limited by the energy storage capability of sensor nodes, it is crucial to jointly consider security and energy efficiency in data collection of WSN. The disjoint multipath routing scheme with secret sharing is widely recognized as one of the effective routing strategies to ensure the safety of information. This kind of scheme transforms each packet into several shares to enhance the security of transmission. However, in many-to-one WSN, shares have high probability to traverse through the same link and to be intercepted by adversaries.

NEED FOR ENERGY-EFFICIENT MULTIPATH ROUTING IN WSN

High availability communication networks with very low failure rates are often designed by using physical diversity. The traffic between a given pair of nodes is routed by using several physically disjoint paths. The selection of the pair of routes that maximizes the connectivity of a node is not an easy problem, because such connectivity cannot be expressed as an additive function of the availability of links and nodes in the path pairs. The dynamic source routing and AODV algorithms for searching the optimal route use additive costs, which can be a loose assumption either when high failure rates can be locally present, or when fully disjoints paths do not exist. So, in order to increase the network life time optimal double search algorithm is proposed for determining the most efficient and shortest path. Multipath routing schemes (Dimokas et al 2010; Kuila et al 2013) provide load-balance for improving network performance. The forwarded packets affected due to the link failure of intermediary nodes. It is essential to provide reliable and load balancing over multi paths (Guo et al 2009; Li et al 2010). Multipath routing schemes including Ad hoc On demand Multipath Distance Vector (AOMDV)(Valera et al 2005), TORA(Li et al 2011), On-demand multiple Route Maintenance in AODV extensions (ORMAD) (Yu & Guan 2010), and Interference minimized Multipath Routing (I2MR) (Jiguo et al. 2012) are common examples in ad hoc networks. AOMDV supports multi-paths by providing a number of loops free and link disjoint paths where the control packet of AODV is redesigned and an advertising hop count field and a route list field that can deal with mobility-induced routing failures are added (Augustin et al 2011).

Most of the previously reported schemes (Amgoth et al 2013; Kuila et al 2014) are based on single path routing mechanism. In these schemes a single communication path may be selected at an instant based on a specified routing metrics. On the other hand, choice of multipath data transfer scheme (Fariborzi et al 2009; Gagarin et 2010) is to provide the source with the choice of having multiple paths between a source destination pair. Multipath routing is a promising technique to deal with unreliable network environment to increase end-to-end packet delivery ratio (Shuang et al 2010; Chen &Leneutre 2009). In traditional network multipath is used for load balancing and reliable data delivery. Further, multipath reduces delay and decreases packet loss ratio that occurs due to traffic congestion (Shujiang et al 2011).

LOAD BALANCING MULTIPATH ROUTING SCHEME

A new energy-aware load balancing multipath routing scheme is proposed for WSN that used optimal double search mechanism to provide a reliable minimum energy cost routing. The proposed scheme is able to increase the network lifetime and find reliable and energy-efficient routes simultaneously. Optimal double search finds minimum energy cost routes, where the energy cost of packet forwarding from a node is a function of the remaining battery energy of the node, reliability of the physical link, and required energy for packet transmission.

Optimal Double Route Scheme (ODRS)

The main objective of the optimal double search algorithm is to provide an energy-efficient routing through selecting the best shortest path from source node to destination node. This can be achieved through multi path searching process; a source node broadcast a route request packet (RREQ) to destination in multiple paths, as result destination replies a multiple route reply (RREP) message in three different paths. Fitness function is used to select the best path among multiple paths to transmit the data to destination in sensor environment. Path discovery, routing and Path maintenance phases are performed to find the multi-path.

- **Path Discovery**

The goal is to select the pair of paths maximizing the connectivity of node S and energy efficiency. This must be done for every node in the network .The First shortest path is minimum cost and selected for transmission. If any failure in first path means, then the alternative path is selected for transmission.

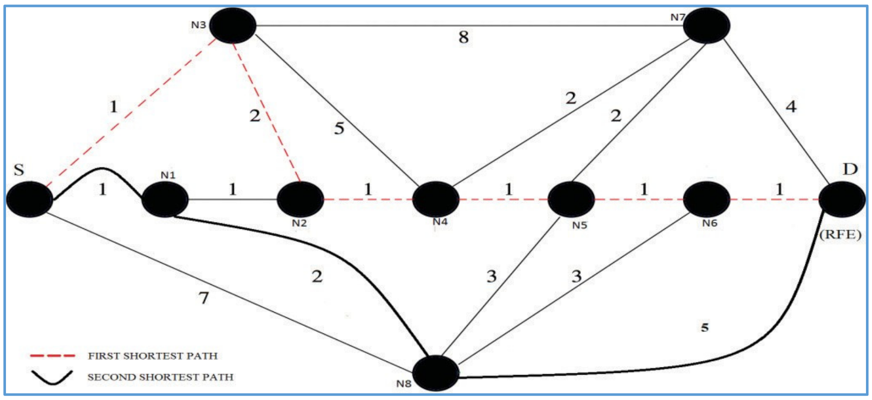

Figure 1: Path discovery

In the above path discovery process, node S act as source and node D act as destination then the Double path is selected by path discovery mechanism. There are two shortest paths from source node (S) to the RFE destination node (D). The two alternative disjoint paths are S-N3-N2-N4-N5-N6-D and S-N1-N8-D.

- **Routing Phase**

The source node S discovers the best shortest path to destination through fitness function, after discovering the source node S starts transmitting data to receivers using user data gram protocol, the optimal double search routing is based on the link stability factor of nearest neighbour nodes. Path maintenance provides different mechanisms to ensure that packets can be safely transmitted from source to destination. Each path is associated with a refresh time after which a new path discovery phase is triggered. This is done to avoid path failure as the network topology may change after a certain time. Nodes may also have unanticipated behaviour that may cause path failure. In this case, a reactive path recovery procedure is triggered in addition to the previous mechanism, which can be seen as a hybrid path recovery.

- **Path Maintenance Phase**

The every node is responsible for confirming that the next hop in the Source Route receives the packet. Also each packet is only forwarded once by a node that is hop-by- hop routing. If a packet cannot be received by a node, it is retransmitted to up some maximum number of times until a confirmation is received from the next hop. Only if retransmission results then in a failure, a Route Error message is sent to the initiator that can remove that Source Route from its Route Cache. So, the initiator can check his Route Cache for another route to the target. If there is no route in the cache, a Route Request packet is broadcast.

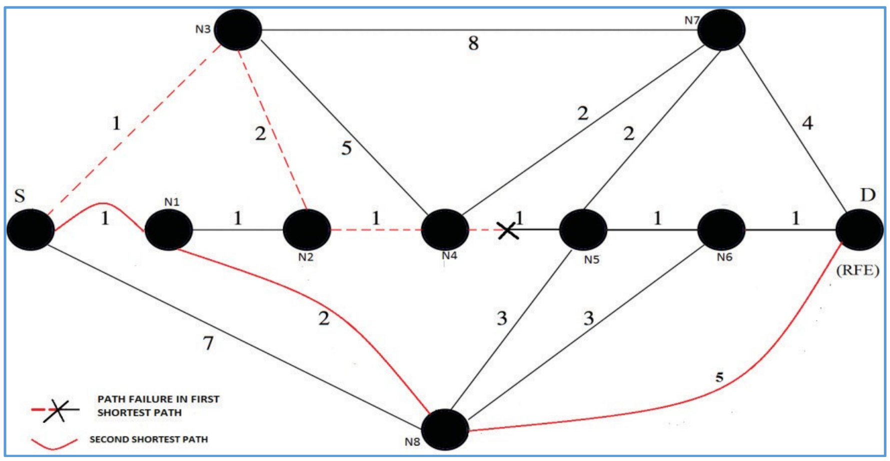

Figure 2 Path maintenance phase

In the diagram, consider the link between N4 and N5 is failure due to mobility and drops the packets. As soon as node receives the Route Error message, it deletes the broken- link-route from its cache. If S has another route to D, it sends the packet immediately using this new route. Then, the second shortest path is selected for transmission.

There are two shortest paths from source node (S) to the RFE destination node (D): S-N3-N2-N4-N5-N6-D and S-N1-N8-D. The goal is to select the pair of paths maximizing the connectivity of node S and energy efficiency. This must be done for every node in the network. Double path search scheme optimizes additive metrics on weighted graphs which are computationally efficient.

The proposed scheme assumes that each node has two network paths to its RFE that is even though there may be many paths connecting each node with its RFE, it assume that only two of them can be used by the sensor network. If the network paths are fully disjoint that is, they do not share any node and any link, then node connectivity can be determined as follows.

Step1: Find the shortest path from S to D with the modified Dijkstra algorithm

Step2: Replace each edge of the shortest path by a single arc directed towards the source vertex

Step3: Make the length of each of the above arcs negative

Step4: Find the shortest path from S to D in the modified graph with the modified Dijkstra algorithm

Step5: Transform to the original graph, and erase any interlacing edges of the two paths found

Step6: Group the remaining edges to obtain the shortest pair of edge- disjoint paths

Algorithm 1

Input

G = (V, E)

d(n) / distance of vertex n from source vertex S, n Є V and S Є V

//it's the sum of arcs in a possible path from vertex S to vertex n.

d(S)=0;

P(n) // the predecessor of vertex I on the same path. D// The destination vertex.

Step 1

d(s) =0

d(n)=1(Sn) if n Є ΓS = ∞, otherwise;

Γn ≡ set of neighbor vertices of vertex a, l(ab) = length of arc from vertex a to vertex b. Assign P = V-{S}, where V is the set of vertices

Assign P(n)=S, □ n Є P

Step 2.

Find b Є P such that d(b)=min d(a), a Є A

set P=P-{b}

If b = D(the destination vertex), END; otherwise go to Step3.

Step 3.

$$\forall a \in \Gamma b, \text{ if } d(b)+l(ab)<d(a)$$

set d(a) = d(b) + l(ab), P(a) = b.

$$P_i = P_i \cup \{a\}$$

Go to Step 2.

$R_P = \{A_1, A_2\}$

$$E_{Ai} = \sum_{i=1}^{n} E_T(A_i)$$

ET(Ai)

This equation states an additive unavailability model, where the impact of adding a new node gives an unavailability increment that depends only on the unavailability of the added node or link. The optimization process may stop when the probability of finding a better pair of paths is low enough. The algorithm proceeds by exploring over a set of possible paths, which are progressively built by adding a new hop, and computing the availability of all the possible paths. The sequence of steps is as follows.

Consider the following two shortest paths P1 and P2.

P_i= {n0,n1,n3,… }

Pj= {n0,n2,n4,………..}

Rp = {Pi ,Pj} (1)

Then the energy of Ith is calculated by the following method.

$$En_i = E_{idle} + E_{TX} + E_{RX} \quad (2)$$

$$Ep_i = \sum_{i=1}^{np} En_i \quad (3)$$

$$Ep_j = \sum_{j=1}^{np} En_j \quad (4)$$

After finding individual path energies then compare both energies to achieve energy efficiency in WSNs.

EEP = max(Epi , Epj) (5)

Finally, the best energy-efficiency path is selected from both the alternative paths. The Bhandari algorithm involves two steps of the Dijkstra algorithm, and can be extended to the case where no disjoint paths exist by searching the minimization of the total cost. It is computationally efficient, but the replacement of a multiplicative cost optimization of an additive cost may be sub optimal. If the connectivity loss is large, the availability of the path pairs is substantially different. Because the connectivity is a nonlinear function of the unavail**a**bility, the optimization of an additive cost is sub- optimal, and even in simple network the connectivity loss of the pair of paths obtained by the Bhandari algorithm can be several orders of magnitude higher than the optimal value.

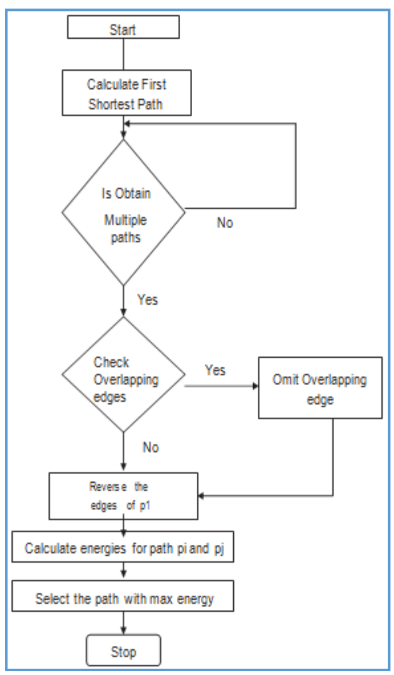

Figure 3: Flow chart for proposed ELMRS

The shortest path between the source and destination has been found out and checked whether it is the obtained multiple path, if not the process is repeated until multiple path is obtained. Then, the overlapping edges between the two shortest paths are calculated and overlapping edges are omitted. The same process is repeated for the second path. The path with maximum energy among the two is selected and used for transmission. Figure 3 shows the flow chart of proposed scheme.

Here, the sensor nodes are deployed in a random manner and are placed intermediate area. Each node knows its location relative to the neighbours. Here, source node broadcasts a dual RREQ route request packet to discover the best path, based on the RREQ the destination node replies the RREP route reply message to the source node. By this, a shortest path is established between source and destination.

The source node s discovers the best shortest path to the destination based on the fitness function, the fitness function is based on the minimum hop count, nearest distance range and link stability of the sensor nodes. Based on this selected path, the packets are transmitted to destination. Selection of Alternative disjoint path after failure of one node in first path. Due to the failure of one of the nodes in the first path, the network automatically selects the second from the established double route for the transmission.

The objective of the proposed scheme is to keep on working while at least one of the paths keeps on working, and the performance comes down only if both the paths come down. A path is a concatenation of several links and nodes. One link or node down is necessary and sufficient for the path being down. One path can be down as a consequence of other causes different from the failure of a link, for instance, a power failure in the installation at a node. So, the proposed scheme considers a Path vacant ratio for load balancing in WSN for a path with maximum energy.

Total Energy Consumption of the Network

The total energy is calculated by the sum of transmission energy and residual energy. Each node loses the energy for transmission. The proposed ELMRS protocol is less energy consumption compared with AOMDV and SEDR. The energy consumption of the network achieved by ELMRS, SEDR and AOMDV are 35.05mj, 37.85mj and 39.35mj respectively.

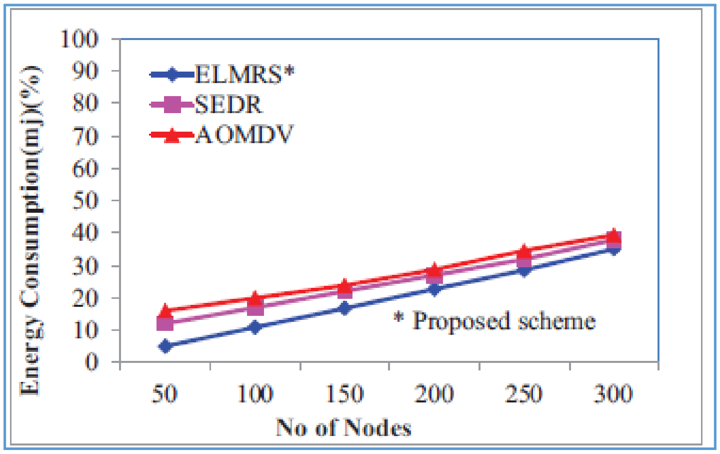

Figure 4: Total Energy consumption of the network

Double routes were established between source and destination, the route which is having maximum energy is selected for transmission. The selection of maximum energy paths enhances the energy efficiency of the whole network.

Table 1: Energy consumption of the network

Protocols	Energy consumption(mj)
AOMDV	39.35
SEDR	37.85
Proposed ELMRS	35.05

Figure 4 show that the ELMRS has less energy consumption than AOMDV and SEDR. The SEDR has spent more energy because of implementing security algorithm.

CONCLUSION

Routing protocols for homogeneous WSNs are more widely investigated than heterogeneous ones. More studies 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.In addition to many applications of wireless sensor networks, it is necessary to transmit information appropriately with regard to power utilization and network lifespan as well as limited resources of such networks. The most significant difficulty in such networks is routing and transferring data to the destination node in compliance with the energy problem. Therefore, energy-efficient routing protocols have significant and effective roles in wireless sensor networks. They are divided into three major groups based on data, network structure and reliability. In this study, energy-efficient routing protocols were investigated in wireless sensor networks. Then the essential classifications were introduced and related parameters of corresponding protocols were compared to each other. Despite the fact that these protocols are performing well in terms of energy conservation but issues like quality of service (QoS) would be expected to address to ensure utilization of most energy proficient way for data transfer and in addition ensuring guaranteed data transfer rate or delay.

Another interesting issue in routing is that the majority of the present routing conventions accept that the sensor hubs and the sink is stationary. In circumstances, for example, on the battlefield where the sink and maybe the sensors should be versatile In such cases, new routing techniques are required keeping in mind the end goal to deal with the overhead of portability and topology changes in such power constrained circumstances. Integrating WSN with wired networks (i.e. Internet) is other possible future research for routing protocols.Since battery-powered sensor nodes have limited energy, enhancing the lifetime of the WSNs is considered to be an important issue. This work used A* algorithm and proposed a new scheme to improve the lifetime of WSNs. The EERP scheme accommodated a node's residual energy, packet reception rate and free buffer in order to fine the optimal path with minimum hop count. The outstanding characteristic of the proposed scheme was that it allocated the task of data dissemination to the sensor node with higher residual energy in order to prevent packet dropping as a result of energy termination. Simulation results showed that our proposed was capable of increasing the network lifetime when compared with scheme. WSN is the diversified field from others as it is designed for specific applications. We have surveyed the objective of WSN, issues they faced and how to resolve them by using routing in efficient manner. This work explains the various clustering techniques to improve the relay, to resolve the computation complexity and to improve the network lifetime. Optimal clustering in the given area is an NP-complete problem.

REFERENCES

1) Suraj Sharma and S. K. Jena, A Virtual Infrastructure based Routing Protocol for Wireless Sensor Networks˝, In 12th IEEE India International Conference (INDICON '15), IEEE, 17-20 December 2015.

2) Suraj Sharma and S. K. Jena, A Cluster-Tree based Data Dissemination Routing Protocol˝, In Eleventh International Multi Conference on Information Processing (IMCIP ’15), Elsevier, Pages 7-13, August 2015
3) Suraj Sharma and S. K. Jena Routing protocol in Wireless Sensor Networks: Research Directions˝, Communicated In Handbook of Research on Advanced Wireless Sensor Network Applications, Protocols, and Architectures, IGI Global publisher, USA, 2015.
4) Suraj Sharma, Dupatta Suresh and S. K. Jena, VGBST: A Virtual Grid-Based Backbone Structure Type Scheme for Mobile Sink based Wireless Sensor Networks˝, In International Conference on Advanced Research in Computer Science Engineering & Technology (ICARCSET), ACM, Pages 1-5, 2015.
5) Suraj Sharma, Pratik Agarwal and S. K. Jena, Energy Aware Multipath Routing Protocol for Wireless Sensor Networks˝, In Fourth International Conference on Networks & Communications (NetCom), Lecture Notes in Electrical Engineering, Springer, Volume 131, Pages 753-760, 2013.
6) Suraj Sharma, Pratik Agarwal and S. K. Jena, EAMRP: Energy Aware Multipath Routing Protocol for Wireless Sensor Networks˝, Accepted for Publication In International Journal of Information & Communication Technology, Special Issue on: Advances in Wireless Sensor Networks and their Applications, Inderscience Publishers, February, 2015
7) Suraj Sharma and S. K. Jena, Cluster based Multipath Routing Protocol for Wireless Sensor Networks˝, Computer Communication Review, ACM, Volume 45, Issue 2, Pages 14-20, 2015.
8) T. Meng, F. Wu, Z. Yang, G. H. Chen, and A. V. Vasilakos, “Spatial reusability-aware routing in multi-hop wireless networks,” IEEE Trans. Comput., vol. 65, no. 1, pp. 244-255, 2016
9) Brar G. S., Rani S., Song H. and Ahmed S. H., "Energy Efficient Direction-Based PDORP Routing Protocol for WSN", IEEE Special Section on Green Communications and Networking for 5g Wireless, Vol. 4, pp: 3182-3194, 2016.
10) M. R. Ahmed, S. M. Tahsien, M. Aseeri, and M. Shamim Kaiser, “Malicious attack detection in underwater wireless sensor network,” in 2015 IEEE International Conference on Telecommunications and Photonics (ICTP), pp. 1–5, Dhaka, Bangladesh, December 2016

11) C. C. Kao, Y. S. Lin, G. D. Wu, and C. J. Huang, "A comprehensive study on the internet of underwater things: applications, challenges, and channel models," Sensors, vol. 17, no. 7, p. 1477, 2017.
12) M. Li, X. Du, K. Huang, S. Hou, and X. Liu, "A routing protocol based on received signal strength for underwater wireless sensor networks (UWSNs)," Information, vol. 8, no. 4, p. 153, 2017
13) M. Aslam, F. Wang, Z. Lv et al., "Energy efficient cubical layered path planning algorithm (EECPPA) for acoustic UWSNs," in 2017 IEEE Pacific Rim Conference on Communications, Computers and Signal Processing (PACRIM), pp. 1–6, Victoria, BC, Canada, August 2017.
14) F. A. Salti, N. Alzeidi, and B. R. Arafeh, "EMGGR: an energy-efficient multipath grid-based geographic routing protocol for underwater wireless sensor networks," Wireless Networks, vol. 23, no. 4, pp. 1301–1314, 2017.
15) I. T. Almalkawi, M. G. Zapata, and J. N. A. Karaki, "A Cross-Layer-Based Clustered Multipath Routing with QoS-Aware Scheduling for Wireless Multimedia Sensor Networks," International Journal of Distributed Sensor Networks, Vol. 2012, Pages 1 – 11, 2012.
16) R. C. Jin, T. Gao, J. Y. Song, J. Y. Zou, and L. D. Wang, "Passive Cluster-based Multipath Routing Protocol for Wireless Sensor Networks," Wireless Networks, Vol. 19, No. 8, Pages 1851 – 1866, November 2013.
17) M. R. Mazaheri, B. Homayounfar, and S. M. Mazinani, "QoS Based and Energy Aware Multi-Path Hierarchical Routing Algorithm in WSNs," Wireless Sensor Network, Vol. 4, Pages 31 – 39, 2012.
18) T. N. Quynh, T. T. Vinh, and M. B. T. Quynh, "Multipath Routing for Cluster-based and Event-based Protocols in Wireless Sensor Networks," In 3rd ACM Symposium on Information and Communication Technology SoICT'12, Pages 172 – 179, 2012.
19) T. Bagheri and A. Ghaffari, "RECM: Reliable and Energy effective Clustering based Multipath Routing Algorithm for Wireless Sensor Networks," In IEEE World Congress on Information and Communication Technologies (WICT'11), Pages 1340 – 1345, December 2011.
20) T. Y. Chen, H. W. Wei, C. R. Lee, F. N. Huang, T. sheng Hsu, and W. K. Shih, "EEGRA: Energy Efficient Geographic Routing Algorithms for Wireless Sensor Network," In International Symposium on Pervasive Systems, Algorithms and Networks, Pages 104 – 113, 2012.

21) R. Ding and L. Yang, "A Reactive Geographic Routing Protocol for Wireless Sensor Networks," In 6th International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP '10), Pages 31 – 36, 2010.

22) R. Alasem, A. Reda, and M. Mansou, "Location based Energy-Efficient Reliable Routing Protocol for Wireless Sensor Networks," In 10th WSEAS International Conference on Electronics, Hardware, Wireless and Optical Communication, Pages 180 – 185, 2011.

23) M. Cherian and T. R. G. Nair, "Multipath Routing With Novel Packet Scheduling Approach In Wireless Sensor Networks," International Journal of Computer Theory and Engineering, Vol. 3, No. 5, Pages 666 – 670, 2011.

24) M. Radi, B. Dezfouli, K. A. Bakarand, S. A. Razak, and M. A. Nematbakhsh, "Interference-Aware Multipath Routing Protocol for QoS Improvement in Event-Driven Wireless Sensor Networks," Tsinghua Science and Technology, Vol. 16, No. 5, Pages 475 – 490, 2011

25) J. Y. Chang and P. H. Ju, "An Efficient Cluster-based Power Saving scheme for Wireless Sensor Networks," EURASIP Journal on Wireless Communications and Networking, Vol. 2012, No. 1, Pages 1 – 10, May 2012.