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A Survey on Energy Efficient Routing Protocol in Wireless Sensor Network

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Abstract: Recent advancement in wireless communications and electronics has enabled the development of low cost sensor networks. The sensor networks can be used for various application areas (e.g., health, military, home). Wireless sensor network is a collection of sensor nodes are distributed separately over the network to monitor the environment or physical conditions such as temperature, sound, pressure etc. All the times node should be in active state to monitor and transforms the monitored information. Energy conservation in Wireless Sensor Network (WSN) has always been the most crucial issue, for the sensor nodes are all powered by limited capacity battery sources which are difficult, if not impossible, to replace or recharge due to the inherent nature and types of applications WSN is used .Therefore, energy efficient design of WSN has drawn considerable attention from many researchers resulting in quite a good number of approaches for saving the precious and limited energy of the sensor nodes. The relative advantages and disadvantages of the protocols are also discussed while the protocols are evaluated based on certain performance metrics

Keywords: Wireless Sensor Network, Energy ConservationRouting, EER.

I. INTRODUCTION

A Wireless Sensor Network (WSN) is a collection of some sensing stuffs usually called sensors which observes an event or gathers some physical data from its area of interest, processes the observed or gathered data by a tiny processor embedded in it and sends processed data via a short range radio transmitter to a central data collector usually called sink either directly or through intermediate sensor nodes. All these activities in a sensor node are carried out by limited energy battery sources which drain out in course of time as these activities are carried out. Therefore, energy conservation has always been a vital factor and a major challenge in the design of WSN. Although WSN is a class of ad hoc network, routing techniques for WSN widely differ from that of the traditional adhoc networks mainly for its energy constrained nature.

Routing is defined as the process of transfer of the packets between the networks or within the network from one host node to the other. Routing is mainly done by specially configured nodes called routers and is often confused with the bridging techniques. Based on network structure, routing strategies are categorized as flat routing; hierarchical routing and geographic position assisted routing [1]. In this paper, the dominant EER protocols for WSN are explored with proper classification. To finish the paper, a comparative study of the EER protocols is also carried out.

II. ENERGY DISSIPATION AND ENERGY WASTE IN WSN

In WSN, sensors dissipate energy mainly for transmitting and receiving data as compared to data sensing and processing, while a significant amount of energy is wasted with regard to data communications as described in [1] which is mentioned below.

- **Data Collision:** Data packets collide when a nodereceives more than one at the same time resulting in all the packets that caused this collision being discarded which will in turn necessitate retransmission of the discarded packets causing significant energy waste.
- **Data Overhearing:** Although a node is not transmitting, it will eventually listen to transmissions destined for other nodes causing continuous energy waste.
- **Idle Listening:** This phenomenon occurs when a node keeps listening to an idle channel in search of a data packet destined for it, thus wasting a good amount of energy.
- **Interference:** Energy is wasted as each node within the transmission and *interference range receives a packet but* cannot decode it.

III. Energy Efficient Routing Protocol in WSN

The main goal of any Energy Efficient Routing (EER) protocol for WSN is to maximize network lifetime by minimizing energy consumption in end-to-end transmission. WSNs are largely application-specific which implies that routing protocols are also dependent on applications. Generalizing the classification given in [2], the EER protocols for WSN are categorized in this paper as follows:

- Data Relaying Protocols
- Data Centric Protocols
- Hierarchical or Clustering-based Protocols
- Location-based or Geographical Protocols
- Mobility-based Protocols

A. Data Relaying Protocols

Data relaying protocols are very simple in nature and easy to implement as they don't require any routing table nor do they require maintaining topology information about the network. Gossiping [3], Flossiping [4], and LGossiping [5] are some popular protocols of this family.

1. **Gossiping:** A Gossiping [3] was the straight forward flooding mechanism with a view to overcoming the implosion problem with flooding. Implosion is a phenomenon where a node broadcasts a packet to all of its neighbors which in turn continue with broadcasting the packet creating multiple copies of the same packet in the network. On the other hand, Gossiping doesn't broadcast a packet to all the neighbors, rather only to a single one chosen randomly which in turn forward the packet randomly to one of its neighbors including the one from which it received the packet. This process continues until the ultimate destination is reached. Gossiping reduces energy consumption over flooding to a great extent, but it heavily suffers from long propagation delay.
2. **Flossiping:** Y. Zhang and L. Cheng proposed Flossiping [4] which is a balance between flooding and Gossiping. When a node has a packet to send, it decides a threshold value and then forwards the packet in Gossiping mode by saving the threshold in the packet header. Receiving the packet, a neighbor node generates a random number and chooses flooding if the random number is smaller than the threshold, otherwise; Gossiping is used.
3. **LGossiping:** LGossiping [5] proposed by S. Kheiri et.al. requires the nodes to have their location information available through GPS. Actually, it improves over Gossiping by choosing a known neighbor that is closer to the source based on GPS location information. Thus, it reduces the long latency problem of Gossiping, but introduces some extra cost for GPS device per node.

B. Data Centric Protocols

Because of the sheer number of nodes, in a WSN global addressing technique is not feasible. As a result, every sensor node has to transmit data to the sink which results in huge redundancy in the transmitted data causing significant energy waste. Therefore, routing techniques have been developed that are able to select a set of sensor nodes based on a query driven model and are also able to aggregate data while relying to the sink leading to a new class of routing called Data Centric Routing. SPIN [6] is considered to be the first of this kind of protocols, but the most influential one is Directed Diffusion(DD) [7]. An overview of the dominant and recent data centric protocols is given below.

1) Location Aided routing (LAR):

All the above described algorithms flood the route request, into the network to find the route. This causes a lot of routing overhead. To reduce the routing overhead the authors of [5] suggest the use of the location information. Location information can be obtained with the use of GPS enabled device. The algorithm marks out an expected zone, and a request zone. Expected zone is the region that the source

1. **SPIN:** Adaptive Protocols for Information Dissemination in Wireless Sensor Networks (SPIN) [6]overcame the limitations of Implosion, Overlapping, and Resource Blindness of the traditional data flooding protocols by negotiating meta-data among the nodes before transmitting real data. Whenever a node has some new data to share, it sends an ADV message to its neighbors who then place a request to get the new data if they haven't already availed it via a REQ message in response to the ADV message. Eventually, the originator of the ADV message sends the real data to all REQ message issuers via DATA message to complete the whole process. Figure 1, which is redrawn from[6], shows the phases of SPIN. While SPIN achieves a reduction in energy consumption by a factor of 3.5 less than that of flooding [6], it can't guarantee the delivery of data in case the potential neighbors are far away from the ADV message generator (i.e. source node) and the nodes in between the source and destination are not interested in the new data.

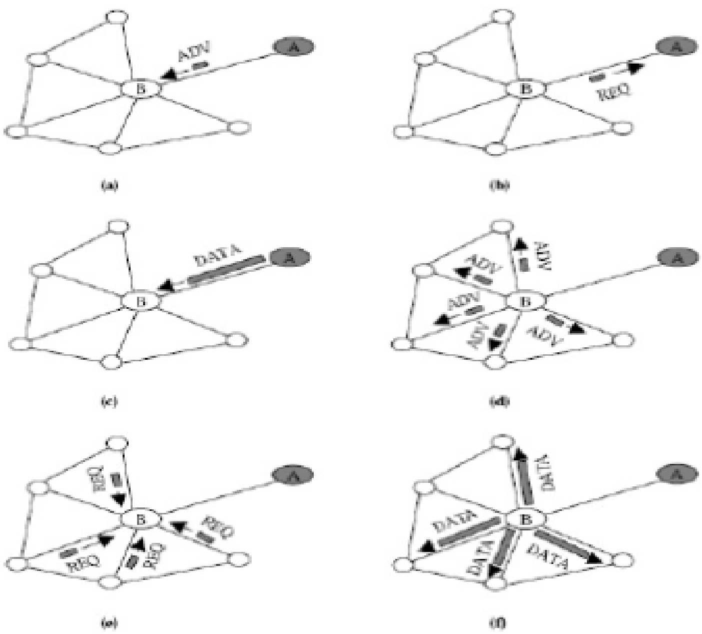

Figure 1. SPIN protocol. (a) Node A starts by advertising its data to node B.(b) Node B responds by sending a request to node A. (c) After receiving the requested data. (d) node B then sends out advertisements to its neighbours, (ef) who in turn send requests back to B.

2. **Modified SPIN (MSPIN):** MSPIN [8] transmits information only to sink node instead of the whole network thereby making the response to the sink faster than SPIN.Here, total number of packet transmissions is less than SPIN.Therefore a significant amount of total energy can be saved. But, MSPIN is not free from the typical drawbacks of SPIN.

3. **Directed Diffusion:** Directed Diffusion (DD) described in [7] consists of 3 steps: interest propagation, gradient setup, and path reinforcements. An interest is a message that describes the sensing task the sensor network is meant for with a view to acquiring data. DD names each data by an attribute-value pair. Thus, a sensing task is disseminated with the help of interest messages throughout the network for named data. This dissemination of interest also sets up a gradient in each node that receives an interest event. The gradient which is characterized by data rate, duration and expiration time is a reply link to the neighboring node from which the interest is received. Events start flowing toward the originators of interests along multiple gradient paths out of which only one or a few are reinforced by the network. Figure 2, which is redrawn from [7], illustrates these steps. DD brings many advantages such as, no global addressing, less energy consumption due to on-demand nature and less delay. But in its downside, DD suffers from limited scope of applications due to its dependence on a query-driven data delivery model which may not be feasible for all WSNs specially networks that require continuous data delivery to the sink.

C. Hierarchical or Clustering-based Protocols

A single-tier flat sensor network cannot scale well when the number of sensor nodes increases to larger amount, simply because it will cause the single gateway to overload with huge amount of data. Therefore, the whole WSN is broken into some clusters having multiple gateways where nodes within a cluster communicate in multi-hop fashion consuming energy efficiently. Every cluster has a cluster head that performs data aggregation and/or data fusion before forwarding them to the sink and the selection of cluster head is dominated by the energy reserve of the nodes within a cluster. Among many hierarchical protocols, LEACH [9] is the pioneering one with its different versions like E-LEACH [10], M-LEACH [11],LEACH-C [12], V-LEACH [13] etc. Other remarkable hierarchical protocols include PEGASIS [14], TEEN [15] and APTEEN. These protocols are briefly discussed below.

1. **LEACH:** LEACH [9] divides the whole WSN into some clusters each containing some cluster members and a cluster head which regulates channel access among the cluster members using TDMA. The cluster members wake up from sleep state during their respective TDMA slot during which they transmit data to the cluster head which then aggregates, fuses and finally transmits the data directly to the sink. So that the cluster head doesn't die out quickly, at a fixed interval anew cluster head is dynamically elected from the not-yet chosen cluster members based on their residual energy. LEACH is used to reduce energy consumption by a factor of 7compared to direct communication and a factor of 4-8compared to minimum energy transmission routing protocols by limiting the data transmission to long distance sink to only a few cluster heads [9]. Moreover, each cluster head also performs local computation on the gathered data to reduce its volume. But, due to broadcast required during the cluster head selection process, good amount of energy is wasted.

2. **E-LEACH:** Energy-LEACH (E-LEACH) [10]improves over LEACH by considering the residual energy of each node during the second round of the cluster head selection process thereby making it more energy-efficient over LEACH.

3. **M-LEACH:** Multi-hop-LEACH [M-LEACH] [11]improves on LEACH by relaying cluster head data to the sink through multiple intermediate cluster heads which act as relay stations. This effectively solves the problem of LEACH or other earlier versions of LEACH where a cluster head is located far away from the sink in which case huge energy is consumed for direct or single-hop transmission between cluster head and the sink.

4. **V-LEACH*:*** The new Version LEACH (V-LEACH)protocol proposed in [13] keeps the provision of a vice-cluster head that takes over the role of the cluster head in case the cluster head dies.

5. **PEGASIS:** Instead of forming any cluster, Power efficient GAthering in Sensor Information Systems (PEGASIS)[14] forms a chain of nodes where each node transmits and receives data from a neighbor and at a time only one node can send data to the sink. Data are aggregated at the nodes when they move from node to node. PEGASIS can outperform LEACH by about 100-300% for different network sizes and topologies. But, it causes long latency for nodes located at a distance on the chain. It is subject to single point of failure in case the single leader on the chain fails which is also the reason for performance bottleneck of the system.

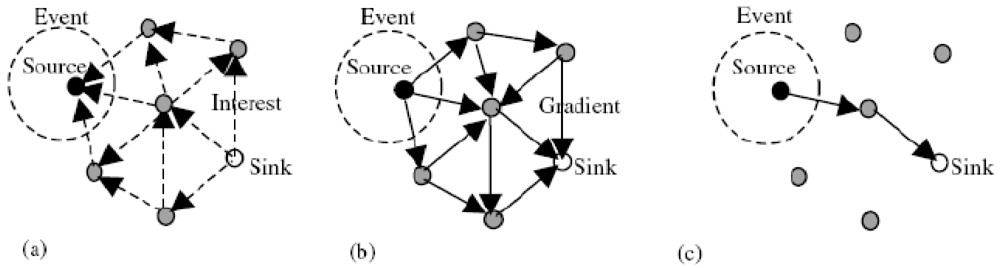

Figure 2. Simplified schematic for directed diffusion. (a) Interest propagation. (b) Initial gradients setup. (c) Data delivery along reinforced path.

6. **TEEN:** Threshold Sensitive Energy Efficient Network Protocol (TEEN) [15] combines both data-centric and hierarchical approach. Instead of having a flat clustering of nodes like LEACH or PEGASIS, TEEN creates multi-level hierarchy of nodes by grouping closer nodes into clusters on the first level, then on the second level and so on until the sink node is reached. Figure 3, which is redrawn from [15], depicts this concept of clustering. TEEN tries to reduce energy consumption by reducing the number of transmissions with the help of two thresholds as broadcast by the cluster heads after the clusters are formed – hard and soft thresholds. Hard threshold is a minimum possible attribute value that causes a sensor node to switch on its transmitter and transmit the sensed data to the cluster head, whereas a node sensing an attribute value at or beyond the hard threshold will transmit the sensed data only when the attribute value changes by an amount equal to or greater than the soft threshold. Although TEEN is quite energy-efficient, it is not useful for applications that require periodic reporting of the sensed data. Most importantly, the forming of multi-level hierarchy, implementing different thresholds and attribute-based naming impose huge overhead and complexity to this approach.

D. Location-based or Geographical Protocols

Location based or geographical protocols rely on the location information of the sensor nodes to find out the most energy efficient path between a source node and the sink or the cluster head. Location information is usually made available to the nodes by the use of GPS devices as it gives very accurate location information but imposes an extra cost per node.

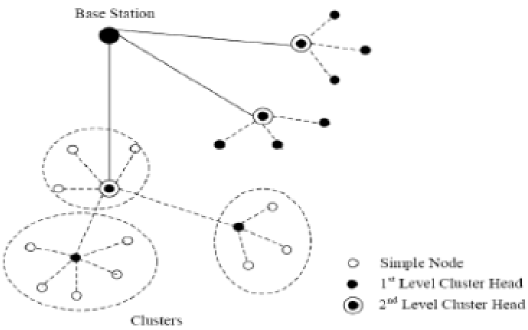

Figure 3. Hierarchical Clustering in TEEN

Sometimes, some localization algorithms such as the one described in [17] are also used to find out the position of anode which is very cost effective. But this approach suffers from inaccuracy or approximation in estimating the position of a node.

Some of the popular and representative geographical routing protocols for WSN include GAF [18],GEAR [19] and LEAR [20] which are discussed below.

1. **GAF:** Geographic Adaptive Fidelity (GAF) [18]proposed by Y. Xu et. al. forms a virtual grid where each node is associated with a point on the virtual grid by exploiting its GPS-indicated position information. GAF tries to reduce energy consumption by switching some nodes to their sleeping states provided that some equivalent nodes are kept active. Figure 4, which is redrawn from [18], depicts the idea. Here, node 2, 3 and 4 are considered to be equivalent as node1 can reach all of them which all can reach node 5.

2. **GEAR:** Geographical and Energy Aware Routing(GEAR) [19] complements the Directed Diffusion (DD)protocol by restricting the dissemination of interest messages to only a certain region rather than to the whole network as is the case with DD. This is possible in GEAR since it enables each node to possess the location information and remaining energy level of itself and its neighbors.

3. **LEAR:** Location Based Energy-Efficient Reliable Routing Protocol (LEAR) [20] proposed by Alasem et al. is based on the geographical positioning and clustering of the nodes. In LEAR, each node constructs a routing table based on the distances to its neighbors where distance is computed from the location information which is made available by GPS devices and published by each node to its neighbors. The core of the LEAR protocol is Enhanced Greedy Forwarding(EGF) algorithm which, unlike the greedy approach used by most other geographic routing protocols, selects the nearest node to the active node based on its distance which is a good attempt to minimize energy consumption. EGF is implemented by selecting only and only the forward nodes in the routing path on the way to the destination while pruning gall the nodes in the backward routing path which ultimately minimizes the number of hops to reach the sink thereby, significantly reducing energy consumption. Simulation result shows that LEAR significantly improves network lifetime and throughput over other reference protocols like LEACH or EGF [20]. But it bears the common drawbacks of geographical routing; i.e. extra cost for GPS devices.

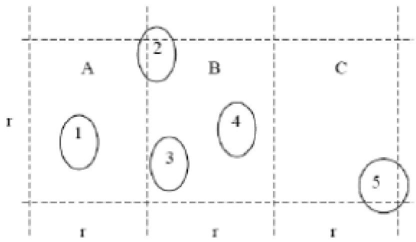

Figure 4. Virtual Grid in GAF

E. Mobility-based Protocols

WSN, in most applications, consists of sensor nodes that are static. But in some cases, in order to have better connectivity, wider coverage or to support multiple missions, it is beneficial to equip the nodes with mobility feature having restricted movement within a few meters which in turn, causes the topology of the network to change frequently. Nevertheless, the sink in a WSN may also be mobile putting much more challenges to the problem of data routing. Therefore, the mobility-based protocols should be designed taking into consideration the mobility characteristic of the nodes as well as the sink. Popular mobility-based protocols like EAGRP [21] and LBDD [22] are discussed below.

1. **EAGRP:** Energy Aware Geographic Routing Protocol[21] first calculates the average distance between the source node and all its neighbors based on the location information of the nodes and then checks their energy levels.Finally, it selects the neighbor having energy level above a set threshold, having the maximum energy plus whose distance equal to or less than the calculated average distance among its entire neighbors.

2. **LBDD:** Line-based Data Dissemination (LBDD)protocol [21] addresses the fact that in a WSN there may be multiple sink moving randomly in the sensor field. LBDD, like other geographical protocols, assumes that each node has its own location information available to it either through the use of GPS devices or by some virtual coordinate system. Then it defines a virtual vertical line of a certain width w intersecting the sensor field at the middle thereby, dividing the whole sensor field into two parts. The line itself is divided into g groups. The nodes lying closer to the boundary of the line are termed as in-line nodes while the other nodes are referred to as ordinary nodes. LBDD forwards data towards sink in two phases [21]. When an ordinary sensor node generates some new data, it forwards the data to the nearest inline node. Whenever a sink wishes to retrieve a specific data, it sends a query towards the line in a perpendicular fashion. The first inline node receiving the query propagates it in both directions along the perpendicular line until the inline node that owns the data is reached.

IV. Analysis of the EER Protocols

Now that a comprehensive study of the representative routing protocols from each of the EER categories is conducted, a relative comparison among the different categories taking one protocol from each can be drawn. For comparison, we consider different metrics such as class, scalability, lifetime, energy efficiency, data aggregation, latency, hop communications and extra overhead. To be more precise, Gossiping, Directed Diffusion (DD), LEACH, LEAR, EAGRP and SEP are compared in table 1.

V. Conclusion

WSN, by nature, is extremely energy constrained thereby forcing the routing protocol designers to go for energy efficient design. In this paper, a comprehensive list of the EER protocols for WSN has been studied. Through this discussion, it is obvious that still there are plenty of issues the EER protocols are left with to address such as QoS, bandwidth utilization, exact but cost effective localization etc. Therefore, it is expected that researchers will of course go for these open areas of research to put things into shape so that the yet-to-be standardized EER protocols could be standardized.

Table 1: Comparison

PROTOCOLS / CHARACTERISTICS	GOSSIPING	DD	PEGASIS	LEAR	EAGRP
CLASS	Data Relaying	Data Centric	Hierarchical	Geographical	Mobility-Based
SCALABILITY	Low	Medium	Low	High	High
LIFE TIME	Medium	Medium	Low	Low	High
ENERGY EFFICIENCY	Low	High	Very low	Very High	High
DATA AGGREGATION	No	Yes	Yes	No	No
LATENCY	Very High	High	Moderate	Medium	Medium
HOP COMMUNICATION	Multi-Hop	Multi-Hop	Single-Hop	Multi-Hop	Multi-Hop
EXTRA OVERHEAD	No	Yes	Cluster Formation	Location Tracking	Location Algorithms
RESOURCE AWARENESS	No	Yes	Yes	Yes	Yes

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References

1. P. Minet, “Energy efficient routing”, in Ad Hoc and Sensor Wireless Networks: Architectures: Algorithms and Protocols, Bentham Science,2009.
2. K. Akkaya and M. Younis, “A survey on routing protocols for wireless sensor networks”, Ad Hoc Networks, vol. 3, issue: 3, pp. 325–349,2005.
3. S. M. Hedetniemi, S. T. Hedetniemi, and A. L. Liestman, “A survey of gossiping and broadcasting”.2001
4. M. Y. Zhang and L. Cheng, “Flossiping: A new routing protocol for wireless sensor networks”, in Proceedings of the 2004 IEEE. International Conference on Networking, Sensing & Control, Taipei, Taiwan, Mar. 21-23, 2004.
5. S. Kheiri, MB. Ghaznavi Goushchi,M. Rafiee and B. Seyfe, “An improved gossiping data distribution technique with emphasis on Reliability and Resource Constraints”, in IEEE 2009 International conference on communications and mobile computing, vol. 2, pp. 247-252, 2009.
6. W. Heinzelman, J. Kulik, and H. Balakrishnan, “Adaptive protocols for information dissemination in wireless sensor networks”, in Proceedingsof the 5th Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom_99), Seattle, WA, Aug. 1999.
7. C. Intanagonwiwat, R. Govindan, and D. Estrin, “Directed diffusion: a scalable and robust communication paradigm for sensor networks”, in Proceedings of the 6th Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom_00), Boston, MA, Aug.2000.
8. Z. Rehena, S. Roy, and N. Mukherjee, “A Modified SPIN for Wireless Sensor Networks”, in Proceedings of the 3rd International Conference on Communication Systems and Networks (COMSNETS), Jadavpur University, Kolkata, India, 2011.
9. W. Heinzelman, A. Chandrakasan and H. Balakrishnan, “Energy efficient communication protocol for wireless micro sensor networks”, in Proceedings of the 33rd Hawaii International Conference on System Sciences , Vol. 2, 2000.
10. F. Xiangning and S. Yulin, "Improvement on LEACH Protocol of Wireless Sensor Network", in International Conference on Sensor Technologies and Applications, pp. 260-264, doi:10.1109/SENSORCOMM.2007.60, 2007.
11. H. Zhou, Z. Jiang and M. Xiaoyan, “Study and design on cluster routing protocols of wireless sensor networks”, 2006.
12. W.B. Heinzelman, A.P. Chandrakasan, and H. Balakrishnan, “An application-specific protocol architecture for wireless micro sensor networks,” IEEE transactions on wireless communications, Vol. 1, NO.4, pp. 660-670, Oct. 2002.
13. M.B. Yassein, A. Al-zou'bi, Y. Khamayseh, and W. Mardini,“Improvement on LEACH protocol of wireless sensor network(VLEACH)”, International Journal of Digital Content Technology and its Applications, Vol. 3, No. 2, pp. 132-136, Jun. 2009.
14. S. Lindsey and C.S. Raghavendra, “PEGASIS: power efficient gathering in sensor information systems,” in Proceedings of the IEEE Aerospace Conference, Big Sky, Montana, Mar. 2002.
15. A. Manjeshwar and D.P. Agrawal, “TEEN: a protocol for enhanced efficiency in wireless sensor networks”, in Proceedings of the 1stInternational Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, San Francisco, CA, Apr.2001.
16. A.Manjeshwar and D.P. Agrawal, “APTEEN: a hybrid protocol forefficient routing and comprehensive information retrieval in wirelesssensor networks”, in Proceedings of the 2nd International Workshop onParallel and Distributed Computing Issues in Wireless Networks andMobile computing, Ft. Lauderdale, FL, Apr. 2002.
17. N. Bulusu, J. Heidemann, and D. Estrin, “GPS-less low cost outdoor localization for very small devices”, IEEE Personal Communication Magazine, vol. 7, no. 5, pp. 28-34, Oct. 2000.
18. Y. Xu, J. Heidemann, and D. Estrin, “Geography-informed energy conservation for ad hoc routing”, in Proceedings of the 7th Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom_01), Rome, Italy, Jul. 2001.
19. Y. Yu, D. Estrin, and R. Govindan, “Geographical and energy aware routing: a recursive data dissemination protocol for wireless sensor networks”, UCLA Computer Science Department Technical Report, UCLA-CSD TR-01-0023, May. 2001.
20. R. Alasem, A. Reda, and M. Mansour, “Location Based Energy-Efficient Reliable Routing Protocol for Wireless Sensor Networks” ,Recent Researches in Communications, Automation, Signal processing, Nanotechnology, Astronomy and Nuclear Physics, WSEAS Press, Cambridge, UK, 2011, ISBN: 978-960-474-276-9.
21. Adel Gaafar, A.Elrahim, Hussein A.Elsayed, Salwa H.Elramly, and Magdy M.Ibrahim, “A new Routing Protocol for Mobility in Wireless Sensor Networks”, Cyber Journals: Journal of Selected Areas in Telecommunications (JSAT), Feb. 2011.