ENERGY EFFICIENCY IMPROVEMENT METHODS IN WIRELESS SENSOR NETWORK

1SUSHRUTA S. BHONDE, 2ARCHANA R. RAUT

1ME Student, Department of Computer Science and Engineering, G. H. Raisoni College of Engineering Nagpur, India
2Assistant Professor, Department of Computer Science and Engineering, G. H. Raisoni College of Engineering Nagpur, India
E-mail: sushrutabhonde@gmail.com, archana.kakade5@gmail.com

Abstract- Wireless sensor network has been an active area of research. It provides quick, uninterrupted access to information, making the required data readily available to user. The nodes in wireless sensor network are battery powered and these batteries being irreplaceable, energy efficiency becomes an important issue. Many techniques have been proposed to increase the energy efficiency, thereby increasing the network lifetime in wireless sensor networks. This paper provides an overview of various energy-efficiency improvement techniques used in wireless sensor networks, thus, it also improves network lifetime.

Keywords- Wireless Sensor Networks, Energy Efficiency, Heterogeneous Nodes

I. INTRODUCTION

Wireless sensor networks (WSNs) provide rapid, uninterrupted access to information and computing, eliminating the barriers of distance, time, and location for many applications in national security, civilian search and rescue operations, surveillance, area/target monitoring, and many more. In typical scenarios, all nodes in sensor network have equal processing powers.

Consider a network where some nodes have higher processing power and energy and are called as „Manager Nodes“ or „super nodes“ and some nodes have lower capacities in terms of processing power and energy called „Normal nodes“. These normal nodes can be used as monitoring nodes or can act as relay nodes in between the path leading to manager-nodes. Normal nodes are in charge of passing the data to the Manager nodes which act as data collector node. Hence, to find a suitable path two types of routing techniques can be used viz. Forward Routing and Reverse Routing.

The paper is organized as follows, Section II elaborates various techniques used in wireless sensor network for improving energy-efficiency. Section III provides comparative analysis of various techniques and section IV concludes the paper.

II. RELATED WORK

A. Energy Efficient Data Gathering (EEDG)

The heterogeneous connected set covers (HCSC) problem, used to solve the target connected-coverage problem in heterogeneous WSNs. The HCSC problem has as objective to determine maximum network lifetime when all targets are covered, sensor energy resources are constrained, and active sensors are connected to at least one supernode. Several distributed algorithms for computing the set covers using clustering, Rule-K, and greedy techniques are proposed. A consideration about heterogeneous wireless sensor network consisting in several resource-rich supernodes used for data relaying and a large number of energy constrained wireless sensor nodes is done. Sensor nodes are deployed randomly to monitor a number of targets. Since targets are redundantly covered by more sensors, in order to conserve energy resources. In this, the Heterogeneous Connected Set Covers (HCSC) problem that has as objective for finding a maximum number of set covers such that each set cover monitors all targets and is connected to at least one supernode. Wireless Sensor Networks (WSNs), are constructed from tiny autonomous sensor nodes and are utilized for various applications, such as civilian and environmental monitoring. In this, the active sensor nodes are selected based on the competition between the nodes surrounding each node. The network lifetime is increased by the maximum usage of the nodes in each area and by moderating the energy consumption. Comparing the proposed algorithm results with the previous methods showed the superiority in performance respect to the other methods. Moreover, the efficiency of the suggested method in decreasing the energy consumption and increasing the lifetime of the covering network is demonstrated. The complexity and communication overload caused by the effort in choosing the relay nodes is much less in
the suggested algorithm compared to the other methods, and the execution time is very short for reaching the optimum response. A heterogeneous wireless sensor network consists of different types of nodes in sequence. Some of these nodes have high process powers and significant energy, which are called the manager nodes or super-nodes. The second type nodes, which have normal process power, are only used as monitoring nodes or act as relay nodes in the path to the manager nodes are called the normal nodes. An energy-aware algorithm is presented for the optimum selection of sensor and relay groups that are used for monitoring and sending messages from goals in point coverage, using the competition between the nodes. This algorithm is effective in decreasing the energy consumption of the network and increasing its life-time. Moreover, providing that no node saves the information about the routing table and relay nodes; therefore, it will have less complexity and overload.

Wireless sensor networks are used to provide quick, unattended access to computing and information. It helps in eliminating barriers of time, location and distance. Wireless sensor networks have wide variety of applications, some of which include military operations, rescue operation, target tracking and much more. As wireless sensor networks consider various parameters like energy-efficiency and network lifetime, the focus lies on enhancing these parameters. Energy-Efficient Data Gathering in Heterogeneous Wireless Sensor Networks i.e. EEDG focuses mainly on improving the network lifetime.

The energy-efficient method schedules the sensor nodes between sleep mode and active mode. As these nodes have limited power, the switching of modes leads to energy-saving. EEDG is designed for target coverage applications. Target coverage implies that targets with known locations are monitored by the sensor nodes. Network activity in EEDG is organised in rounds. Initialisation phase and data collection phase are the two phases in this protocol. Relay nodes are selected through Kruskal’s algorithm, based on greedy approach. EEDG is used to solve the target connected problem pertaining in heterogeneous wireless sensor network.

B. Collective Flooding(CF)
Flooding protocols are used in wireless sensor networks in order to facilitate reliable and efficient communication. Many enhancements have been done in flooding protocol but these protocols consider link-independence which requires costly ACKs i.e. acknowledgements. This reduces network lifetime and energy efficiency. A collective flooding mechanism can be used, which exploits link-correlation. This mechanism achieves link-reliability by the use of collective ACKs. As this method needs only one hop information at each node, the design becomes scalable and highly distributed in nature along with low complexity. Collective Flooding also incorporates dynamic forwarder selection in which forwarder is selected by a dynamic process through competition among nodes that has received the broadcasting packet. The conversion of direct ACKs into collective ACKs tremendously decreases the redundancy in re-broadcasting.

C. Probabilistic routing technique To design a robust protocol in a heterogeneous wireless sensor networks considering asymmetric links is another challenge in the field of WSNs. Maintaining the efficiency, reliability and scalability of the network is an issue in networks having asymmetric links. Thus, a protocol named ProHet finds a reverse path for each asymmetric link thus producing bidirectional routing abstraction. Then it uses probabilistic approach and chooses forwarding nodes which depends upon historical statistics using local information. ProHet contains preparation part and routing part. It achieves high delivery rate and is efficient in heterogeneous networks considering asymmetric links.

D. Hop-number-constrained multi-hop routing Increased network lifetime is yet another important parameter in cluster-based sensor networks. In order to ensure stable communication period from sensor nodes to base station, there is a consideration of maximum number of hops. Nodes with high amount of residual energy undertake more load of relaying the information. Thus, the balance of energy consumption in entire network is maintained. It increases the network lifetime and also the number of effective messages is more in the case of HMR algorithm. The multi-hop algorithm is based on LEACH i.e. Low Energy Adaptive Clustering Hierarchy protocol. Cluster-head election process is carried out and CHs are thus elected. As this technique uses the concept of residual energy, so there is stabilization of transmission timeperiod between base station and the nodes.

E. Logic co-ordinate references to establish data routes In heterogeneous wireless sensor networks, where the concept of mobile sink is involved, the asymmetric links have to be efficiently utilised. This type of scenario involves the use of GPS device or...
predefined landmarks. These landmarks, which may be through GPS or predefined, hamper the delivery rate, as the overhead is increased. In order to achieve higher delivery rate and increased energy efficiency, an algorithm named Energy Efficient with Assured Delivery Rate Routing Protocol for wireless Heterogeneous Sensor Networks i.e. EEADR is developed. It does not use any predefined landmarks or GPS device. It uses logical co-ordinate reference for the purpose of forwarding and routing data packets. Thus, energy-efficiency is improved.

F. CH election considering battery power and number of members under a cluster head. Prolongation of network lifetime and increased energy efficiency are two main parameters to be achieved in wireless sensor networks. Although many algorithms are developed to meet the said parameters, but these algorithms are not properly optimised to meet the requirements of heterogeneous wireless sensor networks. In Novel Energy Adaptive Protocol (NEAP), there is probabilistic election of CH, which is mainly dependant on threshold per round. The cluster is formed considering the battery power at current and number of members under a CH. These considerations improve lifetime of the network and results in reduced energy consumption.

III. COMPARATIVE ANALYSIS

Table 1 shows comparative analysis between various techniques used in wireless sensor networks. Utilization of these techniques leads to increased energy efficiency. These techniques when implemented in various scenarios can also lead to increased network lifetime. The techniques along with their inferences are discussed below.

In cluster based forward routing technique, the sensor environment is modeled into target coverage problem and the sensors are organized in set covers.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Technique</th>
<th>Reference</th>
</tr>
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<tbody>
<tr>
<td>Waed Amadoh</td>
<td>2006</td>
<td>Cluster based forward routing technique [5]</td>
<td>To address the larger coverage problem.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Data is relayed to near nodes.</td>
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<td></td>
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<td></td>
<td>Increases network lifetime with increase in number of members under CH.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CH is elected based on battery power and number of members under CH.</td>
</tr>
<tr>
<td>Zijie Guo</td>
<td>2012</td>
<td>Hop-number constrained multi-hop routing algorithm</td>
<td>Establish the transmission period between the nodes and the base station.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(HMCRA) [4]</td>
<td>Provides longer lifetime.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Redundant energy is considered to balance network energy.</td>
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<td></td>
<td></td>
<td></td>
<td>Find neighbors from nodes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Increases reliability and availability.</td>
</tr>
<tr>
<td>Yong Zhou</td>
<td>2013</td>
<td>Collective forwarding (CF) [1]</td>
<td>To use collective ACKs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reduce packet transmission and dissemination delay.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Provides efficient and reliable message dissemination services with low complexity</td>
</tr>
<tr>
<td>Bikshu S. Malli</td>
<td>2015</td>
<td>Logic overhear reference for monitoring data delivery</td>
<td>To obtain an efficient delivery rate with less overheads.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reference [6]</td>
<td>Does not require GPS or extra land marks to be installed.</td>
</tr>
</tbody>
</table>

Table 1: Analysis of different energy-efficiency improvement Techniques

Once the clusters are formed two techniques viz, relay nodes selection using shortest path mechanism and the rule-K mechanism have been suggested. As the complete area is divided using target-coverage concept and data is relayed through intermediate relay nodes, the energy efficiency is bound to increase.

In Novel Energy Aware Routing, a new energy adaptive protocol to reduce overall power consumption and maximize network lifetime is introduced in heterogeneous wireless sensor networks. In this technique, the cluster head is elected by probability. The other considerations while forming a cluster include nodes current battery.
CONCLUSION

In this paper, a glimpse of energy efficiency improvement techniques is provided. Forward routing technique is generally used in all these techniques involving heterogeneous nodes. The idea is to try to implement reverse routing by utilizing higher capabilities of supernodes, thus saving the energy of normal nodes.

After studying various techniques, it is observed that much work can be done in field of WSNs with target coverage scenarios. In future, the target coverage problem can be defined using reverse routing technique in order to increase energy efficiency by harnessing the higher capabilities of supernodes. Moreover, improved protocols for increased energy-efficiency in WSNs can be designed.

REFERENCES


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