International Journal of Enhanced Research in Management & Computer Applications
ISSN: 2319-7471, Vol. 4 Issue 7, July-2015

Shield and Shelter by used clustering in Wireless sensor network

Abolfazl Akbari[1], Mohammad Mehdi Hasani[2]

[1,2]Ayatollah Amoli Branch, Islamic Azad University, Amol, Iran

ABSTRACT

In wireless sensor networks that consist of a large number of low power, short-lived, unreliable sensors, one of the main design challenges is to obtain long system lifetime, as well as maintain sufficient sensing shield and reliability. Sensor networks also pose a number of new conceptual and optimization problems. Some, such as location, deployment, and tracking, are fundamental issues, in that many applications rely on them for needed information. Shield preservation is one of the basic QoS requirements of wireless sensor networks, yet this problem has not been sufficiently explored in the context of cluster-based sensor networks. Specifically, it is not known how to select the best candidates for the cluster head roles in applications that require complete shield of the monitored area over long periods of time. In this paper, we take a unique look at the clustering problem, specifically concentrating on applications where the maintenance of full network shield and shelter is the main requirement.

Keywords: shield, shelter, cluster heed, wireless sensor networks.

INTRODUCTION

With a sensor clustering network, the nodes are separated into groups called clusters. There are usually three types of m nodes in clustering networks, as shown in Figure 1: cluster heads (CHs), gateway nodes and normal nodes. In each cluster, one node is elected as a CH to act as a local controller. The size of the cluster (the number of nodes in the cluster) depends on the transmission range of the nodes in single hop cluster and the number of hops made by the cluster in multi-hop clusters. The normal node sends or relays data to the CH which transfers the collected packets to the next hop. The gateway node, belonging to more than one cluster, bridges the CHs in those clusters. Both CHs and gateway nodes form the backbone network, yet the presence of gateway node is not compulsory in the clustering network.

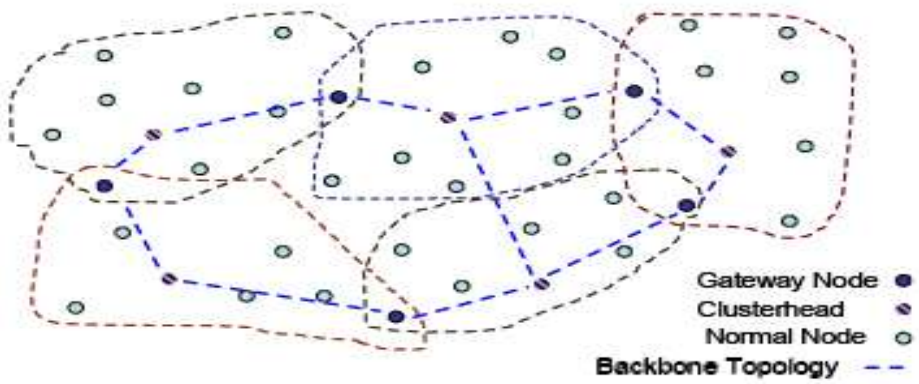

Figure 1: Clustering network.

The following is a list of some advantages of clustering scheme. 1) Only the CHs and gateway nodes form the backbone network, results in much simpler topology, less overhead, flooding and collision. 2) The change of nodes only affects part topology of the networks, making the topology more stable. 3) Only CHs or gateway nodes need to maintain the route information.

Organizing sensor networks into clustered architectures has been extensively explored over the last few years, leading to the appearance of a great number of task-specific clustering protocols. Clustering is one of the basic approaches for designing energy-efficient, robust and highly scalable distributed sensor networks. Utilizing clusters reduces the communication overhead, thereby decreasing the energy consumption and interference among the sensor nodes. In many applications, cluster organization is a natural way to group spatially close sensor nodes, in order to exploit the correlation and eliminate redundancy that often exists among the sensor readings. Through data fusion and aggregation of the sensors' data at the cluster centers, called cluster heads, the total amount of data sent to the sink can be significantly reduced, saving energy and bandwidth resources. Oftentimes sensor networks must provide persistent coverage of the entire monitored area. Many applications require the ability to provide information from each part of the monitored area at any moment in order to meet the application's quality of service (QoS). As an example, in surveillance applications, the sensors must detect and track intruders, requiring that the entire monitored area be ''covered" by the sensing region of the sensors. Furthermore, oftentimes sensors are deployed with much greater density than is needed to satisfy coverage requirements, which enables the redundantly covered nodes to conserve their energy by entering a low-power sleep mode.

While both cluster-based sensor network organization and coverage-maintenance protocols have been extensively studied in the past, these have not been integrated in a coherent manner. Existing techniques for the selection of cluster head nodes base this decision on various criteria, such as: maximum residual energy [3,5], location of the cluster head candidate relative to the other nodes [16], topology information[6], or previous activity of the sensor node as a cluster head [2]. Most of these cluster head selection approaches are designed with the goal to provide balanced energy consumption among sensor nodes, but at the same time, these approaches do not consider the network's requirement for full coverage over extended periods of time. In other words, energy-balanced clustered network organization does not ensure that the wireless sensor network is able to persistently provide coverage of the entire monitored area. However, sensor coverage is one of the basic network QoS metrics, as it expresses the network's ability to provide constant monitoring sensing of some area of interest.

CLUSTERING SCHEMES FOR SENSOR NETWORKS

Energy efficiency is important for ad hoc sensor networks. The main task for clustering schemes is therefore to extend the lifetime of the networks.

A. OPTIMIZING CLUSTER ORGANIZATION

Cluster organization details how to partition clusters and to select CHs, how to define cluster size and how to assign transmission ranges to the nodes, all of which will affect the power consumption of the network. Therefore, optimizing the cluster organization can improve energy efficiency

A.1 MINIMIZING TOTAL DISTANCES TO CH

The first method optimizes the organization of the clusters and the selection of the CHs to achieve the minimum sum of the square of distance between the normal nodes and their CHs. The energy e to transmit a message from a source to a receiver depends on the distance d between them:

$$e = k\, d^{c}\ ,\ (2<c<4)\ ,\ (1)$$

where k and c are constants for a specific wireless system, and where usually 2<c<4. These distances are affected by how the nodes are organized into clusters. S. Ghiasi et al. [23] propose an optimal algorithm for clustering the sensor nodes so that the sum of the square of distance of the normal nodes from their CHs is minimized. Assuming there are 3 nodes for each CH, there are two sample clustering options named A-B and C-D as shown in Figure 2. The sum of the square of the distances between CH and nodes in clusters A-B is less than that in clusters C-D. According to (1), energy can be saved by the A-B partition scheme.

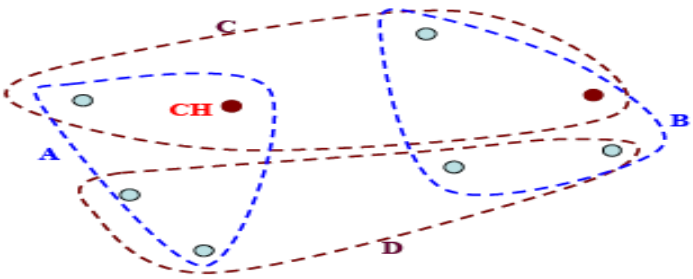

Figure 2. Low power consumption cluster design

The above minimization of total distances in a cluster is subject to the constraint, that the power consumption of the CHs can be maintained to be approximately equal to each other.

A. 2 ASSIGNING THE LOWEST TRANSMISSION POWER NEEDED

The second method to optimize the cluster organization assigns the normal nodes, or the CHs the lowest power needed for intra-cluster communication, and also the gateway nodes the lowest power needed for inter-cluster communication. The solution by K. S. Manousakis and J. S. Baras [24] first brings together the closer nodes in the network to reduce the transmission ranges. Then it assigns each node in the cluster with the lowest possible transmission range while keeping the intra-cluster connection. The pair of nodes that have the minimum distance between any two clusters are chosen as gateway nodes. The communication between the CHs is realized through these nodes. The last step is to assign the gateway nodes the lowest possible transmission range to keep the connection of the backbone network.

A. 3 OPTIMIZING ROUTE USING DIFFERENT POWER LEVEL CLUSTERS

The third method involves clusters with different power levels. The highest power level is needed to connect all the nodes in the entire network through multihops. A lower power level will form clusters for only the nodes that are close enough to be connected using these lower power level multihops. Each node may belong to different clusters of different power levels so that different routes are possible by taking different combinations of these power levels for each hop. Energy is then saved by optimizing these routes from source to destination. V. Kawadia and P. R. Kumar [25] group the network nodes into different power level clusters, as shown in Figure 3.

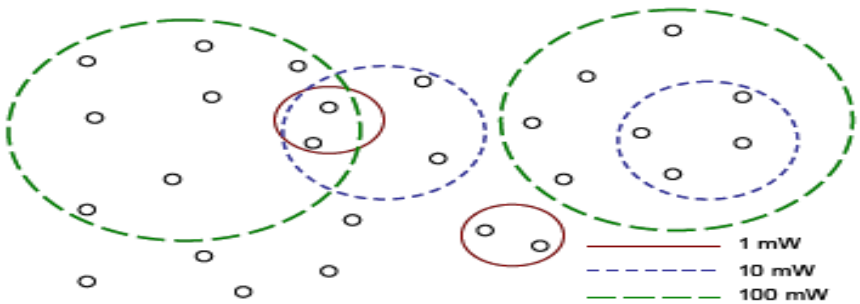

Figure 3. Group the nodes into different power level clusters

A. 4 OPTIMIZING SIZE OF K-HOP CLUSTER

The size of the cluster is important for energy saving. The small size of the cluster may result in lower total power consumption of the cluster. Yet the backbone formed by CHs of the network will become complicated. The large size of the cluster may result in a simple backbone network. Yet the transmission power in each cluster becomes higher or the mutihop route within the cluster becomes more complicated. There is then a tradeoff between the cluster size and the complexity of the backbone network. The fourth method of optimizing cluster organization therefore uses k-tree and optimizes the value of k to save energy. A k-tree cluster is a framework in which the clustering of nodes is such that any two nodes in a cluster are at most k hops from each other [29]. K-tree clusters are more energy efficient because the normal nodes may send data to its CH through multihops, each with lower power rather than single hop with higher power. In addition, the cluster size can be optimized by choosing the parameter k that can result in best energy saving . S. Bandyopadhyay and E. J. Coyle [26] propose single-level and multi-level algorithms to cluster the nodes in the networks.

In single-level algorithm, the clusters are formed in the following way: Each sensor in the network becomes a CH, called a volunteer CH, with probability p, and advertises itself as a CH to the sensors of no more than k hops. Any sensor that receives such advertisements and is not a CH joins the cluster. If a sensor does not receive a CH advertisement within time duration T (time needed to send data to k hops away), it can infer that it is not within k hops of any volunteer CHs and hence becomes a forced CH. In multi-level cluster algorithm, the network first elects the level-1 CHs, then level-2 CHs from the level-1 CHs. That means, the normal nodes in a higher level cluster is the CH of the lower lever cluster. The probabilities to become a CH of the node in different level clusters are p1, p2 ...ph. The hops in different level clusters are k1, k2…kh. The parameters k, T in single-level algorithm and parameters p1, p2 …ph, k1, k2…kh in multi-level algorithm affect the power consumption of the network. Thus optimizing these parameters can reduce power consumption.

B. AVERAGING POWER CONSUMPTION

The normal nodes in a cluster only transmit their data to their CH and will also relay the data in case of a multihop cluster. In addition to transmitting their data, the CHs also receive data from the normal nodes and relaying them. The CHs therefore consume more energy than the normal nodes, and when the CHs run out of energy the clusters break down. The power consumption of the CH will also be affected by the number of normal nodes in the cluster. Therefore energy efficiency can be improved by averaging power consumption among the nodes in the cluster through rotating the role of CH or among the CHs through assigning approximately the same number of nodes to each CH.

B. 1 ROTATING THE ROLE OF CH IN THE CLUSTER

One approach rotates the roles of CHs only within each cluster. In the re-clustering strategy and redirection scheme by Liu and Lin [27], periodically the node with the highest energy in the cluster is identified and re-selected as the CH, known as a redirector. This scheme has three steps as shown in Figure 4.

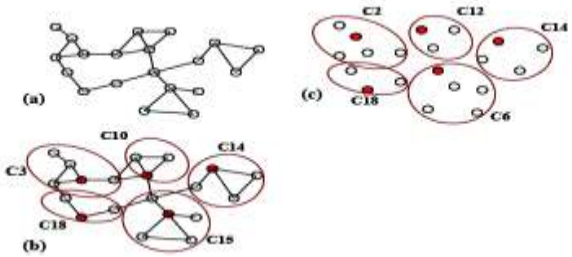

Figure 4. Energy efficiency clustering protocol

The neighboring relationship is first established according to a hop distance range (Figure 4a). Next, the clusters are organized using a dynamic transmission range adjustment protocol such that the number of the nodes in each cluster lies between a minimum and a maximum value (Figure 4b). Every now and then, the node with the highest residual energy in each cluster is selected as the new CH (Figure 4c). Power consumption will then be averaged among the nodes in the cluster.

B.2 ASSIGNING THE SAME NUMBER OF NODES TO EACH CH

The second method distributes the power consumption among CHs by assigning approximately the same number of nodes to each CH. In Base-Station Controlled Dynamic Clustering, proposed by S. D. Muruganathan et al. [28], the nodes are periodically reclustered by the data sink such that (1) only those nodes with higher energy levels will become CHs, (2) the CHs are uniformly spaced, and (3) the clusters have approximately the same number of normal nodes. The CH in each cluster is then randomly chosen among those higher energy level nodes.

C. SCHEDULING ACTIVE AND NON-ACTIVE NODES

There are usually many nodes within the same area in a sensor network, whereas only a smaller number of them are needed to collect the required data in that area. At a given time, we need only some of the nodes to be active while the rest are turned into energy saving state. A scheduling approach will be applied to select nodes to be active. In the clustering scheme proposed by Z. Abrams, et al. [30], the nodes in one area are grouped into several clusters, each cluster covers part (yet not all) of this area, as shown in Figure 6. Assume there are 12 nodes in this area, which are separated into three groups, as marked A, B and C. These clusters are active by turn, which means that at any time only one cluster is active; the others are set into sleep state with negligible power consumption.

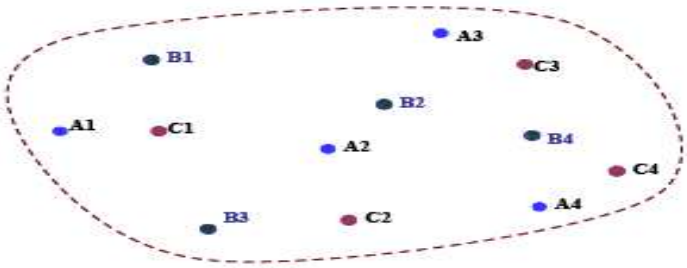

Figure 5. Nodes in one area are grouped into several clusters

Cluster head election techniques for shield and shelter

Work in the area of cluster-based wireless sensor networks is quite extensive, with energy efficiency and scalability being the main focus of many of the clustering protocols proposed so far. Similarly, much work has been done on sensor activation protocols, which focus on selecting a subset of the active sensor nodes that are sufficient to satisfy the network's shield requirements, while allowing the remainder of the sensors to conserve their energy by entering the sleep mode. In this section, we discuss the related work that has been done in both these areas.

A. Clustering protocols

Probabilistic approaches for cluster head election, such as those proposed in [2,3], ensure that the cluster head role is shared equally among the nodes in the network, therefore prolonging the lifetime of the sensor nodes through balanced energy consumption. In [4] the authors found the optimal clustering parameters such as the probability of becoming a cluster head and the cluster radius for a network organized into single and multi-level clusters by minimizing the communication cost of the network. The HEED clustering protocol [5] uses a hybrid criterion for cluster head selection, which considers the residual energy of the node and a secondary parameter, such as the node's proximity to its neighbors or the node's neighbor degree. HEED prolongs the network lifetime by ensuring balanced energy dissipation as well as uniform distribution of cluster head nodes in network scenarios that contain uniformly dispersed sensor nodes. All of this work aims to extend network lifetime by balancing energy dissipation among the nodes. In our approach, we aim to keep alive the most critical sensors, thereby preserving coverage and extending network lifetime for coverage-based applications.

The works presented in [6,7] deal with the problem of power-balanced energy consumption among the cluster head nodes. In both papers the coverage-time is defined as the time until one of the cluster head nodes runs out of energy, leaving a hole the network's coverage. Shu et al. [6] stress the importance of simultaneous design of clustering strategies and routing, and they provide two mechanisms for balancing power consumption, called routing-aware optimal cluster planning and clusteringaware optimal random relay. However, in this work we are concerned with sensor networks where cluster head nodes are not deployed deterministically. Also, the definition of coverage-time in this work is stricter, corresponding to the time for which every part1 of the monitored area is under the sensing range of at least one sensor node. The partitioning of a network into uniformly dispersed clusters is the focus of the ACE clustering algorithm [8]. ACE provides uniform clusters by reducing the overlap among the clusters established in the initial phase.

Those nodes that have the largest number of either ''uncovered" neighbors or neighbors in non-overlapping cluster areas are recruited as favorable new cluster head nodes. However, menergy issues are not discussed in this paper. Several papers deal with the design of clustering methods for the case of non-uniform deployment of sensor nodes. For example in [9], the authors consider the problem of power control and clustering in heterogeneous sensor networks. A clustered network structure is established to ensure that transmit power used by all nodes within the cluster converges to the same level. The authors in [10] notice that in non-uniformly deployed networks where the node density is globally high, the network can be partitioned into locally isotropic non-overlapping clusters with small density variations that will have high correlation in sensor measurements. While these techniques aim to create uniform or coherent clusters, they do not consider the coverage-preserving task required by many sensor network applications. Clustering in the context of sensor management, topology control and routing was extensively investigated in the past.

For example, the authors in [11] present the GAF routing protocol that controls the network topology and exploits node density to prolong the network lifetime. GAF uses geographical information to build a virtual grid across the network, and it selects only one sensor node to be active in each cell. The CEC [12] clustering protocol improves GAF by not relying on location information, further reducing redundant nodes by grouping them into clusters, where nodes with highest remaining energy are selected as cluster head nodes. Neither GAF nor CEC guarantee the complete coverage of the area covered by the network. The problem of scheduling nodes to enter the sleep mode in cluster-based sensor networks was studied in [13]. The authors proposed a linear distance-based sleep scheduling scheme, where the probability that a sensor enters the sleeping state is proportional to its distance from the cluster head. Since such a scheme leads to unequal energy consumption of sensor nodes in the cluster, the same problem is further investigated in [14].

Here the authors present a balanced energy scheduling scheme, which accounts for the total energy spent in communication and sensing, thereby assuring that energy is uniformly spent by the nodes. Again, these approaches balance the nodes' energy consumption rather than reducing the energy consumption of the critical sensors, as is done in our approach. An autonomous clustering algorithm based on coverage estimation self-pruning is presented in [15]. The sensor nodes with the largest expected coverage are the best candidates for the cluster head roles. The algorithm

minimizes the clustering overhead compared to LEACH [2], and provides lower variation in the number of cluster head roles over time. However, this clustering scheme does not ensure full coverage of the network.

B. ACTIVE SENSOR SELECTION PROTOCOLS

Network coverage is one of the fundamental problems in sensor networks, since it affects the outcome of the network sensing task. Therefore, coverage together with sensor management has been a strong research focus for the last few years [17]. In [18] the authors provide a method for achieving full coverage of targets by dividing the sensors into disjoint cover sets that are active successively. In each cover set, a sufficient number of sensor nodes necessary to cover the targets is active, while the remainder of the nodes are put to sleep. However, their approach is based on a centralized solution. In PEAS [19] the nodes use a simple rule to decide about their activity. If a node cannot find another active node in its probing range, it becomes active; otherwise it returns to the sleeping mode. Although this approach eliminates the complexity of maintaining neighbor state and it does not require location information, it does not guarantee full sensing coverage of the network, which is our main concern. In [20] the authors propose a scheduling scheme that enables each node to enter the active or sleeping mode based on the coverage information obtained from its neighbors, without compromising full network coverage.

In order to avoid the ‘‘blind point” problem that occurs when two neighboring nodes simultaneously decide to turn off leaving a part of the area uncovered, the authors introduce a random back-off time before the node makes a decision about its status. In our clustering scheme the ‘‘blind problem” is solved by introducing delays in node activation based on the nodes’ current cost values, thereby giving priority to low cost nodes to deactivate, anticipating the network’s need for full coverage. The problem of achieving full coverage in wireless sensor networks was also explored in [21]. The proposed algorithm (OGDC) tries to minimize the number of active nodes by reducing the overlapped area between the active sensors. To ensure that different nodes are active in each round, the starting node broadcasts a power-on message in a random direction along which working nodes are found. A node decides to turn off if it covers an intersection point between two active sensors and if it minimizes the overlapped area with active sensors. However, nodes do not consider the energy levels of their neighbors, so they can send the power-on messages in the direction of nodes with low remaining energy.

Family of coverage-aware cost metrics

The distributed activation with predetermined routes (DAPR) protocol proposed in [1] is the first routing protocol designed to avoid routing of data through areas sparsely covered by the sensor nodes. The idea behind this approach is that nodes in sparsely deployed areas, as well as nodes with small remaining energies are used less often as data routers, so that these nodes can collect data for longer periods of time. To accomplish this goal, the importance of every sensor node for the coverage-preserving task is quantified by a coverage-aware cost metric, which combines the information about the node’s remaining energy with information about how redundantly this node’s sensing area is covered by its neighboring nodes’ sensing areas. To explore the benefit of this approach in cluster-based sensor networks, we introduce several coverage-aware cost metrics. We assume that Ns sensor nodes from a set S, $s_i \in S$, i= 1,…,N_s ;N_s are scattered randomly over a rectangular monitored area A. We assume the application requires that every part of the area be covered by the sensors throughout the network lifetime.

Each sensor performs reliable sensing within its sensing area $C(s_i)$, which is approximated by a circular area around the node with radius Rsense. Note that this is a simple model for sensor coverage. Other techniques such as utilizing a learning phase where sensors learn their sensing area $C(s_i)$ based on training data can be used as well. For every sensor node s_i we define a group of neighboring nodes N(i) that includes all nodes with sensing areas either partially or fully overlapped with the sensing area of node s_i. Using our model for sensing area, we obtain(1) where $d(s_i,s_j)$ is the Euclidean distance between nodes s_i and s_j. To reduce the number of active nodes while ensuring that every point (x,y) of the monitored region is covered by at least one sensor, each node needs to determine the overlap of its sensing area with the sensing areas of its neighboring nodes. For this, we assume that sensor nodes have localization capabilities. Considering each node’s position and its residual energy, for each point(x,y) of the monitored area A we define the total energy $E_{total}(x,y)$ that is available for monitoring that location
where E(sj) is the remaining energy of node s_j.

$$(1) \qquad N(i) = \{s_j | d(s_i, s_j) <= 2 \cdot R_{\text{sense}}\}, \qquad (2) \qquad E_{\text{total}}(x,y) = \sum_{s_j:(x,y)\in C(s_j)} E(s_j),$$

A. Minimum-weight coverage cost
The minimum-weight coverage cost is defined as This cost

$$C_{mw}(s_i) = \max \frac{1}{E_{total}(x,y)} \quad (x,y) \in C(s_i). \tag{3}$$

metric measures node si's importance for the network coverage task by considering the energy of the most critically covered location ًx; yق within the sensing area of the node.

B. Weighted sum coverage cost. The weighted-sum coverage cost is defined as

(4)

$$C_{ws}(s_i) = \int_{C(s_i)} \frac{dxdy}{E_{total}(x,y)} = \int_{C(s_i)} \frac{dxdy}{\sum_{s_j:(x,y)\in C(s_j)} E(s_j)}.$$

This cost metric measures the weighted average of the total energies of all points that are covered by the sensing area of node s_i.

C. COVERAGE REDUNDANCY COST

The coverage redundancy cost metric does not depend on a node's remaining energy nor on the remaining energies of its neighbors. Instead, this cost considers only the coverage redundancy of the overlapped sensing areas between the sensor and its neighboring nodes. Similarly to the previously defined $E_{total}(x,y)$, we define a total coverage $O_{total}(x,y)$; which provides the number of nodes that cover each point(x,y)of the area A

$$O_{total}(x,y) = \sum_{s_j:(x,y)\in C(s_j)} 1. \tag{5}$$

Then, the coverage redundancy cost of sensor s_i is

$$C_{cc}(s_i) = \int_{C(s_i)} \frac{dxdy}{O_{total}(x,y)} = \int_{C(s_i)} \frac{dxdy}{\sum_{s_j:(x,y)\in C(s_j)} 1}. \tag{6}$$

D. Energy-aware cost

The energy-aware cost function evaluates the sensor's ability to take part in the sensing task based solely on its remaining energy $E(s_i)$

$$C_{ea}(s_i) = \frac{1}{E(s_i)}. \tag{7}$$

E. Coverage-aware routing cost

The cost metrics introduced in the previous subsections are the basis for coverage-aware routing, where the minimum cost routing paths are determined such that high cost nodes are excluded from the routing task. The cost of a link between two nodes si and sj is equal to the energy spent by these nodes to transmit ($E_{tx}(s_i,s_j)$) and to receive ($E_{tx}(s_i,s_j)$) one data packet, weighted by the costs of these nodes

$$C_{link}(s_i,s_j) = C_{aa}(s_i) \cdot E_{tx}(s_i,s_j) + C_{aa}(s_j) \cdot E_{rx}(s_i,s_j), \tag{8}$$

where C_{aa} represents any of the cost metrics described above. Therefore, the minimum cumulative cost path from each node to the sink is found as

$$C_{final}(s_i) = \sum_{s_j,s_k \in p(s_i S_{dst})} C_{link}(s_j,s_k), \tag{9}$$

where p is the minimum cost path from node si to the sink S_{dst}. The cost defined by Eq. (9) is called the coverage aware routing cost. Data routing from every cluster head to the sink is done over multi-hop paths, which are found by minimizing C_{final} in Eq. (9).

V. COVERAGE-PRESERVING CLUSTERING PROTOCOL (CPCP)

To ensure balanced energy consumption among the cluster head nodes throughout the network lifetime, many clustering protocols favor uniformly distributed clusters with stable average cluster sizes. However, obtaining the same

number of well distributed clusters over time is a real challenge in clustered sensor networks. In coverage-based applications, the best candidates for cluster head roles should be the redundantly covered nodes in densely populated areas with high remaining energy. These nodes can support clusters with a large number of members. While the excessive energy consumption of the cluster head nodes makes these nodes die before the other nodes, their death should not affect the overall network coverage since these nodes are located in densely populated areas. By our approach, which considers the application's requirements for full network coverage, the set of cluster head nodes can be selected based on the cost metrics defined in Section 3. However, cluster head selection based solely on any of the proposed cost metrics using existing clustering techniques will lead to an undesirable situation: the densely populated parts of the network will be overcrowded with cluster head nodes, while the scarcely covered areas will be left without any cluster head nodes. In such a situation, it is likely that the high cost sensors from poorly covered areas will have to perform expensive data transmissions to distant cluster head nodes, further reducing their lifetime. In order to avoid this situation, we propose the clustering method called coverage-preserving clustering protocol (CPCP). CPCP consists of six phases: information update, cluster head election, route update, cluster formation, sensor activation and data communication.

CPCP spreads cluster head nodes more uniformly throughout the network by limiting the maximum cluster area. Thus, clusters in sparsely covered areas are formed as well as clusters in densely covered areas, which prevents the high cost nodes from having to perform costly packet transmissions to distant cluster head nodes. Also, nodes from the sparsely covered areas elected to serve as cluster head nodes support clusters with a smaller number of nodes compared to cluster head nodes in dense areas. We define the cluster radius Rcluster as a tunable parameter that determines the minimum distance between any two cluster head nodes in the network. Using this parameter, CPCP prevents the appearance of non-uniformly distributed clusters within the network. Rcluster can be easily tuned by changing the transmission power of the cluster head nodes. In CPCP the sensor nodes communicate directly with their elected cluster head nodes, while data routing from the cluster head nodes to the sink is done over multi-hop paths using the sensors.

CONCLUSION

The nodes in sensor networks are usually stationary, making the topology more stable. Yet these networks usuallym have large number of nodes and work in hostile environment making energy recharge infeasible. Therefore, clustering schemes for sensor networks mainly aim at improving energy efficiency. The proposed schemes save energy by optimizing the organization of the clusters, by averaging power consumption, or by scheduling active cluster. These clustering schemes do save energy for ad hoc sensor networks. However more efficient schemes may be proposed if the directional and uneven data traffic in sensor networks is taken into account. The directional data traffic towards the data sink makes the density of data traffic uneven. That is, the nodes near the data sink will forward more data and thus run out of energy sooner. The data sink may then be isolated due to the limited transmission range of sensor nodes resulting in the energy in other areas to be wasted. Therefore if the power consumption can be evenly distributed throughout the networks, the issue that some of areas exhausting energy sooner can be avoided and all energy can be used before the network loses its connectivity. The data sink being the same destination of all sensor nodes makes it possible to efficiently find a route by directing the route request messages towards the data sink so that flooding in route discovery can be reduced, which also improves energy efficiency. we explore different coverage-aware cost metrics for the selection of the cluster head nodes, active nodes and routers in wireless sensor networks whose aim is to maintain coverage of a monitored space. In such coverage-preserving applications, both the remaining energy of the sensor nodes as well as the redundancy in their coverage have to be jointly considered when determining the best candidates for cluster head nodes, active nodes and data routers. using the coverage-aware cost metrics prolong coverage-time over the monitored area, by minimizing the use of sensors in sparsely covered areas and those with low remaining energy.

REFERENCES

[1] M. Perillo, W. Heinzelman, DAPR: a protocol for wireless sensor networks utilizing an application-based routing cost, in: Proceedings of the IEEE Wireless Communications and Networking Conference (WCNC'04), 2004.

[2] W. Heinzelman, A. Chandrakasan, H. Balakrishnan, An applicationspecific protocol architecture for wireless microsensor networks, IEEE Transactions on Wireless Communications 1 (4) (2002).

[3] M.J. Handy, M. Haase, D. Timmermann, Low energy clustering hierarchy with deterministic cluster head selection, in: Proceedings of IEEE MWCN, 2002.

[4] S. Bandyopadhyay, E.J. Coyle, An energy efficient hierarchical clustering algorithm for wireless sensor networks, in: Proceedings of the 22nd Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM), 2003.

[5] O. Younis, S. Fahmy, Distributed clustering in ad-hoc sensor networks: a hybrid, energy-efficient approach, IEEE Transactions on Mobile Computing 3 (4) (2004).

[6] T. Shu, M. Krunz, S. Vrudhula, Power balanced coverage-time optimization for clustered wireless sensor networks, in:Proceedings of MobiHoc'05, 2005.

[7] S. Soro, W. Heinzelman, Prolonging the lifetime of wireless sensor networks via unequal clustering, in: Proceedings of the Fifth International Workshop on Algorithms for Wireless, Mobile, Ad Hoc and Sensor Networks (IEEE WMAN'05), 2005.
[8] H. Chan, A. Perrig, ACE: an emergent algorithm for highly uniform cluster formation, in: Proceedings of EWSN, 2004.
[9] V. Kawadia, P.R. Kumar, Power control and clustering in ad hoc networks, in: Proceedings of INFOCOM, 2003.
[10] R. Virrankoski, A. Savvides, TASC: topology adaptive spatial clustering for sensor networks, in: Proceedings of the 2nd IEEE International Conference on Mobile Ad Hoc and Sensor Systems (MASS'05), 2005.
[11] Y. Xu, J. Heidemann, D. Estrin, Geography-informed energy conservation for ad hoc routing, in: Proceedings of the Seventh Annual ACM/IEEE International Conference on Mobile Computing and Networking, 2001.
[12] Y. Xu, J. Heidemann, D. Estrin, Energy conservation by adaptive clustering for ad-hoc networks, in: Proceedings of MobiHoc, 2002.
[13] J. Deng, Y. Han, W. Heinzelman, P. Varshney, Scheduling sleeping nodes in high density cluster-based sensor networks, ACM/Kluwer MONET Special Issue on Energy Constraints and Lifetime Performance in Wireless Sensor Networks, vol. 10, No. 6, December 2005, pp. 825–835.
[14] J. Deng, Y.S. Han, W. Heinzelman, P. Varsney, Balanced-energy sleep scheduling scheme for high density cluster-based sensor networks, Elsevier's Computer Communications Journal (2005).
[15] K. Bae, H. Yoon, Autonomous clustering scheme for wireless sensor networks using coverage estimation self-pruning, IEICE Transaction on Communications E88-B (3) (2005).
[16] W. Choi, S.K. Das, A framework for energy-saving data gathering using two-phase clustering in wireless sensor networks, in: Proceedings of MobiQuitous Networking Conference, 2004.
[17] M.T. Thai, F. Wang, D. Du, Coverage problems in wireless sensor networks – designs and analysis, International Journal of Sensor Networks, Special Issue on Coverage Problems in Sensor Networks, 2005.
[18] M. Cardei, D.Z. Du, Improving wireless sensor network lifetime through power aware organization, ACM Wireless Networks 11 (3) (2005).
[19] F. Ye, G. Zhong, J. Cheng, S. Lu, L. Zhang, PEAS: a robust energy conserving protocol for long-lived sensor networks, in: Proceedings of IEEE International Conference on Distributed Computing Systems (ICDCS 2003), 2003.
[20] D. Tian, N.D. Georganas, A coverage-preserving nodescheduling scheme for large wireless sensor networks, in: Processing of ACM Wireless Sensor Network and Application Workshop, 2002.
[21] H. Zhang, J. Hou, Maintaining coverage and connectivity in large sensor networks, in: Proceedings of International Workshop on Theoretical and Algorithmic Aspects of Sensor, Ad hoc Wireless and Peer-to-Peer Networks, 2004.
[22] S. Soro, W.Heinzelman, Camera selection in visual sensor networks, in: Proceedings of IEEE International Conference on Advanced Video and Signal-Based Surveillance, 2007.
[23] S. Ghiasi, A. Srivastava, X. Yang, and M. Sarrafzadeh, "Optimal Energy Aware Clustering in Sensor Networks," Sensors, Feb. 2002, pp. 258- 269.
[24] K. S. Manousakis and J. S. Baras, "Clustering for transmission range control and connectivity assurance for self configured ad hoc networks," Proc. of IEEE MILCOM 2003.
[25] V. Kawadia and P. R. Kumar, "Power Control and Clustering in ad hoc Networks," Proc. of IEEE INFOCOM 2003.
[26] S. Bandyopadhyay and E. J. Coyle, "An energy efficient hierarchical clustering algorithm for wireless sensor Networks," Proc. of IEEE INFOCOM 2003
[27] J. S. Liu and C. H. Richard Lin, "Energy-Efficiency clustering protocol in wireless sensor networks," Ad Hoc Networks, Elsevier, Volume 3, May 2005, pp371-388.
[28] S. D. Muruganathan, D. C. F. Ma, R. I. Bhasin, and A. O. Fapojuwo, "A centralized energy-efficient routing protocol for wireless sensor networks," IEEE Radio Communications, March 2005, pp. S8-S13.
[29] Y. Fernandess and D. Malkhi, "K-clustering in wireless ad hoc networks," Proc of POMC'02, Oct. 2002, France, pp. 31-37.
[30] Z. Abrams, A Goel, and S Plotkin, "Set K-Cover Algorithms for Energy [4] S. Bandyopadhyay and E. J. Coyle, "An energy efficient hierarchical clustering algorithm for wireless sensor Networks," Proc. of IEEE INFOCOM 2003. Efficient Monitoring in Wireless Sensor Networks," Proc. of the 3rd ACM International Symposium on Information Processing in Sensor Networks, April 2004, pp. 424-432.