AN ENERGY-EFFICIENT CONGESTION BASED CLUSTERING PROTOCOL FOR WIRELESS SENSOR

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ABSTRACT

A wireless sensor networks consists of spatially distributed autonomous sensors nodes called motes. Clustering is an effective way for prolonging the lifetime of a wireless sensor network. Current clustering algorithms consumes much time in setup phase and they hardly consider the congestion problem at the base station and inter- cluster communication in wireless sensor network. The proposed protocol deals the minimum energy consumption and congestion less transmission between the multihop clustering because one cluster head is sending data to base station and the remaining cluster heads perform intra-cluster communication during this time for receiving data packets from its nodes in finite duration time.The proposed protocol minimizes the congestion at the base station and improved throughput.

Key Words*: *Clustering, Residual energy, Wireless Sensor Network.

I. INTRODUCTION

A wireless sensor networks (WSNs) consists of spatially distributed autonomous sensors nodes called motes. The Sensor Nodes are low power device equipped with one or more sensors, a processor, memory, a power supply, a radio and an actuator [1]. The nodes are used for sensing and monitoring physical or environmental conditions such as temperature, pressure, vibration, humidity, sound etc. [2]. The information sensing node is known as source node The nodes are working together to monitor region. The sensor node has resource constraints due to its physical size and capabilities. Each node consists of limited resources such as battery, memory, processing capability. So the careful resource utilization is required to prolong the network efficiency. In order to achieve high energy efficiency and increase the network scalability, sensor nodes can be organized into clusters. Within a clustering organization, intra-cluster communication can be single hop .Multihop communication between a data source and a data sink is usually more energy efficient than direct transmission. However, the hot-spots problem arises when using the multihop forwarding model in inter-cluster communication, because the cluster heads closer to the data sink are burdened with heavy relay traffic, they will die much faster than the other cluster heads, reducing sensing coverage and causing network partitioning. Although many protocols proposed in the literature reduce energy consumption on forwarding paths to increase energy efficiency, they do not necessarily extend network lifetime due to the continuous many-to-one traffic pattern.

The sensor network consisting of N sensor nodes uniformly deployed over a vast field to continuously monitor the environment, into levels. The cluster heads are elected by localized competition, and rotation is performed only when the residual energy of current cluster head goes below threshold. The proposed Protocol based on congestion and multihop routing technique for inter-cluster communication. The cluster head with higher level of residual energy and distance are considered for data transmission.

The rest of the paper organized as follows: Section II covers the related work Section III The proposed protocol

Section IV validation of the proposed protocol Section V conclusion and references

II. RELATED WORK

Many clustering algorithms have been proposed for wireless sensor network in recent years. We review some of the most relevant papers [4][5][6][7]. In LEACH [4], each node has a certain probability of becoming a cluster head per round, and the task of being a cluster head is rotated between nodes. In the data transmission phase, each cluster head sends an aggregated packet to the base station by single hop. In PEGASIS [5], further improvement on energy-conservation is suggested by connecting the sensors into a chain. To reduce the workload of cluster heads, a two-phase clustering (TPC) scheme for delay-adaptive data gathering is proposed in [6]. Each cluster member searches for a neighbor closer than the cluster head within the cluster to set up an energy-saving and delay-adaptive data relay link. HEED [5][6] In the implementation of HEED [7], multihop routing is used when cluster heads deliver the data to the data sink. All these methods require re-clustering after a period of time because of cluster heads' higher workload. However, few works has considered the hot spots problem when multihop forwarding model is adopted during cluster heads transmitting their data to the base station. In [8], an unequal clustering model is first investigated to balance the energy consumption of cluster heads in multihop wireless sensor networks. The work focuses on a heterogeneous network where cluster heads (super nodes) are deterministically deployed at some precomputed locations, thus it's easy to control the actual sizes of clusters. Through both theoretical and experimental analyses, the authors show that unequal clustering could be beneficial, especially for heavy traffic applications. A similar problem of unbalanced energy consumption among cluster heads also exists in single hop wireless sensor networks. Cluster heads farther away from the base station have to transmit packets over longer distances than those of heads closer to the base station. As a result, they will consume more energy. In EECS [9], a distance-based cluster formation method is proposed to produce clusters of unequal size in single hop networks. A weighted function is introduced to let clusters farther away from the base station have smaller sizes, thus some energy could be preserved for long-distance data transmission to the base station. Many energy-aware multihop routing protocols have also been proposed for wireless sensor networks. According to different application requirements, those protocols have different goals and characteristics. However, these multihop routing protocols may not be applied to applications that require continuous data delivery to the data sink. In the optimization problem of transmission range distribution of network is not balanced. The nodes can vary their transmission range as a function of their distance to the data sink and optimally distribute their traffic so that network lifetime is maximized. There simulation results show that energy balance can not be achieved by expense of using the energy resources of some nodes inefficiently. The work reveals the upper bound of the lifetime of a flat sensor network and gives some valuable guidelines for designing multihop routing protocols for wireless sensor networks.

III. PROPOSED PROTOCOL

Consider a wireless sensor network consisting of N sensor nodes, distribution of nodes is uniform in a particular region R_c. Each sensor node contains the value of its residual energy with node ID i.e. randomly generated coordinate value (x, y). Assuming that the node ID of all nodes known by each other after deployment.

3.1 Algorithm

REGION DIVISION ALGORITHM

1. Select region R_c with n number of nodes

   Each Node n $\leftarrow$ (Node ID, R_E)
2. Region R_c divides in equal sized levels.

   $R_c = L_1, L_2 \ldots\ldots\ldots L_M$

   $L_1 = r_1 + \Delta r = L_2 = r_2 + \Delta r \ldots\ldots\ldots\ldots = L_M = r_M + \Delta r = r$ where r_i = area of level $i = 1 \ldots\ldots M$

   Δr is the error in area
3. Set level L_1 = Hotspot zone
4. The number of clusters at each level upto M level

   No. of cluster/level$_i$ = 2^j

   where $M+1>i>0$ and $0<j<M+1$

   Total no. of clusters in R_c, $C_T = C_{L1} + C_{L2} + \ldots + C_{LN}$

CLUSTER HEAD SELECTION ALGORITHM

1. $\forall$ C_T select competitive cluster heads

   E_R $N_{i=1\ldots n} > Th_{qual}$

   where E_R is residual energy of nodes in region R_c
2. Set of 'x' competitive cluster head S = ($N_{i=1\ldots x}$)
3. Implement bubble sort on S in descending order and store result in sort[i], where i = 1….x
4. REPEAT IF (sort[i] = = sort[i + 1])

   THEN j $\leftarrow$ i+1

   ELSE Exit

   $CH_i \leftarrow$ sort [1]
5. IF (j>1)

   THEN

   m=n-j , m = Remaining nodes Calculate Distance

   CH_i= **min** [$\sum$ **[d** (sort[i], N_m)]] where $0<i<j+1$

PATH SELECTION ALGORITHM

1. Select data forwarding routes for $CH_1, CH_2 \ldots\ldots CH_{T-1}$
2. Calculate distance for cluster head at level (L_i) to higher level (L_{i-1})], where i=M……1
3. Implement MARGE sort on calculated distances in ascending order,

   d_r[i] = Sorted[distance from cluster head at level (L_i) to higher level (L_{i-1})], where i=M……1
4. Implement MARGE sort to sort distances in descending order,

   R_E[i] =Sorted[Residual energy of cluster heads at L_{i-1}]
5. Assign position_count $\forall$ route[i] $\forall$ [(R_E[i]) ^ (d_r[i])]
6. Sum of position_count $\forall$route[i] = $\forall$(position_count $\vee$ route[i]) $\forall$ (R_E[i] ^ d_r[i]))
7. Select_Path(CH_i) = min[$\forall$ (Sum_of_position_count)]

3.2 Region Division With Path Formation In Levels

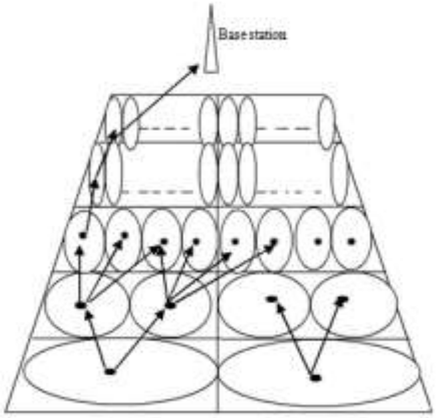

Figure 1. Region division with path formation in levels from L1, L2 …LM

IV. VALIDATION

Consider a wireless sensor network consisting of N sensor nodes, distribution of nodes is uniform in a particular region R_c. Each sensor node contains the value of its residual energy with node ID.

Step 1

Consider a region R_C = 500x500m with total number of nodes 15,000, divide R_C into levels i.e.

Area of level = $L_1 = L_2 = L_3 \approx 100m$

No. of cluster/level$_i$ = 2^j, N<i<1 and 1<j<N N=3

No. of cluster at L_1, C_{L1} = 16 No. of cluster at L_2, C_{L2}= 8 No. of cluster at L_3,

C_{L3}=4 No. of cluster at L_4, C_{L4}=2

Total No. of clusters $C_T = C_{L1} + C_{L2} + C_{L3} + C_{L4} = 16 + 8 + 4 + 2 = 30$

Suppose total number of nodes at level L_3 = 25, and dividing the level into two clusters

Nodes in cluster C_1 = 25/2 =12

Nodes in cluster C_2= 13

The area of clusters at same level is approximately equal.

Step 2

Performing Cluster head selection in Cluster C_1 at level L_3 any node can become competitive cluster head with if its energy is greater than qualifying threshold.

$TH_{qual} < R_E\_CH_{11}, R_E\_CH_{12}, R_E\_CH_{13}, R_E\_CH_{14}$

Final Cluster Head, $CH_1 = CH_{12}$

If maximum residual energy (R_{E_max}) of two or more cluster heads in a set is equal then find among these cluster heads that is reachable from all remaining nodes.

For this, calculate distance from these cluster heads to remaining nodes.

Suppose, No. of nodes with equal energy, j = 2

$R_E\_CH_{11} = R_E\_CH_{14}$

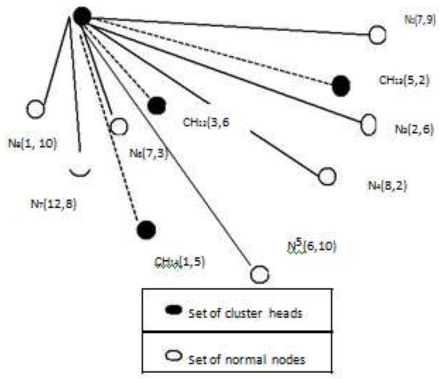

Figure 2. Cluster head selection at level L_3

Then calculate distance from CH_{11} and to all nodes in a cluster CH_{14}

Table 1. Distance from CH_{11} to all nodes in a cluster

Distance from CH_1	Distance Calculation	Final Distance
$d_{CH11-N1}$	$[(8-3)^2+(5-5)^2]^{1/2}$	5.0
$d_{CH11-N2}$	$[(8-7)^2+(5-9)^2]^{½}$	4.1
$d_{CH11-N3}$	$[(8-2)^2+(5-6)^2]^{½}$	6.0
$d_{CH11-N4}$	$[(8-8)^2+(5-2)^2]^{½}$	3.0
$d_{CH11-N5}$	$[(8-6)^2+(5-10)^2]^{½}$	5.3
$d_{CH11-N6}$	$[(8-7)^2+(5-3)^2]^{½}$	2.2
$d_{CH11-N7}$	$[(8-12)^2+(5-8)^2]^{½}$	4.4
$d_{CH11-N8}$	$[(8-1)^2+(5-10)^2]^{½}$	8.6
$d_{CH11-CH12}$	$[(8-3)^2+(5-6)^2]^{½}$	5.0
$d_{CH11-CH13}$	$[8-5)^2+(5-2)^2]^{½}$	4.2
Average Distance across the cluster head		4.61

Table 2. Distance from CH_{14} to all nodes in a cluster

Distance from CH_4	Distance Calculation	Final Distance
$d_{CH14-N1}$	$[(1-3)^2+(5-5)^2]^{1/2}$	2.0
$d_{CH14-N2}$	$[(1-7)^2+(5-9)^2]^{1/2}$	7.2
$d_{CH14-N3}$	$[(1-2)^2+(5-6)^2]^{1/2}$	1.4
$d_{CH14-N4}$	$[(1-8)^2+(5-2)^2]^{1/2}$	7.6
$d_{CH14-N5}$	$[(1-6)^2+(5-10)^2]^{1/2}$	7.0

$d_{CH14-N6}$	$[(1-7)^2+(5-3)^2]^{1/2}$	6.3
$d_{CH14-N7}$	$[(1-12)^2+(5-8)^2]^{1/2}$	11.4
$d_{CH14-CH8}$	$[(1-1)^2+(5-10)^2]^{1/2}$	5.0
$d_{CH14-CH12}$	$[(1-3)^2+(5-6)^2]^{1/2}$	2.2
$d_{CH14-CH13}$	$[(1-5)^2+(5-2)^2]^{1/2}$	5.0
Average Distance across the cluster head		5.51

The average Distance across the cluster head CH_{11} is lower than CH_{14}, so it will be selected for routing data packet to level 2.

Cluster Head = MIN [Average Distance among Set of competitive cluster heads]

Final cluster head for the given problem,

$CH_1 \leftarrow CH_{11}$

This procedure is performed for all the clusters $C_1, C_2 ... C_{14}$ to select cluster head.

In each cluster, rotation is performed only when the residual energy of current cluster head goes below certain threshold TH_{ACT}.

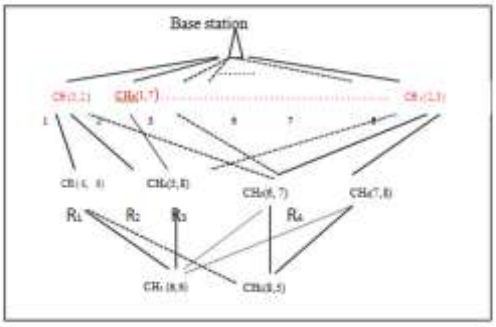

Figure 3. Tree Representation of Cluster Head Nodes

Step 3.

The scheduling of inter-cluster communication is followed by time quantum size

Let quantum size = 1 millisecond

CH_1	CH_2	CH_3	CH_4	CH_5	..	CH_{14}

0 1 2………………… 14 15

Sorting of residual energies of higher level cluster heads in descending order and their distance from CH_1 in ascending order shown in table 3.

Table 3.Path selection table

Position count	Path for CH_{11} to next higher level	Residual energy of higher level cluster heads	distance from CH_{11}
1	R_1	$E_R\_CH_6$ (35)	$d_{CH1-CH5}$ (2.8)
2	R_2	$E_R\_CH_5$ (30)	$d_{CH1-CH6}$ (3.6)
3	R_3	$E_R\_CH_3$ (25)	$d_{CH1-CH3}$ (4.1)
4	R_4	$E_R\_CH_4$(20)	$d_{CH1-CH4}$ (4.2)

Sum of Position count, R_1 = 3+3=6

R_2 =4+4=8

R_3 =2+1=3

R_4 =1+2=3

Minimum position count route will be selected for the data forwarding, Select_Route (CH_1) = R_3

Same calculation will be performed upto L_{i-1}, L_M levels.

Select_Route (CH_1) = R_3 - R_5 - R_{10}

CH_1 will not perform route selection in its next time quantum unless the residual energy of any of the cluster head in the following route goes below threshold.

Table 4 For CH_1 after its schedule at T_{0m}

clusters Heads	No of Packets in buffer	Route	Packet Transmission Sequence
CH_1	12	R_3 - R_5 - R_{10}	12

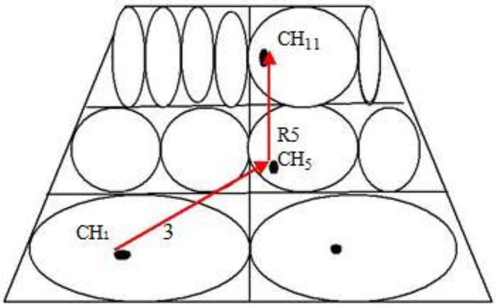

Figure 4. Selected path for CH1 to CH11

For the cluster heads CH_5, CH_{11} ,

V. CONCLUSION

The proposed protocol An Energy-Efficient Position Based Clustering Protocol for Wireless Sensor Network provides an effective algorithm to deal with the problem congestion at base station. The proposed protocol deals the minimum energy consumption and congestion less transmission between the multihop clustering because the remaining cluster heads perform intra-cluster communication during this time for receiving of data packets from its nodes in finite duration (C_{LN}-1) time. So the congestion at the base station is minimum and throughput is improved. The overall energy utilization of network is improved and it is more scalable.

REFERENCES

[1] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A Survey on Sensor Networks", IEEE Communications Magazine, vol. 40, no. 8, 2002.

[2] B. Krishnamachari, D. Estrin, and S. Wicker, "The Impact of Data Aggregation in Wireless Sensor Networks", in Proceedings of IEEE Int'l Conference on Distributed Computing Systems Workshops (ICDCSW), 2002.

[3] V. Mhatre and C. Rosenberg, "Design Guidelines for Wireless Sensor Networks: Communication, Clustering and Aggregation", Ad Hoc Networks, vol. 2, no. 2004.

[4] W. Choi, P. Shah, and S. K. Das, "A Framework for Energy-Saving Data Gathering Using Two-Phase Clustering in Wireless Sensor
Networks", in Proceedings of Int'l Conference on Mobile and Ubiquitous Systems: Networking and Services (MOBIQUITOUS), 2004.

[5] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Microsensor 2002.

[6] O. Younis and S. Fahmy, "HEED: A Hybrid, Energy-Efficient, Distributed Clustering Approach for Ad Hoc Sensor Networks", IEEE Transactions on Mobile Computing, vol. 3, no. 4, 2004.

[7] S. Lindsey, C. Raghavendra, K. M. Sivalingam, "Data Gathering Algorithms in Sensor Networks Using Energy Metrics", IEEE Transactions on Parallel and Distributed Systems, vol. 13, no. 9, 2002.

[8] S. Soro and W. Heinzelman, "Prolonging the Lifetime of Wireless Sensor Networks via Unequal Clustering", in Proceedings of the 19th IEEE International Parallel and Distributed Processing Symposium (IPDPS),2005.

[9] M. Ye, C. F. Li, G. H. Chen, and J. Wu, "EECS: An Energy Efficient Clustering Scheme in Wireless Sensor Networks", in Proceedings of IEEE Int'l Performance Computing and Communications Conference (IPCCC), 2005.