Energy Efficient Techniques for Data aggregation and collection in WSN

Sumit Chaudhary[1], Neha Singh[2], Avinav Pathak[3] and A.K Vatsa[4]

[123]IIMT Institute of Engineering & Technology, Meerut, U.P, India
iimtsumit@gmail.com,singh.neha773@gmail.com, avinav05@gmail.com
[4]Shobhit University, Meerut, U.P, India
avimanyou@rediffmail.com

ABSTRACT

A multidisciplinary research area such as wireless sensor networks (WSN) have been invoked the monitoring of remote physical environment and are used for a wide range of applications ranging from defense personnel to many scientific research, statistical application, disaster area and War Zone. These networks are constraint with energy, memory and computing power enhance efficient techniques are needed for data aggregation, data collection, query processing, decision making and routing in sensor networks. The problem encountered in the recent past was of the more battery power consumption as activity increases, need more efficient data aggregation and collection techniques with right decision making capabilities. Therefore, this paper proposed the efficient and effective architecture and mechanism of energy efficient techniques for data aggregation and collection in WSN using principles like global weight calculation of nodes, data collection for cluster head and data aggregation techniques using data cube aggregation.

KEYWORDS

Wireless Sensor Network (WSN), Energy Efficient, Clustering, Cluster Head Selection, Data Aggregation, Data Collection, Data Cube.

1. INTRODUCTION

A multidisciplinary research area such as wireless sensor networks [2, 4, 6, 7, 18] where close collaboration between users, application domain experts, hardware designers, and software developers is needed to implement efficient systems.

Wireless sensor networks consist of small nodes with sensing, computation, and wireless communications capabilities. Many routing, power management [17, 19, 24], and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue. Routing protocol [5, 20] in WSNs might differ depending on the application and network architecture.

Sensor nodes are small, inexpensive battery power wireless devices with only few memory spaces and processing power. A sensor network is a collection of sensor nodes cumulated in an ad-hoc fashion. The parameter being used to control the overall energy and battery power are rationalized to provide best possible solution. Accuracy can be a matter of consideration as distance varies from cluster to cluster but can be used to provide a variety of research application, mobile communication and location tracking system.

DOI : 10.5121/ijcsea.2012.2405

Wireless Sensor Network [1, 2, 4, 6] generates a large amount of data that has to be aggregated at various levels. A multidimensional aggregation approach [7, 9, 13, 14, 15] is considered for exhibiting the node parameters for each network. Bandwidth, memory, signal strength, time, battery power etc. have been utilized to examine the performance of a sensor network, its efficiency can be enhanced by reducing the cost of cluster development. Sensor nodes are becoming popular in mobile communication technology due to their fast communication speed and better result generation in information systems.

Sensor nodes are useful in disaster, war zone and several modern technology like mobile technology, laser technology etc where the data has to be transferred accurately and in a fraction of time where each node is responsible for the extraction and transfer of data such that the data to be exchanged cannot be lost on its way to the receiver.

Data Aggregation uses the parameters of nodes joining the cluster so that the data attributes are selected and stored in an aggregated format for further evaluation and usage. Aggregation refers to the technique that models the data and information in a dimensional construct that is easy to store and retrieve. The data collection technique is being employed to store and collect data items and parameters on a database server. All the related data items are stored in accessible data form. The problem encountered in the recent past was of the battery power consumption [5, 6], more efficient data aggregation and collection techniques with right decision making capabilities, Therefore, this paper proposed the efficient and effective architecture and mechanism for mentioned problem using principles like global weight calculation of nodes , data collection for cluster head and data aggregation techniques using data cube aggregation.

This paper is organized into sections. The sections provide the information about the parts and modules of the research undertaken by the current statements. Section-I provides the introduction. On basis of literature survey the Section - II includes the background of the paper, Section - III deals with the proposed work for energy efficient data collection and aggregation techniques in WSN. The conclusion is stipulated in Section - IV. The proposed work may be extended further with reference to the different situations are mentioned in section - V under heads of future aspect. Finally Section - VI mentioned all references used in this paper under heads of References.

2. BACKGROUND

A multifaceted approach in the field of WSN for research has been undertaken in recent past. Several Parameters were used for decision making, especially in disaster and war zone with a limited field of works. Therefore the efficiency and power consumption [5, 6] was of very much concern and conflict in usage. Wireless sensor nodes were initially used to transfer the information about the node with associated data and exchange the facts along with the existing base station of the mobile user. The user had to suffer with considerable energy loss and bandwidth consumption [17, 18, 21]. There is no efficient techniques were present in previous ages that could enable a better power and battery efficient framework for data transfer. Continuous research and development in the field has provided new improved solutions so that the clustering methods can be used for efficient outputs. The flexibility, fault tolerance, high sensing fidelity, low cost, and rapid deployment characteristics of sensor networks create many new and exciting application areas for remote sensing [3, 5, 9, 13, 15, 23]. This wide range of application areas will make sensor networks an integral part. However, realization of sensor networks needs to satisfy the constraints introduced by factors such as fault tolerance, scalability, cost, hardware, topology change, environment, and power consumption.

A WSN consists of a large number of sensor nodes. Each sensor node senses environmental conditions such as temperature, pressure and light and sends the sensed data to a base station (BS), which is a long way off in general. Since the sensor nodes are powered by limited power batteries [5, 6] in order to prolong the life time of the network, low energy consumption is important for sensor nodes. In general, radio communication consumes the most amount of energy, which is proportional to the data size and proportional to the square or the fourth power of the distance. In order to reduce the energy consumption, a clustering and data aggregation [7, 9, 13, 14, 15, 23] approach has been extensively used. In this approach, sensor nodes are divided into clusters, and for each cluster, one representative node, which called cluster head (CH), aggregates all the data within the cluster and sends the data to BS. Since only CH nodes need long distance transmission, the other nodes save the energy consumption. Efficient data collection [2] in WSN plays a key role in power conservation. It has spurred a number of researches focusing on effective algorithms that reduce power consumption with effective in-network aggregation techniques. Up to now, most approaches are based on the assumption that data collection [11] involves all nodes of a network. There are large numbers of queries that in fact select only a subset of the nodes in a WSN. Thus, the selective queries like queries that request data from a subset of a WSN. It is also argue that selective queries are an important class of queries that can benefit from algorithms that are tailored for partial node participation of a WSN.

3. PROPOSED WORK

The proposed work is discussed in Section 3.1 and 3.2 are as follows.

3.1. Architecture of energy efficient techniques for data aggregation and collection in WSN

- **Sensor node:** Sensor node is the primary working component that performs various activities like cluster creation, data collection, transfer data among switching centers and so on.
- **Sensors Parameters:** The parameters like bandwidth, memory, time-to-live, radio signal strength Indicator (RSSI), MRIC are identification factors for WSN architecture.
- **Newly Arriving Node:** Current numbers of nodes present in the cluster and newly arriving nodes are managed by functional parameters used in cluster creation parameters.
- **Cluster Creation:** Collection of nodes that satisfy the parameter requirements ultimately form a cluster.
- **Cluster Head Assignment:** An individual cluster head is selected by evaluating the minimum cost of that node who will serve as the head.
- **Threshold battery power:** Threshold battery power is checked or evaluated against the present status of battery of the cluster head.
- **Collection of Data:** Data is collected from various nodes participating in the communication and stored in a remote location for further access.
- **Query Processor:** User defined queries are accepted and generated at clients end and data is retrieved from the database for a specific query.
- **Aggregation:** Aggregation technique like data cube collection approach has been used for storage of node parameter values and cluster locations (Base Station). Data cube approach supports various phases in a graphical format that is easy to understand and access.

3.2. Working Principle

The working of WSN proposed architecture model illustrated in Figure -1, which starts working by selecting group of nodes and divided into clusters. These clusters will satisfy the intended parameter requirements and conditions. The parameters like RSSI, TTL, MRIC, bandwidth, battery consumption have been used to determine the number of nodes that would be considered in a cluster. Thereafter a cluster head (CH) is selected among nodes lies inside the every cluster. CH will be responsible for administration of all other nodes inside respective cluster and collecting the data from the nodes inside the cluster and transferring the data to the neighboring cluster head for further information exchange and updation. The newly arrived nodes will be assigned as cluster head if the global cost of arrived node is minimum , otherwise other cluster nodes will be given opportunity to participate and global cost is again recalculated. Thereafter the data aggregation approach is presumed as the collection of data and various queries from the user end are checked and transformed into low level schemes by a query processor. All data collected and aggregated is stored at a storage location in database server. Finally at last the data is aggregated by data cube approach and all the aggregated data will be transfer to the base station for further use.

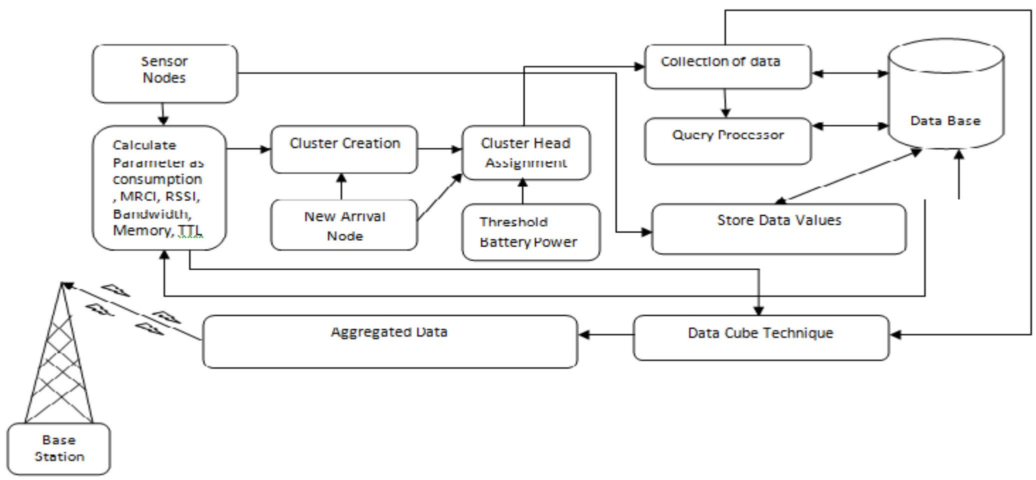

Figure 1. Architecture of Data Collection and aggregation for WSN.

3.3. Mechanism of energy efficient techniques for data aggregation and collection in WSN

The proposed mechanism is discussed into four phases

Phase 1 - Cluster and Cluster Head creation in WSN

Step 1:- Assign node id for each node of WSN:

```
No of node=N
For (i=0; i<N; i++)
{
 ss_id[i] =RandomNoGenerator ( );   // ss_id is Sub System ID
 }
```

Step 2:- cluster creation:

```
ClusterCreation ( )
{
For (ss_id=0; ss_id<N; ss_id++)
{
        If (B_con >= A_pr && P_m>=T_m)      // B_con = Battery consumption
                                            // A_pr =Present Cluster battery level
                                            // P_m= Present memory
                                            // T_m= Total cluster memory
        {
                Node will not be Included in Cluster
        }
        else if ((TTL_new>TTL_clst))
                                            // TTL_new= Time To Live new node
                                            // TTL_clst=Time To Live cluster

    If ((MRICnew>MRICclst) && (RSSInew<RSSIclst) && (Bandnew>Bandclst))
                        /* MRIC_new= Multicast Routing Information Cost
                           MRIC_clst=Multicast Routing Information Cost of
                                 cluster
                           RSSI_new=Reverse Signal Strength Indication of new
                                 node
                           RSSI_clst =Reverse Signal Strength Indication of new
                                 node
                           Band_new= Level Bandwidth new node
                           Band_clst= Level Bandwidth cluster
                        */
        {
                No new node can join Cluster ( );
        }
    else
        {
                Join cluster;
        }
    }
```

Step 3:- ClusterHeadAssignment:

```
ClusterHeadAssignment ( )
{
Total no of node = n;
For (cluster_1 to cluster_n)
{
For (i=0; i<n; i++)
{
/*initialize parameter for cost evaluation*/
B_con[i] = {}; /* Battery consumption at node i*/
A_pr[i] = {}; /*Present Cluster battery level at node i*/
P_m[i] = {}; /*Present memory at node i*/
T_m[i] = {}; /*Total cluster memory*/
TTL_new[i] = {}; /*Time To Live new node*/
```

TTL_{clst}[i] = {}; /*Time To Live cluster*/
$MRIC_{new}$[i] = {}; /* Multicast Routing Information Cost at node i*/
$MRIC_{clst}$[i] = {}; /* Multicast Routing Information Cost of cluster*/
$RSSI_{new}$[i] = {}; /* Reverse Signal Strength Indication of new node*/
$RSSI_{clst}$ [i] = {}; /* Reverse Signal Strength Indication of new node*/
$Band_{new}$[i] = {}; /* Level Bandwidth new node*/
$Band_{clst}$[i] = {}; /* Level Bandwidth cluster*/

/* now calculate the cost for each node */
C (i_1) = (A_{pr}[i]* $Band_{new}$[i] /B_{con}[i]*$Band_{clst}$[i])
C (i_2) = (Pm[i] * TTL_{new}[i] /T_m[i] *TTL_{clst}[i])
C (i_3) = ($MRIC_{new}$[i]*$RSSI_{new}$[i]/ $MRIC_{clst}$[i]* $RSSI_{clst}$ [i])
}
Find out min. global cost for each node.
GC_{min}=∑ C (i_1) + C (i_2) + C (i_3)
}
min = 0; max = 0;
{
for (i=1 to n)
{
C (i_1) = (A_{pr}[i]* $Band_{new}$[i] /B_{con}[i]*$Band_{clst}$[i])
C (i_2) = (P_m[i] * TTL_{new}[i] /T_m[i] *TTL_{clst}[i])
C (i_3) = ($MRIC_{new}$[i]*$RSSI_{new}$[i]/ $MRIC_{clst}$[i]* $RSSI_{clst}$ [i])
GC_{min} = C (i_1) + C (i_2) + C (i_3);
If (max< GC_{min})
{
max = GC_{min};
}
else if (min> GC_{min})
{
min = GC_{min};
}
}

Step 4:-Newly Arriving Node In WSN:

NewlyArrivingNodeInWSN ( )
{

- Calculate the following factor B_{con}[i], A_{pr}[i], Pm[i], $Band_{new}$[i], $Band_{clst}$[i], TTL_{new}[i], T_m[i], TTL_{clst}[i], $MRIC_{new}$[i], $RSSI_{new}$[i], $MRIC_{clst}$[i], $RSSI_{clst}$ [i];
- Calculate C (i_1), C (i_2), C (i_3);
- Calculate GC_{min};
- If (newly arrive node GC_{min} < cluster head GC_{min})
  {
  Assign new node as cluster head;
  }

else
{
Join cluster ( );
}
}

Step 5:-Threshold For Battery Power:

```
ThresholdBatteryPower ( )
  {
      Check the battery power of cluster head
      If (CH_battery power < P_THRESHOLD)
      {
      CH sends battery power low signal to its neighbor & recalculates the global weight for
      each node and minimum global weight node assign as cluster head.
      }
      else
      {
      No requirement;
      }
  }
```

Phase 2 – Cluster head data collection:

ClusterHeadDataCollection ( )
{

- The number of nodes has to be associated with various parameter or node parameters.
- All the nodes are aggregated at cluster level.
- The parameters useful for node information are collected and stored at each cluster head
- The cost is evaluated on the basis of collected parameters.
- Minimum global cost is evaluated.
- All the cost parameters are send to the cluster head for further association
- Next the transfer is to the base station.

}

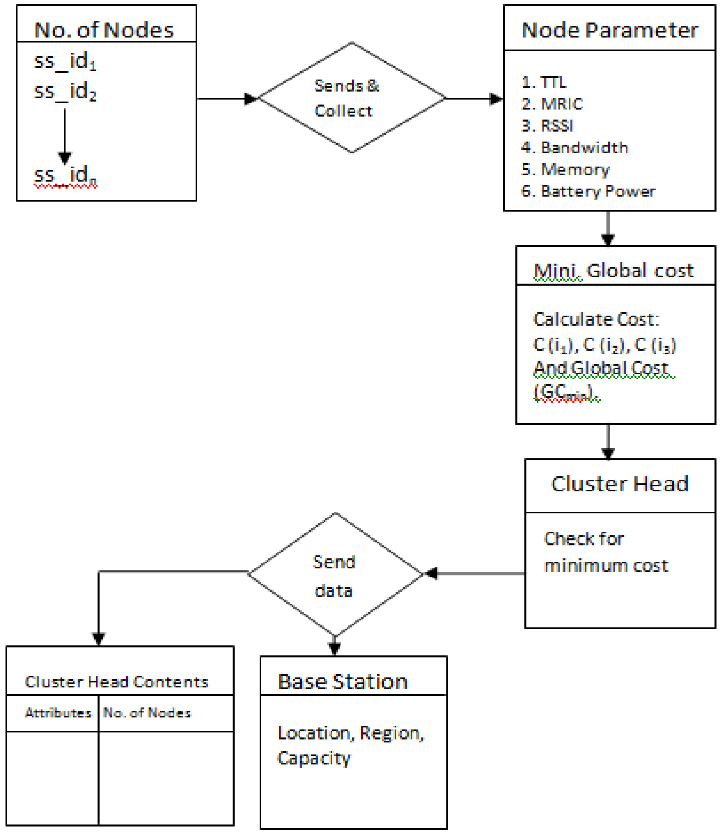

Figure 2. UML diagram of data collection technique

Phase 3 – Data aggregation technique based on data cube aggregation

Data Cube Aggregation: It is a multidimensional approach for data aggregation. The values are stored in separate cell of a data cube, each phase of cube is divided into separate rows & columns and each value & node such as consumption, bandwidth, MRIC, RSSI etc are represented at the beginning of rows.

Parameter/ss_id	1	2	3	4	5	6	7	8	9	10	11
Consumption											
Bandwidth											
RSSI											
MRIC											
Memory											
TTL											

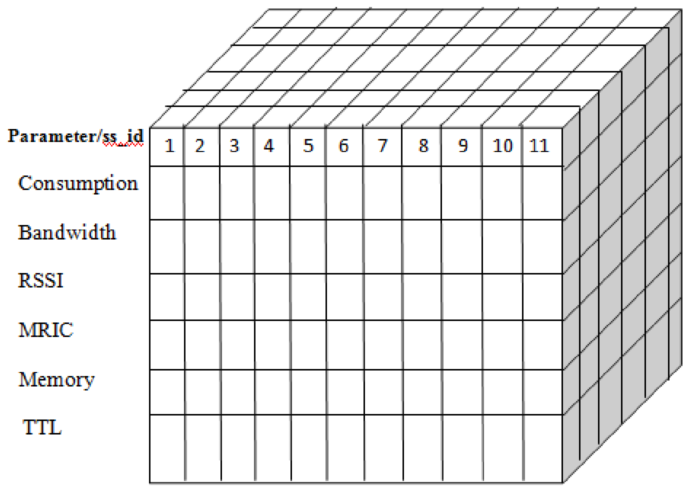

Figure 3. Data cube technique of data aggregation

4. CONCLUSIONS

The paper widely acclaims the improved technology for energy efficient techniques for data aggregation and collection in WSN. The paper provides the accurate usage of battery and low power consumption so that the user can send multiple messages in limited resources. The parameters that are used manage the cluster head generation, and the node selection methods so that the message can be easily transferred under such circumstances with right decision using principles like global weight calculation of nodes, data collection for cluster head and data aggregation techniques using data cube aggregation.

5. FUTURE SCOPE

The proposed architecture and mechanism is efficient and effective but the field of scalability, heterogeneous behavior of node and base station, mobility of sensor node is fully composite with respect to the ongoing advancement in this field. The work done related to mentioned methodology has been effectively stipulated in mobile computing, disaster, war zone and infrastructure-less environment etc. All the approaches are designed to be user- friendly and more importantly is a futuristic gerard of technology.

REFERENCES

[1] Guan Xin, "An Energy-Efficient Clustering Technique for Wireless Sensor Networks", IEEE Conference, ISBN: 978-0-7695-3187-8, 25 July 2008

[2] Mohammad Hossein Anisi, Abdul Hanan Abdullah, Shukor Abd Razak, "Energy-Efficient Data Collection in Wireless Sensor Networks", Wireless Sensor Network, pp.329-333, October 2011.

[3] Ademola P. Abidoye, Nureni A. Azeez, Ademola O. Adesina, Kehinde K. Agbele, "A Novel Clustering Algorithm for Energy Efficiency in Wireless Sensor Networks", pp.307-312, September 2011.

[4] Xin Guan, Lin Guan and Xingang Wang, "A Novel Energy Efficient Clustering Technique Based on Virtual Hexagon for Wireless Sensor Networks", Volume 7, Issn 1349-4198, pp. 1891-1904, April, 2011.

[5] Shio Kumar Singh, M P Singh, D K Singh, "A Survey of Energy-Efficient Hierarchical Cluster-Based Routing in Wireless Sensor Network's", 570 Volume: 02, Issue: 02, pp: 570-580 (2010).

[6] Shio Kumar Singh, M P Singh, and D K Singh, "Energy Efficient Homogenous Clustering Algorithm for Wireless Sensor Networks", International Journal of Wireless & Mobile Networks (Ijwmn), Vol.2, No.3, August 2010.

[7] D. Kumar, T.C. Aseri, R.B. Pate, "Energy Efficient Clustering and Data Aggregation Protocol for Heterogeneous Wireless Sensor Networks", ISSN 1841-9836, E-Issn 1841-9844 Vol. No. 1, pp. 113-124, (March 2011).

[8] Carlos F. Garcia Hernandez, Pablo H. Ibargüengoytia-González, Joaquín Garcia Hernandez, and Jesus A. Perez Diaz, "Wireless Sensor Networks and Applications: A Survey", Ijcsns International Journal of Computer Science and Network Security, Vol.7 No.3, pp. 264-273, March 2007.

[9] Kiran Maraiya, Kamal Kant, Nitin Gupta, "Architectural Based Data Aggregation Techniques in Wireless Sensor Network: A Comparative Study", International Journal on Computer Science and Engineering (Ijcse), ISSN: 0975-3397, Vol. 3 No. 3, Pp. 1131-1138, Mar 2011.

[10] Noritaka Shigei, Hiromi Miyajima, Hiroki Morishita, Michiharu Maeda, "Centralized and Distributed Clustering Methods for Energy Efficient Wireless Sensor Networks", Proceedings of the International Multiconference of Engineers and Computer Scientists 2009 Vol Iimecs 2009, pp. 18 - 20 March, 2009.

[11] Lars Kulik, Egemen Tanin, and Muhammad Umer, "Efficient Data Collection and Selective Queries in Sensor Networks", S. Nittel, Gsn 2006, Lncs 4540, pp. 25–44, 2008. _C Springer-Verlag Berlin Heidelberg, pp. 25-44, 2008.

[12] Jaydip Sen., "Secure and Energy-Efficient Data Aggregation in Wireless Sensor Networks", IEEE Explorer, Volume: 2, Issue: 4, pp: 384–391, Symposium On(2003).

[13] K. Akkaya, M. Demirbas, and R. S. Aygun, "The Impact of Data Aggregation on the Performance of Wireless Sensor Networks", Wiley Wireless Communications and Mobile Computing (Wcmc) Journal, Vol. 8, pp. 171-193, 2008.

[14] H. C¸ Am, S. Ozdemir, P. Nair, and D. Muthuavinashiappan, and H.O. Sanli, "Energy-Efficient and Secure Pattern Based Data Aggregation for Wireless Sensor Networks", Special Issue of Computer Communications on Sensor Networks, Pp. 446-455, Feb. 2006.

[15] R. Mudumbai, D. R. Brown, U. Madhow, and H. V. Poor, "Distributed Transmit Beamforming: Challenges and Recent Progress," Vol. 47, pp. 102– 110, February 2009.

[16] J. Feng, C.-W. Chang, S. Sayilir, Y.-H. Lu, B. Jung, D. Peroulis, and Y. Hu, "Energy-Efficient Transmission for Beamforming in Wireless Sensor Networks," 2010 7th Annual IEEE Communications Society Conference, pp. 1 –9, June 2010.

[17] E. Liu, Q. Zhang, and K. Leung, "Residual Energy-Aware Cooperative Transmission (React) in Wireless Networks," In Wireless and Optical Communications Conference (Wocc), pp. 1–6, May 2010.

[18] M. Ahmed and S. Vorobyov, "Collaborative Beamforming for Wireless Sensor Networks with Gaussian Distributed Sensor Nodes," Wireless Communications, IEEE Transactions, Vol. 8, No. 2, pp. 638 –643, Feb.2009.

[19] K. Zarifi, A. Ghrayeb, and S. Affes, "Distributed Beamforming for Wireless Sensor Networks with Improved Graph Connectivity And Energy Efficiency," Signal Processing, IEEE Transactions, Vol. 58, No. 3, pp. 1904–1921, March 2010.

[20] M. Z. Siam, M. Krunz, and O. Younis, "Energy-Efficient Clustering Routing for Cooperative Mimo Operation in Sensor Networks," In Infocom, pp. 621–629, 2009.

[21] J. Heidemann, F. Silva, C. Intanagonwiwat, R. Govindan, D. Estrin, and D. Ganesan, "Building Efficient Wireless Sensor Networks with Low-Level Naming", In Proceedings of the Eighteenth Acm Symposium, pp: 146-159 October 2001

[22] C. Intanagonwiwat, D. Estrin, R. Govindan, and J. Heidemann, "Impact of Network Density on Data Aggregation in Wireless Sensor Networks", In Icdcs-22, November 2001.

[23] Mohamed Watfa , William Daher And Hisham Al Azar, "A Sensor Network Data Aggregation Technique", International Journal of Computer Theory and Engineering, Vol. 1, No. 1, pp. 1793-8201, April 2009.

[24] Mohammad Mehrani, Ali Shaeidi, "A Novel Energy Efficient, Distributed, Clustering Based Network Coverage Method for Enormous WSN", Global Journal of Computer Science and Technology Volume 11 Issue 4 Version 1.0, pp. 59-65, March 2011.

BIBLIOGRAPHY OF AUTHORS

Sumit Chaudhary is presently working as Assistant Professor (CSE) at IIMT Institute of Engineering & Technology, Meerut, (U.P.), INDIA. He received his M.Tech (Computer Engineering) degree from Shobhit University, Meerut, (U.P) and B.Tech (C.S) degree with Hons. from SCRIET, C.C.S University Campus, Meerut, (U.P). His area of research includes Wireless Sensor Networks (WSN), MANET (Mobile Ad-Hoc network) and Neural Network.

Neha Singh is presently working as Assistant Professor (CSE) at IIMT Institute of Engineering & Technology, Meerut, (U.P.), INDIA. She received her M.Tech (Computer Engineering) degree from Shobhit University, Meerut, (U.P) and B.Tech (C.S) degree with Hons. from SCRIET, C.C.S University Campus, Meerut, (U.P).). Her area of research includes Wireless Sensor Networks (WSN) and MANET (Mobile Ad-Hoc network).

Avinav pathak is presently working as Assistant Professor (CSE) at IIMT Institute of Engineering & Technology, Meerut, (U.P.), INDIA. He is pursuing his M.Tech (Computer Engineering) from IIMT Engineering College, Meerut, (U.P) and B.Tech (C.S) degree from Vidya College of Engineering, Meerut, (U.P.).

Avimanyou Kumar Vatsa is working as Assistant Professor and Coordinator - CSE at Shobhit University, Meerut, (U.P.), INDIA. He obtained his M-Tech (Computer Engineering) with Hons. from Shobhit University and B-Tech(I.T.) from V.B.S. Purvanchal University, Jaunpur (U.P.). He has worked as software engineer in software industry. He has been in teaching from more than one decade. During this short period of time, he has been supervised several dissertation of M.Tech. students. He is on the editorial board and reviewers of several international and national journals in networks and security field. He has been member of several academic and administrative bodies. During his teaching he has been coordinated many Technical fests and National Conferences at Institute and University Level. He has attended several seminars, workshops and conferences at various levels. His many papers are published in various national, international journals and conferences. His area of research includes MANET (Mobile Ad-Hoc network), Network Security, Congestion Control and VOIP-SIP (Voice over IP).