International Journal of Pure and Applied Mathematics
Volume 117 No. 15 2017, 299-312
ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)
url: http://www.ijpam.eu
Special Issue

Reduction of Data Redundancy Using Data Aggregation in Wireless Sensor Networks

[1]R.Mohansundaram,[2] M. Thenmozhi, [3]AdwaithSreekumar,
[4]K.S. ArunAdithiyan
[1,3,4]School of Computer Science and Engineering,
VIT, Vellore, TN, India.
[2]School of Social Sciences & Languages,
VIT, Vellore, TN, India.

Abstract

Wireless sensor networks (WSN), is a widely researched topic, since it has many interesting applications.In WSN the nodes are self-configurable i.e. they autonomously organize themselves into communication networks and begin sensing data and propagating it to the nearest base station. Data aggregation is a technique that is used to eliminate the data redundancy in the network, since the same data can be transmitted by multiple sensors. In this paper, our proposed work is to develop an efficient algorithm for grid formation over an irregular geographical area and then selecting the best path for sending the aggregated data to the base station.

Key Words: Wireless sensor networks, data aggregation.

1. Introduction

Wireless Sensors Networks (WSN's) is an attractive area for the researchers since it has a wide range of application. The sensors in these networks can efficiently monitor the environment. They are integrated with micro sensing devices, computational units, low power and low cost signal processingunits [2]. Their functionality is not restricted to sensing and gathering the data. They are also capableof processing the data and transmitting it to the nearest base station. The potential of WSN's include variety of application such as object detection, military intelligence, wildlife monitoring, detection of machine failures, tracking enemies in the battle field, health care monitoring, under water surveillances etc. Theconcept of micro-sensingand wirelessconnection of thesenodes promisesmany newapplication areas such asdefence, environment, health, domestic and other commercial areas [6][7]. The sensors which are battery powered are deployed over a geographical area for gathering variety of information. The areas of interest, where the sensors are randomly deployed,are termed as sensing fields. Once deployed in the sensing field, it is very difficult to replace these sensors when they are dead since the environment can be hostile [1]. Detecting or monitoring an event by using large number of sensors, is known as Sensor Network. We don't need to program the sensors, as they are programmed at the time of installation. For example, if we need to use a sensor for a security purpose, the sensor should be programmed for the security purpose. In real time,sensors are capable to detectwhat is happening and what the event is[5]. This ensures functionality in critical times. A sensor has limited sensing range beyond which it is unable to communicate with other sensors in the network. The range of the sensor can be broadly classified into three different range such as Transmission range, Detection range and Interference range[8][9].Fig.1 shows the diagrammatic representation of different ranges of a sensor.

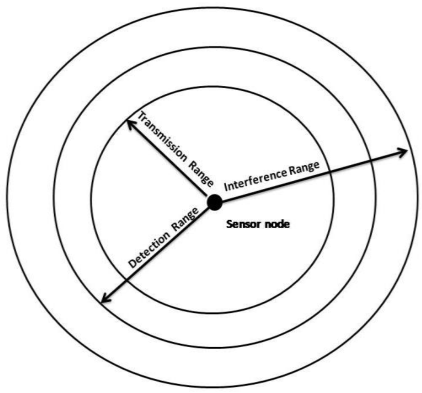

Figure 1: Different Range of a Sensor

Transmission Range: This is the smallest range of the sensor. Within this range, the sensor can easily sense the required data with very low error rate. The communication between different sensors is also possible in this range. The channel setup in the transmission range contains negligible amount of noise, which does not interfere with the communication between any two sensors.

Detection Range: Within this range, the sensor can detect the data and is able to distinguish it from the back ground noise, but the error rate is too high to establish communication between the sensors.

Interference Range: The Interference range is the outer most range of the sensor. Within this range, the frequencies of different sensors interfere with the frequencies ofeach other. The communication between the sensors is not possible within this range, as it is very difficult to establish communication.

The sensors are self-configurable i.e. they autonomously organize themselves in the communication network and start sensing and propagating data to the nearest BS. As a huge number of sensors nodes are deployed over a region, situations like data redundancy occurs frequently at the BS[6]. Due to this data redundancy, the cost of data transmission increases and the life time of the network decreases drastically. The data redundancy can be eliminated by using a technique known as Data Aggregation [11]. For our modelling purposes in this paper, we make a simplifying assumption that the aggregation function is such that each intermediate node in the routing network transmits a single aggregate packet even if it receives multiple input packets. This technique reduces the traffic load of the network by converting multiple data packets into single data packets. The Data aggregation increases the efficiency of the network and thus reduces the consumption of resources such as energy. Data aggregation offers several advantages [10] for the network and they are: -

1. Data aggregation Process is used to enhance the strength of the sensors (robustness) and the information will be accurate.
2. By using data aggregation, we can enhance the traffic load.

The data aggregation technique is classified as Structured Data Aggregation [11]and Structure-free Data Aggregation[12]. In the structure based technique, a pre-determined and a pre-organized structure is used for the data collection from the sensing field whereas, in the structure-free technique there is no pre-planned structure for data collection. There are various advantages in structure based communication over structure free communication.For instance, the route discovery overhead of structure based communication is less as compared to structure-free aggregation,since the paths are constructed at the time of network setup.Whereas, in structure-free aggregation, the path needs to be computed for each round of data transmission. We can take an efficient routing decision in the structured technique as the aggregation points are fixed during the path establishment [4]. In structured communication, the aggregation points are aware of the membersof the descendent node. Thus, the waiting time and the expected volume of data to be aggregated can be computed easily. Structured data aggregation reduces the chance of transmitting multiple copies of the same data towards the aggregation point. Any error that has occurred during data transmission can be easily detected in structured data aggregation. As structured data aggregation is well planned, load balancing can be easily performed among the sensors in the network[3]. Therefore, we are using the Structured Data Aggregation technique, which is further classified into different types based on the structured formed for aggregating and transmitting data in a network. These structures are Chain, Tree[12], Cluster[13] and Grid[7], which are often use for communication among the sensors. We are using a grid based structure for our protocol which has various advantages over other structures. The disadvantage of using a Cluster based structure is that the sensor nodes areunevenly distributed and are concentrated at some part of the network[6]. The Chain based structure incurs communication delay, if the chain is single and long. In the Tree based structured, one side of the tree may expand more heavily thanthe anotherside, which affects the load balancing of the network. Therefore, these problems can be overcome by the grid based structure. The grid based technique uses the “Divide and Conquer” strategy which divides the whole sensing field into small grid cells and techniques like Cluster, Chain or Tree based technique can be incorporated within it.

There are various parameters which should be considered during the time of construction of a Grid network such as Energy-efficiency, Network-lifetime, Data accuracy and Latency.

Objective: The objective of the proposed work is to develop an efficient algorithm for grid formation over an irregular geographical area and to then select the best path for sending the aggregated data to the BS.

2. Related Work

Over the years, many protocols have been proposed for extending the network lifetime by efficiently distributing the power among the different functions of WSN’s. As stated before, there are many protocols for structure based communication like Chain, Tree, Cluster and Grid. In Cluster Based Data Aggregation, the nodes are grouped in a cluster and a node is elected which is referred to as cluster head and it is responsible for aggregating and transmitting data to the BS. In Chain Based Data Aggregation, a node sends its data is to its nearest neighbour who further forward the data to its neighbour and so on until the data is reached to the BS. The Tree based data aggregation scheme elects a root which is generally a BS and the intermediate nodes are responsible for aggregating data and sending it to the root or BS. In Grid based data aggregation technique, the whole sensing field is first divided into grid of some size and an aggregator is fixed in each grid, which is responsible for data aggregation. In this paper, our main focus is on Grid Based Data Aggregation technique, and hence we are discussing some of them.

Table 1

Protocol Name	Mechanism	Advantage	Disadvantages
TTDD	Data transmission source to multiple mobile sink.	Suitable for Event driven system.	Grid is constructed on per source basis which increases the cost overhead.
EEDD	Virtual grid construction.	The active mode turns into sleep mode when they are not in use which saves lot of energy.	It does not maintain a query routing path for sending the data back to the sink.
GCR	Traditional flooding used in grid based network.	Load balancing was used to distinguish routing load over all the nodes.	Huge amount of duplicate packets of same data is generated.
GBDD	Grid construction based on sink appearance.	Diagonal forwarding of data is possible.	Life time of grid is based on the life of the sink, which can lose data if the life time of the sink gets expired.
DDSMSGB	Macro and micro mobility data dissemination scheme.	It can trace the macro movement.	Inefficient for handling multiple sources due to buffer overflow.
RADAT	Adaptive routing mechanism.	It uses techniques like temporal correlation and spatial correlation for data aggregation.	The sensor nodes are to be placed at an equal distance which is extremely difficult and not viable.
EEGDG	Combination of grid and clustering technique.	A new grid node is chosen in each turn of data transmission for balancing the energy consumption among the nodes.	If the chain is long then delay in data transmission increases.
GBDAS	Divides the whole network into a two dimensional logical grid.	Reduces the time consumption by sending two tokens in opposite directions.	If the chain leader fails, the whole network will fail.
CBDAS	Combination of chain and grid techniques.	Only the cell head is responsible for forwarding the data.	A long chain can form which can incur delays in data transmission.

3. Proposed Work

In our proposed protocol, we are considering a sensing field which is irregular in shape. As the area of interest for gathering information is basically a geographical area, so this area can never be in a regular shape. The geographical area, which is the area for collecting different types of information, is first determined by the Base Station (BS). The sensors are then deployed over this Geographical area randomly. This determined area is irregular and the structure is less in shape. We are assuming that the sensors are aware of their location using GPS technique. We are enclosing this sensing field within a rectangular area. This rectangular area is drawn by taking the tangent at four extreme points of sensing field. As the sensors are aware of their coordinate positions, we can calculate the four extreme point of the sensing field by considering the lowest and highest values of x and y. The coordinates which has the lowest value of x and the lowest value of y is represented as x_min and y_min, respectively. Similarly, the coordinates which has the highest value of x and the highest value of y is represented as x_max and y_max, respectively. Consideringx_min, x_max, y_min and y_max, the tangent is drawn which is finally enclosed in a rectangular structure. After enclosing the sensing field, we can calculate the area of this field by using the formulae Area= L*B where L and B is the Length and breadth of the rectangular area, respectively. We can now divide the whole enclosed structure into cells of p*qnumber of cells. The size can be calculated by using the formulae size =3/4*fc, where fc is the frequency range constant set at the network initialization state.

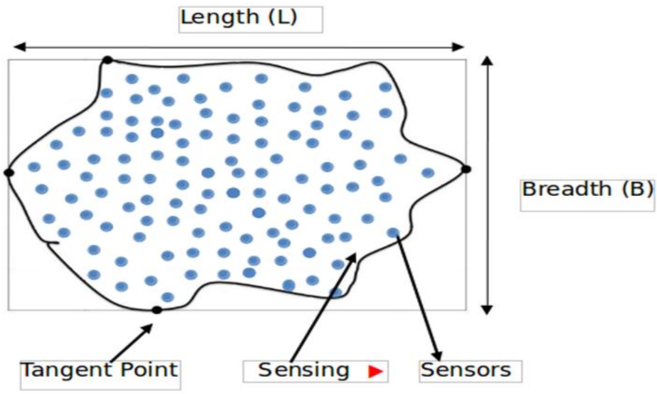

Figure 2: Selection of Tangent Point for an Irregular Geographical Area

Figure 2 shows the selection of tangent points for an irregular geographical area where sensor nodes are deployed randomly. After the tangent lines are drawn, the construction of the Grid lines or cells get initiated. The algorithm for grid construction is shown in Table 2.

Table 2: Algorithm for Grid Construction

Algorithm for Grid Construction *Form_Grid( )* ***If** sensing field is not enclosed within Rectangular field* *Take tangent on four extreme point of the sensing field.* *Return tangent points to the Base station* ***End if*** *While rectangular area is not divided into cells* *Divide the whole rectangular area in cell* *Cell_area*=p*q*// where* q=*3/4*frequency of a single sensor* ***Return**Cell_area* *Exit*

- **Selective cell head:** The proposed protocol forms the selective cell head for the grids. The cell head consumes more energy during communication and cell formation. More number of cell heads distributes the data aggregation process throughout the sensing area. Thus, data convergence to the aggregation point i.e. cell head reduces. The selective cell head can increase the data convergence towards the aggregation point. Minimum number of cell heads, reduces the inference loss during data aggregation. The amount of memory space required to store the data at the intermediate node also reduces by using selective cell head technique.

In selective cell head technique, the cells will have a cell head, if it encloses more than 3/4th of the sensing area. The cells which encloses less than 3/4th of sensing area will not contain any cell head and the sensor deployed in this area is dependent on the neighbouring cell head for aggregating and forwarding the data to the BS. The selective cell head calculates its cell id [cx,cy] from its geographic location x,y as cx=x0+I,cy=y0+j, where I is the row number, j is the column number and (x0,y0) is the location of the virtual origin set at the network initialization stage. The ordinary sensors maintain a table which will only contain its own id which is randomly assigned and the id of selective cell head where-as the selective cell head will have a table which will contain its own cell ID, neighbouring cell head ID, the route through which the aggregated data can be routed to the BS and the amount of residual energy.

Initially all the nodes have same amount of energy so any random node can be elected as selective cell head. After the first round of data transmission the energy of selective cell head decreases more rapidly than an ordinary node. Therefore, a sensor which is adjusted as the selective cell head will die more quickly than an ordinary cell. Therefore, an energy calculation is required for selective cell head. A selective cell head will remain active until its energy is greater than the threshold energy. The threshold energy (THenergy) can be calculated by the formula, (THenergy)= Senergy+Tenergy+DAenergy, where Senergyis the amount of energy required for sensing the event, Tenergyis the amount of energy required for transmitting the fused data and DAenergyis the energy required for aggregating the sensed data received from the sub nodes. All the Selective Cell Heads are joined together in a network forming a tree like structure. The algorithm for the tree construction in the grid is given below in Table 3.

Table 3: Algorithm for the Formation of Tree Structure for Gathering the Data

Algorithm for the formation of Tree structure for gathering data.
Sink initiates the tree formation
For *each node in the sensing field do*
If*(Sink energy is greater than Threshold energy)* ***then***
Broadcast form_tree(S_ID,S_LOC, path_Info,S_Energy)
If(*the energy of Selective cell head is greater than the threshold energy)*
Join_tree(SS_LOC, SS_Energy)
Construct a tree structure consisting of all the Selective cell head with the sink as the root.

- **Selection of Sink node:** The BS generally communicates with a single sensor in the sensing field which is known as the sink node. This sensor node is responsible for transmitting the aggregated data of whole sensing area to the BS. The election of the sink node starts after the selection of the selective cell head for the cell is completed. The BS is responsible for selecting a sink node on the basis of distance and energy. The BS will broadcast a SS (Selective Sink) message to the Selective cell heads. The Selective cell head, which is closest to the BS and has high residual energy, will reply to this message. If two or more sensors are at same distance from the BS and have same amount of residual energy, then the sink node is selected on the basis of highest cell id by the BS. The node which is elected as the sink node will broadcast a sink confirmation message (Sconfirm) with its cell ID. The cell ID of the sink is stored by all the nodes in their respective table.

- **Selective data aggregation:** We are proposing a Selective data aggregation technique for the sensors in the sensing field. This technique aggregates the data in two levels. The first level of data aggregation performed after collecting the data by the selective cell head, while the second level of data aggregation is done by the sink node which is elected by the BS. The selective data forwarding technique is used within a cell when the data packets are sent to the Selective cell head which performs the first level of data aggregation inside a cell. The second level of data aggregation gets initiated when the aggregated data from the first level moves from one selective cell head to the next selective cell head until it reaches the sink node and then final aggregation is performed over the data and it is send to the BS.
- **First level data aggregation:** The first level of data aggregation is carried out by the selective cell head in their respective cell. The sensors within a cell send their sensed data to its selective cell head or to the nearby selective cell heads (the cells which does not have a cell head) for data aggregation, which is the First level of data aggregation. The aggregated data moves from one selective cell head to the next selective cell head until it reaches the BS. The first level of data aggregation uses selective data forwarding technique which reduces the amount of data to be aggregated and thus saving energy which is required for aggregating the data.
- **Selective data forwarding:** Selective data forwarding is a technique in which an event is detected by many sensors, but only one sensor which is more reliable for sending the sensed data is allowed to send the required information to the sink. This forwarding technique enables the selective cell head to process fewer amounts of data as the generation of duplicate packet is reduced to great extent. The less amount of data processing saves lot of energy in each round of data transmission. Now, consider an event which has occurred in the sensing field and it is sensed by more than one sensor. The sensor will check for the reliability of the event by using formula

$$R = fc/\sqrt{}((y2 - y1)2 + (x2 - x1)2$$

- Where (x_1,y_1) is the coordinates of sensor and (x_2, y_2) are the coordinatesof the event occurred in the sensing field and f_c is the frequency constant set at the network initialization stage. We are considering the reliability factor, which is directly proportional to the distance between the sensor and the event. According to the Doppler's effect, the intensity of the sound decreases with the increase in the distance between the source of the sound and the receiver. This is also applicable with the wireless sensors. A wireless sensor can sense an event properly when it is closer to the occurring event. The sensing and transmitting power decreases with the increase in the distance between the sensor and the occurrence of the event. This decreases the reliability of the sensor and therefore, we infer that the reliability of a sensor is directly proportional to the distance between the sensor and the occurrence of the event.

- **Second level of Data aggregation:** The first level of data aggregation is carried out by the selective cell headsamong their respective cells. After the 1st level of data aggregation is completed, the selective cell headsproceed to the second level of data aggregation among themselves. The second level of data aggregation gets initiated when a selective cell head forwardsit's aggregated data to the next Selective cell head. The second level of data aggregation comprises of aggregation of data at each cell head and finally at the sink node. The sink node which is the root node is designated for collecting the aggregated data, performing the final aggregation on the collected data and finally transmitting the aggregated data to the BS directly. The second level of data aggregation terminates when the sink node i.e. root node performs the aggregation upon the received data.
- **Routing the aggregate data:** Routing is one of the major concerns in WSN. The routing of data packet from a selective cell head to the sink should be optimal. The optimal routing scheme should be used for reducing the time delay of delivery of data packets. The transmissions of data packets from one node to the next consumes a lot of energy. Therefore, an optimal routing algorithm can reduce the unnecessary consumption of energy by the transmission path.

  We are proposing a tree structure within the grid for routing the aggregated data by the selective cell head to the sink node and finally to the BS. The tree formation gets initiated after the election of sink node. Considering sink as the root, we try to construct a tree-like hierarchical path of selective cell head nodes. The path is computed centrally by the BS and then it broadcasts the path information to the whole network. The selective cell head stores the path information in a table. The sink initiates the tree formation by sending a "From_tree" message. The selective cell head replies to this message by sending an acknowledgemening"Join_tree" message. Thereafter, a network of the hierarchical path like structure is formed which comprises of all the active selective cell heads. Fig. 3 shows the selection of Selective cell head nodes and the formation of tree structure for the collection of data from the sensing field. The data in this network can be collected by using three different model i.e. Query driven model, Event drivenmodel or by Continuous drivenmodel.

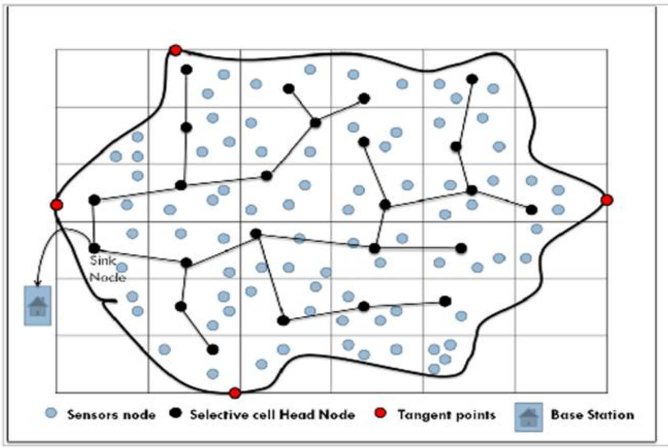

Figure 3: Routing of Aggregated Data Through Selective Cell Head

- **Query driven model:** In this model, the root (Sink) initiates the data gathering process by sending a small control packet towards the child nodes, using analgorithm. As the size of the control packet is very small, it consumes some negligible amount of energy but suffers from some delays. This model is generally used when some information is required by the BS.
- **Event driven model:** This model is used when some information is required at frequent interval of time.
- **Continuous model:** In this model, all the nodes have a clock which is synchronized with the sink node. The leaf node takes the responsibility of sensing the required data and sending it to the sink node at a fixed interval of time.

4. Conclusion and Future work

- In this paper, we proposed to convert an irregular area converted into a grid based WSN and apply energy efficient data aggregation in that WSN. This work is relevant to hostile environments of any geographical area irrespective of size and terrain. Further, we shall try to simulate this network and implement it with our proposed algorithm.We shall also attempt to reduce network traffic and increase the network lifetime and make comparisons with other protocols.

References

[1] Ogwueleka Francisca Nonyelum, AdeoyeOlamideOlayinka, EzeUdokaFelista, Odirichukwu Jacinta Chioma, Data Gathering System in Sensor Network, Lecture Notes in Engineering and

Computer Science: Proceedings of The World Congress on Engineering (2017), 534-542.

[2] Jiming Jiang , Christian Claudel, A high performance, low power computational platform for complex sensing operations in smart cities, HardwareX 1 (2017), 22-37.

[3] TanujKumar Mishra, Raj Kumar Paul, ASurvey on Load Balancing Techniques for Wireless Sensor Networks, International Journal of Advanced Research in Computer and Communication Engineering (2017), 342–348.

[4] Nabil Sabor, Shigenobu Sasaki, Mohammed Abo-Zahhad, Sabah M. Ahmed, A Comprehensive Survey on Hierarchical-Based Routing Protocols for Mobile Wireless Sensor Networks: Review, Taxonomy, and Future Directions, Wireless Communications and Mobile Computing (2017).

[5] Subutai Ahmad, Alexander Lavin, Scott Purdy, Zuha Agha, Unsupervised real-time anomaly detection for streaming data, Neurocomputing, 262(1) (2017), 134-147.

[6] SarigaArjunan, Pothula Sujatha, A Survey on Unequal Clustering Protocols in Wireless Sensor Networks, Journal of King Saud University-Computer and In-formation Sciences(2017).

[7] Estrin D., Heidemann J., Kumar S., Rey M., Next Century Challenges: Scalable Coordination in Sensor Networks, 99 Proceedings of the 5th annual ACM/IEEE international conference on Mobile computing and networking (1999), 263-270.

[8] Intanagonwiwat C., Ramesh Govindan, Deborah Estrin, Directed Diffusion : A Scalable and Robust Communication Paradigm for Sensor Networks, Proceedings of the 6th annual international conference on Mobile computing and networking (2000), 56-67 .

[9] Hoblos G., Staroswiecki M., Aitouche A., Optimal design of fault tolerant sensor networks, Proceedings of the IEEE International Conference on Control Applications. Conference Proceedings (2000), 467–472.

[10] Agre J., Clare L., An integrated architecture for cooperative sensing networks, Computer (Long. Beach. Calif) 33(5) (2000), 106–108.

[11] Bhardwaj M., Garnett T., Chandrakasan A.P., Upper bounds on the lifetime of sensor networks, IEEE International Conference on Communications. Conference Record 9 (2001), 1–37.

[12] Bonnet P., Gehrke J., Seshadri P., Querying the physical world,"IEEE Personal Communications 7(5) (2000), 16-27.

[13] Surendar, A., Arun, M.”FPGA based multi-level architecture for next generation DNA sequencing”,(2016) Biomedical Research (India), 2016, pp. S75-S79.

[14] Surendar, A., Arun, M., Basha, A.M.”Micro sequence identification of bioinformatics data using pattern mining techniques in FPGA hardware implementation”,(2016) Asian Journal of Information Technology, 15 (1), pp. 76-81.

[15] Cerpa A., Elson J., Hamilton M., and Zhao J., Habitatmonitoring: Application driver for wireless communications technology, ACM SIGCOMM Computer Communication Review-Workshop on data communication in Latin America and the Caribbean 31(2) supplement (2001).

[16] Cho S., Chandrakasan A., Energy-efficient protocols for Low duty cycle wireless micro sensor, Proceedings of the 33rd Annual Hawaii International Conference on System Sciences 2 (2000).

[17] Jaikaeo C., Srisathapornphat C., Shen C., Diagnosis of sensor networks, IEEE International Conference on Communications ICC’01 (2001).

[18] Warneke B., Liebowitz B., Pister K.S.J., Smart dust: Communicating with a Cubic-millimeter computer, IEEE Computer 34 (2001), 2–9.

[19] Mohanasundaram R., Periasamy P.S., Clustering Based Optimal Data Storage Strategy Using Hybrid Swarm Intelligence In WSN, Wireless Personal Communications (2015).

[20] Mohanasundaram R., Periasamy P.S., Hybrid Swarm Intelligence Optimization Approach for Optimal Data Storage Position Identification in Wireless Sensor Networks, The Scientific World Journal (2015).

[21] Mohanasundaram R., Periasamy P.S., Swarm Based Optimal Data Storage Position Using Enhanced Bat Algorithm In Wireless Sensor Networks, International Journal of Applied Engineering Research 10(2) (2015), 4311-4328.

[22] Mohanasundaram R., Periasamy P.S., A Meta heuristic Algorithm for Optimal Data Storage Position in Wireless Sensor Networks, Pakistan Journal of Biotechnology (2016), 463- 468.

[23] Aarthy S.L., Prabu S., A computerized approach on breast cancer detection and classification, Iioab journal 7(5)(2016), 157-169.

[24] Aarthy S. L., Prabu S., An approach for detecting breast cancer using wavelet transforms, Indian Journal of Science and Technology 8(26) (2015).

[25] Gopinath M.P., Prabu S., Classification of thyroid abnormalities on thermal image: a study and approach, Iioab journal 7(5) (2016), 41-57.

[26] Gopinath M.P., Prabu S., A Comparative study of Techniques Involved in Thermal Image Diagnostic System, International Journal of Applied Engineering Research, 9(24) (2014), 26393-26416.

[27] Kahn J.M., Katz R.H., Pister K.S.J., Next century challenges: Mobile networking for Smart dust, Proceedings of the 5th annual ACM/IEEE international conference on Mobile computing and networking (1999), 271–278.

[28] Noury N., Herve T., Rialle V., Virone G., Mercier E., Morey G., Moro A., Porcheron T., Monitoring behavior in home using a smart fall sensor, IEEE-EMBS Special Topic Conference on Micro technologies in Medicine and Biology (2000), 607–610.

[29] Surendar, A., Arun, M.”Efficient DNA sequence analysis for reduced gene selection using frequency analysis”, (2016) Journal of Chemical and Pharmaceutical Sciences, 9 (4), pp. 3367-3373.

[30] Surendar, A., George, A.”A real-time searching and sequencing assembly platform based on an FPGA implementation for Bioinformatics applications”,(2016) International Journal of Pharma and Bio Sciences, 7 (4), pp. B642-B647.

[31] RAJESH, M. "A SYSTEMATIC REVIEW OF CLOUD SECURITY CHALLENGES IN HIGHER EDUCATION." The Online Journal of Distance Education and e-Learning 5.4 (2017): 1.

[32] Rajesh, M., and J. M. Gnanasekar. "Protected Routing in Wireless Sensor Networks: A study on Aimed at Circulation." Computer Engineering and Intelligent Systems 6.8: 24-26.

[33] Rajesh, M., and J. M. Gnanasekar. "Congestion control in heterogeneous WANET using FRCC." Journal of Chemical and Pharmaceutical Sciences ISSN 974 (2015): 2115.

[34] Rajesh, M., and J. M. Gnanasekar. "Hop-by-hop Channel-Alert Routing to Congestion Control in Wireless Sensor Networks." Control Theory and Informatics 5.4 (2015): 1-11.

[35] Rajesh, M., and J. M. Gnanasekar. "Multiple-Client Information Administration via Forceful Database Prototype Design (FDPD)." IJRESTS 1.1 (2015): 1-6.

[36] Rajesh, M., and J. M. Gnanasekar. "Consistently neighbor detection for MANET." Communication and Electronics Systems (ICCES), International Conference on. IEEE, 2016.