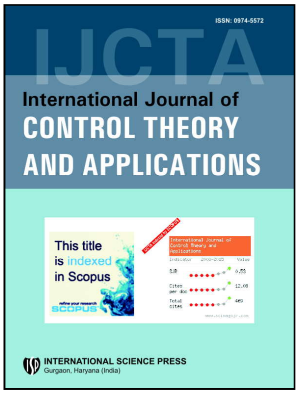

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Does Virtual Hexagon Based Data Aggregation Solve the Overhead of Wireless Sensor Nodes?

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Abstract: Wireless sensor networks (WSNs) is a distributed collective tiny sensors which is responsible for collecting sensed data from different environments and forwarding it to process. In such networks, local data collection from nodes creates much overhead. Topology maintenance in the network needs more energy than for transmission of data. Data aggregation is a key step to conserve energy in dense network by eliminating the redundant data transmission. This paper studies the literature of structured wireless sensor network and analysis the performance of existing system. In this paper a virtual hexagon based data aggregation protocol (VHDA) has been proposed which works on two phase dynamic aggregator selection process. The VHDA protocol performs search of missing node during critical situation with the selection of aggregator. In the next phase it selects the forwarding node for data transmission towards sink node. This reduces the overhead of redundant data transmission and improves energy efficiency. Simulation results shows that the proposed work proved with performance metrics as packet delivery ratio, jitter, control overhead, delay and energy of sensor nodes.

Keywords: Wireless Sensor Node; Orphan Node; Aggregation; Packet Delivery Ratio; Transmission; Energy

I. INTRODUCTION

Wireless sensor network is an emerging and progressive technology in wireless communication in recent decade. It is all about collection of small sensed devices that has energy constraints. Each node is having the capability of sensing the current sensor field and transmitting the sensed data into base station [7]. The advantages of sensor communication includes environmental monitoring, health monitoring, process monitoring, inventory tracking and military surveillance [8].The network lifetime strategy depends on the number of ways as topology control, routing protocol For example, the lifetime is determined depends on the duration until the first node expires [9].Therefore, it is an important factor to manage energy in order to extend the life of nodes [10, 11]. Data aggregation reduces number of transmission in the network hence increases life time of the network [12, 13]. In this paper, a novel data aggregation protocol has been proposed in which orphan nodes are collected to aggregate the packets in first phase. In second phase, forwarding nodes transmit the data to base station. The proposed work also describes the minimum weight factor to schedule the forwarding node. The proposed method has been simulated and its numerical achieved results illustrate the better performance in terms of reduced transmission overhead. Rest of the paper is organized as follows. In Section 2, the related work is described briefly. The paper presents the proposed work in Section 3. Section 4 shows the simulation results. Finally, we conclude the work in Section 5.

2. RELATED WORKS

Data aggregation is shown as effective way to conserve the energy of mobile nodes by dropping out the amount of transmissions. It needs two necessary conditions as spatial and temporal convergence to perform in a better way [22, 23]. Data aggregation is an important method for collecting data which always improves power efficiency, lessens data redundancy [30]. So it is able to reduce traffic rate on transmission. The author [18] proposed Ant colony aggregation to optimize the data aggregation which extends the lifetime of network. With support of GPS identification, a virtual hexagon-based coverage approach [15, 14 & 16] can considerably reduce the amount of redundant rebroadcasting approach. It also minimizes the overhead of overlapping by selecting the forwarding nodes. The author [17] focused the coverage and connectivity by designing C3R (coverage conscious connectivity restoration) algorithm which is mainly for reducing the problem of temporarily replacement of failed node. An energy based heuristic method was implemented by [19] to solve target Coverage problem by choosing high energy nodes first. The identification of critical node which means findings of fail node to reduce further lose on transmission was described in [20]. The PCA algorithm (Principal Component Analysis) [21] was proposed for reducing the workload of intermediate node [29] during transmission. This method performed the data aggregation process by grouping all incoming nodes and send as single packet instead of relaying that data. In this approach, the number of transmission is considerably reduced. Most of the research is based on structured approach to find out the solution of energy efficiency nodes, such as cluster- based [24, 25] and tree-based [10, 26]. Since, it is a self-motivated mobile environment the advantage from structured data aggregation may not recommend the reducing overhead of dynamic deployment and maintenance. Most of the energy is wasted on taking of unwanted routes during the event of spatially covered node detection. To overcome these overhead virtual hexagon based data aggregation (VHDA) obtains the better solution which shows as structure less approach without concentrating much attention on build a new structure [22,28]. In SFEB [28], Structure-Free and Energy-Balanced data aggregation protocol performed the two-phase working model for efficient data aggregation which also concentrated on reducing transmission overhead.

3. PROPOSED WORK

3.1. *Virtual* hexagon based data aggregation protocol (VHDA)

In this section, the proposed framework of virtual hexagon based data aggregation protocol for sensor nodes has been detailed. Initially it describes the system to construct the logical deployment of sensor environment. In the next section, it presents the way of selecting eligible neighbors to transmit the current sensed data. The waiting time for efficient data aggregation and data forwarding is presented in the next section.

3.2. Logical deployment

The logical network deployment is deliberated for the provisions of data aggregation, and forwarding data towards sink node. The figure 1a shows the number of orphan nodes in virtual hexagon path. Since these are mobile nodes, there is a chance of missing the node in corner of hexagon which depicted in figure 1b. The topology restriction on sensor field minimizes the overhead progressed from redundant data on its dense network. Since it is dynamic environment, the overhead may be with maximum number routing, maximum energy consumption for communicating the distant nodes. For that, virtual hexagon deployment [1] conserves connectivity of networks with minimum energy level. The network setup follows some assumptions as, each sensor node

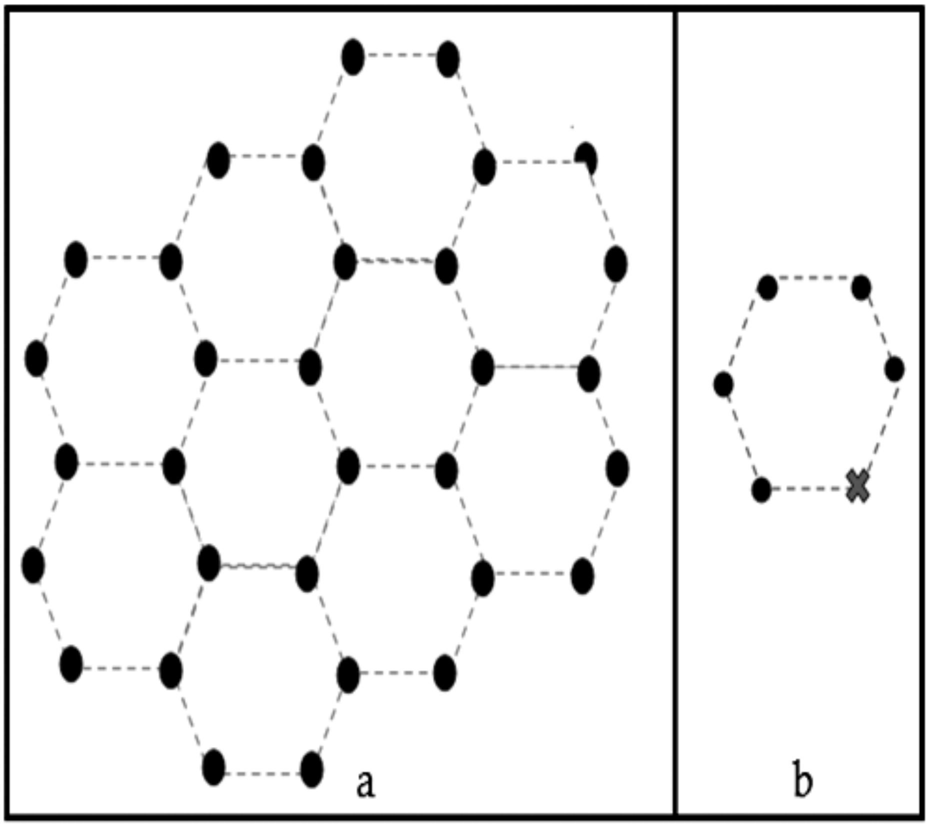

Figure 1: Orphan nodes in virtual hexagon & Missing corner node

must know about its own GPS location and the location of neighboring nodes and sink node. The residual energy E_R is calculated in eq. (1) where Ei is energy level at initial stage and Es is the energy spent for data transmission of orphan nodes.

$$ER = Ei - Es \tag{1}$$

3.3. Phase I: Act of Aggregator node

The logical network deployment is triggered by assigning initial energy to each node. Here the sensor nodes are called as orphan nodes initially and it is started to send hello messages to all neighbors on its virtual hexagon path. Here orp is called as orphan nodes. Ag denotes as aggregator which is null initially. VHh is height of virtual hexagon. If the number of virtual hexagon is equal to 6 edges [3], the algorithm considers that it has all orphan nodes in 6 corners of virtual hexagon. Then it selects the adjacent (Adjn) neighbors with minimum cost which means residual energy of orphan node is greater than predefined threshold value. And further stage, these nodes are added by checking the condition of distance is less than ½ Rc. By sending the JOIN message from each orphan node, the aggregator group the orphan nodes for collecting data.

Algorithm1: searching missing node during critical situation

1: orp= Set of all sensor nodes

2: E_R= residual energy of orphan node orp

3: Ag= {} // null aggregation value initially

```
Node orp store GPS positions Xn(i)i....Yn(i) upto N neighbors
while VHh== 6h do //[3]checks number of edges of virtual hexagon is equal to 6 edges
Adjn = ∅ //contain all orphan nodes
Select orphan nodes orp that has minimum cost
if (ER> Eth)
select aggregators Ag of N nodes such that (dist< ½RC)
AgN = AgN U orp
orp = orp - AgN
orp send JOIN message to aggregator Ag
end while
exit
```

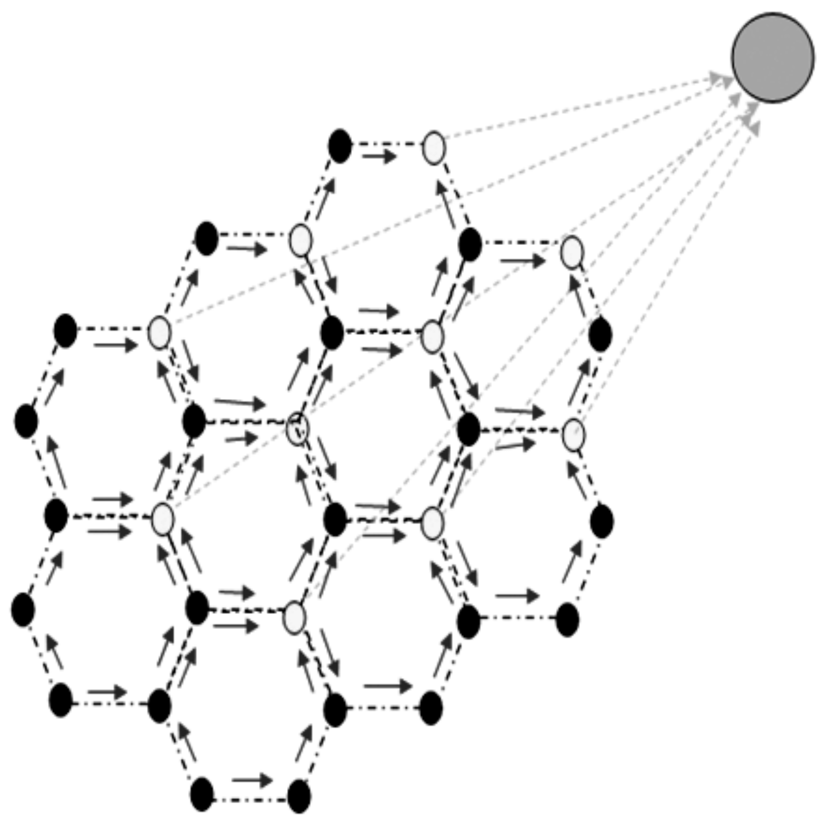

Figure 2: Aggregators and forwarding node transmission

3.4. Phase II: Act of forwarding node

Once the aggregator selection gets over, the system describes the method of selecting the forwarding node sensor node. In this phase, forwarding node involves in data transmission towards sink node. The collective data from aggregators is now ready to transmit which depicts in figure 2. The corresponding cost function is calculated for each data forwarding by considering minimum weight factor. Since the nodes are having the mobility, it needs to find out the coverage cost for minimum weight factor [2] for forwarding node selection is defined as below.

$$MW_C(Ni) = \max * (1 / E_{sum}(Xi,Yi)) \quad (2)$$

Forwarding node selection algorithm starts by assigning target ID (TID) and calculates the cost function. If the event of network receives control packet, set TID to forwarding node and schedule the routing process. Otherwise the sensor node involves in sensing process which means the minimum weight factor is calculated until the last node receives for forwarding process towards target sink node.

Algorithm2: Forwarding node selection ()

```
assign TID target node ID
calculate cost function Cf of node N
begin:
sensor node has Ag to transmit;
if (Event==receive (ctrl_pkt)) then
set forwarding node_ID = ctrl_pkt TID;
set routing_schedule for the node;
else if (Event==sensing)
For i = 1 to N do
MW_C(Ni) = max * (1 / E_sum(Xi,Yi)) // minimum weight factor
end for;
set forwarding node_ID = MWc (Ni) _ID;
set routing_schedule for the node;
end if;
end;
```

3.5. Structure free data aggregation

In structure based aggregation method, the format of packet is structured previously based on its parent-child node or hierarchical structure. Since the proposed work is structure free approach with mobile sensor nodes supports no predefined packet format for aggregation. Here, the orphan nodes are ready to transmit data once the timer triggers initially. This work continues with all orphan nodes involve in data transmission until the timer expires from the stipulated period. The orphan node becomes idle if it is not involved in data transmission and hence the energy saved. The aggregator node collected the data packets during first phase. The minimum factor node is calculated and makes a schedule for choosing the forwarding node. Then the collected data is ready to forward towards sink node.

4. SIMULATION BACKROUND

In this section, VHDA protocol has been implemented in NS-2.34 simulator for its performance evaluation. Initially the logical network deployment has 500 nodes which is partitioned into number of virtual hexagons with 1000 × 1000 meter area. The transmission range of sensor is setup with 25m and highest speed of node is 4ms. Initial total energy is assigned by 100 J to senor field. The network nodes were eligible to transmit 512 byte data packet every second with various packet structure. Using random waypoint model, different scenarios were generated and transmission consumed 0.2 J per unit of transaction.

4.1. Performance Evaluation

The performance evaluation of VHDA protocol is evaluated in this experiment with various operational scenarios and the output with metrics are considered. In this section, the simulation parameters are depicted in table 1.

Table 1
Simulation Parameters

Parameters	*Values*	*description*
Simulator	NS2.34	Advanced version of simulator
Simulation Time	200 sec	Based on simulation timer
Simulation area	1000 x 1000 m	Squared XY coordinate values
Number of nodes	500	Sensor nodes
Transmission range	25m	Valid power range of nodes
Movement Model	Random waypoint	Mobility of nodes
Highest speed	4 m/s	Speed of movement
Packet size	512 bytes	Size of data packets
MAC	IEEE 802.11	MAC layer protocol
Mobility interval	2-10 sec	Pause time of node
Antenna	Omni antenna	Omni directional
Transmission power	2×10^{-1} J	power to transmit a packet
Receiving power	1×10^{-1} J	Power to receiving a packet

The work demonstrates with the comparison of algorithms as UCR [4], MTA [5], DLSTA [6] and SFEB [7]. The performance metrics are considered to evaluate the proposed work as,

1. *Packet delivery ratio* is calculated for the amount of successful packets at destination from source node.
2. *Jitter shows the delay variations of received packets in any critical traffic situation.*
3. *Control packet overhead* denotes the quantity in terms of control packets on transmission.
4. *Delay* indicates average latency value of delivery packets.
5. *Energy consumption* specifies the amount of consumed energy of active mobile senor node.

4.2. Results and Discussion

This section shows the results of proposed work and evaluation is done with the comparison of different algorithms. The objective of work is achieved with reduced transmission overhead by considering performances metrics as packet delivery ratio, jitter, delay and control packet overhead. This consideration makes our work to sense in order to enhance the network lifetime efficiently. Protocols were implemented and analyzed for various pause times. It also forwards the packets of other nodes toward the sink node.

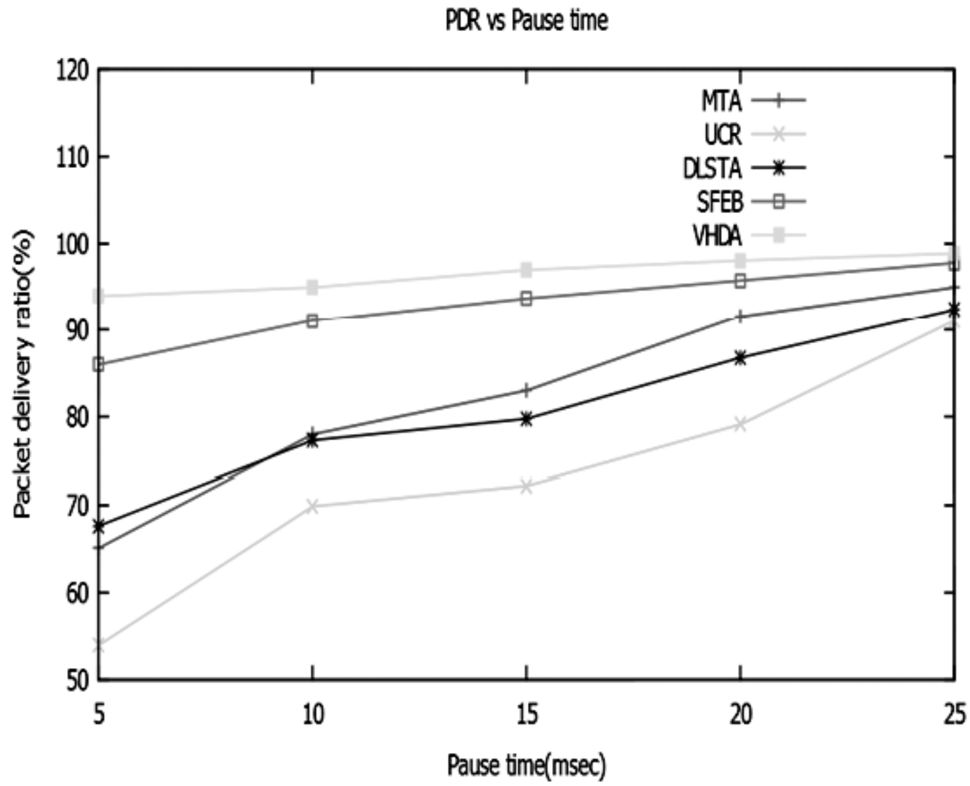

Figure 3: Packet Delivery Ratio Vs Pause Time

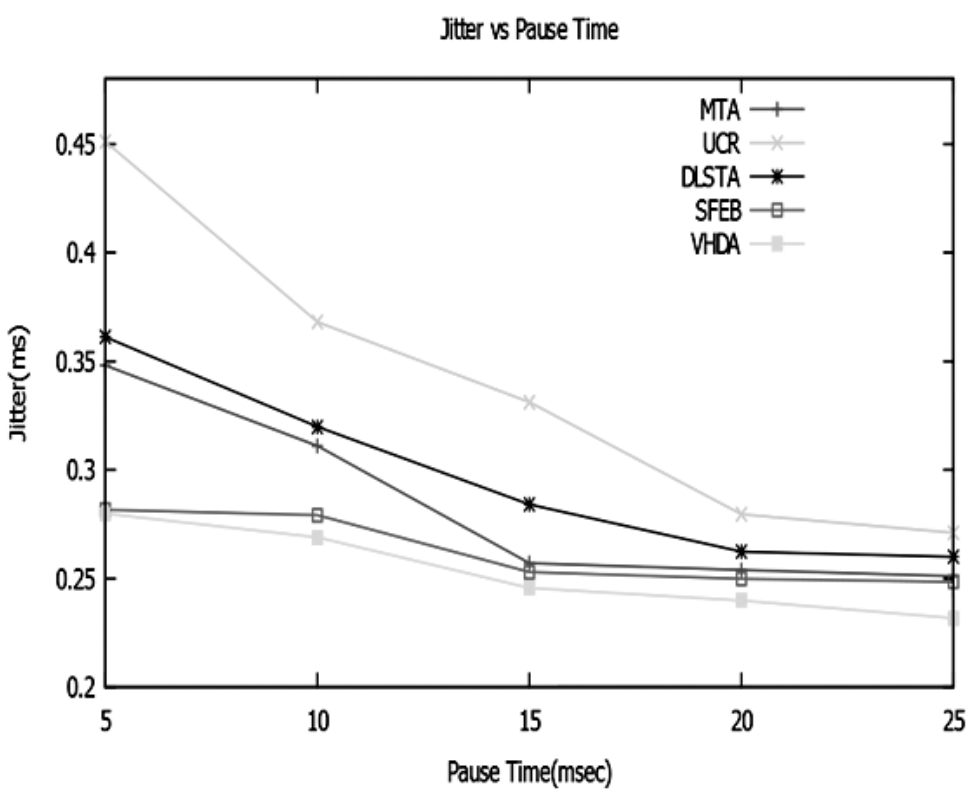

Figure 4: Jitter Vs Pause Time

In Figure 3, protocols were compared for different packet delivery ratio of VHDA with UCR [4], MTA [5], DLSTA [6] and SFEB [7]. It can be observed that the packet delivery ratio of VHDA is increased than other approaches. Since it is a structure free approach, it also shows the difference in packet delivery ratio is much better than UCR and DLSTA.

The plot of simulation result for VHDA protocol shows with the average of 98.91% packet delivery ratio at different pause time. Figure 4 plots the level of the jitter value over various pause time for different algorithms. VHDA protocol minimizes delay variation of received packets on virtual hexagon network. It shows the increased value for jitter on UCR, DLSTA and MTA which reflects reduced jitter range of VHDA approach. The pause time of 5 and 10 represents extreme change of jitter is measured.

The number of transmission with hello packets and acknowledgment packets are increased the complexity on transmission overhead. By reducing the control packets overhead, VHDA protocol achieves higher performance. The figure 5 shows the steady state of reduced control packet overhead by VHDA protocol. This comparison clearly shows structure less approach protocol produce better results against the comparison of MTA.

Figure 6 shows that delay in the transmission for various pause times. The proposed work has been compared with DLSTA and SFEB protocols. The intension of plot shows only the comparisons of dynamic mobile nodes without any predefined structured protocols which can show cleared difference in delay time. Particularly it achieves reduced delay time on pause time of 5 and 10. Simulation results shown in Figure 7, represents that VHDA protocol has reduced energy consumption of 0.286 joules in pause time of 5 and the average of 1.032 joules against the comparison of DLSTA. It was also observed that the variation of energy consumption in the proposed protocol is much reduced for different pause time.

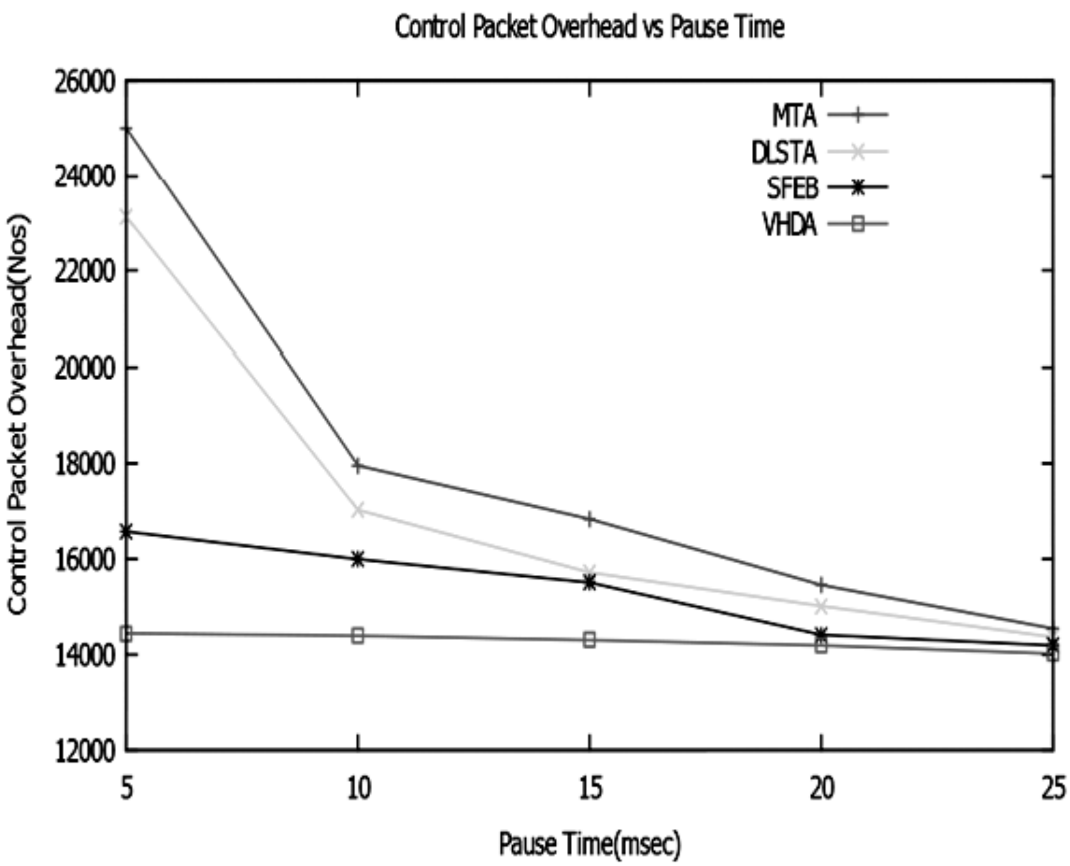

Figure 5: Control Packet Overhead Vs Pause Time

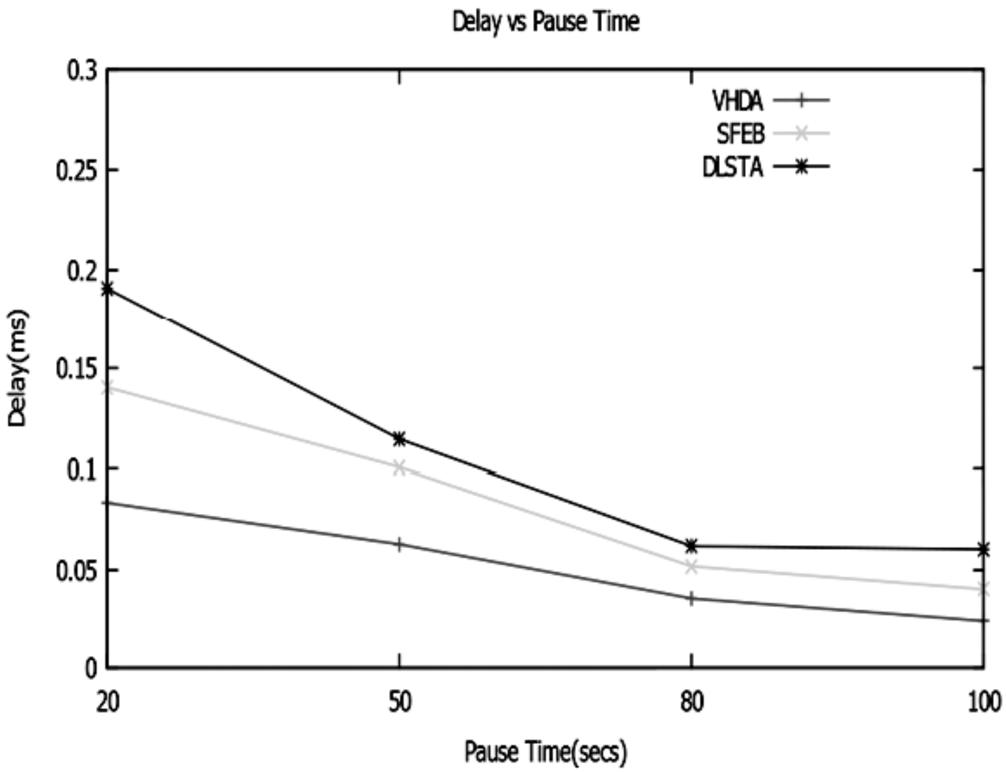

Figure 6: Delay Vs Pause Time

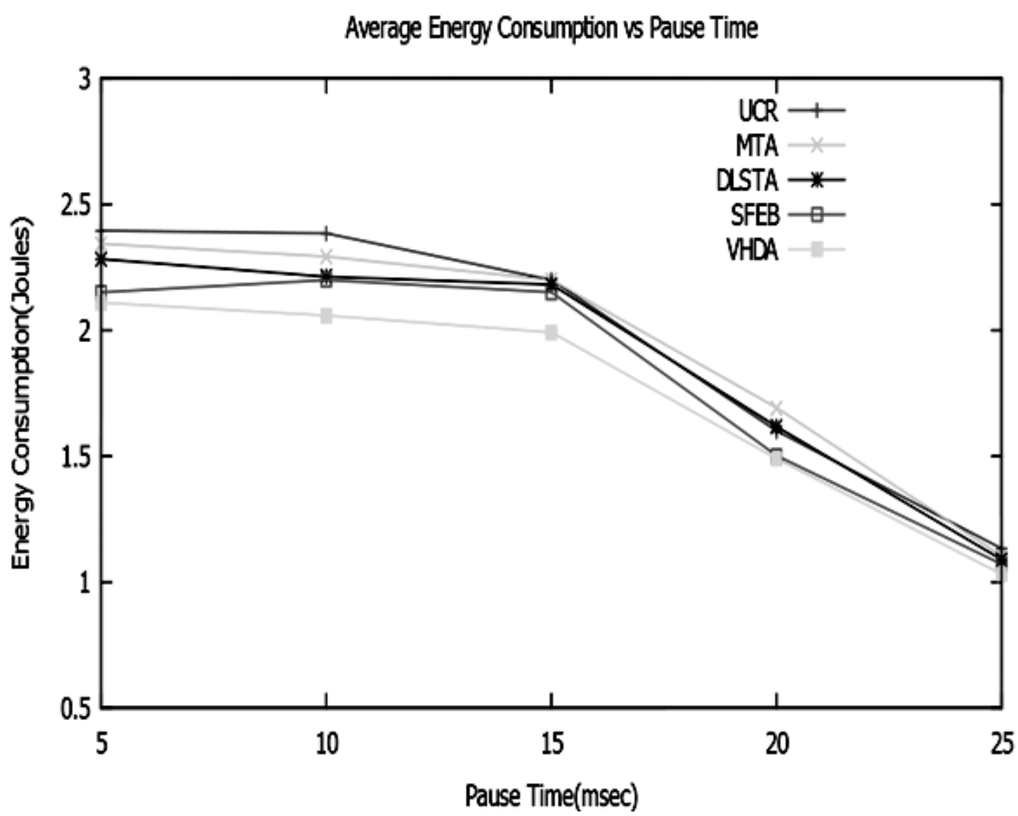

Figure 7: Energy Consumption Vs Pause Time

4. CONCLUSION

In this paper a virtual hexagon based data aggregation protocol has been proposed for reducing the transmission overhead of sensor nodes. VHDA protocol was implemented in two-phase logical deployment network and investigated for its performance in terms of packet delivery ratio, jitter, control packet overhead, delay and energy consumption. The simulation results show energy efficiency of the proposed protocol at varying pause time. In addition the method of missing node search on critical situation causes better aggregation service before transmitting toward packets into base station. Results of simulation shows, VHDA with higher PDR, reduced jitter and reduced control packet overhead. These performance analysis indicated the reduce energy consumption proposed work efficiently. The simulation result shows that VHDA protocol is more sustaining and improved performance about the average of 1.032 joules in comparison to existing protocol. Thus our work illustrate reduced overhead on transmission of sensor nodes data which helps to enhance the lifetime of network.

REFERENCES

[1] Zhang J, Q. Wu, F. Ren, T. He, and C. Lin.," Effective Data Aggregation Supported By Dynamic Routing In Wireless Sensor Networks," In Proceedings of the IEEE International Conference on Communications (lCC'10), pp.I-6, May 2010.

[2] S. Soro and W. B. Heinzelman, "Cluster head election technique for coverage preservation in wireless sensor networks," Ad Hoc Networks, vol. 7, no. 5, pp. 955-972, July 2009.

[3] K. Shashi Prabh, Tarek F. Abdelzaher, "On Scheduling and Real-Time Capacity of HexagonalWireless Sensor Networks," NSF grants CNS 05-53420 and CNS 06-26342, 2004.

[4] G. Chen, C. Li, M. Ye, and J. Wu, "An unequal cluster-based routing protocol in wireless sensor networks," Wireless Networks, Vol. 15, no. 2, pp. 193–207, 2009.

[5] M.-X. Chen, C.-C. Hu, and W.-Y. Weng, "Dynamic object tracking tree in wireless sensor network," EURASIP Journal on Wireless Communications and Networking, Vol. 2010, Article ID 386319, 2010.

[6] A. Alaybeyoglu, A. Kantarci, and K. Erciyes, "A dynamic lookahead tree based tracking algorithm for wireless sensor networks using particle filtering technique," Computers and Electrical Engineering, Vol. 40, No. 2, pp. 374–383, 2014.

[7] Yousefi H, Yeganeh MH, Alinaghipour N, Movaghar A,"Structure-free real-time data aggregation in wireless sensor networks," Comput. Commun., Vol. 35, pp.1132–40, 2012.

[8] Nandini. S. Patil, Prof. P. R. Patil, "Data Aggregation in Wireless Sensor Network," 2010 IEEE International Conference on Computational Intelligence and Computing Research, ISBN: 9788183713627, 2010.

[9] H. Karl and A. Willig, "Protocols Architectures for Wireless Sensor Networks," New York, NY, USA: Wiley, 2005.

[10] M.Umadevi and Dr.M.Devapriya, "An Enhanced Ant Colony Based Approach to Optimize the Usage of Critical Node in Wireless Sensor Networks," Procedia Computer Science, Vol. 47, pp. 452 – 459, 2015. DOI: 10.1016/j.procs.2015.03.229.

[11] Pantazis, N., Nikolidakis, S. and Vergados, D. "Energy-efficient routing protocols in wireless sensor networks: a survey," Communications Surveys & Tutorials, Second Quarter, Vol. 15, No. 2, pp.551–591, IEEE, 2013.

[12] Ramesh, K. and Somasundaram, K, "A comparative study of clusterhead selection algorithms in wireless sensor networks," International Journal of Computer Science & Engineering Survey (IJCSES), Vol. 2, No. 4, pp.153–164, 2011.

[13] M.Umadevi and Dr.M.Devapriya, "Supervising the Employees of Clusters in WSN – A Novel Perusal", International Journal of Scientific Research And Education (IJSAE), Vol. 2, Issue 9, Pages 1785-1796, September 2014, ISSN (e): 2321-7545.

[14] S. Madden, M. J. Franklin, J. M. Hellerstein, and W. Hong, "Tag: a tiny aggregation service for ad-hoc sensor networks," SIGOPS Oper. Syst. Rev., Vol. 36, pp. 131–146, 2002.

[15] A. Durresi, V. K. Paruchuri, S. S. Lyengar, and R. Kannan, "Optimized Broadcast Protocol for Sensor Networks," IEEE Trans. on Computers, Vol. 54, No. 8, pp. 1013-1024, 2005.

[16] D. Kim and N. F. Maxemchuk, "A Comparison of Flooding and Random Routing in Mobile Ad Hoc Networks," In Proc. New York Metro Area Networking Workshop, 2003.

[17] Y. Lai and J. Jiang, "Broadcasting with Optimized Transmission Effciency in Wireless Networks," In Proc. ICWMC '09, pp. 334.339, 2009.

[18] Tamboli N, Younis M. "Coverage-aware connectivity restoration in mobile sensor networks," In IEEE international conference on communications, ICC'09, pp. 1–5, 2009.

[19] M. Xie and H. Shi, "Ant Colony Optimization Based In-Network Data Aggregation in Wireless Sensor Networks," International Symposium on Pervasive Systems, Algorithms and Networks, 2012.

[20] Manju and A. K Pujari, "High-Energy-First (HEF) heuristic for energy efficient target coverage problem," International Journal of Adhoc sensor and Ubiquitous Computing, Vol. 2, No. 1, March 2011.

[21] Sitanayah, L., Brown, K.N., Sreenan, C.J, "Fault-tolerant relay deployment based on length-constrained connectivity and rerouting centrality in wireless sensor networks," In: Proceedings of the 9th European Conference on Wireless Sensor Networks (EWSN'12), pp. 115–130, 2012.

[22] Amirmohammad Rooshenas, Hamid R. Rabiee, Ali Movaghar, M. Yousof Naderi, "Reducing The Data Transmission in Wireless Sensor Networks Using The Principal Component Analysis," In Proceeding of the Sixth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP'10), 2010.

[23] K.W. Fan, S. Liu, P. Sinha, "Structure-free data aggregation in sensor networks," IEEE Transactions on Mobile Computing, Vol. 6, pp. 929–942, 2007.

[24] J. Zhang, Q. Wu, F. Ren, T. He, C. Lin, "Effective data aggregation supported by dynamic routing in wireless sensor networks," In Proceedings of the IEEE International Conference on Communications (ICC'10), pp. 1–6, 2010.

[25] W.R. Heinzelman, A. Chandrakasan, H. Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks," In Proceedings of the 33rd Annual Hawaii International Conference on System Sciences, 2000.

[26] J.Y. Choi, J.W. Lee, K. Lee, S. Choi, W.H. Kwon, H.S. Park, "Aggregation time control algorithm for time constrained data delivery in wireless sensor networks," In Proceedings of the 63rd IEEE Vehicular Technology Conference, pp. 563–567, 2006.

[27] H. Li, H. Yu, B. Yang, A. Liu, "Timing control for delay-constrained data aggregation in wireless sensor networks," Communication Systems, Vol. 20, pp. 875–887, 2007.

[28] C.M. Chao, T.Y. Hsiao, "Design of structure-free and energy-balanced data aggregation in wireless sensor networks," In Proceedings of the 11th IEEE International Conference on High Performance Computing and Communications (HPCC'09), pp. 222–229, 2009.

[29] J. Sandeep and J. Satheesh Kumar,"Energy efficient neighbor coverage-based probabilistic rebroadcasting in MANET," Journal of Engg. Research, Vol. 3, No. 3, pp. 39-58, September 2015.

[30] M.Umadevi and Dr.M.Devapriya,"Perceptions on Data Aggregation in Wireless Sensor Network," International Journal of Advance Foundation and Research in Computer (IJAFRC), Vol. 2, Issue 7, July - 2015. ISSN 2348 – 4853.