IJRSET Volume 2, Issue 3 Pages: 12-20

ISSN 2394-739X

International Journal for Research in Science Engineering and Technology

PROGRESSIVE NODE DEPLOYMENT AND HYPER-CLUSTER FORMATION FOR INFORMATION PROCESSING IN WIRELESS SENSOR NETWORK

[1] V. KISHORE, [2] M. MALATHI., M.C.A., M.Phil.,
[1] Research scholar, [2] Assistant Professor
[1] PG & Research Department of Comp.Sci, [2] PG & Research Department of Comp.Sci,
[1] Government Arts College (Autonomous), [2] Government Arts College (Autonomous),
[1] Salem, [2] Salem.

Abstract:-

Wireless Sensor Networks (WSNs) consist of thousands of tiny nodes having the capability of sensing, computation, and wireless communications. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy consumption is an essential design issues. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy consumption is an essential design issues. Utility of wireless devices is that they can be used anywhere at any time. In WSN sensor nodes are deployed to sense the data but these sensor nodes have limited recourses and that is why WSN is a resource constraint network. In order to save resources and energy, data must be aggregated, and avoid amounts of traffic in the network. . Since wireless sensor network protocols are application specific, so the focus has been given to the routing protocols that might differ depending on the application and network architecture. The objective of data aggregation is to eliminate redundant data transmission and to enhance the life time of energy in wireless sensor network. Efficient clustering schemes are beneficial for data aggregation process. Thus, in this paper we propose new schemes for clustering with respect cluster head selection to attain energy efficiency and to extend the lifetime of WSN. The process for node deployment is Network formation, Region Division, Number of Node calculation, Number of dead node calculation, Coverage area calculation, Probability calculations for regions. And we also process the Clustering Concept to increase the efficiency of the network. We employed to increase the Quality of service parameters.

Keywords: - Wireless sensor network (WSN), Network formation, Region Division, Energy model, Cluster head selection, Cluster formation, Quality of service parameters.

1. INTRODUCTION

A sensor network1 is an infrastructure comprised of sensing (measuring), computing, and communication elements that gives an administrator the ability to instrument, observe, and react to events and phenomena in a specified environment. There are four basic components in a sensor network: (1) an assembly of distributed or localized sensors; (2) an interconnecting network (usually, but not always, wireless-based); (3) a central point of information clustering; and (4) a set of computing resources at the central point (or beyond) to handle data correlation, event trending, status querying, and data mining. Wireless sensor networks are formed by small devices communicating over wireless links without using a fixed networked infrastructure. Because of limited transmission range, communication between any two devices requires collaborating intermediate forwarding network nodes, i.e. devices act as routers and end systems at the same time.

Communication between any two nodes may be trivially based on simply flooding the entire network. However, more elaborate routing algorithms are essential for the applicability of such wireless networks, since energy has to be conserved in low powered devices and wireless communication always leads to increased energy consumption.

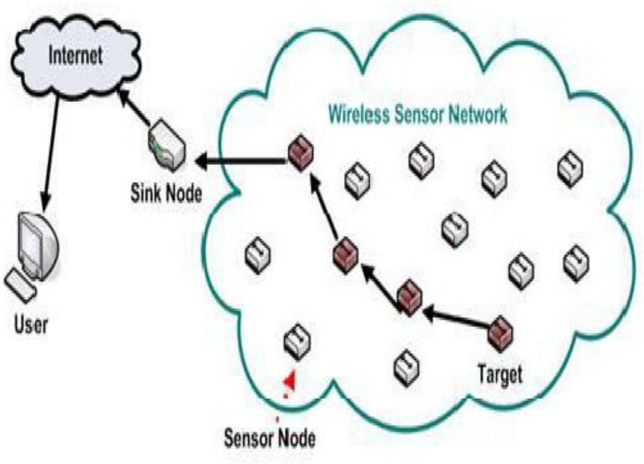


Figure 1.1: Wireless Sensor Networks

Sensor networks represent a significant improvement over traditional sensors, which are deployed in the following two ways: 1. Sensors can be positioned far from the actual phenomenon, i.e., something known by sense perception. In this approach, large sensors that use some complex techniques to distinguish the targets from environmental noise are required. 2. Several sensors that perform only sensing can be deployed. The positions of the sensors and communications topology are carefully engineered. They transmit time series of the sensed phenomenon to the central nodes where computations are performed and data are fused [15]. Many researchers are currently engaged in developing schemes that fulfil these requirements. In this paper, we present a survey of protocols and algorithms proposed thus far for sensor networks.

WSN network topology is constantly changing, WSNs use broadcast communication mediums and finally sensor nodes don't have a global identification tags [3]. The major components of a typical sensor network are:

- Sensor Field: A sensor field can be considered as the area in which the nodes are placed.
- Sensor Nodes: Sensors nodes are the heart of the network. They are in charge of collecting data and routing this information back to a sink.
- Sink: A sink is a sensor node with the specific task of receiving, processing and storing data from the other sensor nodes. They serve to reduce the total number of messages that need to be sent, hence reducing the overall energy requirements of the network. Sinks are also known as data aggregation points.
- Task Manager: The task manager also known as base station is a centralized point of control within the network, which extracts information from the network and disseminates control information back into the network. It also serves as a gateway to other networks, a powerful data processing and storage centre and an access point for a human interface. The base station is either a laptop or a workstation.

Data is streamed to these workstations either via the internet, wireless channels, satellite etc. So, hundreds to several thousand nodes are deployed throughout a sensor field to create a wireless multi-hop network. Nodes can use wireless communication media such as infrared, radio, optical media or Bluetooth for their communications. The transmission range of the nodes varies according to the communication protocol is used.

1.1. Characteristics of Wireless Sensor Networks

WSNs have some unique characteristics. These are:

- Sensor nodes are small-scale devices with volumes approaching a cubic millimetre in the near future. Such small devices are very limited in the amount of energy they can store or harvest from the environment.
- Nodes are subject to failures due to depleted batteries or, more generally, due to environmental influences. Limited size and energy also typically means restricted resources (CPU performance, memory, wireless communication bandwidth and range).
- Node mobility, node failures, and environmental obstructions cause a high degree of dynamics in WSN. This includes frequent network topology changes and network partitions. Despite

partitions, however, mobile nodes can transport information across partitions by physically moving between them.

- The resulting paths of information flow might have unbounded delays and are potentially unidirectional. Communication failures are also a typical problem of WSN.

The large number raises scalability issues on the one hand, but provides a high level of redundancy on the other hand. Also, nodes have to operate unattended, since it is impossible to service a large number of nodes in remote, possibly inaccessible locations.

1.2. WSN Designing Challenges & Issues

Most sensor networks are application specific and have different application requirements. Thus, all or part of the following main design objectives is considered in the design of sensor networks:

Small node size: Since sensor nodes are usually deployed in a harsh or hostile environment in large numbers, reducing node size can facilitate node deployment. It will also reduce the power consumption and cost of sensor nodes.

Low node cost: Since sensor nodes are usually deployed in a harsh or hostile environment in large numbers and cannot be reused, reducing cost of sensor nodes is important and will result into the cost reduction of whole network.

Low power consumption: Since sensor nodes are powered by battery and it is often very difficult or even impossible to charge or recharge their batteries, it is crucial to reduce the power consumption of sensor nodes so that the lifetime of the sensor nodes, as well as the whole network is prolonged.

Scalability: Since the number sensor nodes in sensor networks are in the order of tens, hundreds, or thousands, network protocols designed for sensor networks should be scalable to different network sizes.

Reliability: Network protocols designed for sensor networks must provide error control and correction mechanisms to ensure reliable data delivery over noisy, error-prone, and time-varying wireless channels.

Self-configurability: In sensor networks, once deployed, sensor nodes should be able to autonomously organize themselves into a communication network and reconfigure their connectivity in the event of topology changes and node failures.

Adaptability: In sensor networks, a node may fail, join, or move, which would result in changes in node density and network topology. Thus, network protocols designed for sensor networks should be adaptive to such density and topology changes.

Channel utilization: Since sensor networks have limited bandwidth resources, communication protocols designed for sensor networks should efficiently make use of the bandwidth to improve channel utilization.

Fault tolerance: Sensor nodes are prone to failures due to harsh deployment environments and unattended operations. Thus, sensor nodes should be fault tolerant and have the abilities of self testing, self-calibrating, self-repairing, and self-recovering.

Security: A sensor network should introduce effective security mechanisms to prevent the data information in the network or a sensor node from unauthorized access or malicious attacks.

2. PROBLEM STATEMENT

WSN deals with real world environments. In many cases, sensor data must be delivered within time constraints so that appropriate observations can be made or actions taken. Very few results exist to date regarding meeting real-time requirements in WSN. Most protocols either ignore real-time or simply attempt to process as fast as possible and hope that this speed is sufficient to meet deadlines. Some initial results exist for real-time routing. For example, the RAP protocol proposes a new policy called velocity monotonic scheduling. Here a packet has a deadline and a distance to travel. Using these parameters a packet's average velocity requirement is computed and at each hop packets are scheduled for transmission based on the highest velocity requirement of any packets at this node. While this protocol addresses real-time, no guarantees are given. Another routing protocol that addresses real-time process is called SPEED. This protocol uses feedback control to guarantee that each node maintains an average delay for packets transiting a node. Given this delay and the distance to travel (in hops), it can be determined if a packet meets its deadline (in steady state). However, transient behavior, message losses, congestion, noise and other problems cause these guarantees to be limited.

To date, the limited results that have appeared for WSN regarding real-time issues has been in routing. Many other functions must also meet real-time constraints including: data fusion, data transmission, target and event detection and classification, query processing, and security. New results are needed to guarantee soft real-time requirements and that deal with the realities of WSN such as lost messages, noise and congestion. Using feedback control to address both steady state and transient behavior seems to hold promise. Dealing with real-time usually identifies the need for differentiated services, e.g., routing solutions need to support different classes of traffic; guarantees for the important traffic and less support for unimportant traffic. It is important not only to develop real-time protocols for WSN, but associated analysis techniques must also be developed (see the section below on Analysis). Low-cost deployment is one acclaimed advantage of sensor networks. Limited processor bandwidth and small memory are two arguable constraints in sensor networks, which will disappear with the development of fabrication techniques. However, the energy constraint is unlikely to be solved soon due to slow progress in developing battery capacity. Moreover, the untended nature of sensor nodes and hazardous sensing environments preclude battery replacement as a feasible solution. On the other hand, the surveillance nature of many sensor network applications requires a long lifetime; therefore, it is a very important research issue to provide a form of energy efficient surveillance service for a geographic area. Much of the current research focuses on how to provide full or partial sensing coverage in the context of energy conservation. In such an approach, nodes are put into a dormant state as long as their neighbors can provide sensing coverage for them. These solutions regard the sensing coverage to a certain geographic area as binary, either it provides coverage or not. However, we argue that, in most scenarios such as battlefields, there are certain geographic sections such as the general command center that are much more security-sensitive than others. Based on the fact that individual sensor nodes are not reliable and subject to failure and single sensing readings can be easily distorted by background noise and cause false alarms, it is simply not sufficient to rely on a single sensor to safeguard a critical area. In this case, it is desired to provide higher degree of coverage in which multiple sensors monitor the same location at the same time in order to obtain high confidence in detection. On the other hand, it is overkill and energy consuming to support the same high degree of coverage for some non-critical area. Middle ware sits between the operating system and the application. On traditional desktop computers and portable computing devices, operating systems are well established, both in terms of functionality and systems. For sensor nodes, however, the identification and implementation of appropriate operating system primitives is still a research issue. In many current projects, applications are executing on the bare hardware without a separate operating system component. Hence, at this early stage of WSN technology it is not clear on which basis future middleware for WSN can typically be built.

3. EXISTING APPROACH IN NODE DEPLOYMENT

There is a gap between network protocols, on the one hand, and applications in wireless sensor networks, on the other. We need to provide adaptation functions between applications and network protocols to satisfy the requirements of special features of wireless sensor networks and diversity of its applications. The adaptation functions should facilitate provision of quality of service to applications while using the limited resources of WSNs and extending their life span. Middleware [8.17,8.18] is an approach to satisfy the adaptation. In this chapter we examine the existing middleware for WSNs.

WSNs are constrained in resources such as bandwidth, computation and communication capabilities, and energy. WSN topology is variable due to node mobility, depletion of energy, switching between sleep and active states, radio range, and routing possibilities.

A WSN may also need to support several applications simultaneously.

Therefore, a WSN is a wireless/mobile and resource-constrained network with diverse applications.

The problem in this resource-constrained environment is how to design middleware that is capable of adaptation between applications and network protocols. Middleware is usually below the

application level and on top of the operating systems and network protocols. It marshals the application requirements, hides details of lower levels, and facilitates application development and deployment and their management. Challenges in the design of middleware for WSNs are [8.5]:
(1) topology control, to rearrange the sensor nodes into a connected network; (2) energy-aware data-centric computation; (3) application-specific integration, since integration of application information into the network protocol improves performance and conserves energy; (4) efficient utilization of computational and communications resources; and (5) support for real-time applications. The existing middleware functions for WSNs are as follows [8.5]:

1. System services to diverse applications. To deploy current and future applications easily, middleware needs to provide a standardized system service.
2. An environment that coordinates and supports multiple applications; this is required to implement the diverse applications and to create new ones.
3. Mechanisms to achieve adaptive and efficient utilization of system resources; these mechanisms provide algorithms that dynamically manage limited and variable network resources of WSNs.
4. Efficient trade-offs between the multiple QoS dimensions; this can be used to adjust and optimize the required network resources.

The middleware gathers information from the application and network protocols and determines how to support the applications and at the same time adjust network protocol parameters.
Sometimes the middleware interfaces with the operating system directly while bypassing the network protocol.
The major difference between WSN and traditional middleware is that the former needs to dynamically adjust low-level network protocol parameters and configure sensor nodes for the purpose of performance improvement and energy conservation. The key is for the middleware to abstract the common properties of applications and to map application requirements into those actions that boil down to protocol parameter adjustment.
The resource management functional element monitors the network status and receives application requirements. It then produces the command to adjust the network resource.

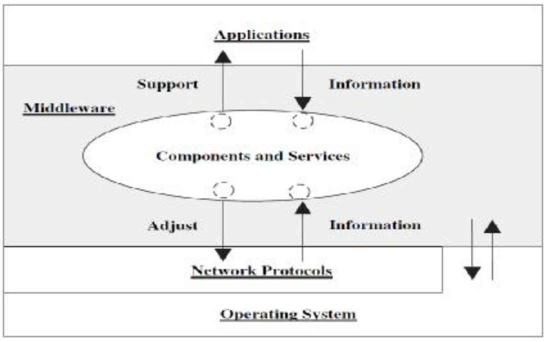


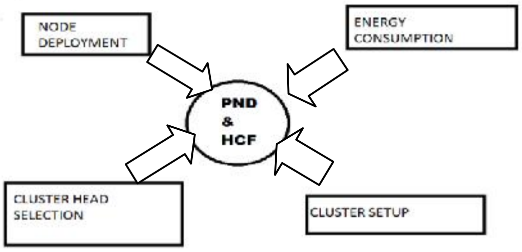
Figure 3.1: Existing System Structure

In WSNs, the sensor nodes deployed produce data. The data sensed need to be transmitted to some special node or a sink for further analysis, management, and control. Therefore, a data dissemination protocol is required to provide effective data transmission from sensor nodes to the sink. Data dissemination protocols have a certain relation to the routing protocols. The routing protocols are general and are designed to find a path between the source and destination nodes. On the other hand, data dissemination protocols should guarantee successful transmission from nodes to the sink.

4. PROPOSED SYSTEM AND ITS CONTRIBUTIONS

Fast growth of different applications requires the attainment of data from the physical world in a trustworthy and automatic manner. This requisite infers the emergence of new kinds of networks. Hence wireless sensor network (WSN) has been introduced. In recent years, fast growth of wireless services and wireless devices clearly indicate efficiency of WSN. Utility of wireless devices is that they can be used anywhere at any time. In WSN sensor nodes are deployed to sense the data but these sensor nodes have limited recourses and that is why WSN is a resource constraint network. In order to save resources and energy, data must be aggregated, and avoid amounts of traffic in the network. The objective of data aggregation is to eliminate redundant data transmission and to enhance the life time of energy in wireless sensor network. Efficient clustering schemes are beneficial for data aggregation process. Thus, in this paper we propose new schemes for clustering with respect cluster head selection to attain energy efficiency and to extend the lifetime of

WSN. The process for node deployment is Network formation, Region Division, Number of node calculation, Number of dead node calculation, Coverage area calculation, Probability calculations for regions. And we also process the Clustering concept to increase the efficiency of the network. We employed to increase the Quality of service parameters.



WSN is a special type of wireless network, possibly with ad hoc structure and probably with limited resources.

Due to these WSN constraints, networking protocols, the application model, middleware, and sensor node operating systems should be designed very carefully. Network management for WSNs is required to use those limited resources effectively and efficiently. Network management is much more important for WSNs than for traditional networks for the following reasons:

1. In order to deploy an adaptive and resource-efficient algorithm in WSNs, the current resource level needs to be gathered through network management.
2. Most WSN applications need to know the coverage area so that they ensure that the entire space is being monitored.

Topology management can be used in case an uncovered area is detected. Generally, there are three approaches to increasing the coverage area: (1) increase the node's radio power, (2) increase the density of deployment of senor nodes, and (3) move the sensor nodes around to achieve equal distribution.

3. Nodes in WSNs are usually arranged in an ad hoc manner. The parameters of this ad hoc network are obtained by the network management system.
4. Collaboration and cooperation between sensor nodes are required to optimize system performance. Network management is an effective tool to provide the platform required for this purpose.

The proposed consist of the following four modules and each has separate functions and responsibility

- **NODE DEPLOYMENT**
- **ENERGY MODULE**
- **CLUSTER HEAD SELECTION**
- **CLUSTER SETUP**

Module 1-NODE DEPLOYMENT:

The Random node deployment algorithm is carried out in this method. The sub modules for the module 1 is Network formation, Region Division, Number of node calculation, Number of dead node calculation, Coverage area calculation, Probability calculations for regions.

Module 2- ENERGY MODULE:

For a first order module, the overall energy for a transmitter to send a B-bit message over a distance d, energy is given by:

$$E_{Tx}(B,d)= B * E_{con} + B* \varepsilon_{sf}* d^2 \text{ if } d \leq d_0$$
$$B * E_{con} + B* \varepsilon_{pm}* d^4 \text{ if } d \leq d_0 \quad (1)$$

Where E_{con} is the energy consumed per bit to run the transmitter or the receiver circuit. $\varepsilon_{sf}$and ε_{pm} depend on the transmitter amplifier model, and d is the distance between the transmitter and the receiver. By equating the two expressions at $d=d_0$. To receive an B-bit message the radio expends $E_{Rx} =B * E_{con}$

Module 3- CLUSTER HEAD SELECTION:

Most of the methodical results of prior research are gained assuming that the nodes of the sensor network are armed with the identical amount of energy.

But this is not the case, thus in this paper, influence of heterogeneity in terms of node energy is introduced. Let develop a model for a WSN with nodes heterogeneous in types of nodes in the sensor field with unlike energy (node_type1, node_type2, node_type3).

Let node_type1, node_type2 are having αandβ times more energy than node_type3.

And P_1 and P_2 are the percentage of node_type1 and node_type2 in the nodes set.

Spontaneously, node_type1 and node_type2 have to become cluster heads more frequently than node_type3.

Obviously new heterogeneous setting has improved the total initial energy of the network.

Assume, IE_1 IE_2 and IE_3 are an initial energy of node_type1, node_type2, node_type3 resp.

Module 4- CLUSTER SETUP:

Every non-cluster-head node that is a cluster member (CM) defines to which cluster it belongs by selecting the cluster head with the maximum residual energy, and that needs the least communication energy, based on the received signal strength of the advertisement from each cluster head. Initially all cluster members compute the approximate distance d between the sender nodes and itself based on the received signal strength. Every node decides to which cluster it belongs by the maximum Cassis.

Afterwards the node notifies the cluster head node that it will be a member of the cluster. Each node transmits an assist request message back to the elected cluster head.

This message is a little message, consisting of the node's ID and the cluster head's ID. Because the cluster head nodes consume their energy faster than other nodes, we must elect some subordinate cluster head (subordinate -CH) nodes to assist the cluster head's work.

In every round, every cluster head node broadcasts to other in its cluster, and these cluster member nodes will send back their confirmation message to the CH.

The confirmation message contains the residual energy $E_{residual}$ of this CM node. Every cluster head node sorts downward by $E_{residual}$ and elects the top y stronger nodes as the subordinate -CH nodes.

These subordinate -CH nodes assist the cluster head to collect, aggregate the information and allot tasks to other nodes. The flow is as follows:

1) The cluster head node is numbered No. 1 CH node, other y stronger subordinate-CH are numbered No. 2, . . . , No.(x+ 1) nodes in incline order by $E_{residual}$.

2) The cluster heads deed as local control centers to assist the data transmissions in their cluster.

3) The CH node establishes a TDMA schedule and transmits this schedule to the nodes in the cluster.

4) This confirms that there are no collisions among data messages.

5) The entire data transmission time is distributed equally into m TDMA slots. In each TDMA slot, No. 1, No.2, . . . ,No. (x+l) node will collect, aggregate information and transmit data to Base Station sequentially.

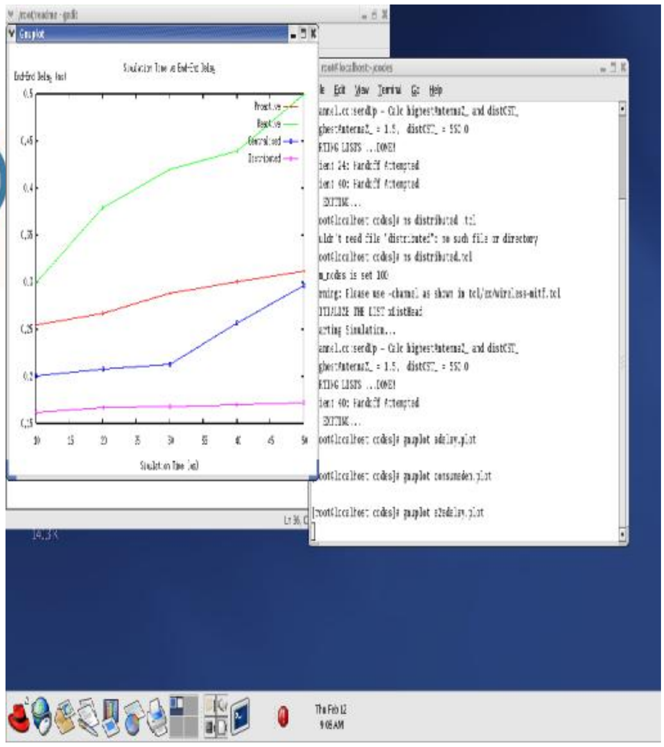
6) The approach of using the association of cluster head and subordinate CH nodes improves energy efficiency and lengthens the system lifetime.

5. RESULTS & DISCUSSIONS

The routing protocols in wireless sensor network and all are used for evaluating performance of different parameters in different scenario. Researchers specify the difference between routing protocols and its performance for different parameters and which one is best for the case of Wireless Sensor Network.

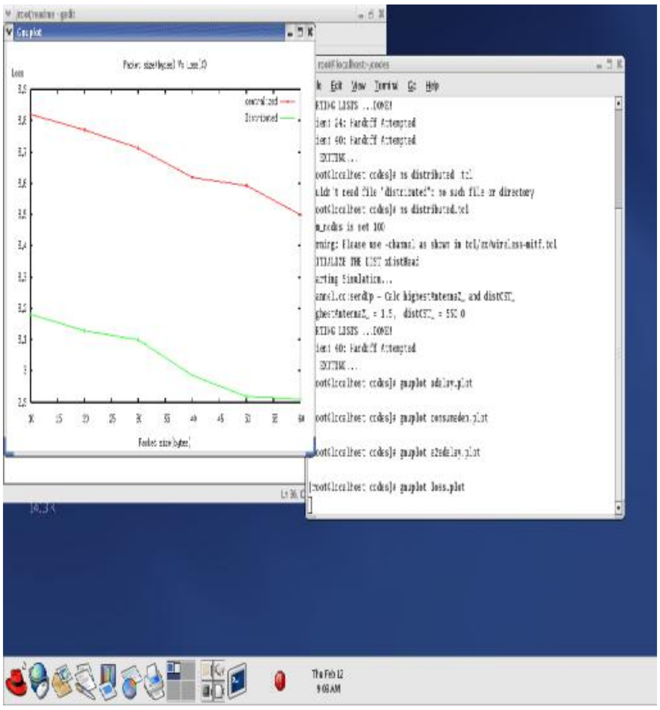
I) Average delay

The investigations were performed on Parameters such as Average End-End Delay using AntSens protocol. When Nodes-100, Pause Time - 0-100secs, Maximum Speed- 10m/s, Routing protocol- DSR, and Evaluating Parameter: Average End- to-End Delay.



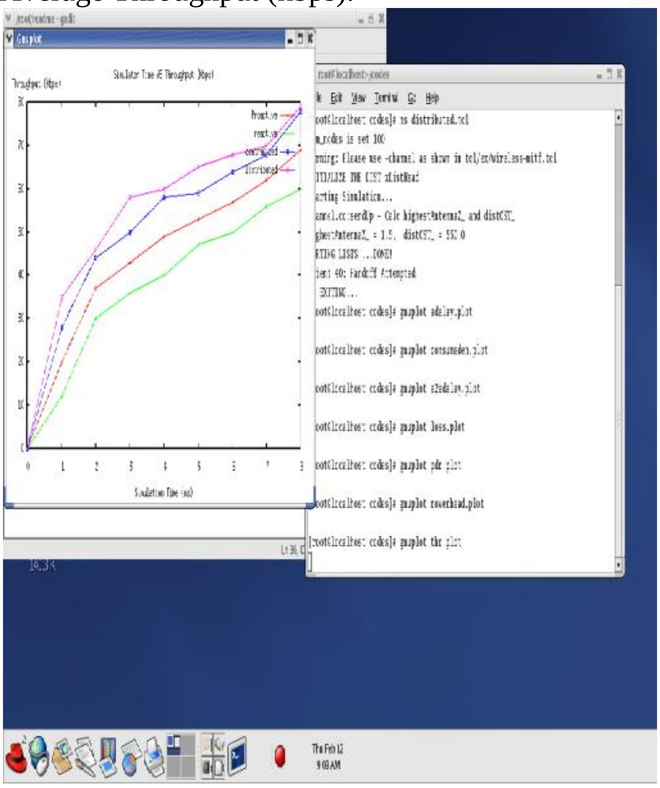
ii) Packet Delivery

The investigations were performed on Parameters such as Packet Delivery Fraction (pdf) using SntSens protocol. When Nodes-100, Pause Time - 0-100secs, Maximum Speed 10m/s, Routing protocol- DSR, and Evaluating Parameter- Packet Delivery Fraction.



iii) Throughput

The investigations were performed on Parameters such as Average throughput using AntSens protocol. When Nodes-100, Pause Time - 0-100secs, Maximum Speed- 10m\s, Routing protocol- AntSens, and Evaluating P parameter: Average Throughput (kbps).



CONCLUSION & FUTURE WORK

In WSN sensor nodes are deployed to sense the data but these sensor nodes have limited recourses and that is why WSN is a resource constraint network. In order to save resources and energy, data must be aggregated, and avoid amounts of traffic in the network. The objective of data aggregation is to eliminate redundant data transmission and to enhance the life time of energy in wireless sensor network.

Efficient clustering schemes are beneficial for data aggregation process. Thus, in this paper we propose new schemes for clustering with respect cluster head selection to attain energy efficiency and to extend the lifetime of WSN. To further increase the energy efficiency in the network, introduce the protocols like LEACH, HEED, ASEEP, PEGASIS, and APTEEN. By the use of these protocols the energy consumption of the network is reduced when we increase the quality of service parameters in the better way.

REFERENCES

[1] G. Tolle, J. Polastre, R. Szewczyk, D. Culler, N. Turner, K. Tu, S. Burgess, T. Dawson, P. Buonadonna, D. Gay, and W. Hong, “A macroscope in the redwoods,” in Proc. 3rd ACM SenSys, New York, NY, USA, 2005, pp. 51–63.

[2] G. Werner-Allen, K. Lorincz, J. Johnson, J. Lees, and M. Welsh, USENIX Association, “Fidelity and yield in a volcano monitoring sensor network,” in Proc. 7th OSDI, Berkeley, CA, USA, 2006, pp. 381–396.

[3] M. Li and Y. Liu, “Underground coal mine monitoring with wireless sensor networks,” ACM Trans. Sen. Netw., vol. 5, pp. 10:1–10:29, Apr. 2009.

[4] P. Vicaire, T. He, Q. Cao, T. Yan, G. Zhou, L. Gu, L. Luo, R. Stoleru, J. A. Stankovic, and T. F. Abdelzaher, “Achieving long-term surveillance in VigilNet,” ACM Trans. Sen. Netw., vol. 5, pp. 9:1–9:39, Feb. 2009.

[5] N. Xu, S. Rangwala, K. K. Chintalapudi, D. Ganesan, A. Broad, R. Govindan, and D. Estrin, “A wireless sensor network for structural monitoring,” in Proc. 2nd ACM SenSys, New York, NY, USA, 2004, pp. 13–24.

[6] L. Liu, X. Zhang, and H. Ma, “Optimal node selection for target localization in wireless camera sensor networks,” IEEE Trans. Veh.Technol., vol. 59, no. 7, pp. 3562–3576, Sep.2010.

[7] Y. Weng, W. Xiao, and L. Xie, “Sensor selection for parameterize random field estimation in wireless sensor networks,” J. ControlTheory Appl., vol. 9, pp. 44–50, 2011.

[8] B. Eksioglu, A. V. Vural, and A. Reisman, “The vehicle routing problem: A taxonomic review,” Comput. Ind. Eng., vol. 57, no. 4, pp. 1472–1483, 2009.

[9] O. Bräysy and M. Gendreau, “Vehicle routing problem with time windows, Part I: Route construction and local search algorithms,” Tr a n s p o r t . S c i ., vol. 39, no. 1, pp. 104–118, Feb. 2005.

[10] Z. Ozyurt, D. Aksen, and N. Aras, “Open vehicle routing problem with time deadlines: Solution methods and an application,” in Operations Research Proceedings 2005, ser. Operations Research Proceedings, H.-D. Haasis, H. Kopfer, and J. Schnberger, Eds. Berlin, Germany: Springer, 2006, vol. 2005, pp. 73–78.

[11] K. Tan, L. Lee, Q. Zhu, and K. Ou, “Heuristic methods for vehicle routing problem with time windows,” Artif. Intell.Eng., vol. 15, no. 3, pp. 281–295, 2001.

[12] “ns-3,” Tech. Rep. [Online]. Available: http://www.nsnam.org/

[13] Y. Yao, Q. Cao, and A. V. Vasilakos, “EDAL: An energy-efficient, delay-aware, and lifetime-balancing data collection protocol for wireless sensor networks,” in Proc. 10th IEEE MASS, 2013, pp. 182–190.

[14] M. M. Solomon, “Algorithms for the vehicle routing and scheduling problems with time window constraints,” Oper. Res., vol. 35, no. 2, pp. 254–265, 1987.

[15] L. Du and R. He, “Combining nearest neighbor search with tabu search for large-scale vehicle routing problem,” Phys. Proc., vol. 25, no. 0, pp. 1536–1546, 2012.

[16] C.-B. Cheng and K.-P. Wang, “Solving a vehicle routing problem withtime windows by a decomposition technique and a genetic algorithm,”Expert Syst.With Appl., vol. 36, no. 4, pp. 7758–7763, 2009.

[17] W.-C. Chiang and R. Russell, “Simulated annealing metaheuristics for the vehicle routing problem with time windows,” Ann. Oper. Res., vol. 63, pp. 3–27, 1996.

[18] C. C. Skiścim and B. L. Golden, “Optimization by simulated annealing: A preliminary computational study for the TSP,” in Proc. 15th IEEEWSC, Piscataway, NJ, USA, 1983, vol. 2, pp. 523–535.

[19] J. H. Holland, Adaptation in Natural and Artificial Systems: An Introductory Analysis With Applications to Biology, Control and ArtificialIntelligence. Cambridge, MA, USA: MIT Press, 1992.

[20] C. Caione, D. Brunelli, and L. Benini, “Distributed compressive sampling for lifetime optimization in dense wireless sensor networks,”IEEE Trans. Ind. Inf., vol. 8, no. 1, pp. 30–40, Feb. 2012.

[21] J. Wu, “Ultra-lowpower compressive wireless sensing for distributed wireless networks,” in Proc. IEEE MILCOM, Oct. 2009, pp. 1–7.

[22] G. Cao, F. Yu, and B. Zhang, “Improving network lifetime for wireless sensor network using compressive sensing,” in Proc. 13th IEEE HPCC, Sep. 2011, pp. 448–454.

[23] C. Luo, J. Sun, F. Wu, and C. W. Chen, “Compressive data gathering for large-scale wireless sensor networks,” in Proc. ACM MobiCom, 2009, pp. 145–156.

[24] H. Zheng, S. Xiao, X. Wang, and X. Tian, “Energy and latency analysis for in-network computation with compressive sensing in wireless sensor networks,” in Proc. IEEE INFOCOM, Mar. 2012, pp. 2811–2815.