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1	**Database Match**
2	**Database Match**
3	**Database Match**

Suspected Content

Abstract A wireless sensor network (WSN) is set of distributed autonomous devices called sensors for monitoring properties like motion, vibration, pressure, temperature, sound, pollutants at different locations. WSN is a set of sensors, located in a remote location equipped with sensing and computational and capabilities. Along with sensors, each node in WSN is mounted with a radio transceiver, an energy source (battery) and a small microcontroller. These low power and low cost devices form a set for monitoring the area of interest. Using the collaboration of sensors, the Wireless Sensor Nodes collects and sends information about the area of interest (e.g. surveillance, rain, humidity, temperature etc.) to the Processing Node. Then received information is processed at Processing Node and used by users. Due to limited energy capacity of nodes, network overall lifetime will not be long. Giving continuous power supply to nodes or changing the used battery is a difficult task in such remote location. This could interrupt or badly affect the flow of information from area of observation. Major portion of the energy consumption of sensor node in the sensor network is happens in the information flow (transmission and reception), and only very few portion in other activities (clustering, broadcasting etc). So to increase the network lifetime once can target to make the sensor nodes into sleep mode as frequent as possible without significant loss in information. If sensor nodes are deployed densely in the area of observation there are chances of getting similar information from the neighboring nodes. Also if the frequency of sending information to the processing node by the sensor node is high, again there are chances of observing similar information by the same node. This means observed information can be Spatially and Temporally correlated information will be observed by the deployed nodes. Thus Spatial and Temporal correlation provides a basis for proposing and developing techniques for energy saving of sensor nodes. We are proposing a hybrid approach to achieve target of battery saving and the approach is based on Spatial and Temporal Co-relation among various sensor nodes. On sensing a physical phenomenon in an area all nodes start sending observed information to the Processing Node. In a highly dense deployed sensor networks there are lot of chances that these nodes will be sending Spatially and Temporal correlated information. Thus it is not necessary that all deployed nodes send information to the Processing Node, and some nodes which are sending spatially correlated information can be made to sleep mode. Network is divided into number of clusters, which we have taken as 5% of the total number of nodes of a network. Nodes are assigned to the cluster having minimum distance to the cluster head having maximum energy. The distance between nodes is Euclidean

Distance. Simulations results show that our proposed technique which is based on clustering and exploiting Spatial and Temporal Correlation can lower the energy consumption of data transmission and thus increasing node and overall network lifetime. Chapter 1 Introduction 1.1 General Concepts What Is Sensor Sensor is a device which detects some type of physical properties from its surroundings. Physical properties it detects can be light, heat, motion, moisture, pressure. It is basically a transducer which detects change in physical properties and provides the result as output. Physical properties are converted to signal which can be measured. Sensor Types: 1. Physical property to be measured 2. Transduction principles 3. Area of usage 4. Physical characteristic 5. Technique involved 6. Used content to manufacture it Applications such as Surveillance have a great limitation of sensor energy, as sensors are battery operated. It is always very difficult to change battery or to charge battery in such applications. So we need some methods to save sensor energy. What is a Sensor Network? A wireless sensor network (WSN) is a set or group of smart devices with limited processing and power capacity and have the capabilities of monitoring and low power consumption to monitor the area of interest and send observed environmental and physical measurements, related to temperature, sound, pressure, etc to the Processing Node. A wireless sensor network (WSN) is a collection of randomly deployed sensor nodes of hundreds to thousands in numbers. Long sensor lifetime & overall network life time, shared responsibility of entire area of observation, are some considerable requirements in Wireless Sensor Networks. Forming groups of sensor nodes based on their locations: Clustering provides a very good solution to fulfill these requirements. Various clustering algorithms also differ in their objectives. Every sensor node in sensor network node has following parts: - Transceiver, - Energy source - Communication circuit for sensors and an energy source Sensors come in various sizes from few millimeters to few centimeters. Depending on the application, area of usage accuracy many other factors cost of Sensor nodes may vary from low to very high. There are some limitations such as storage; computational capabilities, continuous supply and transmission capabilities, which are result of constraints in cost and size of sensor nodes. Wireless sensor network architecture can be either random distribution to an organized multi-hop network. The communication between the nodes can be guided or unguided. Characteristics Wireless sensor networks exhibits following characteristics: * Small in size * Intelligent devices * Limited Memory * Capable of data processing * Heterogeneity * Moving Nodes * Self organized within network * Deployed in rough environmental condition * Battery constraint * Cross-layer design Cross-layer design in Wireless Sensor Networks is an important area for researchers these days. Main reason behind this is the limitation in conventional layered design: 1. The conventional designs are unable to cop-up with changing conditions. 2. Each layer cannot have whole data. They cannot make sure the optimization of the network. 3. Not applicable for WSNs as the interference between the various users, access confliction, fading, and the change of environment. So to enhance improve the transmission performance, such as QoS (Quality of Service) high data rates, energy efficiency, etc the cross-layer designs are used to achieve best optimization. Sensor nodes can be viewed as tiny intelligent devices which can perform basic data processing tasks and have limited HW. Processing Nodes The Processing Nodes can be considered as bridge between the person who needs the data (actual user) and deployed sensors. Processing Nodes consists of single or multiple units, which together form Processing Node and are integral part of Wireless Sensor Networks. Processing Nodes are rich in power and other resources. Routers are also one of important component, are used to accomplish the routing between nodes. Using routers data can be forwarded from the Wireless Sensor Networks to a server. Types of Sensor Networks Based on application there are two types of networks as below: Proactive Networks The nodes in Proactive network observe the physical properties and send the observed data of and periodically switch on their sensors and transmitters. By this, they provide a blueprint of the required components with their standard values periodically. Application which requires data monitoring at regular frequency are best example for Proactive Networks Reactive Networks Whenever there are considerable changes observed in measuring physical property reactive networks transmits such information to the processing node. Time critical applications are the best example for this type of applications. 1.2 Clustering in wireless sensor network As we have already discussed that in a densely deployed sensor network, Spatially and Temporally correlated information can be observed. So a logical grouping based on the node's location can be done, which simply 'Clustering'. Each cluster is having a representative node termed as 'Cluster Head' (CH). All the communication between other nodes and to the processing node is done through the CH. Individual nodes will send the observed information to the CH and CH will do some processing (data aggregation and compression) and forward the aggregated data to the processing node. Thus by clustering we can avoid longer distance communication by each individual node, and only CH will do direct communication with the processing node. By this total number of data communication rounds, energy consumption of each individual node can be reduced and overall network lifetime can be increased. Figure 1: Sensor Networks Advantages of Clustering: * Transmit aggregated data to the processing node * Very few nodes transmit data to the processing node * Flexibility in network size * Less message transmission as compared to direct method * Optimized usage of battery and other resources 1.3 Motivation Weather reporting, Warfield monitoring became main motivation for developing of Wireless Sensor Network. These days usage of WSNs have expanded to many commercial, manufacturing and daily life related applications, for example manufacturing line observation, security related, monitoring health of equipments and other industrial process monitoring and control. The unique properties mentioned above become challenges to set up a sensor network. The key challenge in setting up and proper operation of WSN is to reduce battery dissipation of individual node and enhance the overall network life span. Since from last few years' variety of changes have been made to limit the energy requirement in WSN, as mainly energy dissipation is more for wireless transmission and reception. Main approaches till proposed were focusing at making the changes at MAC layer and network layer to minimize the energy dissipation. Two more major challenges are how to place the cluster heads over the grid and how many clusters would be there in a network. If the cluster heads are properly placed over the grid and sufficient clusters are formed, it will help to minimize the dissipation of energy and would help to increase the lifetime of the network. Clustering is always been referred as an effective method to enhance the lifetime of WSN. 1.4 Problem Statement Chapter 3 Proposed Technique Clustering based on Spatial and temporal correlation is proved to be an efficient way of saving sensor node energy, and by this increasing overall network lifetime. To use this effectiveness we have proposed a new technique, which is a hybrid technique of existing techniques which is based on Spatial and Temporal Correlation, HEED, PEGASIS. Main motivation of proposing this technique is to use Spatial and Temporal correlation in which those nodes which have highest residual energy will be selected as Cluster representative i.e. Cluster head and data communication will use Supernode. 3.1 Correlation Models

3.1. 1 Spatial Correlation Model Spatial correlation model used 3

in our proposed hybrid technique is based on [1] Sensor Deploying Model The Spatial correlation model in our technique is taken is as follows: Area of observation is a circular area in which random and dense distribution of sensor nodes are done. The followings are a few assumptions: (i) Sensor nodes will have a sensing radius, all the activities inside this radius will be captured and no information will be captured outside this radius. (ii) Sensor nodes can communicate to a distance which is much greater than their sensing range. (iii) Only aggregated data will be sent to the processing node. (iv) Once deployed node's position will be fixed and then every node's location and other related data will be shared to every other node. Figure 6: Model architecture The Correlation Model The correlation characteristics on which the degree of spatial correlation between sensor nodes in the area of monitoring are: 1. Interdistance between nodes 2. Node's sensing range ? = 2r, and d = distance between nodes Above equation clearly shows that the correlation between sensor nodes is a direct function of Euclidian distance between nodes. To simplify our calculation in our proposed model we have taken the Euclidian distance between nodes as main clustering criteria. Cluster formation: 1. Initialize every node and insert into an empty set E 2. For every node Define a minimum distance dmin between nodes for being cluster member 3. Each node n in the area do while E is not empty : 4. Calculate distance of every node from every other node dinter-node 5. If dinter-node <= dmin : Insert node n into set S = S {n} 6. End if 7. E= E- {n} 8. End while 9. Construct new cell C = E 10. N=n - {C} 11. End For 12. Return C = {C1, C2, C3...} 13. Cluster formation completed 3.1.2 Temporal Correlation Model Wireless Sensor Networks applications may need periodic readings from the sensor nodes. Such periodic observations may have temporal correlation continuous observed information. Depending on the physical phenomenon is changing the amount of Temporal correlation [2] between consecutive observation may change. We consider that every node has multiple data to send (say n). Each data is divided into L different chunks. Each sensor is has allocated separate memory for Base signal, which is collection of data which is extracted from the observed values. This Base signal is used to transmit along with the partial message signal. Base signal is then used at the Processing Node to reconstruct the original signal. Figure 7: Data compression-Temporal Correlation When enough data is collected (till there is no remaining space in sensor memory), recent data values are approximated by signal value B (smaller than L). Resulting approximated value shall be transmitted to the Processing Node, which is nothing but the compressed data. A history/log is maintained at the Processing Node which is generated by adding latest information received from the various nodes. A dedicated space is allocated for each sensor which transmits information to the receiving end i.e. Processing Node. It is depicted in above figure. Base signal is collection of differential information which is gathered from the observed values by the sensor nodes. Base signal is then used at the Processing Node to recover the approximated/compressed signals sent by specific sensor node. Sensor nodes transmits signal to the Processing Node which are approximated using the memorized data by the Base signal. Information in the Base signal can be refreshed every time whenever there is new information is seen by the sensor nodes. This ensures the best quality of approximation. On receiving such updated in base signal transmission of base signal also occurs with the actual data and it is updated in Base signal field of dedicated space for each sensor in the Processing Node. The base signal created using differential samples of the original observations by the sensor nodes at specific intervals. The process is initiated by extracting smallest data unit of each observation. Sorting is done by the Processing Node using their starting position and there is no requirement of end point. 3.2 Energy Dissipation in transmission The communication model used in this technique is similar to that used in [3,5] which is most basic communication model. A node dissipates Ptrans/rec = 50 nJ/bit to send and receive the information from and to other nodes and Pamp = 100 pJ/bit/m2 energy is dissipated to amplify the signal so that information to the other nodes can be received within a set signal to noise ratio (S/N). Data transmission dissipates energy in two ways, Energy required in transmission of data to distance l : PTx-elec and amplifying signal to maintain required S/N ratio PTx- amp. Data reception dissipates energy in receiving PRx Energy dissipation required in data transmission with n bits and distance

l: PT (n,l) = Ptrans (n) + Pamp (n,l) PT (n, **2**

l) = Ptrans*n + Pamp*n*l2 Our model shows that the energy consumption is the transmission is the combination of transmission energy plus the amplifying energy. Receiving requires the energy to receive the transmitted signal. So the cost of transmission is almost double of the receiving cost. Also receiving is also consuming a considerable amount of energy. So our approach should be to minimize both transmission and reception of the signal. Figure 8: Radio Transmission Model Reception dissipates energy as below: PR (n; l) = Prec (n) PR(n; l) = Prec * n 3.3 Assumptions: Proposed Technique 1. Nodes are distributed randomly in remote location 2. Nodes are deployed to observe weather data which includes temperature, air pressure, humidity, wind speed. 3. There will be a Spatial correlation between the observations given by sensor nodes 4. There will be a Temporal correlation between the observations given by sensor nodes. 5.

For a given signal to noise ratio (SNR), energy 1

consumption in transmission and reception between two nodes will be same. 6. All sensor nodes will be considered at same level of energy before starting our simulation. Idle time dissipation is ignored for all type of networks 3.4 Flow Chart Temporal Correlation Spatial Correlation No Yes No Yes No Yes Figure 9: Flow chart-Proposed Technique 3.5 Performance Evaluation For performance evaluation we will implement our code in 'C' language and output will compared between various techniques and our proposed technique. Comparison of various techniques with our proposed technique will be based on: 1. Number of live nodes after each round of communication 2. Total number of communication rounds-Network total lifetime In simulation a network of 100 randomly deployed nodes and a Processing Node is at fixed position at far distance from sensor networks. All the Nodes have been initialized with an initial energy 0.5 J. 3.6 Different techniques for Comparison 5 runs for each technique including our proposed method have been done, readings have been taken and graph plotted. The technique in which more number of nodes will be live and maximum number of rounds of data communication will occur shall be considered as most efficient technique. 1. Direct technique: Every node (100 in our case) will send its data directly to Processing Node 2. Clustering_Each Node: Cluster Head will receive data from each node which are attached to it. CH will aggregate information at cluster head will send to the Processing Node. 3. Clustering_Only CH: Only Cluster head will be active and other nodes will be in sleep mode. Thus entire observation of the area will be sent by the CH only. 4. In our proposed technique Clusters will be formed on basis of Spatial Co-relation and only Cluster head will send its data to Super node of Cluster heads. Finally only Super node will send aggregated data to the Processing Node. Chapter 4 Simulation and Results 4.1 Simulation Environment For our experiments, we simulated an environment with randomly distributed nodes in 100x100 unit area. 100 random nodes are deployed in this area. Processing Node is placed at far distance from the monitoring area: Far distance Figure 10: Sensor node deployment 4.2 Readings Node Initial energy = 10; Number of bits transferred = 2000 Iteration 1: 1. Node distribution : Figure 11: Cluster formation using correlation (1) 2. Comparison of communication rounds at different instances of died sensor nodes : Initial Energy Protocol 5% 20% 50% 100% 10 Direct 59 78 127 720 Clustering_All Nodes 19 66 185 815 Clustering_Only CH 200 800 2000 4000 Clustering_Supernode 97 583 1967 8674 Iteration 2: 1. Node distribution : Figure 12: Cluster formation using correlation (2) 2. Comparison of communication rounds at different instances of died sensor nodes : Initial Energy Protocol 5% 20% 50% 100% 10 Direct 51 73 114 674 Clustering_All Nodes 16 53 156 1000 Clustering_Only CH 200 800 2000 4000 Clustering_Supernode 89 413 1604 7106 Iteration 3: 1. Node distribution : Figure 13: Cluster formation using correlation (3) 2. Comparison of communication rounds at different instances of died sensor nodes : Initial Energy Protocol 5% 20% 50% 100% 10 Direct 52 70 107 755 Clustering_All Nodes 16 57 162 967 Clustering_Only CH 200 800 2000 4000 Clustering_Supernode 112 522 1581 6692 Iteration 4: 1. Node distribution : Figure 14: Cluster formation using correlation (4) 2. Comparison of communication rounds at different instances of died sensor nodes : Initial Energy Protocol 5% 20% 50% 100% 10 Direct 56 77 114 733 Clustering_All Nodes 21 67 210

1042 Clustering_Only CH 200 800 2000 4000 Clustering_Supernode 100 564 1860 8864 Iteration 5: 1. Node distribution : Figure 15: Cluster formation using correlation (5) 2. Comparison of communication rounds at different instances of died sensor nodes : Initial Energy Protocol 5% 20% 50% 100% 10 Direct 53 74 100 820 Clustering_All Nodes 13 52 154 1033 Clustering_Only CH 200 800 2000 4000 Clustering_Supernode 99 635 1823 6024 1. Average Comparison of communication rounds at different instances of died sensor nodes of 5 Iterations : Initial Energy Protocol 5% 20% 50% 100% 10 Direct 54 74 112 740 Clustering_All Nodes 17 59 173 971 Clustering_Only CH 200 800 2000 4000 Clustering_Supernode 99 543 1767 7472 2.

Node death vs. Number of rounds : Figure 1

16:

Node death vs. Number of rounds 1

3. Network Life span : Figure 17: System lifetime comparison for various techniques Chapter 5 Conclusion and Future Work We have seen the importance of Correlation (both Spatial and Temporal) in clustering in Wireless Sensor networks. It reduces communication overhead significantly by reducing correlated data: Spatially as well as temporal. Thus reduces energy consumption in data transmission in WSN. Reduction in energy consumption results in enhanced overall lifetime of network. Clustering play a vital role in reducing energy consumption in transmission and increasing the network lifetime. By using Correlation model we can see the correlated information in certain area of observation. Nearby Sensor nodes based on their location observes similar information and thus the observed information is correlated. As observed information is correlated, only few nodes can participate in data transmission without loss of information. Spatial correlation helps to avoid the redundant information transmission to the Processing Node. Spatial correlation allows compressing similar information observed at various time spaces. Base signal which stores the differential information observed by the sensor nodes. Base signal helps to reconstruct the partial information at the Processing Node which is transmitted to the Processing Node. If deployed nodes are having data to be sent at different time intervals then various approximation, synchronization and communication techniques need modifications. Main reason behind this is that in most of techniques data compression and aggregation considering same transmission frequency from all the nodes. Proposed technique in the this research has not considered the energy loss in creating cluster, and internal communication within cluster such as CH signals other nodes to go into sleep mode, which node is currently CH, who is having highest probability of becoming next CH etc. Our proposed technique can be further explored and compared with similar kind of techniques.