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Optimization of network based on Node mobility and Topology change

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Abstract— Efficient use of the limited energy resources of wireless sensor network (WSN) nodes is critically important to support these advances, and application of topology control methods will have a profound impact on energy efficiency and hence battery lifetime. In this survey, we focus on the energy efficiency issue and present a comprehensive study of topology control techniques for extending the lifetime of battery powered WSNs. Finally, compared the performance of protocols like DMP and LEACH.LEACH provides better result than DMP in terms of delay, throughput, and energy.

Index Terms— DMP, LEACH, Network lifetime, Node mobility, Topology change, Topology control, WSNs.

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1 INTRODUCTION

Smart environments represent the next evolutionary development step in building, utilities, industrial, home and transportation systems automation. In Fig.1, the smart environment relies first and foremost on sensory data from the real world. Sensory data comes from various sensors of different modalities in scattered locations. The smart environment needs information about its surroundings as well as about its internal workings. Wireless sensor networks, consist of a data acquisition network and a data distribution network, monitored and controlled by a management centre.

A communication network has nodes, each of which has computing power and can transmit and receive messages over communication links, wireless or wired.

Sensor networks find its applications in military, home environment, etc. The simulation tool used here is NS2, which is an event driven simulation tool to study the dynamic nature of the networks.

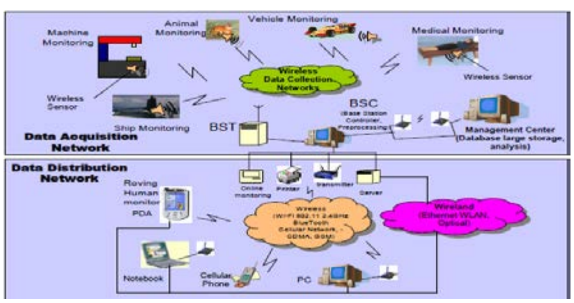

Fig.1 Wireless Sensor Networks

1.1 Network Topology

The basic issue in communication networks is the transmission of messages to achieve a prescribed message throughput (Quantity of Service) and Quality of Service (QoS). QoS can be specified in terms of message due dates, bit error rates, message delay, packet loss, transmission power, economic cost of transmission, etc. Depending on QoS, economic considerations, the installation environment and the application, one of several basic network topologies may be used. The basic network topologies are fully connected, mesh, ring, tree, star, bus.A single network may consist of numerous interconnected subnets of different topologies. Networks are further classified as Local Area Networks (LAN), e.g. inside one building, or Wide Area Networks (WAN), e.g. between buildings.

Fully connected networks suffer from problems of NP-complexity; as additional nodes are added, the number of links increases. Therefore, for large networks, the routing problem is computationally inflexible even with the availability of large amounts of computing power.

Mesh networks are regularly distributed networks that generally allow transmission only to a node's nearest neighbors. The nodes in these networks are generally alike, so that mesh nets are also referred to as peer-to-peer nets.

Mesh nets can be good models for large-scale networks of wireless sensors that are spread over a geographic region, e.g. personnel or vehicle security surveillance systems. The regular structure reflects the communications topology; the actual geographic distribution of the nodes need not be a regular mesh. Since there are generally many routing paths between nodes, these nets are frequent to failure of individual nodes or links. An advantage of mesh nets is that, though all nodes may be identical and have the same computing and transmission capabilities, certain nodes can be elected as 'group leaders' that take on extra functions. If a group leader is disabled, another node can then take over the duties.

All nodes of the star topology are connected to a single hub node. The hub requires greater routing, message handling and decision-making capabilities than the other nodes. If a communication link is cut, it affects only one node. However, if the hub is incapacitated the network is destroyed. In ring topology all the nodes perform the same function and there is no leader node. Messages generally go around the ring in a single direction. In the bus topology, messages are broadcast on the bus to all the nodes. Each node checks the destination address in the message header and processes the messages addressed to it.

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The bus topology is passive in that each node simply listens for messages and is not responsible for retransmitting any messages.

1.2 Topology Change

Topology control is an important technique used in WSNs to achieve energy conservation and extend network lifetime without affecting important network performance such as connectivity and throughput. The idea of topology control is to grant sensor nodes a sense of control over certain parameters such that these parameters can be manipulated in a way that benefits the network. In particular, sensor nodes have the capacity to adjust the transmission range of their radio, switch to the various modes of operation or even decide on the eligibility of the nodes joining the network backbone. These features are the parameters that are exploited in enforcing a reduced topology to achieve energy saving and prolong network lifetime.

The main objectives of topology control are two-fold. The first objective is to save energy and prolong the lifetime of the sensor node and network. The second objective is to overcome collisions. Other than discarding the inefficient links, the use of minimal transmission range successfully removes the long distance nodes, thus resulting in a sparse network. The effects of this include a reduction in the packet retransmissions and interference and an improvement in the network capacity.

Topology control can be implemented in three ways: Minimizing the power incurred during transmission by means of adjusting the transmission range of the wireless radio of sensor nodes is a common approach adopted. In addition, sensor nodes that are sitting idle, not participating in transmitting and receiving can turn-off their radios or they can transit to sleep mode. This approach can provide a substantial energy saving since the energy consumption during the idle mode is quite significant in comparison with the energy consumed during the sleep mode. Finally, topology control can be performed through a clustering approach. Based on selection criteria, sensor nodes select a set of nodes to form a cluster. This provides control over the topology to achieve energy saving and permits a structured hierarchical network architecture.

1.3 Network Lifetime

The ability of a network to prolong network lifetime is typically evaluated based on its definition. In this section, we review the definitions widely used in designing topology control algorithms.

• The first node to die: The first node which fails in the network is used to define the network lifetime. The failed node is often called a critical node.

• The number of alive nodes: The number of alive nodes as a function of time is taken as a measure of network lifetime. A higher number of alive nodes is used to describe a longer network lifetime.

• The fraction of alive nodes: The network lifetime is described by the fraction of surviving or alive nodes as a function of time. The network is alive while the fraction of surviving nodes remains above a target threshold value.

2 Related Works

A M.Burkhart, R.Wattenhofer, and A.Zollinger (2009) has proposed that, Topology control in ad-hoc networks tries to lower node energy consumption by reducing transmission power and by interference, collisions and retransmissions. This paper [1] disproves this implication. Based on this definition they show that most currently proposed topology control algorithms do not effectively constrain interference.

M.Rezaee, M.Yaghmaee (2010) has proposed a cluster based routing protocol for mobile ad hoc network. It uses clustering's structure to decrease average end-to-end delay and improve the average packet delivery ratio. Result implies that the packet delivery ratio increases greatly and packet delay decreases significantly. In proposed method [2] the routing is also done quickly and its error tolerance increases. The reason is that, routing is depended on the address of cluster heads.

Hugo Bragaand Fl´avioAssisLaSiD (2011) proposed that, Topology control is one of the chief techniques that can be used to decrease energy expenditure and/or interference in wireless sensor networks. This paper [3], describes a localized topology control algorithm called TCO which is very efficient in terms of interference while minimizing energy efficiency.

HaishengTana, TianchengLoua et.al (2011) proposed a low-interference connected topology is a fundamental problem in wireless sensor networks (WSNs). This paper[4], deals with the minimization of the average interference and the maximum interference for the highway model, where all the nodes are arbitrarily distributed on a line.

Syed Yousaf Shah and Boleslaw K. Szymanskit (2011) present a dynamic multipath routing protocol in which packets from different applications dynamically choose their paths by taking into account the price to be paid for taking each path and their ability to pay. As a result, low priority applications tend to avoid paths with high prices. Instead, they go via low price routes which may be longer but faster to pass by avoid waiting for passage at congested routers. This enables high priority traffic to get through quickly via short paths as their priority enables them to pay high prices with minimum wait. Dynamic pricing mechanism quickly enables routing to the damaged network, increases utilization of the partial network and minimizes delays.

ParikhaChawla, Parmender Singh and et.al (2012) proposed the paper associated with implementation of topology control approach to enhance throughput in wireless sensor network. A wireless sensor network is characterized by limited energy supply and large nodes. To increase the network lifetime of wireless sensor network the topology control is the considered to be the important process. Every attempt is being made to reduce the energy consumption and to enhance throughput [6] of the wireless sensor node. Network topology control is about the management of network topology to support network-wide requirements.

AzrinaAbd Aziz, Y. AhmetS¸ekercio˘glu and et.al (2013) proposed the work focusing on the energy efficiency issue and present a comprehensive study of topology control techniques for extending the lifetime of battery powered WSNs. Further, these algorithms [7] are classified according to the energy conservation approach they adopt and evaluated by the trade-offs they offer to help designers in selecting a technique that best suits their applications.

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3 Existing Method

The existing method has used DMP(Dynamic Multi-Path) which is a level-based protocol that works on cost and priority.

In multi application scenario, data feeds from different applications have different priority (often corresponding to social values of the corresponding applications assigned by information consumer), therefore all applications cannot be treated the same way. Applications with high priority should have their packets delivered with lowest delay as compared to others. The priority of an application is driven by several factors and may change over time depending upon the nature of the system. Often the priority can reflect the loss of Quality of Information (QoI); applications whose QoI is less tolerant to delays have higher priority (social value). Approaches using differentiated services, such as dedicating routing paths to applications based on their priority, have been proposed in the past. In such an approach, the paths are statically allocated which may lead to under utilization of the network because in many sensor network applications the traffic pattern constantly keeps changing. It is very difficult to predict the volume of data that will be flowing between any two nodes. There may be less data produced for high priority applications while high data bursts are generated by the low priority applications. In such a case, the routes dedicated to high priority traffic are highly underutilized whereas routes dedicated to low priority applications get congested. Therefore, there is a need for are active routing mechanism that can respond to varying state of the network by dynamically adjusting routing paths for multi priority applications. Routing nodes intelligently forward packets to nodes with lowest predicted delay. Whenever a router transmits a packet, auction among multiple possible paths is held. Path which incurs lowest delay for the application is selected and packet is forwarded to the neighbour on such a path.

4 Proposed Method

If Clustering is a process that divides the network into interconnected substructures, called clusters. Each has a cluster head (CH) as coordinator within the substructure. Each CH acts as a transitory base station within its zone or cluster and communicates with other CHs.

A clustering algorithm for sensor networks, is Low Energy Adaptive Clustering Hierarchy (LEACH). LEACH arranges the nodes in the network into clusters and chooses one of them as the cluster head(CH).

In Fig.2, the operation of LEACH is divided into rounds. Each round starts with a setup phase when the clusters are organized, followed by a steady-state phase when data are transferred from the nodes to the cluster head and on to the Base Station (BS).

In setup phase, all sensor nodes select a cluster head by threshold T(n). The threshold value depends upon the desired percentage (p) to become a cluster head, the current round r, and the set of nodes that have not become the cluster-head in the last 1p rounds, which is denoted by G.

$$T(n)=p/(1-p\times(r \bmod p^{(-1)})) \qquad \forall n \in G$$
$$T(n)= 0 \qquad \forall n \notin G \qquad (1)$$

where n is a random number between 0 and 1
p is the cluster-head probability
G is the set of nodes that were not cluster-heads the previous rounds.

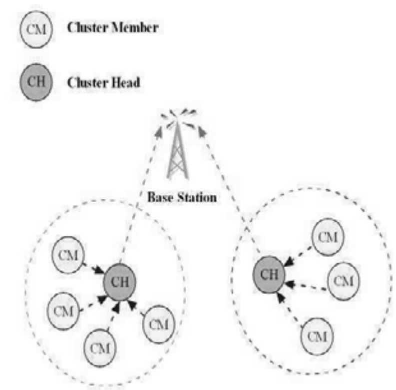

Fig.2 Illustration of LEACH protocol

In steady-state phase, the operation is divided into frames (a frame is the interval during which each regular node sends the sensed data to the cluster head). The nodes send their data to the cluster head at most once per frame during their allocated transmission slot. The cluster head node must keep its receiver on to receive all the data from the nodes in the cluster. When all the datas has been received, the cluster head node sends it to the base station after performs data aggregation to enhance the common signal and reduce the uncorrelated noise among the signals.

5 Results And Discussion

The simulation results are shown for DMP and LEACH protocols using NS2(Network Simulator 2). The result concludes that LEACH provides better options than DMP in terms of energy, throughput and packet delay.

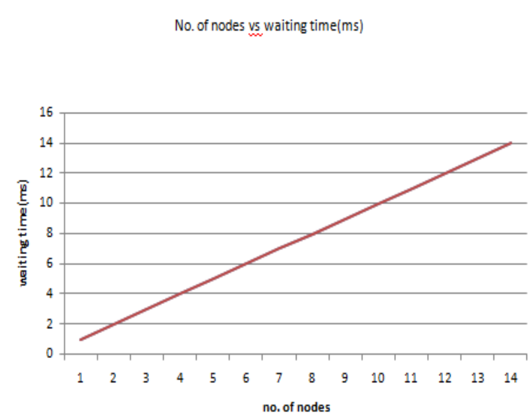

Fig.3 Number of nodes vs waiting in time(ms) in DMP

In Fig.3, as the number of nodes increases, the waiting time for the nodes to send its information to Base station also increases. The increase in waiting time reduces the performance of the network.

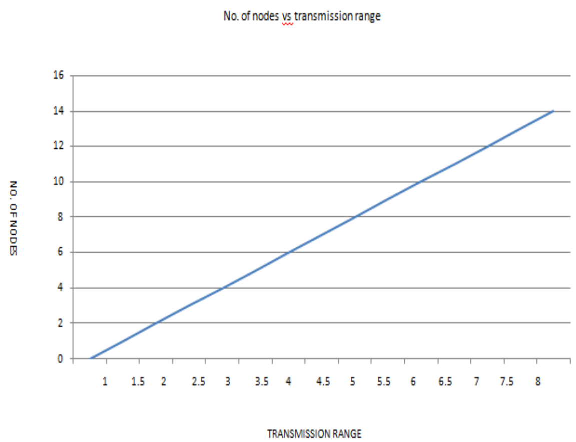

Fig.4 Number of nodes vs transmission range in DMP

In Fig.4 as the number of nodes increases, the transmission range of the nodes to send the information to base station also increases. When the range increases there are chances for more collision.

6 Cumilative Comparision Results

In Fig.5, the comparison graph clearly shows that when number of nodes increases, the throughput is better in LEACH compared to DMP. In DMP as the number of nodes increases the layers are also increased so there is degradation in the delivery of packet or data to the destination so throughput is reduced.

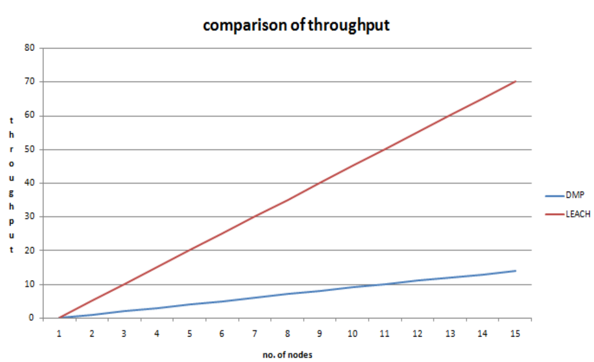

Fig.5 Comparison of throughput

But in LEACH, even when the number of nodes increases it's only the CH that transfers the data so there is a considerable increase in the throughput of the network.

Packet delay is one of the performance parameter that should be reduced for better performance of a network. In Fig.6, Comparing LEACH and DMP, LEACH offers less delay than DMP and hence is the efficient of the two. In DMP as the number of nodes increases the layers are also increased so there is degradation in the delivery of packet to the destination so packet delay is increased. But in LEACH, even when the number of nodes increases its only the CH that transfers the data so the delay is increased to a certain level and gets saturated after that, thus improving the performance of the network.

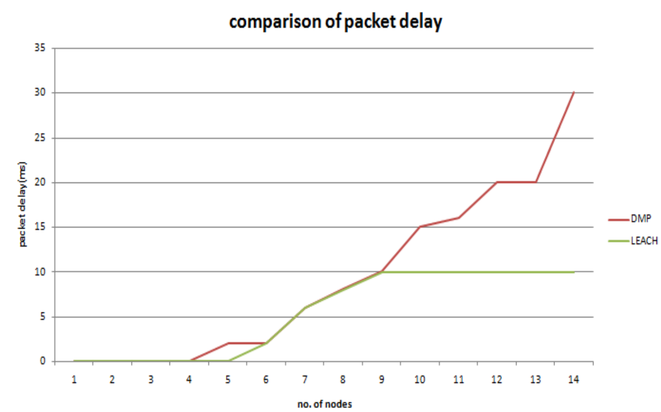

Fig.6 Comparison of packet delay

7 Conclusion

In WSNs, nodes operate with a limited battery source and they cease operating once their battery depletes. A common approach to address the power issue is to develop energy efficient algorithms that optimize the use of the energy supply. The future topology control techniques should explore the hybrid approach to develop a simple and energy efficient topology control solution. For instance, the techniques that combine clustering and power adjustment can utilize the advantage of the clustering approach to simplify the network and use the ability of the power adjustment to solve the optimal transmission power. The power adjustment and power mode approaches can be jointly adopted to find the optimal transmission range for each node.

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