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Performance Analysis Of Energy Optimization Techniques In Wireless Sensor Networks

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ABSTRACT

Fast growth of wireless services in recent years is an indication that considerable value is placed on wireless networks. Wireless devices have most utility when they can be used anywhere at any time. One of the greatest challenges is limited energy supplies. Therefore, energy optimization is one of the most challenging problems in wireless networks. In recent years, Wireless Sensor Networks have gained growing attention from both the research community and actual users. As sensor nodes are generally battery-energized devices, so the network lifetime can be widespread to sensible times. Therefore, the crucial issue is to prolong the network lifetime. In this paper, two Energy Optimization Schemes Clustering and Direct Diffusion for Wireless Sensor Networks (WSN) has been compared on the basis of different parameters like scalability, energy efficiency and reliability etc. on the basis of this comparison we can use better Optimization technique according to the situation.

I. INTRODUCTION

The wireless sensor network consists of numerous applications for monitoring different environments. In comparison to traditional networks, wireless sensor networks offer improved functionalities to monitor larger scaled and changing topology with limited power and computational abilities in dense deployments. Wireless sensor networks have been deployed in application areas for military, environment, health, traffic control and other areas of interest for gathering data[1]. Due to the limited supply of energy that resides on the sensor nodes, it is critical that the lifetime of the nodes span over a long period of months or years. Energy consumption is an inherent problem in wireless sensor networks, and it is largely orthogonal to the general energy efficiency problem. For example, in a data gathering application, multi-hop wireless links are utilized to relay information to destination points called sinks. Inevitably, the nodes closer to the sink will experience higher traffic and higher energy consumption rate. These nodes will be the first ones which run out of power. Algorithms which allow routing around failed nodes will increase the load even more on the remaining active nodes close to the sink[2][3][4]. Due to this limitation, efficiently using energy from the nodes has become a crucial challenge[5]. The main problems that trouble architects are the power and communication of data in the network. Because communication is transferred wirelessly, it is important to mimic the function of transferring uninterrupted and reliable data that is normally carried out by a cable[6]. In order to increase energy efficiency, WSNs also need to reduce energy consumption as to not completely drain the life from the nodes. So we compare two energy optimization techniques[7][8].

Clustering

Proposed cluster-based energy balancing scheme is intended to ameliorate the above energy unbalancing phenomena. We exploit the observation that in a heterogeneous sensor network there are nodes which are more powerful in terms of energy reserve and wireless communication ability[10]. We transform the flat communication infrastructure into a hierarchical one[15][16] where strong nodes act as cluster heads to gather information within the clusters and then communicate with the sink directly via single hop link. In such a way, the hot spot around the sink is divided into multiple regions around the cluster heads in the hierarchical infrastructure.

These distributed regions will assume fewer burdens due to the smaller scale of sensor nodes within the clusters. Wireless sensor networks are composed by a large amount of small, resource constrained devices, called sensor nodes, which have limited sensing, computing and wireless communication abilities. These sensor nodes usually collaborate with each other via multi-hop links[12]. The member node takes care of the transmission and arrangement of nodes within the cluster. The cluster head takes care of transferring the data to other clusters within the network by maintaining the routing information. The member nodes report their data to the respective CHs. The CHs aggregate the data and send them to the central base through other CHs[14]. Because CHs often transmit data over longer distances, they lose more energy compared to member nodes. The network may be re-clustered periodically in order to select energy-abundant nodes to serve as CHs, thus distributing the load uniformly on all the nodes. The cluster formation helps reduce energy consumption, communication latency, traffic load and routing overhead.

The multi-hop organization presents many advantages, from the increase of the network capacity, ability to perform data fusion and more efficient energy utilization[16]. However, under many scenarios, multi-hop sensor networks are utilizing energy in an unbalanced manner. To illustrate this phenomenon, let us consider a simple, unidirectional example. We assume that all nodes communicate only with their neighbors and all the nodes are sending their observations back to the sink. We assume the nodes to be equidistant, and thus the dissipated energy being roughly the same for each node[11][13]. Normally, if all nodes have the same initial energy upon deployment, the node closer to the sink will drain earlier since it has heavier forwarding burden. Moreover, the further nodes which may still have plentiful energy supplies cannot find the routes to the sink. The energy unbalancing problem will aggravate with the increase of the network depth.

Direct Diffusion

Directed diffusion consists of several elements: interests, data messages, gradients, and reinforcements. An interest message is a query or an interrogation which specifies what a user wants. Each interest contains a description of a sensing task that is supported by a sensor network for acquiring data. Typically, data in sensor networks is the collected or processed information of a physical phenomenon. Such data can be an event which is a short description of the sensed phenomenon. In directed diffusion, data is named using attribute-value pairs. A sensing task (or a subtask thereof) is disseminated throughout the sensor network as an interest for named data[18]. This dissemination sets up gradients within the network designed to draw events. Specifically, a gradient is direction state created in each node that receives an interest. The gradient direction is set toward the neighboring node from which the interest is received. Events start flowing towards the originators of interests along multiple gradient paths. The sensor network reinforces one, or a small number of these paths.

These elements of diffusion with specific reference to a particular kind of sensor network one that supports a location tracking task. We elaborate on these design choices while describing the design of our sensor network. Our initial evaluation focuses only a subset of these design choices[19]. Diffusion involves two phases of operation.

-In the first phase, a sink node requests and broadcasts exploratory interest messages that are routed towards nodes in the region throughout the sensor network. Exploratory interest messages are messages that contain the interests, data messages, gradients and reinforcements to interrogate the nodes on specifically what the user needs specify constraints of the data that the sink expects, is named using attribute-value pairs.

-When interest messages are broadcasted to the network from the sink node, each node receiving the interest can do caching for later use. The interests in the caches are used to compare the received data with the values in the interests.

-The interest contains gradients that are setup to direct the interest to the events that match the attributes.

-Paths are established between the sink and the source using the gradients and interest. Sources with data matching these constraints send exploratory data messages back along the gradients with the exploratory interests received

-In the second phase, the sink, upon receiving interest messages send renforcement interest messages to specific neighbours who delivered useful data. These neighbours reinforce the paths established that provided useful data and this process continues.

Duplicate Suppression

The simplest data aggregation function is duplicate suppression. Duplicate suppression is restraining repeated notifications of the same event from nodes in the nearby groups. In this events sent from source one and two contain the same data that is sent to another node. Based on time synchronization, where events are time stamped with the frequency precision, duplicates are easier to recognize and prevents redundant notification of nearby nodes to be recognized[20].

In Duplicate Suppression In-network data processing is used as routing technique. The basic idea behind in-network processing is to reduce the amount of data to be transmitted and equal amount energy usage of entire network. In-network data processing is required because transmitting data requires more energy than processing data[21]. In-network data processing[22] helps lengthen the network lifetime and minimize the amount of data that needs to be transmitted. It consolidates the information acquired by different sensors at specific nodes within the network versus each individual node transmitting data to the sink. Other benefits of in-network processing include equal energy usage, suppression of duplicate messages and prevention of bottleneck at the gateway.

II. PERFORMANCE ANALYSIS

These Optimization techniques can be compared on the basis of different parameters like Scalability, Energy Efficiency, Concurrency, Reliability, Latency etc. First of in scalability Clustering[10][13] is more scalable as compare to Direct Diffusion and Duplicate Suppression. In Direct Diffusion and Duplicate Suppression we can scale the number of nodes up to limited extent. . So in case of scaling Clustering is better as shown in figure.

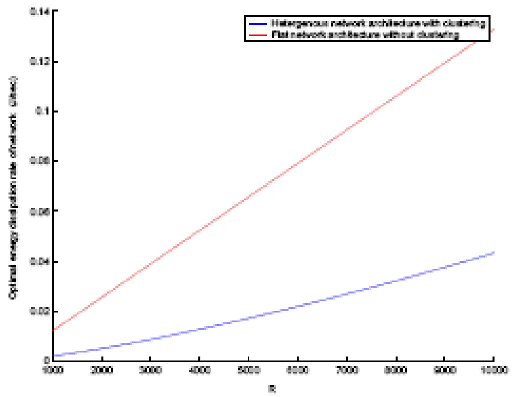

Figure: The impact of network density on the optimal performance of two paradigms of network Where n=2, N=1000

Secondly in case of Flexibility Direct diffusion can be extended to support heterogeneous nodes while in Clustering technique[17] support heterogeneous nodes when cluster head has more energy and computational capability. While in Duplicate Suppression, it applies on the homogenous nodes. So in case of flexibility all techniques are equally good enough.

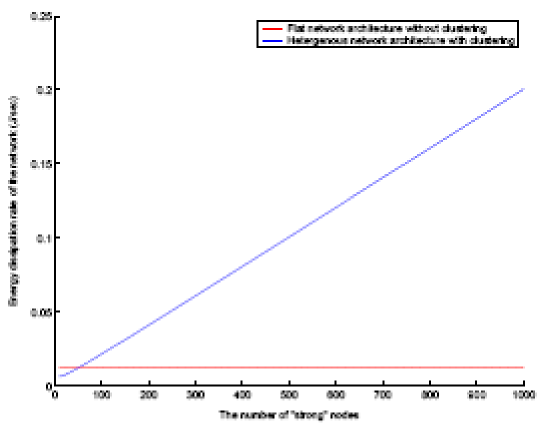

Figure: Performance comparison of two paradigms of network where n=4, N=1000

Technique	**Clustering**	**Direct Diffusion**	**Duplicate Suppression**
Scalability	Highly Scalable	Limited	Limited
Concurrency	Moderate	Good	
Flexibility	Good for heterogeneous nodes when cluster head has more energy	Can be extended to support heterogeneous nodes	Apply to homogenous nodes
Energy Efficiency	Very Good	Very Good	Good
Reliability	Moderate in case of highly scalable	Good	Moderate

In case of Energy Efficiency both Direct Diffusion and Duplicate suppression Clustering techniques are very good while Duplicate suppression is good for data redundancy. In Directed Diffusion[18], the energy of the network decreases rapidly and goes down approximately to zero in 2 minutes .This is because the effective of transmitting and receiving data in the network and the sensor will find the shortest path, and then later it is set the appropriate gradient for the path which enables the node to transmit and receive the appropriate packet or data. The rapid uses of the gradient path also contribute to decrease of energy. This is due to the node only transmitting and receiving data packet with gradient path which is the main basic operation for this routing protocol. This also to make sure that the transmitting and receiving duplicate data or packet can be eliminated. Deploying the small size of network to the directed diffusion protocol dramatically reduce the total system energy usage. Thus, will prolong the life of network it self directed diffusion has the potential for significant energy efficiency. Even with relatively non optimized path selection, it outperforms an idealized traditional data dissemination scheme like omniscient multicast. Second, diffusion mechanisms are stable under the range of network dynamics considered in this paper. Finally, for directed diffusion to achieve its full potential, however, careful attention has to be paid to the design of sensor radio MAC layers. Even then clustering has better energy efficiency.

While in case of reliability Direct Diffusion is good while in case of Duplicate Suppression and Clustering reliability is moderate. Clustering is moderate only in case of highly scalable nodes.

III. CONCLUSION

In this paper, I have thoroughly researched and reviewed some of the popular optimization approaches for wireless sensor networks. The objective of this paper is to provide comparison of these different techniques and suggest a better technique in different situations. Based on our analysis of the existing techniques, we summarized and compared these techniques against different metrics like Scalability, Flexibility, Concurrency, energy efficiency etc and I find that Clustering is better in more cases as compare to Direct Diffusion and Duplicate Suppression.

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