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A Wide Study on Data Dissemination Scheme in Wireless Sensor Networks

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Abstract—Data dissemination from data source to data sink is of prime importance in wireless sensor networks. The current data dissemination scheme is however not energy-efficient in that it constructs a dissemination tree without taking into consideration that data sinks have different requests updating data rates. In order to address this problem several algorithms and routing protocols have been used over the past decade. In trying to determine the best way for energy consumption most research has explored algorithms which use the mesh topology for wireless sensor networks (WSN). This paper tries to study most of the data dissemination schemes used in WSN and is divided into four sections namely; issues, solutions, finding and future works. Finally most of the methodologies will categorized and analyzed.

Keywords: Routing protocols, energy consumption, Tree-based Routing.

1. Introduction

Today many different applications in inaccessible regions such as battlefield surveillance, whether monitoring, disaster management, petroleum, controlling and sensing environment; use wireless sensor networks (WSNs). The main reason for using WSNs in these environments is that each wireless sensor is equipped with small sensing device, wireless communication, finite radio range and bandwidth; with each wireless node having the capability to process, gather and transmit data to any one of the designated base stations (BS). The downside to WSNs is that they have limited battery power, storage and data processing capabilities. Out of the three limitations the primary challenge is energy consumption and prolonging the network life time, especially for sensors deployed in environments that are not easily accessible. As a result it is impossible to replace and change the sensor’s battery. It is therefore important for WSNs to efficiently utilize energy and reduce the consumption cost. Since WSNs collect the data periodically and lots of data has to be transmitted it is thus necessary to examine how the sensor collects data and the minimal processing because this can help in isolating redundant data before it is sent to the base station for processing.

2. Issues and Problems

When dealing with energy, given that the workload in a WSN is uneven it can lead to hotspots and premature energy exhaustion especially on critical routers of the network [1]. In trying to maximize wireless sensor network lifetime [5], it is critical that the network is able to communicate its battery energy in an efficient manner. It must also derive sensor readings with an elevated accuracy [6, 8]. In addition to this, the challenge of unbalanced energy consumption for nodes in wireless sensor networks (WSN) [10] is supposed to be considered as part of the design for sensor network geographic routing in lossy wireless link [11]. Currently the data dissemination scheme that constructs a dissemination tree fails to utilized energy efficiently. This is due to the fact that the data sinks have different requests for data updating rate [17].

As for protocols initially the Tree-based Routing (TBR) protocol was designed to only work with a single wireless system such as IEEE802.11a or 11b, and thus cannot be applied to the cognitive networks configured with multiple wireless systems, which may have the different bandwidths and transmission ranges [4]. This is the reason that most known routing protocols struggle to maintain complex routing structures, for instance N spanning trees or high cost (from the perspective of communications cost) methods for path discovery. Deployments of most MANETs with these methods will invariably lead to excessive communications costs [3]. Not only this but the deployment of a number of routing protocols and data aggregation reduces the amount or size of transmitted packet [2]. Therefore the main challenge is the development of an energy-efficient routing protocol [13]. This must be done in such a way that the lifetime of the network is prolonged and also boost the connections among nodes and reduce energy dissipation is one of the main hot spots in WSN [14].

Bandwidth is related to QoS challenges investigated that included multicast routing in ad hoc wireless networks. Inadequacies in the bandwidth of a wireless node can more often than not cause a QoS multicast call to be blocked. Especially if the single multicast tree that has the requested bandwidth is nonexistent, even though there is enough bandwidth in the system to support the call [7].Maintaining neighborhood information for packet forwarding is a way of attaining a high efficiency in geographic routing, which is important for applications such as mobile target detection and tracking[9], that disseminate data from a dynamic source to multiple mobile sinks However it may not be appropriate for WSNs in highly dynamic scenarios where network topology change frequently due to nodes mobility and availability [12]. For instance in cases when finding the path from each node to its nearest base stations to maximize the network lifetime [15]. Further, the data aggregation is an essential paradigm for routing, through which the multiple data from different sensors can be aggregated into a single data at inter medial nodes enroute, in order to eliminate data redundancy and achieve the goal of saving energy [16]. Likewise wireless sensor network monitoring is also essential for network maintenance, since it alert keeps the observer aware of node failures, resource depletion etc [18].

3. Solution and Methodology

Several solutions and methods have been proposed for instance one scheme forms multiple trees during the initialization phase and, each node selects the least overcrowded route to the root node depending on the network traffic. In terms of network lifetime and traffic distribution EAMTR simulation and performance evaluation results show considerable improvement [1]. In addition a method that provides fault tolerance for packet loss by forming a Directed Acyclic Graph (DAG), which allows a node to have multiple parent nodes, is used. This method guarantees data transmission timing that accurate, because it is based on the actual hop count of the edge of the DAG. Moreover, taking into consideration the error margin of the collected data we evaluated the proposed method in comparison with the preexisting methods [18].

Energy preservation is a key element and thus a number of methods are suggested as a way of reducing energy dissipation from the network. Adopted by UDACH (Uniformly Distributed Adaptive Clustering Hierarchy) is a clustering method which considers the energy of each node unlike LEACH which randomly selects a cluster head. UDACH has three stages which include cluster construction, building a cluster head tree and transmitting the data to the base station. The cluster construction allows for the selection of the cluster node. Once this is done the next stage builds cluster heads to form tree structures for transmitting multi-hops through the parent cluster head. Caution must be taken when selecting the parent cluster head because if it is not done well, UDACH dissipates the energy since the total distance of transmission to the BS becomes longer [2]. Apart from this, an edge cost function that balances energy among sensors is presented. We also showed that ESSR maximizes network lifetime when a limited number of routing trees is used. We presented our simulation results which indicate considerable improvement over existing protocols. We showed that our algorithm works better in dense networks where receiving energy consumption plays a significant role in maximizing network lifetime. Despite the fact that our approach mainly focuses on extending network lifetime it will also attempt to generate small schedules. As a continuation of this work, we are exploring a situation when nodes are not in the same transmission range [5].

Currently most in-network aggregation structures mainly aim to reduce communication costs, however MULT further provides energy balancing. MULT has 3- phases: first building the clusters, second connecting the clusters and third making multiple trees. MULT is based on creating node clusters using distance between nodes. In addition, a new clustering method, called HYC (Hybrid Cluster) is introduced for MULT structure. We compare the MULT with LEACH and EAD, which are typically used in-network aggregation methods. MULT outperforms LEACH and EAD for energy load balance [8].

NSEEAR which is a Network Stability Enhancement by Energy Aware outing organizes the network into concentric tiers around the base station and routes aggregated data packets by forwarding them from one tier to another in the direction of the base station. Relaying nodes are chosen based on their distance from the transmitting node and the base station, together with their residual energy. NSEEAR was evaluated by analysis and simulations that indicate that NSEEAR results have much longer stability periods in contrast to those obtained by the current clustering protocols. Whereas, a novel link estimator and real time energy estimation scheme is designed in the sub layer of the LEGR (Load-Balanced and Energy-Efficient Geographic Routing) protocol to get the neighbor nodes' PRR(packets reception rate) value and current energy level. Some performance metrics were defined to allow for the evaluation of the efficiency and the effectiveness of the new protocol. From the comprehensive simulation results concerning these metrics show that, in contrast to the PRR*distance forwarding scheme, LEGR extend the lifetime of the sensor network about 20% with approximate delivery rate and energy efficiency. Compared with GEAR and GPSR, LEGR performs better in terms of almost all the performance metrics [11].

In another scheme, the data source uses multiple trees to disseminate data to data sinks. The tests conducted clearly indicated that when the number of data sinks is huge, the scheme performs better than prior best data dissemination scheme SEAD about 15% in weighted path length. Then energy utilization in data dissemination is lessened and system lifetime is extended [17].

With EBGR, every node starts by computing its ideal next-hop relay position on the straight line toward the sink depending on the energy-optimal forwarding distance, and every forwarder chooses the nearest neighbor to its ideal next-hop relay position as the next-hop relay utilizing the Request-To-Send/Clear-To-Send (RTS/CTS) handshaking mechanism. By assuming that no packet loss and no malfunctions in greedy forwarding, the lower and upper bounds on hop count and the upper bound on energy utilization under EBGR for sensor-to-sink routing can be e established. Furthermore, a demonstration of the likely total energy consumption along a route toward the sink under EBGR approaches is done to the lessen bound with the increase of node deployment density. The existence of unpredictable communication links may also lead to the extention of EBGR to lossy sensor networks to provide energy-efficient routing. From the simulation it is clear that the scheme extensively outperforms current protocols in wireless sensor networks with highly dynamic network topologies [12]. The MTC algorithm is used to construct routing trees for different base stations resulting in energy efficient transfer of data. We propose a model for optimal placement of base stations for any network. Further, we compare the performance of the network for different number of base stations to validate our model [15]. Another solution is where initially the problem of constructing multiple spanning trees is transformed into a linear programming problem of the data flow network. Based on the solved optimal rate between the two adjacent sensors, the two constructing algorithms of the spanning tree are presented. Trail results show that the technique of multiple spanning trees can be of value to energy reduction for wireless sensor networks, and the corresponding suitable constructing algorithm can extend the lifetime of the sensor network [16].

As for routing protocols, three multicast routing strategies are studied, SPT (shortest path tree) based multiple-paths (SPTM), and least cost tree based multiple paths (LCTM) and multiple least cost trees (MLCT). The routing tree(s) produced at the end can meet the user's QoS requirements so that the delay from the source node to the farthest destination node shall not surpass the bound and the aggregate bandwidth of the paths or trees shall be adequate for the bandwidth requirement of the call. As a way of evaluating the performance a lot of simulations have been carried out. Subsequent to these simulations three major advantages resulted: 1) it significantly lessens the system blocking; 2) multicast routing is in done fully distributed manner; 3)the proposed routing protocol follows the format of existing on-demand multicast routing protocols for ad hoc networks, which makes it easy to be incorporated into the existing on-demand routing protocols [7].

Further, this class of protocols maintains minimum routing structures and uses these structures to boot strap path discovery. This class of routing protocols accomplishes optimal performance with respect to lessening the communications costs related to on-demand routing in suitable conditions. The investigation is focused on the impact of multiple tree implementations for path discovery together with the analysis of their impact on the effectiveness of optimal path discovery [3]. To enable the original TBR routing protocol to adapt to the cognitive environment, we proposed a new cognitive-aware link cost function to calculate the global end-to-end metrics for any source-destination pair. Furthermore, to consider the impact of local contention condition with multiple interfaces, we introduce a local decision rule to select an interface for the intermediate CT. Besides that, we proposed a global decision rule to select a path for a source-destination pair with the best global metric. Our numerical simulation results reveal that the average end-to-end delay of proposed CTBR achieved about 5 times smaller than the one of the hop-count based scheme. Furthermore, the proposed protocol can increase the packet delivery ratio by about 40% over the hop-count based scheme. We conclude that our proposed CTBR routing protocol is beneficial in terms of reducing the end-to-end delay and increasing the packet delivery ratio [4].

A MECH (Maximum Energy Cluster Head) routing protocol is also developed. It is a clustering-based protocol that tries to minimize the energy dissipation in sensor networks. The key features of MECH are: energy dissipation reduction, self-configuration and localized coordination, maximum energy cluster head, hierarchical forwarding, and load balance. In our work, we use the same radio model as discussed in LEACH, which is the first order radio model [13].

On the other hand PECRP combines the advantages of some excellent cluster-based routing protocols, such as HEED (Hybrid Energy-efficient Distributed Clustering Approach), PEGASIS (Power-Efficient Gathering in Sensor Information Systems) and so on. PECRP improves the mechanism in selecting CHs (cluster heads) of LEACH, and opts for more appropriate nodes to be CHs, which could clearly extend the lifetime of WSN. In data transmission, PECRP utilizes the "circle domino effect based on the distance to the BS (Base Station)" that is a multi-hop transmission, to balance the energy consumption in nodes. Proving the rationality that multi-hop transmission can truly extend the lifetime of WSN in narrow sense situation founded on mathematical proofs. The simulations show that PECRP has superior performances than LEACH in extending the lifetime and transmitting data in the symmetrical distribution of nodes in WSN [14]. A huge hindrance in implementing the framework is how to proficiently reconfigure the proxy tree while sources and sinks keep on being modified. The problem is modeled as on-line constructing a minimum Steiner tree in a Euclidean plane, and intends on adopting centralized schemes to solve it. Bearing in mind the stringent energy constraints in wireless sensor networks, we further propose two distributed on-line schemes, a shortest path-based (SP) scheme and a spanning range-based (SR) scheme. In order to evaluate these schemes a lot of simulations are conducted. The results indicate that the distributed schemes have the same performance as the centralized ones. While from among the distributed schemes, SR performs more efficiently than SP [9]. Overall it is essential to design sensor networks that can communicate energy efficiently as well as to obtain sensor readings very accurately [6].

4. Finding

A new light-weight routing protocol, energy conscious multi-tree routing (EAMTR) protocol, to stabilize the workload of data gathering and lessen malfunctioning hotspot and points for high-density sink-type networks [1]. To resolve this problem, a Clustering Method of Enhanced Tree Establishment to construct tree structure for the optimized energy utilization can be used [2].we examine the performance of a scarcely studied class of routing protocols which are refered to as Beacon-Based Routing Protocols [3]. EESR) is yet another energy efficient spanning tree based on multi-hop routing in a homogeneous network that maximizes the network lifetime [5]. A further proposal is NSEEAR – Network Stability Enhancement by Energy Aware Routing, an adaptive routing protocol which leads to a better energy utilization of the network to extend its stability phase (the time interval before the death of the first node) and the significant network lifetime (the time interval before half of the network is dead) which is essential for various sensing applications in which the feedback from the network is supposed to be dependable [10].

In addition an efficient and practical protocol, called Cognitive Tree-based Routing (CTBR) protocol has been proposed. It enlarges and considerably enhances the capability of the known TBR protocol to enable it to support multiple wireless systems such as IEEE802.11g and IEEE802.11j [4]. While a multicast routing scheme by using multiple paths or multiple trees to meet the bandwidth requirement of a call [7] is also put forward. Yet another is a MECH (Maximum Energy Cluster Head) routing protocol. It has self-configuration and hierarchical tree routing properties [13]. This paper proposes a new type of routing protocol for WSN called PECRP (Power-efficient Clustering Routing Protocol), which is suitable to long-distance and complex data transmission (e.g. patient-surveillance or chemical detection in agriculture), and for fixed sensor nodes of WSN [14]. Likewise the LEGR protocol uses energy aware metrics together with geographical information and packets reception rate (PRR) to make routing decisions [11]. To significantly reduce data transmission costs and increase accuracy in WSN with faults a novel routing scheme is proposed[6]. Also a new in-network aggregation structure based on multiple trees, called MULT, for further extending the lifetime of in-network aggregation [8] is proposed too.

A new online routing scheme, called Energy-efficient Beaconless Geographic Routing (EBGR), which offers loop-free, fully stateless, energy-efficient sensor-to-sink routing at a low communication overhead without the help of prior neighborhood knowledge [12]has been proposed. Also in order to address the problem of finding the path from each node to its nearest base stations to maximize the network lifetime a Multiple Tree Construction (MTC) algorithm [15] is used. While there is a focus on applying multiple spanning trees to organize the data aggregation, which is different from the existing single spanning tree methods [16], a multiple tree-based data dissemination scheme [17] and a new in-network aggregation method for sensor network monitoring [18] have also been proposed. To cup it all up a generic dynamic proxy tree-based framework is proposed [9].

5. Future Works

Our future work will fall into several areas of investigation. We plan to expand the type of topology models investigated, beyond that of a homogeneous overlapping disk model [3]. For instance, finding the optimal number of trees and their properties, in terms of maximum depth and children, for a different number of nodes, network topology and traffic load [1]. Also improvements on the CTBR can help reduce the routing overhead and allow for a more detailed study of the performance of the CTBR routing protocol with mobility in the cognitive wireless networks [4].

We shall also investigate how to maximize network lifetime for heterogeneous networks where sensed data is not correlated and aggregation is not possible [5] with the prospect of increasing data transmission by about 70% on average. In the future, we will expand our scheme to improve the network lifetime by considering the amount of residual energy [6]. Further we plan on studying the "void" problem in lossy networks. Facing routing in a planar graph solves the dead-end problem after the greedy forwarding fails. And we also try to avoid routing the packets to the void area by considering the distance to the whole cost in our routing weight calculation [11].

There are some interesting future research directions regarding the concept of energy-efficient geographical routing in WSNs. By taking the residual energy into account for making forwarding decision, our scheme can be extended to alleviate the unbalanced energy consumption in the network while still guarantee that the total energy consumption for sensor-to-sink data delivery is bounded. Another extension is to integrate other energy conserving schemes such as data aggregation to further reduce energy consumption and maximize network lifetime.

It is also interesting to extend our scheme to networks with heterogeneous propagation properties [12]. In addition, we wish to solve the synchronization problem. It is difficult to make thousands of nodes to time synchronization. Therefore, we must modify our algorithm to handle such situation. Parameter setting exploration is another work. Finding optimal parameters is also important to MECH such as the number of members in a cluster and radio range [13]. Ongoing works include studying more efficient constructing algorithms for searching multiple spanning trees for a wireless sensor network, and studying the data aggregation topology changing from one spanning tree to the other spanning tree with a lowest possible cost [16].

6. Conclusion

In this paper, we consider the issues of routing base protocol in Wireless Sensor Networks and highlight those issues. Maximum life time is one of the fundamental problem in wireless sensor networks systems which is directly affect the accuracy and efficiency of the network in the other hand the limited battery power will decrease the possibility of maximum life time in WSNs specially in geographic routing in lossy wireless link, although unbalanced energy consumption for nodes decreasing efficiency particularly in neighborhood depended networks, in the case of energy efficiency maintaining neighborhood information for packet forwarding can achieve a high efficiency and availability. Most probably the main reason of consideration of different protocols in wireless senor networks is to develop and design an energy-efficient routing protocol which should answer the question of, how to design a kind of routing protocol that could prolong the lifetime of network at the same time should be able to enhance the connections among nodes and reduce energy dissipation of network.

Some protocols struggles to maintain complex routing structures such as N spanning tree or use expensive method of path discovery, other type of protocols mainly put more afford to critical nodes, there are some protocols which are using several routing protocol and the data aggregation which decreases the number of transmission or the size of transmission packet, there are types of protocols which specifically designed for single wireless system i.e. original Tree-based Routing (TBR) protocol and thus cannot be applied to the cognitive networks configured with multiple wireless systems, Also some issue has been highlighted in QoS multicast routing because of limited bandwidth of a node, data aggregation and data dispatching plus managing and monitoring the data dissemination is the main focus area of Wireless sensor network monitoring which is responsible of network maintenance and should be able to report node failure and depletion.

7. References

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