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Link Stability Based Energy Aware Backbone Formation in Mobile Wireless Sensor Networks

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Abstract - Mobile Wireless Sensor Networks (MWSNs) are newly evolving smaller field of research area which needs to be given more importance. In MWSNs, nodes can self-propel via springs, wheels, or they might be connected to transporters, for example vehicles. Sensors have restricted energy supply and the sensor network is required to be functional for a long time, so enhancing the energy utilization to extend the network lifetime becomes a significant issue. An important property that distinguishes mobile wireless sensor networks from other distributed systems is their requirement for energy efficiency because sensors have limited energy saves. Since there is no static organization or centralized control in WSN, a connected dominating set (CDS) has been proposed as a virtual backbone. The CDS performs a main role in routing, broadcasting, coverage and movement planning. To decrease the activity during communication and extend the network lifetime, it is desirable to build a minimum CDS (MCDS). The main challenges faced by the mobile sensor network are link breakage, due to mobility or the energy depletion of the nodes. In this paper, we propose a new backbone formation algorithm based on link stability and energy.

Keywords: Dominating sets, connected dominating sets, virtual backbone, rssi, mobile wireless sensor networks, link stability, energy.

I. Introduction

Mobile wireless sensor networks (MWSNs) can simply be defined as a wireless sensor network (WSN) in which the sensor nodes are mobile. Mobile Wireless Sensor Networks (MWSNs) have received major consideration from the wireless networking research community in the most recent year because of their possibility to be deployed in many real-life applications where human openness is restricted. Wireless sensor networks do not depend on any existing or predefined network infrastructure, and sensor nodes randomly placed. In MWSNs, maintaining connectivity between a node is a critical issue to collect information from sensors without any interference.

The key problem in this research field is to assure good signal communication when sensor nodes are in mobile. Sensor networks are used to collect distributed information from a given location or region. Because of the limited radio communication range, sensor nodes communicate via intermediate nodes.

Energy efficiency is an important issue in MWSNs, because energy resources are limited. From the analysis of the energy consumption of a sensor node, it has been found that a great amount of energy is consumed for communications. To improve the lifetime of each node and, hence, the network, power consumption should be minimized and balanced among nodes. In order to achieve the scalability and efficiency of a wireless network, it is necessary to construct a virtual network base station to organize the network into a hierarchical structure. We call this virtual network base station as a virtual backbone of the network (VBN). A virtual backbone can be used as a spine for routing in a network. The nodes which are responsible for routing are limited to the nodes in the backbone, which greatly reduces routing overhead. VBN also has an important role in broadcasting.

In order to construct a virtual backbone for a network Connected Dominating (CDS) sets technique has been used in the wireless sensor networks. A DS is a subset of nodes in the MWSNs where every node is either in the DS or a neighbor of a node in DS. If any pair of nodes in a DS is connected either directly or indirectly, the DS is called a Connected Dominating Set (CDS). A CDS can create a virtual network backbone for packet routing and control. The dominators are the responsible for transferring the information to other nodes in the network. Messages can be routed from the source to a neighbor in the dominating set, along the CDS to the dominator near to the destination node. This is called dominating set based routing, backbone based routing, or spine based routing. First, CDS constructs a dominating set (DS) in which only nodes can relay the broadcasting packets. Finding a Minimum CDS (MCDS) will reduces the packet retransmission, and also transmits the packets to the entire sensor networks more quickly.

Due to link failure a node will become unavailable. So, in mobile wireless sensor networks (MWSN) maintaining the connectivity with other nodes present in the region has become an issue. In order to maintain the links between mobile nodes connected dominating sets has been introduced. But the construction of virtual backbone is very complicated in many of the CDS. In this paper, we propose a new satble based CDS construction algorithm to reduce the routing overhead, and effectively utilizing the energy of the nodes by randomly activating which is responsible for routing.

II. Related Work

Seiven Leu et al., (2012) [1] have presented a CDS algorithm which is suitable for both static and dynamic MANET environments. If the transmission is traditional broadcasting, it has a packet collision problem and it can significantly reduce the wireless network throughput. The CDS (Connected Dominating Set) scheme is a well-known solution to the packet collision problem. In a MANET, a VBN can be constructed by using connected dominating sets. All nodes in the network can transfer information effectively through the virtual backbone network. In the earlier research for this problem, most CDS are only suitable for a static MANET environment, with all nodes being stationary. In this paper they focused only on broadcasting storm problem, and it works well for small regions only.

Yinying Yang et al., (2010) [6] have surveyed the mechanisms that utilize nodes mobility to extend the network lifetime. Sensors have limited energy supply and the sensor network is expected to be functional for a long period, so enhancing the energy utilization to prolong the network lifetime becomes an significant issue. In static sensor networks, if nodes are uniformly deployed, nodes near the sinks will die first. This is because nodes sending their own sensed data as well, they also joining in forwarding data on behalf of other sensors located farther away from the sink. This uneven energy consumption results in network partitioning and limitation of the network lifetime.

Kemal Akkaya., (2012) [3] has presented a distributed partition detection algorithm which quickly makes the sensors aware of the partitioning in the sensor network. This process is led by the sensors nodes whose upstream sensor nodes functionless due to damages. Upon partitioning, sensors federate the partitions and restore data communication by utilizing the former routing information stored at each sensor to the sink node and exploiting sensor freedom of movement. Specifically, the locations of failed sensor nodes on former routes are used to assess the span of the damage and some of the sensors are relocated to such locations to re-establish the routes with the sink node. Replacing such former routes is performed in such a way that the movement overhead on sensors is also minimized. Their proposed approach solely depends on the local information to ensure independency and scalability. The effectiveness of the proposed federation approach is validated through realistic simulation experiments and has been shown to provide the mentioned features.

Hassan Raei et al., (2012) [4] have presented a new timer based energy-aware distributed algorithm for MCDS problem in disk graph with bidirectional links (DGB), in which nodes have different broadcasting ranges, is introduced which has exceptional time and message complexity of O(n) and constant approximation ratio. Theoretical analysis and simulation results are also presented to verify our method's efficiency. To reduce the traffic during communication and prolong network lifetime, it is desirable to construct a

minimum CDS (MCDS). The MCDS problem has been studied intensively in unit disk graph (UDG), in which the nodes have the same transmission range. In real world, this kind of networks is not necessarily containing nodes with equal transmission range.

Anupama Potluri et al., (2013) [2] have presented two metaheuristic algorithms –a hybrid genetic algorithm and a hybrid ant colony optimization algorithm – for the problem of computing minimum weight dominating set. They compared their results with greedy heuristic as well as the only other metaheuristic algorithm proposed, and they proved that their algorithms are far better than other algorithms.

G.N. Purohit and Usha Sharma et al., (2010) [5] have presented an algorithm to find minimum connected dominating (MCDS) sets in unit disk (UD) Graph. It is based on the calculation of curved structures of sensor nodes. Constructing a virtual backbone (VB) in WSNs is an important issue because it reduces unnecessary message transmission or flooding in the sensor network. It helps in reduce interfering and energy consumption because a limited number of sensors are engaged in message transmission and thus it helps in improving the Quality of Service (QoS) in the network.

Michael Gerharz et al., (2000) [7] have presented an adaptive metrics to identify stable links in a mobile wireless networking environment based on the analysis of link durations in several different mobility situation. Their metrics only rely on online statistical evaluation of observed link intervals. In this work, they handled only link failures.

Umesh B.N et al., (2013) [8] have presented an energy efficient routing for Virtual Back Bone Nodes (VBN) in which it maximizes the node life and turns off it's radio when they are not in broadcasting, in order to reduce energy consumption. A concept of restricted virtual backbone neighborhood routing is proposed, which assures the efficient routing with minimum energy consumption of nodes and also implemented the critical transmission radius for Backbone nodes.

Zahra REZAEI., (2012) [9] has presented a unicast routing algorithm in wireless sensor networks, and they made a virtual backbone out of Minimum Connected Dominating Set (MCDS). This virtual backbone is initiated according to level of energy, degree, and distance from Sink node. So, at the end they use an algorithm based on learning automata named UMCDS- LA deal with the unicast routing problem.

Michael Q. Rieck et al., (2003) [10] have presented a distributed algorithm (generalized *d*-CDS) for producing a variety of *d*-dominating sets of nodes that can be used to form the backbone of an ad hoc wireless network. In special cases (ordinary *d*-CDS), these sets are also *d*-hop connected and has a desirable "shortest path property". The algorithm has a "constant-time" complexity in the limited sense that it is unaffected by expanding the size of the network as long as the maximal node degree isn't allowed to increase too.

III. Proposed Work

In this proposed work, a stability based CDS algorithm (SBCDS) is developed to construct a virtual backbone. This algorithm construct a virtual backbone by combining the values RSS and energy. Every node starts the execution of the algorithm at the same time. Only those nodes that have the largest weight value among all the nodes present in their neighborhood will send a Dominator message (D). Given the nature of the weights (RSS and energy), there always exists at least a node *n* that transmits the message D(*n*). All the other nodes just wait to receive a message.

- Each node computes its weight based on the metrics Wi = Stability.
  Stability = RSS + Energy
- Then it'll choose the nodes with largest weight to be a dominator node. The selected node is set as a black node and added into the dominator set.
- This process continues till all nodes are covered. Here *stability* is calculated in terms of *RSS* and *Energy*.

RSS is used to calculate the signal strength between the nodes. If the signal strength is high between any nodes, then the nodes are close to each other.

$$RSS => Pr/P\ t = Gt + Gr\ (\lambda/4\pi D)^2$$

Where,

Pr, Pt -> Receiving & Transmitting power

Gr, Gt ->Receiving & Transmitting Antenna Gain

λ -> Wavelength.

D -> Distance.

IV. Simulation Study

We evaluated the performance of CDS based sensor algorithm in network simulator ns2.29 and 2.35. We placed N sensors, randomly in a field of 200 x 200 m size. The sensing and communication range are set to 30m. We compared the performance of neighbouring nodes, energy consumption and clustering based in terms of CDS size. The network setup is shown in the Table 1.

- Node initialization (initially set as a white node) Table.1
  $n \epsilon$ N.

Parameter	***Values***
Area size	200 x 200
Number of Nodes	50, 75, 100....250
Transmission Range	30 m
Number of iterations	10
Initial energy	10 J
Transmission power	0.024 mA/b
Receiving power	0.0144 mA/b

V. Simulation Result

The fig1.1 shows the result of existing algorithms interms of CDS size. It clearly shows that CDS size is varying depends on the network size.

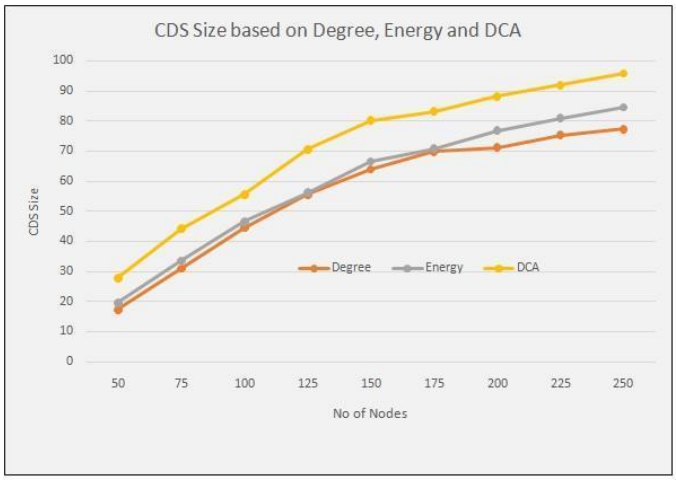

Fig1.1 CDS Size

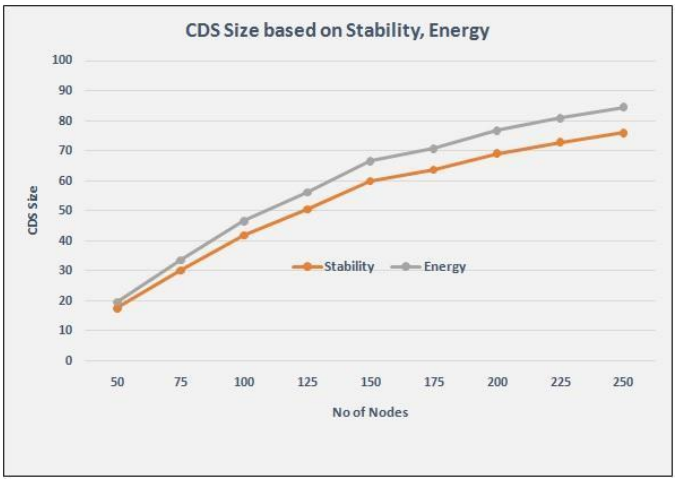

Fig 1.2 Result comparison

VI. Conclusion

The main challenges faced by the mobile wireless sensor networks (MWSN) are link breakage, due to mobility or the energy depletion of the nodes. So optimizing the energy consumption to prolong the network lifetime becomes an important issue. In order to maintaining the connectivity and prolong the network lifetime virtual backbone (VB) concept has been used. A connected dominating set (CDS) algorithm is used to create the virtual backbone in the sensor network.
In this work, stability based connected dominating set (SB-CDS) has been constructed based on link stability and energy. This SB-CDS construction mainly focused on reducing the node reusability and size of the dominating sets (DS).

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