An Efficient Routing Protocol for Wireless Sensor Networks

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Abstract: In Directed Diffusion routing, propagation of interest message could lead to heavy traffic load periodically. The performance of data transmission may severely deteriorate at that moment. In this paper, a new routing scheme by modifying the original directed diffusion to reduce interest messages has been proposed. By considering the mobility speed and number of neighbors, interest message is forwarded to the neighboring nodes. The simulation results show that the proposed algorithm could reduce the overhead messages, no of dropped packets and Consumed power significantly. In addition to that, it maintains the same throughput compared to the original Directed Diffusion.

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INTRODUCTION

Now a day's efficient design and deployment of wireless sensor networks has become an emerging area of research, due to the immense potential of tiny sensor networks enabling applications that connects the real world to the virtual world. In the recent years, advances in nano technology and Micro-Electro-Mechanical Systems (MEMS) [1,2],the production cost of the sensor nodes continues to decrease , increasing deployments of wireless sensor networks that eventually increases to large numbers of nodes. By connecting large numbers of small sensing self powered nodes, it is possible to obtain information or detect special events about physical or environmental conditions that is not viable to obtain in more conventional ways. After collecting the information about physical phenomena, it communicates the data in a wireless fashion, with a goal of sending the data to the base station which makes them available on the Internet. Sensing, Processing and sending are the key functions of WSN. The development of wireless sensor networks has been motivated by military applications such as battlefield surveillance; today such networks are used in variety of fields, including medical monitoring[3], environmental monitoring, home security, and industrial machine monitoring.

The structure of the paper includes the following. An overview of routing in sensor networks and the mobility model is explained. The proposed Mobility Aware and Mobility with Density Aware Diffusion protocol design is illustrated. Finally analyzed the simulation results and exhibits the conclusion.

ROUTING IN SENSOR NETWORKS

The characteristics that make routing in sensor networks as a challenging one are:

In the deployment of large number of tiny sensor nodes, constructing a global addressing and routing algorithms same as classical IP-based protocols is impossible.

The sensed information needs to be transmitted from multiple sensor nodes to the sink for all applications of sensor networks.

There is a possibility for redundancy since the information is being sensed by multiple sensors with the area of a phenomenon. In order to remove those redundancies, routing protocols are needed.

Careful resource management is needed since close proximity of sensor nodes exist with complexities like transmission power, energy, processing capacity and storage.

For this purpose, there are many new algorithms has been developed for routing data in sensor networks. [4] In addition with the application and architecture requirements, these algorithms also consider the characteristics of sensor nodes. Most of the routing protocols fall into any of the three following categories: data-centric, hierarchical and location- based. There are also some algorithms which fall under the category of network flow or QoS routing.

A data-centric protocol depends on the naming of data by which many redundant transmissions could be eliminated as these data centric protocols are query-based.

Clustering of nodes takes place in hierarchical routing. This is done in order to save energy by making the cluster heads to perform data

aggregation and reduction.

Location based protocols make use of the position information which relays on a desired region instead of relaying the data as a whole network.

Certain algorithms which are based on general network flow modeling and that try to meet the QoS requirements in addition with the routing function fall under the last category.

Due to such differences, many new algorithms have been proposed for the problem of routing data in sensor networks. These routing mechanisms have considered the characteristics of sensor nodes along with the application and architecture requirements [5]. Almost all of these routing protocols could be classified as data-centric, hierarchical, location-based, and also some distinct ones based on network flow or QoS routing.

Directed Diffusion(DD)

This protocol is a data-centric routing protocol in wireless sensor networks. [14] In order to perform a sensing task, an interest is created. This interest is defined using a list of attribute-value pairs like name of the objects, interval, duration, geographical area etc.

Then, the created interest messages are brought into the knowledge of all its neighboring nodes by the sink. Once the interest message is received by a sensor node, it is stored in the interest cache.

When the interest is added to the cache, it contains information like interest's type, duration and gradient. After receiving the interest message, nodes starts finding the appropriate entry in the cache and updates the gradient field from the place where message has been received to the rate defined in the message [7],[15]. Each gradient needs to be updated upon receiving the interest message. With the help of forwarding technique, interests are diffused to the whole network towards the sink.

A comparison could be done between the received data and the values in the interests that are already available in the node. The entry for an interest also contains several gradient fields.

A gradient is like a reply to the neighbor from the place the interest is received. Gradients are characterized by their data rate, duration and expiration time that are derived from the received interest's fields. Many paths are established from sink to sources with the help of interests and gradients, which mean data, could be sent to the sink from the source through multiple paths. Considering the rules like best link property, number of packets received from a neighbor and lowest delay, the sink reinforces one specific path by resending the same interest through the specified path [8]. Each node forwards the reinforcement to its next hop along this path [10, 11]. Through this selected path, the sink resends the original interest message with the small interval thus reinforcing the source node on that path to send the data more frequently.

Flooding

Flooding is the most simple and reliable routing technique to route the information to all the nodes in the sensor networks. In this technique[9],[12] any node on receiving the packet broadcasts it to all its neighbors and this continues till the packet reaches its destination or the packet is sent to all the nodes in the network. All nodes in the network share the same character tics. Each node before forwarding the packet to other nodes retains a copy of it.

MOBILITY AWARE DIRECTED DIFFUSION (M-DIFFUSION)

In the proposed M-Diffusion method, a sensor node propagates the interest message only when the speed of the node is satisfied. In this method, the node would check whether the received new packet Pi is an interest packet, if so the mobility factors are calculated. The mobility factor is the ratio of node speed and the expected node speed. If the mobility factor is less than mobility threshold then it propagates the interest packets into the network or else it would not propagate the interest. If the received packet is not an interest packet then it is handled normally. If the received packet is not a new packet, then the node rechecks the packet which has already been forwarded. If it has been already forwarded, the packets are dropped; else the interest timer is updated. The Pseudo code of the proposed M- Diffusion is given below.

MOBILITY AND DENSITY AWARE DIRECTED DIFFUSION (MD-DIFFUSION)

The proposed MD-Diffusion algorithm is similar to M-Diffusion, but it also checks the number of neighboring nodes Ni. If the received new packet Pi is an interest packet then the Ni is less than the minimum expected neighbors it forwards the message else if the mobility factor is less than the mobility threshold then it propagates the interest packets into the network. Else it would not propagate the interest messages. If the received packet is not a new packet it handles the same manner as M-Diffusion.

If the interest message is allowed to propagate through a node N from X, then the X is considered as the one of the node for routing path. After the completion of the route establishment process, the routing path through the destination sensor node Z would have N as one of the member of its route. If the interest message is not allowed to propagate through a node N from X then, X is not considered as the part of the routing path. Once the route establishment process is over, the routing path through the destination sensor node Z would not have N as one of the member of its routing path.

SIMULATION ENVIRONMENT

Mobility model

This model represents the moving pattern of sensor nodes. This pattern is about their change in direction and speed. For this purpose, "Random waypoint model" [13] is preferred. This model is simple to study about the performance of wireless sensor networks. In order to set the environment close to the reality in the simulation, the movements in sensor networks are needed to be considered. This model in NS2, the node fixes its destination and attempts to reach it with a speed that is selected randomly from the range [Vmin, Vmax] by uniform distribution or by normal distribution where Vmax and Vmin are the maximum and minimum allowable velocities. In this model once the node reaches its destination, the node stops for a duration, then the node selects a random speed and destination.

Simulation results of proposed algorithms

This section projects the comparative results of DD, Flooding, proposed M-Diffusion and MD-Diffusion.

The Figure 1 and 2 show the MAC load of the proposed protocols along with DD and Flooding. As shown in the graph, MAC load of the Flooding is high compared with the DD and M-Diffusion. In the proposed MD-Diffusion, its MAC load is lower than that of the normal DD and M-Diffusion routing protocol.

The Figure 3and 4 show the overhead comparisons of the protocols. Because of broadcasting the messages to all its neighbors, the overhead is more in flooding. In MD-Diffusion, overhead is reduced by controlling the number of interest messages, compared with all other protocols that give less overhead.

The Figure 5 and 6. illustrate the power consumption of the protocols. The power consumption of the nodes in MD-Diffusion is low compared to other protocols because of less transmission of messages.

The Figure 7.and 8 highlights the average throughput in the case of three compared protocols. The average throughputs in all the cases are equal. It means, the proposed protocols provide the same good performance with minimum overhead.

The Figure 9 and 10 show the dropped packet counts of the proposed protocols. In the proposed MD–Diffusion, number of packets dropped is less compared to normal DD and other proposed Diffusion routing protocol.

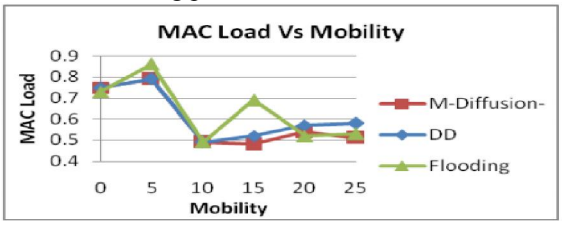

Figure 1: Mac Load (M Diffusion)

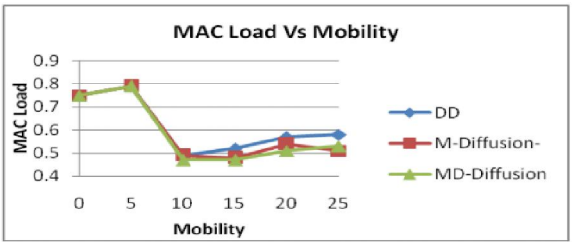

Figure 2 : Mac Load (MD Diffusion)

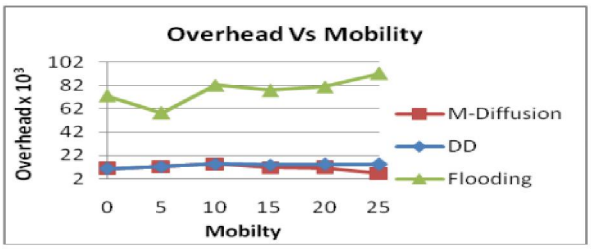

Figure 3: Overhead (M Diffusion)

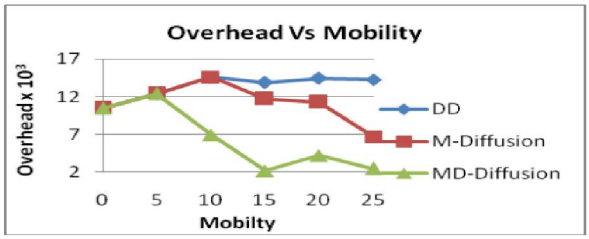

Figure 4: Overhead (MD Diffusion)

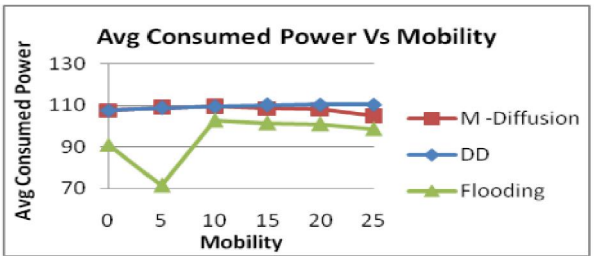

Figure 5: Avg Consumed Power (M Diffusion)

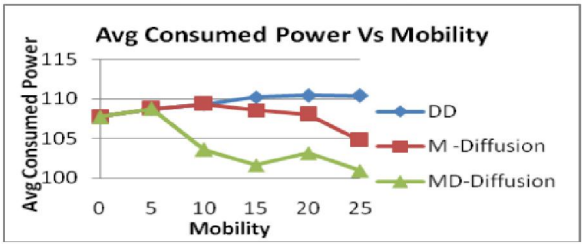

Figure 6: Avg Consumed Power (MD- Diffusion)

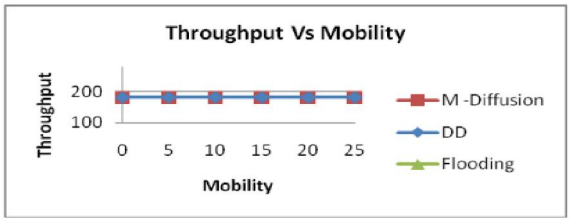

Figure 7: Throughput (M Diffusion)

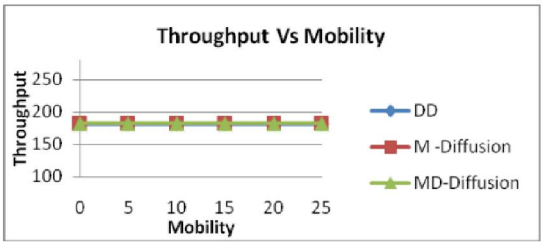

Figure 8: Throughput (MD Diffusion)

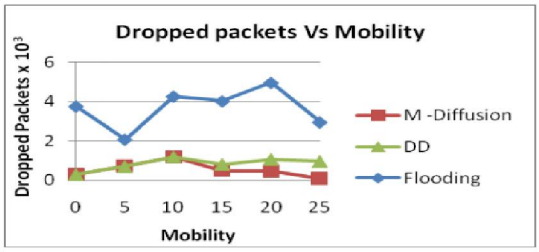

Figure 9: Dropped packets (M Diffusion)

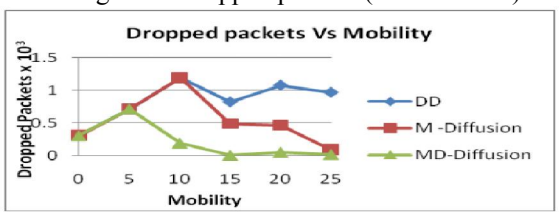

Figure 10: Dropped Packets (MD Diffusion)

CONCLUSION

In this study, the performance of the directed diffusion protocol is improved by implementing the mobility aware and mobility with density aware interest propagation mechanism.

The evaluation of M-Diffusion and MD-Diffusion protocol along with other data centric protocols is carried out using Ns2. The comparison results have been visualized in the form of graphs. The simulation results show that MD-Diffusion could more effectively deliver data from sources to sink with much lower overhead, dropped packets, Mac load and power consumption than in flooding and other DD protocols. Moreover, the throughput of MD- Diffusion is quite close to normal DD. Hence, it is concluded that the proposed MD-Diffusion algorithm is suitable and recommended for mobile and very dense networks. There are variety of different models of directed diffusion protocols available based on data propagation and gradient filter mechanisms. In this work, it is confined and emphasized only with the DD protocol by using new mobility and density aware interest propagation mechanism. Future works could be carried out on the issues in applying the proposed mechanism in other sensor network routing protocols.

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