IS-MAC Based Flooding Protocol for Sensor Networks

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Abstract

We proposed ISF routing protocol that gives energy efficient data delivery mechanism for wireless sensor networks. Special features of IS-MAC makes the ISF most promising candidate for the routing protocols for wireless sensor networks. ISF protocol uses hop count/location information to achieve energy efficiency for the data delivery mechanism. The proposed protocol can lead the flooded packets to flow towards their destination, hence eliminating unnecessary packets in forwarding and reducing the total energy consumption. Our simulation results show the reduced energy consumption of ISF over existing flooding protocols

1. Introduction

For wireless sensor networks, there has been recently lots of attention on routing protocols. Most of the routing protocols in wireless sensor networks are based on variations of "flooding" even though they use some optimizations. Flooding is clearly a straightforward and simple solution, but it is very costly in general. Furthermore, most protocols are based on IEEE 802.11 MAC protocol [1]. This MAC protocols could cause a serious problems of contention, collision, and redundant broadcasts can be referred as the broadcast storm problem [2]. And above all this gives the ideal listening problem that waste lots of energy of sensor nodes [3]. We proposed IS-MAC protocol that gives energy efficiency as well as addressed QoS issues likes channel capacity utilization, per node fairness and latency [3]. There have also been a number of recent works on efficient data delivery in wireless sensor networks. Theses schemes also use routing cost to determine whether to forward or not. However, such schemes typically require full neighbor information, thus necessitating initial set-up time when the nodes get to know their neighbors. In case of dynamic environment, these protocols require periodic monitoring of neighbor's information and it causes many overhead in the aspect of number of packets, energy consumption, and delay.

In this paper, we proposed the flooding protocol that is based on the IS-MAC protocol. For delivering the packets to destination node IS-MAC uses RTS, CTS, and F-RTS signals. To generate RTS, CTS and F-RTS signals frame needs destination or next hop ID hence, routing table on each node. Periodic advertisement to maintain the routing table is energy consuming procedure. The proposed ISF falls into on-demand protocol category for which node doesn't need to maintain any routing table. Hence node doesn't use RTS, CTS and F-RTS signal for communication. Without these handshaking signals it is very difficult to overcome ideal listening and data overhearing problems. To solve these problems we used filter signal that uses hop count information or location based information. In the later section we will discuss more about this signal in details. Thus, by utilizing hop counting, location or any other matrices information, we attempt to reduce the number of nodes unnecessarily involved in the flooding process. In [4] authors proposed directional flooding but it is based on the IEEE 802.11 MAC. Authors minimized the number of node for flooding using directional information but the basic question of ideal listening and data overhearing remains unsolved. The proposed ISF's simulation results shows the superiority over directional flooding and direct flooding. As far as our knowledge is concerned it's the first time to represent the flooding protocol based on sensor network's MAC protocol especially for sensor networks.

2. The proposed IS-MAC based flooding (ISF) protocol

In this subsection, we described The ISF algorithm. Here we used only hop counting information for forwarding the data packets and also assumed that data packets flow from sensor nodes to sink. Sink node periodically transmits its location information and all nodes know its location information.

2.1 IS-MAC background

We described the IS-MAC protocol's basic operation and mechanism in [3]. Here, we briefly discussed about IS-MAC to give clear understanding of ISF. For flooding

IS-MAC will work in buffered mode without future mode and IS timer is defined as follows

$$T_{IS} > F_{filter} + Ack. \qquad (1)$$

Where, F-Filter frame is for filter signal, and *Ack* for acknowledgement signal. And this timer runs only after contention period. Active time will be fixed as per maximum traffic conditions available in the sensor networks. As IS-MAC is worked in buffered mode without future reservation it can pass data to only one hop distance within one cycle. So its latency performance will be similar to S-MAC but with better energy efficiency. For further details reader can refer [3].

ISF protocol used hop counting information for flooding. We define new filter frame for the protocol in which nodes keeps the hop count value after calculating its own distance from sink node, own id and etc information. In response to filter frame addressed node will send acknowledge frame. In this way F-Filter and *Ack* frame will act like RTS and CTS frame and gives the same advantage of handshaking method of MAC without even maintaining routing table information.

2.2 ISF Working

Figure 1 shows the self explanatory flow diagram of ISF protocol.

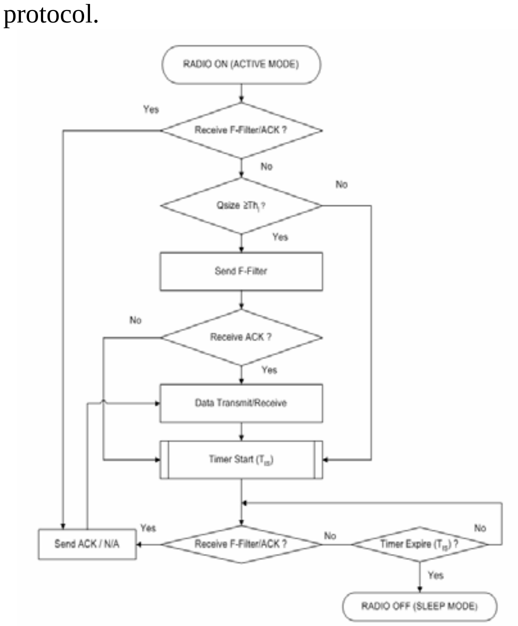
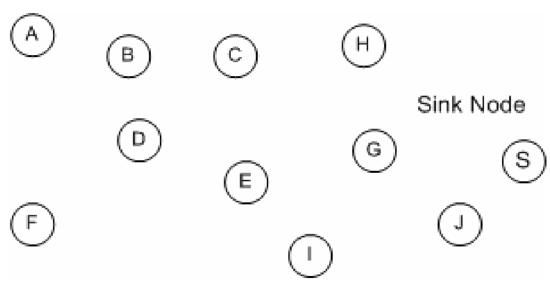


Figure 1. Flow diagram of ISF

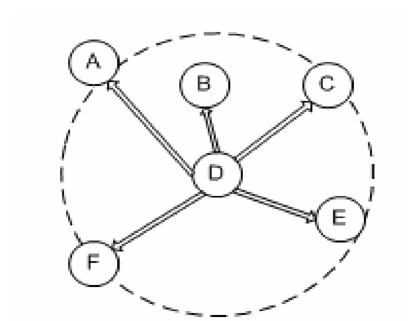
2.3 ISF Algorithm

- Initially sink node transmits its location information periodically. All nodes can listen to this information and calculate the number of hope required by them to send data to sink node.
- When any node satisfies the buffer condition will send filter packet [3].
- All near by node will listen to this frame and compare its own hop count with the frame. Node will send *Ack* frame to sender node if it value is lower than the value loaded in filter frame. These two frames will create same effect like RTS and CTS signal. Data transfer will take place till the active time is on.

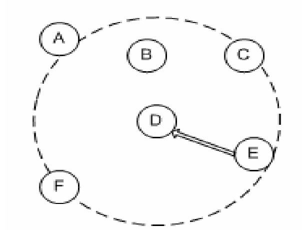
Working: Figure 2 provides an illustration for more detailed operations of the proposed ISF algorithm. Figure 2 (a) shows the initial topology of sensor networks with one source and sink node. Node D first satisfies the lower threshold condition and get chance to access the channel. It transmits the F-Filter frame with the hop count information for our example hop count value is 3. Node A, B, C, E, and F listen to F-Filter frame and compares their hop count value with Node D’s value as shown in the figure 2(b). Only Node C and E satisfied the condition: hop count > current hop count. As shown in figure 2 (c) and 2 (d) Node E send the acknowledgement frame to node D and be ready for data transmission. Nodes C will go back to sleep after listening to acknowledgement frame and save the energy from unnecessary overhearing of the data. Similar operation carried out by the nodes E and G till data packets reaches to the Sink node as shown in the figure 2 (e).



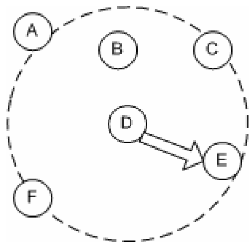
(a) Sensor networks with one sink and source node.



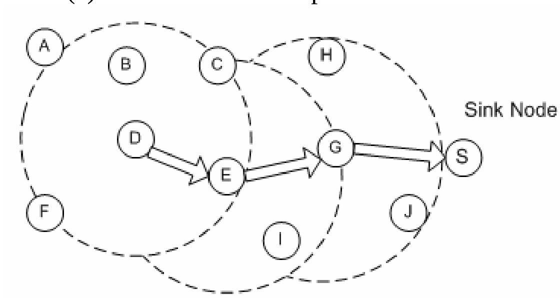
(b) Node D transmits F-Filter frame



(c) Node E transmits *ACK* frame



(c) Node D sends data packets to node E

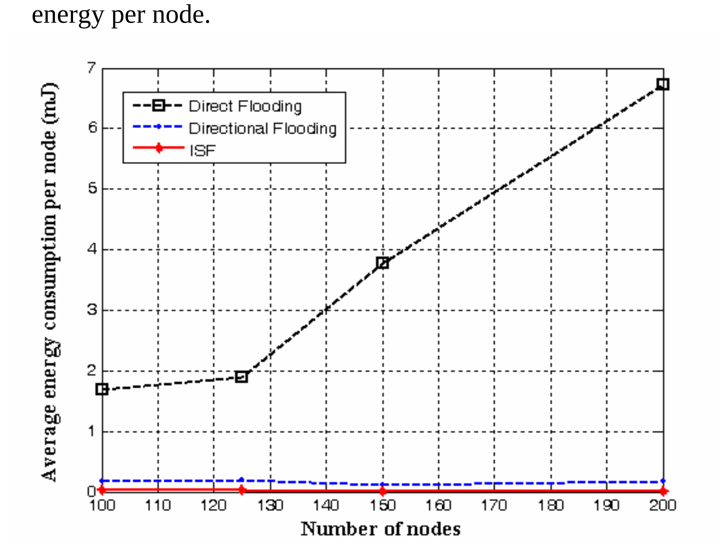


(d) Data flow from node D to sink node

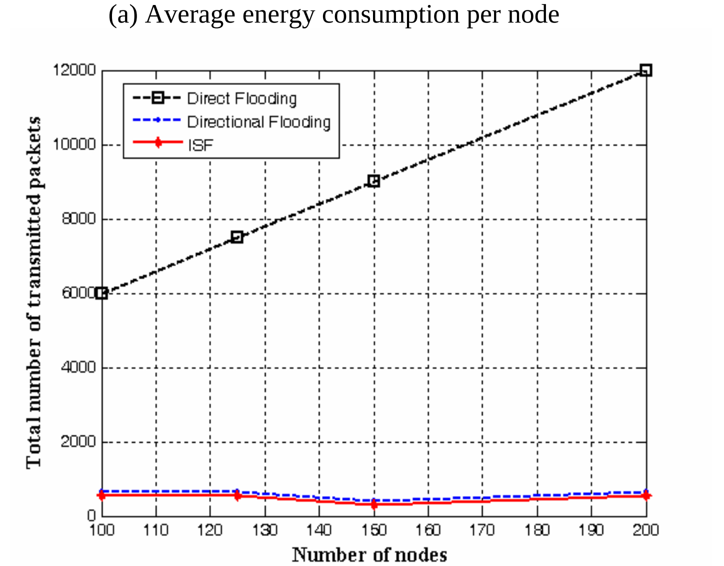
Figure 2. ISF Working

3. Performance Evaluations

In this subsection, we evaluated the performance of ISF and compared with the directional and direct flooding. For our evaluation we consider basically two matrices; average energy consumed by a node and total number of packet transmitted in the networks. ISF reduces both the matrices values hence, increases networks lifetime. For our performance evaluation we modified the CMU wireless extended version of ns-2 [5]. All nodes are randomly distributed in confined space of $200 \times 200m^2$. Transmission range of each packet size is fixed to 64 bytes. We used Berkly motes physical layer specification for calculation [6]. We run the simulation for 300 sec. As we mentioned earlier, we consider only one way communication scenario that is nodes to sink. Figure 3 shows the performance of the ISF when we vary the number of nodes. We considered the data arrival rate/event generating rate of 5 sec and just one source node. As the number of nodes increases, both the matrices value start increasing for all protocols but ISF performance remains almost constant. Figure 4 shows the performance of the ISF under varying the source nodes. For this analysis we considered the 125 sensor nodes with data arrival rate of 5 sec. From the graph we can observe the superiority of ISF especially for higher number of source nodes. Figure 5 shows the performance of the ISF under varying the data arrival rate. For this result we considered the one source node and 125 nodes. As the data arrival time begins to increase, total generated traffic reduces and hence both the matrices value for all protocols. From all given graphs we can conclude that ISF performs better than direction flooding. Because ISF minimize the number of nodes for delivering the data and also removes the ideal listening and data overhearing problems for nearby node hence, reduce the average energy per node.

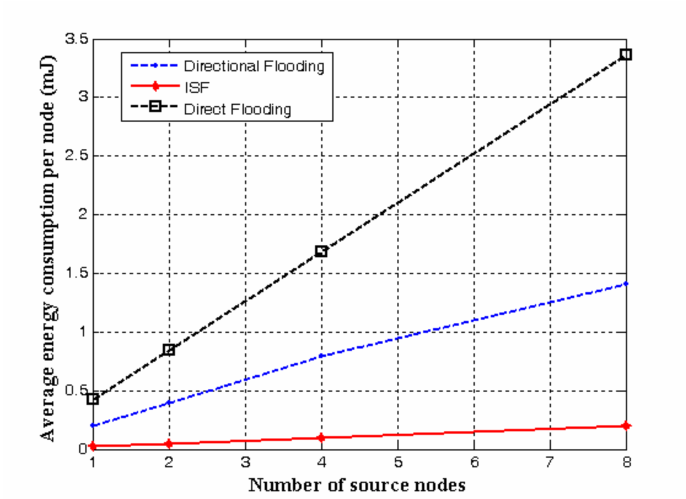


(a) Average energy consumption per node

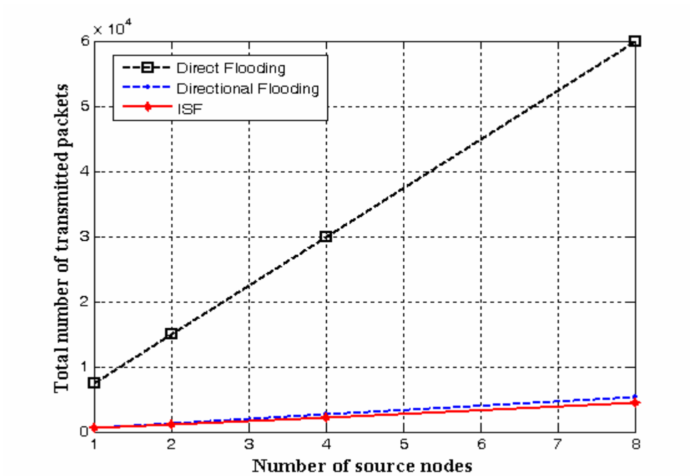


(b) Total number of transmitted packets

Figure 3. Performance of the ISF by varying the number of nodes

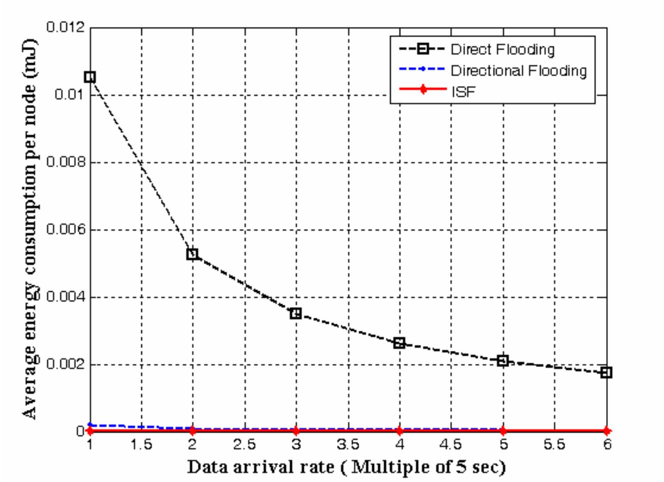


(a) Average energy consumption per node

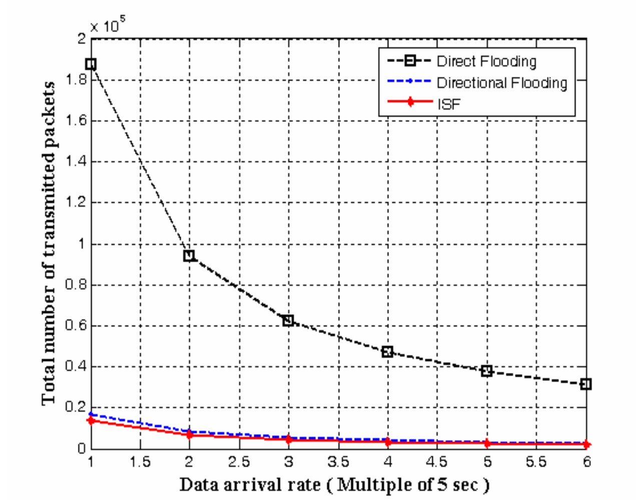


(b) Total number of transmitted packets

Figure 4. Performance of the ISF by varying the number of source nodes



(a) Average energy consumption per node



(b) Total number of transmitted packets

Figure 5. Performance of the ISF by varying data arrival rate

4. Conclusions

In this paper, we presented ISF routing protocol for wireless sensor network. ISF uses the hop information to deliver data towards sink node. ISF optimized the number of sensor node for flooding the data as well as solves the problem of ideal listening. Our performance evaluation shows the superiority of ISF over the direct and directional flooding.

5. References

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