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Performance Improvement of Direct Diffusion Algorithm in Sensor Networks

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Abstract: Providing methods in wireless sensor networks to transmit data at desirable rate with considering criteria such as furnishing energy, storage and processing constraints is prominent. In this paper a routing metric is suggested for determining the validity of paths to select intermediate node. This validity is calculated according to the factors of link's reliability, remaining energy of nodes, buffer capacity and transmission delay. The proposed metric is applied on AODV and directed diffusion algorithms. Carrying out multiple analyses and simulations, we have shown the efficiency of this proposed routing metric. The experimental results show that the delay and packet loss of the proposed method are less than the original algorithm. Also the energy consumption in proposed method is reduced.

Key words: Sensor networks · Directed diffusion · AODV · Routing · QoS

INTRODUCTION

A wireless sensor network consists of a number of sensor nodes spread across a geographical area. Each sensor node has a sensing capability as well as limited energy supply, computation power, memory and communication ability. These networks are increasingly being used for managing and controlling emergency situations because of their accurate and rapid deployment characteristics.

Nodes in a sensor network have very limited energy supplies which are always equipped with battery and it is almost impossible to recharge or replace the battery after deployment. Therefore, energy efficiency is one key issue in wireless sensor networks. Also bandwidth, storage and processing constraints cause to decrease bit rate. This problem brings about applications of wireless sensor network face serious challenges. For example, entering a target inside an area of interest, the delay to report the sensed event could be critical. If the reported event is not received by the sink node within the deadline, the end-to-end (ETE) delay requirement is not satisfied. After locating and detecting the target, sensor nodes may periodically report that event to a sink node. Reducing delay is an important goal in wireless sensor networks.

Considering the above reasons, introducing methods to support energy saving and reducing delay are strongly requested. Choosing an efficient routing algorithm to transmit packets between nodes has a direct effect to optimize energy and reduce packets delay of nodes.

In IP-based and Ad-Hoc Networks many mechanisms have been proposed to perform routing process which cannot directly apply to wireless sensor networks because of their inherently distinct attributes. Global addressing in sensor nodes is utilized. Also, a sink node gathers data from other sensor nodes in network. This characteristic makes a distinct difference from above mentioned networks. Furthermore, excessive traffic due to nodes movement, link breakage and etc. in sensor networks are problems which affect routing protocols.

To optimize node energy consumption and to cater the desired QoS in sensor networks several routing algorithms have been proposed.

An energy-aware QoS routing protocol introduced for sensor networks [1]. Cost and delay are the constraints which are considered to reduce communication error and node's energy consumption.

SAR, Sequential Assignment Routing, is a routing algorithm which introduces organization and mobility management in sensor networks [2].

To extend the sensor network lifetime in [3], DERP, Delay-Minimum Energy-Aware Routing Protocol, has been proposed. The aim of DERP is to minimize delay in network considering energy. Furthermore, to prolong the network lifetime in a scheme based on Zigbee AODV has been proposed regarding to communication delay [9].

Directed diffusion is a routing protocol which is used in wireless sensor networks. The aim of this method is to find efficient routes between nodes considering desired QoS. Each task is reflected as an interest. To perform a

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task, an interest process will be spread in a related area. An interested node, a sink node, broadcasts interest messages into the network during a flooding process. On the other hand, a node sends these interest messages containing detailed description to advertise itself as a sink candidate node. When this interest is received by a node, the node stores sender specifications and assigns a gradient regarding sender of interest message. The assigned gradient shows direction of data stream and status of request which can be active, inactive, or updating necessity. Receiving interest messages from several neighbors, gradients will be assigned for each of them. If a node predicate route according to previous gradient or geographical information, request will be sent only to correlated candidate neighbors otherwise, request will be sent to all adjacent neighbors. Receiving an interest message by a node, it activates its sensor to collect requested data and to send it [4].

Briefly the directed diffusion algorithm uses three steps in sensing data transmission. The first step is that the sensing task (interest) is disseminated throughout the sensor network as shown in Fig. 1 (a). The second step is that the intermediate nodes relaying interests create and save the information of the previous hop as their routing information called gradients as shown in Fig. 1 (b). A gradient is utilized as a routing state toward the information collecting (sink) node when sensing data is relayed. As the third step, the originators select and reinforce one or a small number of these paths that are better for sensing data transfer as shown in Fig. 1 (c). The main drawbacks of this protocol are related to failure recovery, QoS provisioning and global energy balancing. Many works have been recently done to improve the efficiency of this protocol. So in this paper we extend Directed Diffusion algorithm based on our proposed metric, which in the routing process selects optimized paths. By analysis and simulation, we have shown the efficiency of this proposed routing protocol.

The paper is organized as follows. Section 2, proposes the system model. Section 3, provides the details of the metric, applying the metric on AODV [7] algorithm and applying the metric on directed diffusion algorithm along present simulation method along with results is given section4, finally section 5 gives conclusions and describe future directions.

System Model: In our analyses and simulations, we use the model defined in [5] and [6]. This model captures the packet reception rate (PRR) between two nodes as follows. The behavior is modeled by Eq. (1) in this equation, below a distance D1, nodes exhibit full connectivity, PRR is equal to 1. Nodes are disconnected if they are at least distance D2 away from each other. In the transitional region between D1 and D2, the expected reception rate decreases smoothly with some variation.

$$PRR = \begin{cases} 1 & d < D_1 \\ \left[\dfrac{D_2 - d}{D_2 - D_1} + X \right]_0^1 & D_1 < d < D_2 \\ 0 & d > D_2 \end{cases} \quad (1)$$

Where $[.]^b_a$ = max{a, min{b,.}} and $X \sim N(0,\sigma^2)$ is a Gaussian variable with variance σ^2.

For our analyses and simulations we assume that nodes are uniformly distributed over a 200 * 200 m field a maximum radio range of 30 m with parameters D1 = 10, D2 = 30 and σ = 0.3. Furthermore, the network is stationary without mobility. We consider two nodes to be neighbors if the packet reception rate is at least 1%.

Metrics: Routing metric is a parameter that based on validity of paths which in the routing process selects optimized paths.

The wireless sensor network is presented by a graph G=(V,E), where V is the set of nodes, each node representing a sensor and $E \subset V \times V$ is the set of graph edges for links between any two nodes. To choose the appropriate nodes for routing, every node is given its remaining energy and buffer free space and a packet reception rate is assigned to every link.

This metric considers the path energy efficiency and the delay experienced along this path. We define path deficiency, E, to be the ratio of the path energy efficiency, Eeff, to the delay required to transmit a packet from source to the destination.

$$\left[E = \frac{E_{eff}}{delay} \right] \quad (2)$$

At first, we used two parameter in our proposed Metric, namely delivery rate and energy efficiency. The delivery rate E_r quantifies the fraction of packets that originate at a source node and are properly received at the sink. Since each forwarding node consumes a certain amount of energy for packet reception and transmission, the energy efficiency E_{eff} quantifies the ratio between delivery rate E_r and consumed network energy E_e. That is, the energy efficiency of a single node regarding packet forwarding towards the sink can be calculated by.

$$E_{eff} = \frac{E_r}{E_e} = \frac{E_r}{t \times e} \tag{3}$$

Where t denotes the average number of packet transmissions required reaching the sink and e is the corresponding energy for each packet transmission and the required energy could then be calculated as:

$$e = e_{tx} + n.\ e_{rx} + (N - n).\ e_h \tag{4}$$

Where e_{tx} and e_{rx} are the amount of energy for packet transmission and receiving, n is the number of addressed receivers and N is the number of neighbors in communication range. e_h quantifies the amount of energy required only for decoding the packet header. We assume that nodes who are not receivers of a packet will turn their radios off as soon as they have heard the header. According to the sensor board hardware, we set e_{rx} = 0.375 and e_{tx} = 1.

At first for E_e computation, the required energy for the packet delivery for the first transmission is:

$$\hat{E}_e^1 = prr_{i,i+1}(E_e^i + b) + a(b + \hat{E}_e^2) \tag{5}$$

Using a recursive calculation, the required energy for the packet delivery for the R^{th} transmission is given by:

$$\hat{E}_e^{R+1} = prr_{i,i+1}(E_e^i + b) + ab \tag{6}$$

Finally, the required energy for packet delivery is

$$E_e = \frac{(prr_{i,i+1}(E_e^i + b) + ab)(1 - a^{R+1})}{1 - a} \tag{7}$$

Where PRR $_{i,\ i+1}$ is the packet reception rate for the forwarder node i, $E_e^{\ i}$ is its energy cost that refers to the energy consumption from the source to the node i+1. b $=e_{tx}+e_{rx}$ and a=1- $prr_{i,i+1}$.

In the finite retransmission case, each node is allowed to use up to R retransmissions to successfully deliver a data packet to its forwarding node. The number of allowed retransmission is dependent to Mac layer. In the single-link case without retransmissions, the end-to-end delivery rate from a source node to the sink is:

$$E_r = \prod_{k \in \phi, k \neq destination} prr_{k,k+1} \tag{8}$$

Where $\phi$is the path from source to sink and prr $_{k,\ k+1}$ is the packet reception rate between node k and its forwarder k + 1 That $prr_{k,k+1}$ computed from the eq. (1). Allowing up to R retransmissions, the deliver rate changes to:

$$E_r = \prod_{k \in \phi, k \neq destination} (1 - (1 - prr_{k,k+1})^{R+1}) \tag{9}$$

By replacing E_r and E_e in Eq. (3), the energy efficiency is given by:

$$E_{eff} = \frac{\prod_{k \in \phi, k \neq destination} (1 - (1 - prr_{k,k+1})^{R+1})}{(prr_{i,i+1}(E_e^i + b) + ab)(1 - a^{R+1})}(1 - a) \tag{10}$$

Finally the path efficiency is calculated by:

$$E = \frac{\prod_{k \in \phi, k \neq destination} (1 - (1 - prr_{k,k+1})^{R+1})}{delay(prr_{i,i+1}(E_e^i + b) + ab)(1 - a^{R+1})}(1 - a) \tag{11}$$

The remaining energy of the forwarding node named e_i. In each separate node there is a variable parameter for e_i. Calculation of the related parameter for each node will be done in one span of alternative basic rate of this parameter equal to consumption of capacity in the source energy. By applying the remaining energy in the routing metric, the path efficiency E is:

$$E = \frac{\prod_{k \in \phi, k \neq destination} (1 - (1 - prr_{k,k+1})^{R+1})}{delay(prr_{i,i+1}(E_e^i + b) + ab)(1 - a^{R+1})}(1 - a) * e_i \tag{12}$$

Furthermore, end to end delay and packet delivery ratio are directly related to the work traffic load of the intermediate nodes. As such, high traffic load of node increases the delay and work traffic, which lead to greater energy consumption. In this work, it is proposed that for traffic load balancing of nodes, the buffer space is included in the metric. Figure 1 depicts the shape of making a model of one node as a server and a buffer with determined capacity.

Validity of each node is the rate of buffer empty capacity to the buffer actual size. Validity in each node has been calculated by itself. It is represented by:

$$V_l = \frac{free\ space\ of\ Queue}{all\ space\ of\ Queue} \tag{13}$$

V_L represents the packet service rate of node validity. Therefore, if a node has high percentage of V_L, it shows the lower capacity of node so the node is desideratum for

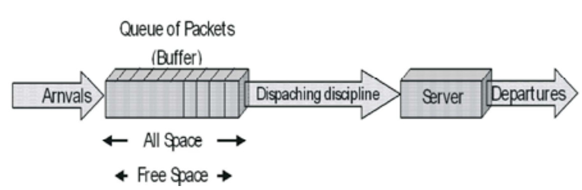

Fig. 1: Node buffer server

selecting. In the other hand, if validity is near to zero, the node buffer is full and this node assigned as crass, because with false selection it the node information dropt is possible. So, we need to retransmit and this operation wastes more energy and reduces node's energy.

For applying parameter V_L, we know if the buffer of one node is full (V_L =0) and practically this node can't service, so route efficiency is zero (E=0) and if the buffer is completely empty (V_L =1) route efficiency is related to other route efficiency parameters. Also if V_L>0 then path efficiency (E) and E' is positive, therefore path efficiency is increased proportional to V_L, $E \propto f(v_L)$.

In this paper we consider f (v_L) = V_L. Simulation shows the effectiveness of V_L. The effect of this parameter increases in high traffic. Finally, regarding the buffer capacity of the node, V_L, in the routing metric must balance the network load. So the path efficiency is calculated by

$$E = \frac{\prod_{k \in \phi, k \neq destination} prr_{k,k+1} * e_i}{delay(prr_{i,i+1}(E_e^i + b) + ab)(1 - a^{R+1})}(1-a) * V_L \tag{14}$$

This is our proposed metric which is capable of including delay, energy, link reliability, as well as capacity buffer factors.

We apply proposed Metric at first on AODV algorithm and then on direct diffusion (DD) algorithm that is especially wireless sensor network and then investigate the efficiency of this proposed routing metric.

Directed Diffusion: Directed diffusion is a data-centric routing protocol. In a Wireless Sensor network the data that the network can provide is interesting, not specific nodes. In order to receive data, an interested node (a "sink") floods the network with an interest message. This message contains a detailed description of the event it is interested in. When this interest is received by a node, it sets up a gradient to the neighbor from which it heard the interest. If it hears the same interest from several neighbors, gradients will be set up for each one of them. This focus on neighbors is a specific feature of directed diffusion, which allows the protocol to scale with the number of nodes in the network.

Briefly the directed diffusion algorithm uses three steps in sensing data transmission. The first step is that the sensing task (interest) is disseminated throughout the sensor network. The second step is that the intermediate nodes relaying interests create and save the information of the previous hop as their routing information called gradients. A gradient is utilized as a routing state toward the information collecting (sink) node when sensing data is relayed. As the third step, the originators select and reinforce one or a small number of these paths that are better for sensing data transfer.

The aim of the proposed metric is to forward packets from a node to adjacent neighbors and this approach has an outstanding operation in the networks with flat structure. In the other hand, the directed diffusion protocol has neighbor-to-neighbor routing characteristic and it is suitable for flatten network structure. The selected protocol is specialized for sensor networks.

Negotiation between neighborhood nodes is another ability of the directed diffusion protocol and this negotiation is efficient and well suitable to establish routes. Furthermore, the proposed algorithm sets the main policy based on the negotiation between neighbors. Therefore, by the selection of the directed diffusion protocol as a platform to simulate the proposed algorithm, required conditions are feasible to make a negotiation.

Also, the directed diffusion protocol utilizes a routing algorithm based on minimum delay such as a shortest route. Thus, it is possible to compare the modified directed diffusion algorithm with the original the directed diffusion protocol.

In the directed diffusion protocol always shortest path between the source and destination nodes is selected to transmit traffic and it is cause to consume the energy of intermediate nodes quickly. Specially, in large scaled networks and in case of high data transmission in a specified zone of a network this problem is so severe. Another drawback which tolerates this problem is occurred during the evacuation of a route. In this time the mostly next shortest route, the adjacent routes of the current route, will be selected and this phenomena cause to segregate the network during the time. Therefore, we need a more fair solution to distribute the transmitted traffic of a source node to a destination node through intermediate nodes.

After proposing effective reasons on selecting the directed diffusion protocol in the rest of this section, the effect s of existed operative on the policy of the proposed directed diffusion algorithm will be explained.

AODV Routing Protocol: AODV routing protocol is a reactive routing algorithm. It maintains the established routes as long as they are needed by the sources. AODV uses sequence numbers to ensure the freshness of routes. Route Discovery The route discovery process is initiated whenever a traffic source needs a route to a destination. Route discovery typically involves a network-wide flood

Fig. 2: Route request message format

Fields	Description
Destination	Destination Address
Sequence number	Sequence number of the previous Number message
Next Hop	Next node address
Hop Count	Hop Count to destination
Max efficiency	Validity of the route

Table 1: Routing table

Src ID	Hop Count	Sequence Number	PRR	Max efficiency	Destination ID

of route request (RREQ) packets targeting the destination and waiting for a route reply (RREP). This algorithm maintains these routes as long as they are needed by the source. However, shortest-hop based routing is not suitable for wireless sensor networks since it neglects the energy issue.

We included proposed metric in the Zigbee routing protocol AODV routing protocol. Thus, our new version of AODV chooses the most efficient path to the destination node by considering energy, delay and buffer capacity.

Applying the Metric: Before sending the data to the sink, a node must start the route discovery process to create a neighbor list, which is the address of all nodes that are able to transmit data from the source. During this process route request and reply messages are exchanged between the nodes. The route request message as shown in Figure 2.

The RREQ packet is enhanced with two additional fields, a packet reception rate (PRR) and Max efficiency. Intermediate nodes calculate PRR and efficiency from eq. (1) and eq. (12) upon receiving a RREP packet. Initial value of PRR is set to 1. After establishing the path between the sink and the source the routes are stored in a routing table as shown in Table 1 to allow future queries for the allocated paths. The routing table stores information about the paths that can be used to direct data messages and verify the validity of each table record.

When a destination node receives a RREQ packet it will process it and sends back a RREP packet on the reverse path. In order to choose the route, this is a efficient path. Destination should not reply to the first route request which received. Instead, it should waits for a set amount of time and compares the delivered RREQs then sends a route reply by selecting an appropriate route.

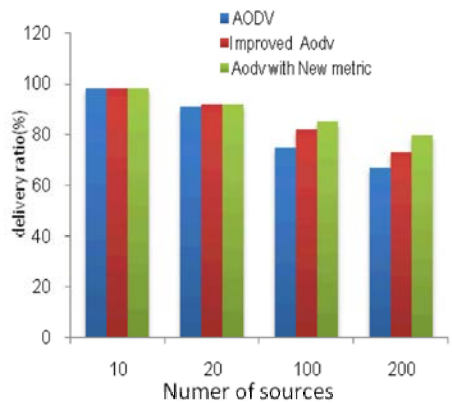

Fig. 3: Packet delivery ratio vs. number of nodes

Simulation Results: In this section we evaluated performance of proposed algorithm and compared it with the AODV algorithm and Improved AODV algorithm. We have changed the existing implementation in NS-2 of AODV to integrate our metric. Thus, we have a new version of AODV, which we call AODV with new metric. It is compared to the Aodv protocol and the Improved AODV in [7]. The simulated networks consist of 10, 20, 100, 200 nodes respectively.

Evaluation parameters that considered for our algorithm are:

Packet Delivery Ratio: This is ratio of the total received packets to the total sent packets in the sensor network. The delivery ratios of the routing protocols increase as the node density increases.

Figure 3 shows the Packet delivery ratio with network traffic rates. From the figure it can be seen that the Packet delivery ratio of AODV algorithm and improved AODV are less than that of call AODV with new metric. In fact, in small sensor network there is almost one path from the source to destination. Thus, the routing algorithms choose the same path. However, for a network with a larger number of source nodes, the Improved AODV performs better than AODV and modify AODV does.

Average Delay: The average delay measures the average time between sending data from sources to receiving data by sinks over all source-sink pairs. It indicates the feasibility and effectiveness of the protocol.

Figure 4 depicts when the number of node is low all algorithms will have the same routing choices. Since validation of paths is almost equal, but when traffic increases, the difference between these routing algorithms appears. The proposed algorithm selects paths with the lower delay.

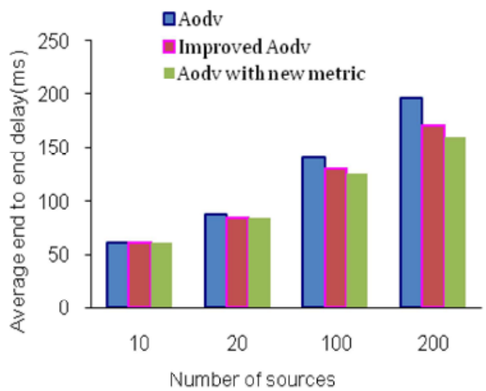

Fig. 4: Average delay vs. number of nodes

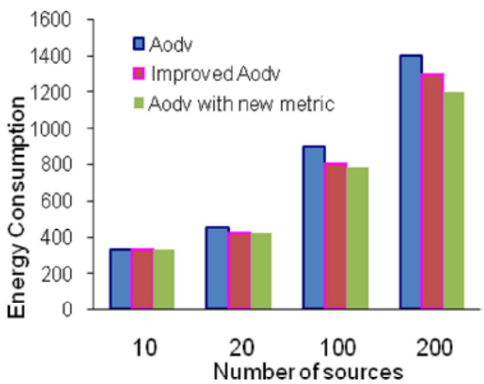

Fig. 5: Energy consumption vs. number of nodes

Energy Consumption: The average energy consumption is calculated across the entire topology. It measures the average difference between the initial level of energy and the final level of energy. This metric is important because the energy level that a network uses is proportional to the network's lifetime. Figure 4 show at the beginning the two routing approaches have the same result. In fact, in the beginning all nodes have a maximal amount of energy. When the number of nodes increases, the average energy consumption proposed algorithm is less than AODV algorithm and improved AODV.

We extend AODV routing protocol using the proposed metric. Simulation was performed with varying network characteristics, the results depicted gains in throughput in terms of packet delivery ratio, reduction delay and optimize consumption energy especially when a large number of nodes existed. Figure 5 demonstrates this effect. However, AODV algorithm is a special algorithm in ad hoc network, it doesn't work efficiently for sensor network when network is dense so we focus on special algorithm in wireless sensor network.

Fig. 6: Interested packet attributes

Fixed Attributes
Sink ID
Application Context (type, operator, value)
ISeqNum
Flow ID
Variable Attributes
PreviousHopID
V_L
gradients
PPR
Hop count
Max efficiency

Fig. 7: Neighbor information entry

Neighbor Id
VL
IseqNum
Breakage flag
Gradient
Hop Count
PPR
Maxefficiency
Lowest-latency-gradient
ETE_Delay(only for traditional DDfilter)

Applying the Metric on Direct Diffusion: In this section, we will study the details on how to set up gradients and describe PRR filter to extend directed diffusion. At last, we make simulation respectively with those two different gradients setup algorithms and make a comparison between them.

PRR Filter: PRR filter is realized by setting up corresponding gradients, which is performed when receiving interest packets. In directed diffusion algorithm, sink node sends interest message for a query. PRR filter is recognized by the related gradient when the initial interest messages are received. The information contained in an interest packet is shown in Figure 6.

Fixed attributes in figure 6 specify which sources and sinks communicate. Whenever a sink initiates the new interest flooding periodically, it will increment its counter, ISeqNum. The fixed attributes are not changed while propagated across the network. On the other hand, when an intermediate node broadcasts an interest packet, it will change variable attributes. But variable attributes are changed by intermediate nodes. PreviouseHopID variable in the interest packet represents the neighbor, where it received the message. Intermediate node calculate PRR and Max efficiency from eq. (1) and eq. (12) when receives interest packet. Hop count counts hope that the packet passed from source to this node.

Fig. 8: PRR gradient setup pseudo code

Intermediate Node Handles Interest packet

Step 1: *Get Information from interest packet:* SinkId, IseqNum, PreviousHopID,HopCount,V_L,Max efficiency

Step 2: *Find NIE in NIT according to the PreviousHopID*
NIT: Neighbor Information Table
NIE: Neighbor Information Entry

Step 3: *In the NIE, update gradient*

Step 4: *Decide whether the Interest should be broadcast or not calculate current efficiency:* case1: first time to receive the Interest {Max efficiency = current efficiency Next hop node = this node Hc = hop count}
case 2: if (current efficiency > max efficiency) {Max efficiency = current efficiency Next hop node = this node Hc = hop count}
case 3: if((current efficiency = max efficiency) and hop count< hc) {Next hop node = this node Hc = hop count}
Step 5: *If one of the above three cases happens, update Interest packet and broadcast it*

Setting up the PRR Gradient: PreviousHopID in the interest packet is the index of the corresponding neighbor information entry (NIE) which is shown in Figure 7. The collection of NIEs is called neighbor information table (NIT). The ID is the unique identification of the neighbor.

When an intermediate node receives an interest packet, first it will look at the information contained in the interest packet.

When a node receives the first interest packet, it sets up PRR gradient to the sender node and calculates PPR and path efficiency from equation (12), then assumes the sender node as the next hop and updates its NIE in NIT. When a node receives other interest packets, first calculates path efficiency, if the new interest path efficiency is less than the current efficiency, the node ignores that interest packet, but if the interest path efficiency is greater, it adopts the new sender as the next node. Because of PRR value, it is very unlikely that the interest packets have the same validity. Even if they have the same validity, intermediate node selects an interest packet with smaller Hop count. Initial value of PRR is set to 1.

Figure 8 shows a setup pseudo code for PRR gradient. In this algorithm, we use the method in for local Repairing in the case of nodes' breakage in during of routing.

If MAC feedback information indicates that transmitting a data packet to the next hop node fails, the intermediate node will mark the next hop node broken in neighbor information entry. The intermediate node will flood a BreakageNotification packet. When the sink receives the BreakageNotification packet, it will initiate interest flooding immediately to update stale gradients over the network. We assume that there is a retransmission mechanism based on acknowledgement packets in media access control (MAC) protocol for reliability. If a predetermined number of retransmission fails, the MAC layer informs this failure to the upper layer [11].

Table 2: Simulation parameters configuration

Simulation area scale	200 m × 200 m
Topology configuration model	Randomized
Each node buffer	50 packet
Initial node energy	4500 Watt. Sec
Interest packet size	32 byte
Time interval that sink floods interest packet	300s
Number of nodes	200
Sensor Data Packet Payload	128 byte

The Simulation Model: In this section we evaluated performance of proposed algorithm and compared it with the standard Directed Diffusion algorithm and proposed algorithm in [9]. We use NS-2 simulators to implement the physical and MAC layers of IEEE 802.11 We have changed the existing implementation in NS-2 of Standard Directed Diffusion to integrate our metric. Thus, we have a new version of Directed Diffusion, which we call Improved Directed Diffusion. for simulation be used of sink but number sourees are different in senariuoes.

The parameters we used in our simulation are shown in Tables 2. In our sensor network model two hundreds of sensor nodes are randomly distributed on a 200 m *200 m area. The sensor nodes are battery-operated except the sink node. The maximum transmission range of sensor node is 15 m.

Sensor nodes have a low mobility that is the case for most of the sensor network applications. The sink node will initiate interest flooding (indicates a new task) periodically. We assume the delay needed to transmit a packet from a source node to a destination node is equivalent to the number of hops counted between these two nodes.

We deploy an energy model according to the power consumption parameters in [10]. The delay needed to transmit a packet from a source node to a destination node is equivalent to the number of hops counted between these two nodes. Also we will consider many-to-one communication with one sink and several sensor nodes reporting data to the sink.

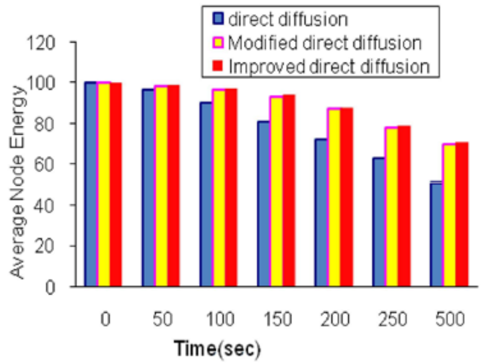

Fig. 9: Average node energy vs. time

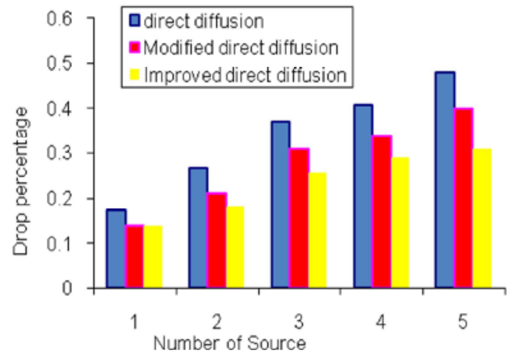

Fig. 10: Packet loss ratio vs. number of sources

Evaluation Metric: Evaluation parameters that considered for our algorithm are:

Energy Consumption: In this section, nodes energy consumption in the proposed algorithm will be discussed. To study the consumption of energy of nodes, the proposed algorithm is named improved. It is compared to the directed diffusion protocol and the modified algorithm with proposed metric in [9]. Numbers of source nodes are considered as 2, 6 and 12 nodes. The simulation time is 500 seconds, average energy consumption is calculated every 100 seconds and node's energy is set to 100 Watt. Energy model and parameters in simulation of the proposed algorithm is assumed as an original directed diffusion code and the required sending and receiving energy is 0.666 Watt for sending and 0.395 watt for receiving data based on energy consumption in PCM-CIA WLAN in ns2 simulator.

The simulation is performed in the three scenarios. In the first scenario, number of source node is 2. The average energy consumption in the proposed algorithm is 5% and 12% more than the directed diffusion protocol in the first and the second scenarios respectively. Number of the nodes in the third scenario is set to 12. Node's energy consumption in this case is shown in the Figure 9 and the average consumption of nodes in the proposed algorithm is 22% further than the directed diffusion algorithm. Lower energy consumption of the proposed algorithm is due to assorting selection of the intermediate nodes.

Packet Loss: Route packet loss is explanatory of the route fault tolerant. Figure 10 shows that the packet loss in the proposed algorithm is 8% less than the directed diffusion protocol. Proper selection of routes causes lower packet loss in the proposed algorithm. The main reason of the packet loss is flooding of the interest and discovery packets which occupy bandwidth. This is an obstacle to receive data packets to the central node.

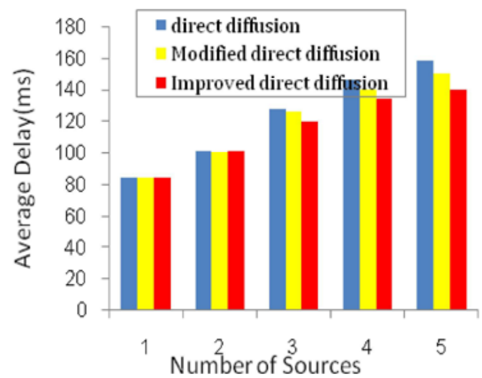

Fig. 11: Average packet delivery vs. number of nodes

Average Packet Delay: In this section, average packet delay is discussed. To calculate this parameter, the average delay of ping packets from 1 to 5 sources will be calculated. Simulation time is set to 500 seconds. Figure 11 illustrates the average packets delay in this scenario. The average packet delay of the proposed algorithm is 6% less than the directed diffusion protocol. In this figure, when the number of source nodes are low, then the packet delay in the two algorithms are almost the same. Furthermore, route credit policies are equal. Increasing the number of source nodes is cause to lower delay due to its credit policy of route selection.

CONCLUSION

In this paper a method of intermediate nodes selection during the routing process will be proposed. This method is based on credit assignment of neighbor nodes. Amount of remained node's energy, buffer size of node and link quality are the parameters which are used to calculate credit. The related neighbor's credit of each node is stored in a table and the tables will be updated during the data sending and receiving. At last, the node with the highest credit is selected to forward data. This metric cause to data traffic distribution between nodes justly and used ability most network nodes also it caused to we hold global routing algorithms of information about routes. Every node in their table keeps information validity related to neighbor node. Finally between neighbors nodes, selected one node with high validity. Simulation results show that the proposed algorithm cause to lower energy consumption, lower packet delay and reduced packet loss in comparison with the directed diffusion protocol. Albeit in case of network's traffic increasing, the proposed algorithm is more efficient because of its capability to use equally all nodes in the routing process and data forwarding.

For future work It is supposed that nodes have no mobility in this paper, so mobility can be considered and Regardless of supposing one sink in the proposed algorithm, the effect of multi sink can be studied also In this paper, a linear traffic model is utilized to study the route efficiency, so in future works this parameter can be used in different traffic models.

REFRENCES

1. Heinzelman, W., A. Chandrakasan and H. Balakrishnan, 2000. “Energy effcient communication protocol for wireless micro-sensor networks, ” In HICSS, pp: 3005-3014.
2. Sohrabi, K., B. Manriquez and G. Pottie, 1999. Near-ground wideband channel measurements, IEEE Proceedings of Vehicular Technology Conference, New York.
3. Boughanmi, Yeqiong, N., 2007. A New Routing Metric for Satisfying Both Energy and Delay Constraints in Wireless Sensor networks, The journal of VLSI Signal Processing, Springer New York, 51: 137-143.
4. Intanagonwiwat, C., R. Govindan, D. Estrin, J. Heidemann and F. Silva, 2003. Directed Diffusion for Wireless Sensor Networking, IEEE/ACM Transactions on Networking, 11(1).
5. Levis, P., S. Madden, D. Gay, J. Polastre, R. Szewczyk, A. Woo, E. Brewer and D. Culler, 2004. The Emergence of Networking Abstractions and Techniques in TinyOS, Proceedings of the First USENIX/ACM Symposium on Networked Systems Designand Implementation, NSDI 2004.
6. Mini, R.A.F., M. Do Val Machado, A.A.F. Loureiro and B. Nath, 2004. Prediction-based energy map for wireless sensor networks, Ad Hoc Networks Journal.
7. Perkins, C.A., E.M. Royer and S.R. Das, 0000. Ad-hoc on-demand distance vector routing, IETF Internet Draft of AODV, Version 10.
8. Zigbee Specifications, 2004. http://www.zigbee.org.
9. Chipara, O., Z. He, G. Xing, Q. Chen, X. Wang, C. Lu, J. Stankovic and T. Abdelzaher, 2006. Real-Time Power-AwareRouting in Sensor Networks, Fourteenth IEEE International Workshop on Quality of Service (IWQoS 2006).
10. Bhaskar Krishnamachari, Deborah Estrin, Stephen Wicker, “The Impact of Data Aggregation in Wireless Sensor Networks,” icdcsw, pp.575, 22nd International Conference on Distributed Computing Systems Workshops (ICDCSW '02), 2002.
11. Chen, M., T. Kwon and Y. Choi, 2005. Energy-efficient differentiated directed diffusion (EDDD) for real-time traffic in wireless sensor networks, Computer Communications.