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Extend Wireless Network's Lifetime Based on Developing Gossiping Routing Algorithm

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Abstract

Prolong node's lifetime that is limited by its battery, as long as possible is an important factor during wireless sensor network designing. Several routing algorithm have been adopted to manage the energy strategy of WSNs. Multi-hoping is considered to be data transmission technique in WSNs, and Gossiping is one of well-defined multi-hopping as an epidemic routing algorithm. Gossip algorithm constructs its routing based on random selection of intermediate nodes, thus leads to its inefficiency. In this paper, three algorithms proposed for developing Gossip algorithm, DGossip, EN_Gossip and ENL_Gossip. Network lifetime improved by considering the information of nodes location, energy and their distance to the base station. The simulation executed in MATLAB, and the results of the proposed algorithms show that they are more efficient than LGossip and ELGossip and prolong the overall network lifetime.

Keywords: *Gossiping, epidemic routing algorithm, DGossip, Network life time, EN_Gossip, ENL_Gossip.*

1. Introduction

Many of tiny sensor devices can be used to configure wireless networks for various applications such as environmental, military, or health applications. Highly effective communication telecommunication protocols are needed to achieve the existing and potential applications for wireless sensor networks (Norouzi, Babamir and Zaim, 2011). Each sensor device is composed of a microcontroller for local data processing, transceiver for transmission/receiving of data, external memory for local storage, power source for supplying energy and one (or more) sensors for data acquisition from the physical environment (Mukherjee and Mukherjee, 2013). Sensor nodes suffer from several limitations such as power supply, bandwidth for communication, processing speed, and memory space, thus making researchers to concentrate on the maximizing the utilization of limited sensor resources. The deployed sensors sense the information from the interesting environment. Then these data are sent toward the base station (BS) for more processing and taking appropriate action (Mudgule, Nagaraj and Ganjewar, 2014).

The nodes in wireless sensor networks are cheap, disposable, and expected to continue till all their energy is drained. So, energy is an important issue for WSNs and it is required to manage in a better method. Data routing in WSN is a significant issue and considerable amount of energy can be conserved if routing can be implemented tactfully (Deva Sarma, Mall and Kar, 2015).

In multi-hop communication, selection of the intermediate nodes in the route is the most important issue. These intermediate nodes are selected such that a best path is realized with minimized needed energy and successfully delivery of the data to the BS. Consequently, the wireless network can work for longer time. In many wireless network situations, changing or recharging node devices is occasionally impossible. Therefore, a lot of protocols have been introduced to prolong network lifetime (Norouzi, Babamir and Zaim, 2011).

Network lifetime relies on several factors such as network protocols and structure, the initiation of data aggregating, definition of life span, models of channel, and approach of the energy drain (Chen and Zhao, 2005). Energy consumption in communication subsystem is higher than that of computation subsystem. Even transmitting the single bit may consume more energy than processing it (Mukherjee and Mukherjee, 2013).

This paper introduces development procedures to gossip as a biological inspired approach for Multi-hop routing algorithm based on node's remaining energy, Its position and the selection process of next node called D_Gossip, EN_Gossip and ENL_Gossip algorithm respectively. Gossiping is a data-relay protocol, based on a Flooding protocol, and does not need routing tables or topology maintenance. It was produced as an enhancement for Flooding and to overcome the drawbacks of Flooding, or implosion (Rabaey et al., 2000).

2. Related works

Many approaches have been introduced to enhance the Gossip protocol.

(Zhang and Cheng , 2004), introduced a combination of two approaches, the Flooding and Gossiping routing protocols called FLossiping. Their proposed work uses Gossiping mode during transmission and flooding mode during broadcast processing. Each sender selects and stores a threshold within the header of the packet. Then a neighbor will be chosen to send and receive this packet in a gossip mode. The neighbors that harken to this packet and produce random numbers less than the threshold will forward it in flooding fashion. Their simulation showed that the FLossip algorithm improves the issues of packet overhead and lateness in flooding and Gossiping respectively.

(Yen, Chen and Yang, 2008), adopted single Gossiping together with directional Flooding (SGDF) algorithm in their proposed routing protocol. The SGDF includes: a) initializing the network by assigning each node with a value representing its remoteness to the sink in terms of hops number, and b) routing step by exploiting single Gossiping and directional Flooding approaches to transfer messages. Their simulation results showed that SGDF realizes shortest route to the sink and increases packet delivery ratio.

(Kheiri et al., 2009), proposed in their research a scheme whose adopted Gossip algorithm with concentrated on the position of all nodes in the network (LGossiping). During packet transmitting, the node selects a node at random within radius of its transmitting (TR). Once it receives this packet, the node repeats the procedure and so on till the sink (base station) is found. According to their results, although they saw that the latency issue can be solved to some extent, the sink still couldn't receive many messages. In addition, the energy which is consumed by the network is inversely proportional to TR.

(Norouzi et al., 2010), in their proposed algorithm employed power of the node and the remoteness between the node and the sink (ELGossiping) to deliver messages from a sender to a base station (BS). A node whose has a message to be sent elects next node in its radio range with the shortest way to the sink. The same procedure repeats for the next node selection until the packet reaches the BS. As a conclusion, their proposed method solves the issue of delay in terms of number of hops and the reliability of packet that reaches the BS in more acceptable degree.

3. Biological inspired model for Multi-hop algorithm

In wireless networks, the process of information dispensation is complex when the nodes have knowledge limitation about network's properties. Thus, problems will rise when certain information requires accessing a particular node or whole nodes within entire the network. Epidemic algorithms have such characteristics. They obey the nature's model through employing unpretentious rules for propagating information by adopting a local environment viewing. Based on this fact, execution of these algorithms is simple and warrants spreading messages within anisotropic areas and is not whole time consistent environments (Shah, 2009).

Gossip is a biologically inspired paradigm of contagion inspired from behavior of the disease infection process. The concept is based on the means of spreading this disease in which an infected person A wants to provide a connection with an uninfected person B in order to infect him with a high probability. It is a data-relayed protocol, utilizing the procedure of flooding without requirements for maintenance of topology or routing tables. It made development for flooding protocol and beat of the flooding issues, i.e., collapse (Rabaey et al., 2000).

Gossiping protocol utilizes a probabilistic theory, where it determines sending the packet with a probability p to its own neighbors and rejects the packet with a probability ($1-p$). It therefore can decrease the degree of traffic and accomplish power preservation by randomization. The Gossiping technique solves the implosion issue of Flooding, but does not the overlap and resource blindness issues (Yen, Chen and Yang, 2008).

4. Energy Consuming Model

In general, the transmitter consumes energy for running the radio electronics plus the power amplifier, while the dissipation energy of the receiver is based only on running the radio electronics. The channel models use the multipath fading and the free space (dα power loss), where d is the sender to the receiver distance, α is path loss exponent which depends on the wireless fading environment, its value is usually (2 for short d, 4 for long d). The power amplifier can be conveniently set corresponding to this loss by using power control, where threshold distance (d0) is adopted in which if (d0) is greater than the distance then free space (fs) paradigm must be used, otherwise, multipath (mp) paradigm is utilized (Rappaport, 1996).

An acceptable signal to noise ratio (SNR) can be achieved using (Tripathi et al., 2013).

$$E_{tx} = \begin{cases} E_{elect} \times k + E_{fs} \times k \times d^2 & if\ d < d_0 \\ E_{elect} \times k + E_{mp} \times k \times d^4 & if\ d \geq d_0 \end{cases} \dots\dots\dots\dots..(1)$$

where:

E_{tx} : the transmission energy consumed for (k) bits

d: acts the remoteness of the sender node to the receiver one.

E_{elect} : energy dissipated per bit.

E_{fs} , E_{mp} depend on the modality of the transmitter amplifier.

The consumed energy (E_{rx}) due to receiving the message is given by:

$$E_{rx} = E_{elect} \times k \quad \dots\dots\dots\dots\dots.. (2)$$

Gossip model adopts equation (2) to calculate the receiving of power consumed and equation (3) for consuming power due to transmitting a packet.

$$E_{tr} = E_{elect} * k + E_{fs} * k * d^2 \quad \dots\dots\dots (3)$$

5. The Proposed Algorithms

This section, presents the proposed algorithms (D_Gossip, EN_Gossip and ENL_Gossip) :

5.1 D_Gossip algorithm:

It involves three phases:-

Phase-1: establishing node's gradient to the sink.

Phase-2: a request message has been sent to other nodes within its radio range to receive the information about other member's node .

Phase-3: DGossiping calculates the factor (F) as follows:

$$F = \frac{e_{cn}}{E_0} + (1-\frac{d_i}{d_t})\dots\dots\dots (4)$$

where: e_{cn} is the current nodes energy, E_0 is the initial nodes energy, d_i is the i-th nodes distance from the sink and d_t is the total distance from the starting source to the sink

The factor (F) possesses sufficient effect on selecting the candidate node to be the next transmitter corresponding to the radio range of the sender node. Figure (1) illustrates the general procedure used in DGossip algorithm to construct a route from the data birthplace node to the sink node.

Figure (1) represents the general form of the developed algorithm (DGossip) which includes the following steps:

a) Predisposing: specifies the location of start node and location of sink node, packet size(in bits), maximum number of rounds, number of nodes, radio range, and threshold energy that represents the amount of energy needed to transmit one packet through using equation (3). Also, it calculates the distance (d_i) of each node to the sink node by using Euclidian distance.

b) Selection of upcoming node: In this step, the sender node finds all nodes that are in its radio range and out of sinks radio range, which can possess energy more than the threshold energy. Then the factor (F) is calculated for each node based on equation (4). Then among these nodes, the node that possesses a large F is selected to be the next (recipient) node.
c) The selected node is added to the route list and a packet transmission will be done. Then the transmission and recipient power consumed are computed according to equations (3) and (2) respectively.
d) Check whether the selection node is the sink node or not. If yes, it is added to the route list and the first path is found for one round. Otherwise steps (a-c) are repeated.
e) For all rounds, the above procedure can be repeated.

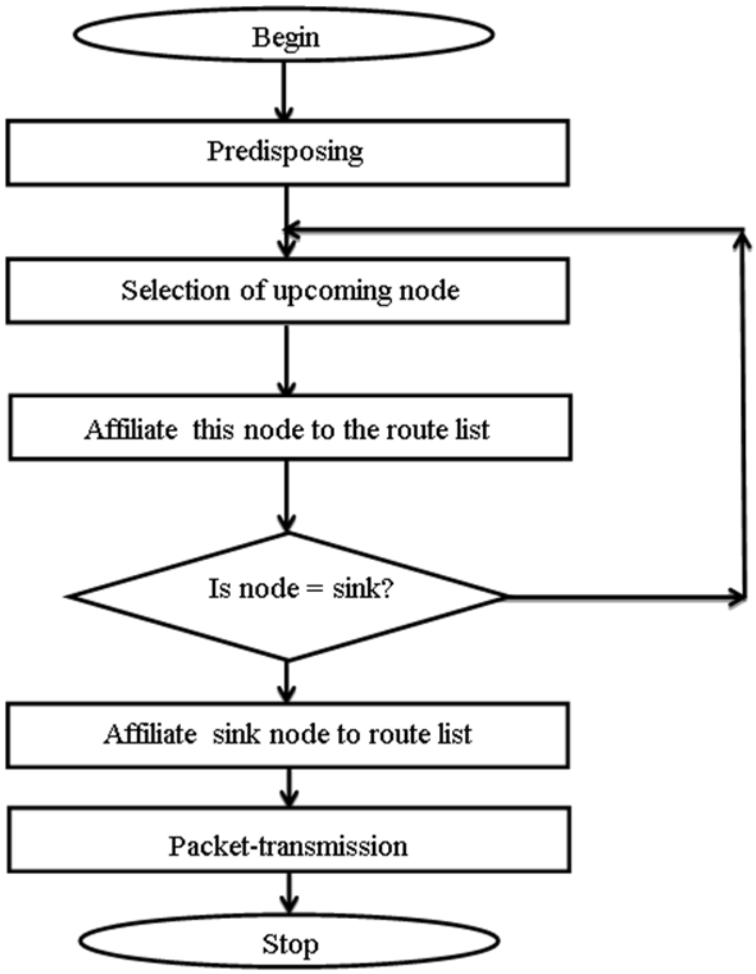

Figure 1: DGossip procedure.

5.2 EN_Gossip algorithm

This algorithm employed power of the node and the remoteness between the node and the sender node (EN_Gossip) to deliver messages from a sender to a base station (BS). A node whose has a message to be sent elects next node in its radio range with the nearest one.

5.3 ENL_Gossip

In this algorithm a combination of EN_Gossip and EL_Gossip is employed to deliver the packets from a source node to the base station (BS). EN_Gossip and EL_Gossip have been used in alternating form to achieve ENL_Gossip, in which at the first hop (time) the source node elect the next node by using EN_Gossip then using EL_Gossip at the second hop and repeated this process till the sink is reached.

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6. Nework Approach

In this network approach, the following assumptions are adopted for this model: the position of base station (BS) located (90,90), all sensor nodes have the same ability in terms of battery capacity, computation, and communication ability. In addition the links are symmetrical between nodes. The used sensor nodes were deployed randomly over a $100m^2$ area. The coordinate (90,90) is the locus of base station (or sink). MATLAB R2013a is utilized as simulation software. Table (1) indicates the procedure parameters.

Table (1): Parameter setting.

Parameter	Value
Packet size	100bits
Efs	10 pJ per bit per m2
Radio range	25m
Emp	0.0013 pJ/bit/m4
EDA	5 nJ/bit/signal
Round	2000 pkt
Eelec	50 nJ per bit
No. of nodes	100
Area	100m×100m

7. Results and Analysis

To assessment the proposed algorithms, five algorithms have been implemented namely LGossip, ELGossip, D_Gossip, EN_Gossip and ENL_Gossip. To investigate the efficient of the proposed algorithms, three factors have been utilized: 1- the average networks energy. 2- the nodes still alive. 3- the number of hops per each round.

Figure (2) illustrates the average remaining energy for overall network in LGossip, ELGossip, D_Gossip, EN_Gossip and ENL_Gossip. A node consumes more energy when transmits a packet to another node for long distance. In EN_Gossip algorithm, selection of the next node always the nearest one so the EN_Gossip algorithm consumes less energy than others as shown. Also D_Gossip and ENL_Gossip have better performance in term of average remaining energy for over all networks.

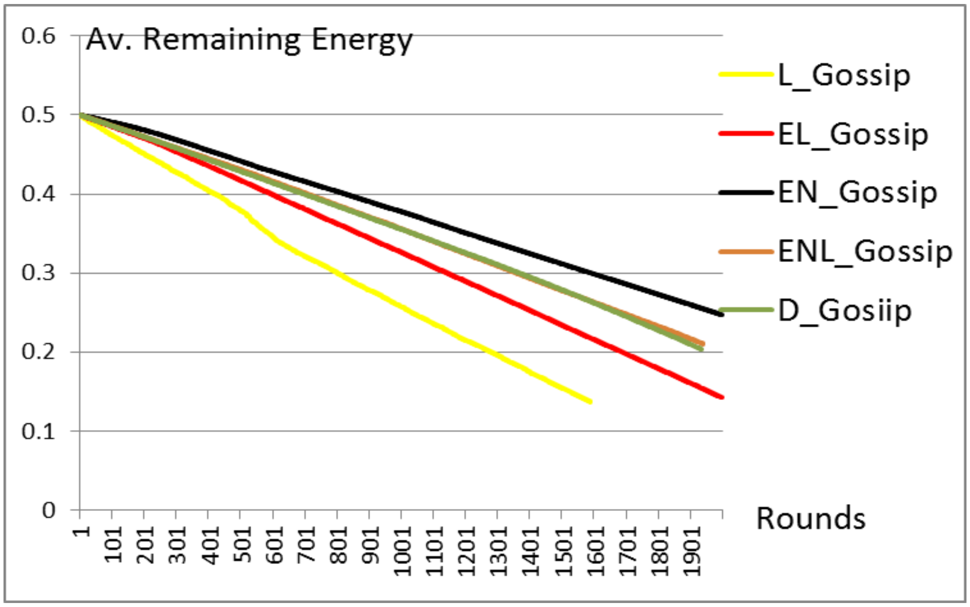

Figure 2: Average remaining energy vs. round.

Figure (3) illustrates the network's live time in terms of number of nodes still alive in LGossip, ELGossip, D_Gossip, EN_Gossip and ENL_Gossip.

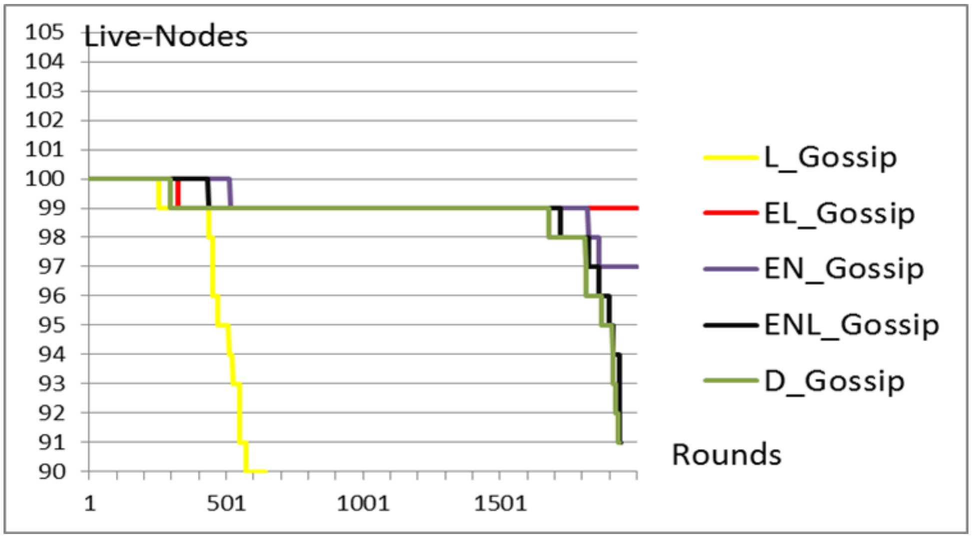

Figure 3: Live nodes vs. rounds.

As shown in figure 3, the nodes in L_Gossip start to die after 255 rounds while after 300, 328, 437 and 516 rounds in D_Gossip, EL_Gossip, ENL_Gossip and EN_Gossip respectively. Therefore the ENL_Gossip and EN_Gossip algorithms have significantly risen the lifetime of network comparing to LGossip and ELGossip algorithms.

Figure (4) depicts the packets average number of hops per 50 rounds in LGossip, ELGossip, D_Gossip, EN_Gossip and ENL_Gossip.

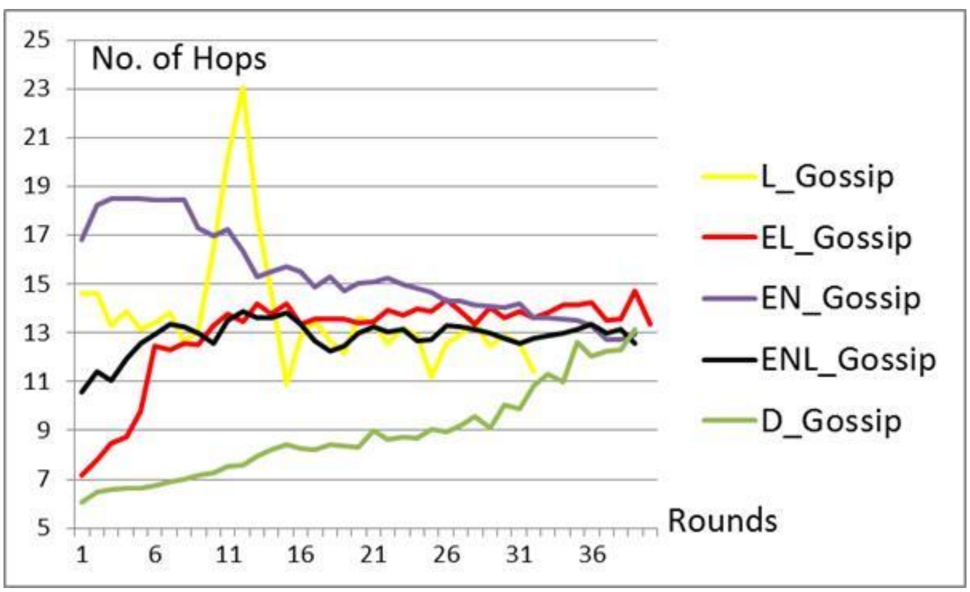

Figure 4: Number of hops vs. rounds.

A packet has a little number of hops during its traveling from the sender to the BS when the next nodes selection is the best nearest to the BS. Therefore the number of hops for DGossip is significantly reduced compared with others as shown in figure (4).

8. Conclusions

In this paper, examination of Gossip algorithm as a bio inspired approach for multi-hop algorithm is introduced and introduced three new procedures called D_Gossip, EN_Gossip and ENL_ Gossip. By considering node's position, its residual energy and the selection process of the next node which affect the network's dissipation energy and improve the algorithm's efficiency can be overcoming the Gossip's shortcomings.

In these algorithms, the selection of the nearest node to the sender node (short distance) as next hop dissipates less energy than the nearest to the sink. These algorithms compared with two other procedures, L_Gossip and EL_Gossip in terms of network's average remaining energy, network's lifetime and travelling packet time in terms of hops number. Simulation results reported that EN_Gossip and ENL_Gossip are more efficient than others in terms of node's average remaining energy and network's lifetime while D_Gossip is better in terms of travelling packet time.

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