Improved Cluster based Routing Protocol for Mobile Nodes in Wireless Sensor Network

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ABSTRACT
In wireless sensor network, high packet loss occurs due to the mobile sensor nodes. Energy consumption is also one of the main challenges in mobile sensor nodes. To overcome these problems, a new algorithm is proposed named as Improved Cluster Based Routing Protocol. This routing protocol follows the routing process similar to CBR-Mobile WSN. In addition, it reduces unnecessary broadcast and collision that occurs due to the selection of same sensor nodes within the same transmission range while sending data to CHs. Improved CBR-Mobile WSN reduces packet loss by calculating angle of the nodes that should be less than or equal to 45°. Improved CBR-Mobile WSN is evaluated using MATLAB. In this paper, comparison is shown of Improved CBR-Mobile WSN with CBR-Mobile WSN. It has been observed that the proposed protocol reduces the packet loss with low energy consumption by 5% compared to CBR-Mobile WSN.

Keywords
Improved CBR-mobile WSN; CBR-Mobile WSN; LEACH-mobile; TDMA; WSN

1. INTRODUCTION
The progression of the wireless technology has enabled the development of smart sensors nodes that are low-cost, communicate in short distance, small in size, low-power devices. These smart sensor nodes have the ability of sensing the environment, data processing and wireless communication. Wireless sensor network signifies a major improvement over traditional network. Wireless sensor nodes have the ability to supervise and control the environment from the remote location. Wireless sensor networks have various applications such as military, environment monitoring, medical treatment, industry and smart transport systems [1][2]. In WSN, there are some major problems like limited energy, limited storage and low computational power. But the main challenge in WSNs is limited energy that enables the researchers to have an embedded study on energy consumption to prolong the network lifetime.

Cluster based WSNs save energy by introducing node clustering. In order to support data aggregation through efficient organization, nodes can be partitioned into a number of small groups called cluster, each cluster has a coordinator called cluster head and a number of member nodes [3]. Rather than direct Communication of sensor nodes to sink node, CHs collect data from member nodes and forward that data to sink node through other CHs. It reduces the communication overhead in the network and saves energy that is consumed by sensor node to do unnecessary broadcast to other sensor nodes while sending data to base station/sink node. Many researchers focused low energy consumption routing protocols in wireless network. There are some routing protocols in wireless ad hoc network like destination sequenced distance vector (DSDV)[4] for mobile network, dynamic source routing (DSR)[5] for static network, ad hoc on demand distance vector (AODV)[6] for hybrid network. All of these routing protocols have been proposed for routing protocols in WSN. But these protocols are not suitable for tiny, low-capacity and battery-operated sensor nodes in WSN because these protocols require higher energy consumption.

Some real time environment imposes fixed and mobile sensor nodes in the same network. Researchers need to give attention for new specifications in WSNs like mobility.

Mobility in sensor nodes also posed some challenges like packet loss and energy consumption. There are some routing schemes for mobile nodes like flat based multi-hop routing scheme and hierarchical routing scheme, but these schemes lack the strategy to control mobility in WSNs [7]. The authors in [7] presented a proposed routing protocol that is Cluster based routing protocol for mobile nodes in WSN (CBR Mobile-WSN). In this protocol, the CH sends message of data request to its member nodes. When the CH does not receive data from its member nodes, the packet is considered lost and at the end of the frame, the CH revokes the sensor node's membership. On other side, when the sensor node does not receive message of data request from the CH then to avoid packet loss, it will try to establish new membership with new cluster. When the sensor node has no data to send and it receives message of data request from CH, then the node will not occupy any time slot. Thus, another member node which has data to send, the timeslot will be assigned to that member node. This protocol ensures efficient bandwidth utilization by avoiding wastage of time. Each CH must keep some free timeslot to permit other incoming nodes from other cluster to join its cluster. In energy efficient transmission, According to the received signal strength of message of data request from the CH, the transmitter will send the message.

In this paper, we propose a routing protocol called Improved-Cluster based routing protocol for mobile nodes in WSN (Improved-CBR Mobile WSN) that reduces the unnecessary traffic and collision. In our proposed protocol, the selection of CHS, membership declaration and process of aggregation of data from member nodes is similar as in CBR mobile-WSN [7]. There is an unnecessary broadcast due to the selection of same nodes within the same transmission range in CBR mobile-WSN. To overcome this issue, a new method is proposed in which energy consumption will be reduced due to the selection of right forwarding node and reduction of unnecessary broadcast. The rest of the paper is organized as follows. We present CBR Mobile WSN in section 2. Improved-CBR Mobile WSN protocol is proposed in section 3 and implemented in section4

We introduce the mobility model and radio model used in the study in section 5. The simulation work and results are discussed in section 6. Finally this paper is concluded in section 7.

2. CBR MOBILE-WSN

CBR Mobile-WSN has been proposed by authors in [7] to support mobility having low packet loss with efficient energy consumption. CBR proposes a method to avoid packet loss. In this method, one of the CH must be free to receive the lost packet that was not able to receive message of data request from its CH, hence unable to send data to its CH. CBR Mobile WSN also sets up registration phase immediately possible to avoid further cumulative losses.

In this protocol, CHs received data not only from its member nodes during TDMA allocated time slot but also from lost nodes. This protocol is query based routing protocol in which sensor node choose minimal power to transmit the message and send data back to CH after receiving the message of data request from CHs. If any sensor node does not receive message of data request then it will send its data to the nearby CHs and also send registration message. When CHs finishes the data receiving messages from their member nodes then it will check whether it receives messages of data request from all nodes and then it will remove all non-receiving sensor nodes. After this, new CHs will check whether it receives any registration message from lost nodes or not. Then it will send advertisement message to them. If CH receives any join acknowledgement message then it will add that node in its list and send them TDMA schedule [7].

3. IMPROVED CBR MOBILE-WSN

CBR Mobile-WSN supports sensor nodes mobility in WSN. CBR Mobile-WSN avoids packet loss by adding a new method in LEACH-Mobile [7]. That method describes that if any node does not receives message of data request from CHs then that node is lost. One of the CH should be free to receive data from lost nodes. In addition, sensor node does not wait for two consecutive failure frames in receiving message of data request. In this protocol, sensor node will move out of that cluster as soon as possible and will send data to any other free CH. But there is an urgent need to optimize the CBR algorithm as it lacked a facility in its routing algorithm which would help to minimize unnecessary broadcast and collision due to selection of same nodes within the same transmission range. To overcome this issue, a new method is proposed in which energy consumption will be reduced due to selection of right forwarding/advanced nodes and reduction of unnecessary broadcast.

3.1 Improved CBR Mobile WSN overview

In our proposed protocol, the selection of CHS, membership declaration and process of aggregation of data from member nodes is similar as in CBR mobile-WSN [7]. There is an unnecessary broadcast due to the selection of same nodes within the same transmission range. To overcome this issue, a new method is proposed in which collision and energy consumption will be reduced due to the selection of right forwarding node and reduction of unnecessarily broadcast.

This is achieved by calculating the angle between nodes which are within d_0 ratio [11] shown in Figure1. d_0 is the ratio that tells, while sending the Data, how much energy is consumed when transmission takes place and how much energy is consumed in data aggregation. This angle is considered if the angle in between the node and forwarding node is less than the threshold value. Node having minimum angle or less than 45° (i.e. threshold value) will get data from source node to forward.

d_0 ratio is calculated with :

$$d_0 = sqrt\,(Efs/Emp)$$

The parameters Efs and Emp is the amount of energy dissipates per bit in the radio frequency amplifier.

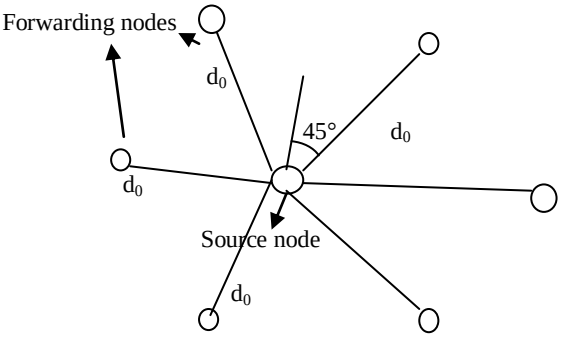


Fig 1: Calculation of angle between node and forwarding node which is within d_0 ratio

4. THE IMPLEMENTATION OF PROPOSED PROTOCOL

Similar to CBR Mobile-WSN, this proposed protocol is implemented in two phases that are setup phase and steady state phase. In setup phase, CHs are selected and TDMA schedule decided. In steady state phase, data is sent to CHs.

4.1 Setup phase

In this phase, most suitable CH will be chosen by each sensor node in the network according to received signal strength and then sensor nodes will send registration message to that cluster head to inform the cluster head that it will be one of its member node. After receiving this message, CH will decide the TDMA schedule and send the schedule back to the member nodes. The algorithm is discussed further in the following sections.

4.1.1. Setup cluster head election

In some protocols like LEACH [8], in the environment where sensor nodes are static, nodes in the cluster randomly become CH. In the environment where sensor nodes are mobile, CH is elected according to mobility factor [10]. In each cluster, the node having smallest mobility is chosen as CH. In our proposed protocol, we select CH randomly. CHs are assumed to be stationary and static through rounds that are similar to LEACH-mobile.

4.1.2. Advertisement

In LEACH and LEACH- mobile, after selection of the CH it will broadcast an advertisement messages to rest of the sensor nodes. CH will choose carrier sense multiple access with collision avoidance medium access control (CSMA/CA MAC) protocol for these advertisement messages. Sensor nodes must keep their receivers ON to receive the advertisement messages from their CHs.

4.1.3. Decision

Sensor nodes after receiving the advertisement message from one or more CHs; it will compare the received signal strength and decide the cluster to which it will belong. After decision of CH to which sensor node will belong, sensor node will send registration messages to inform CH. In this phase, CHs must keep their receivers ON.

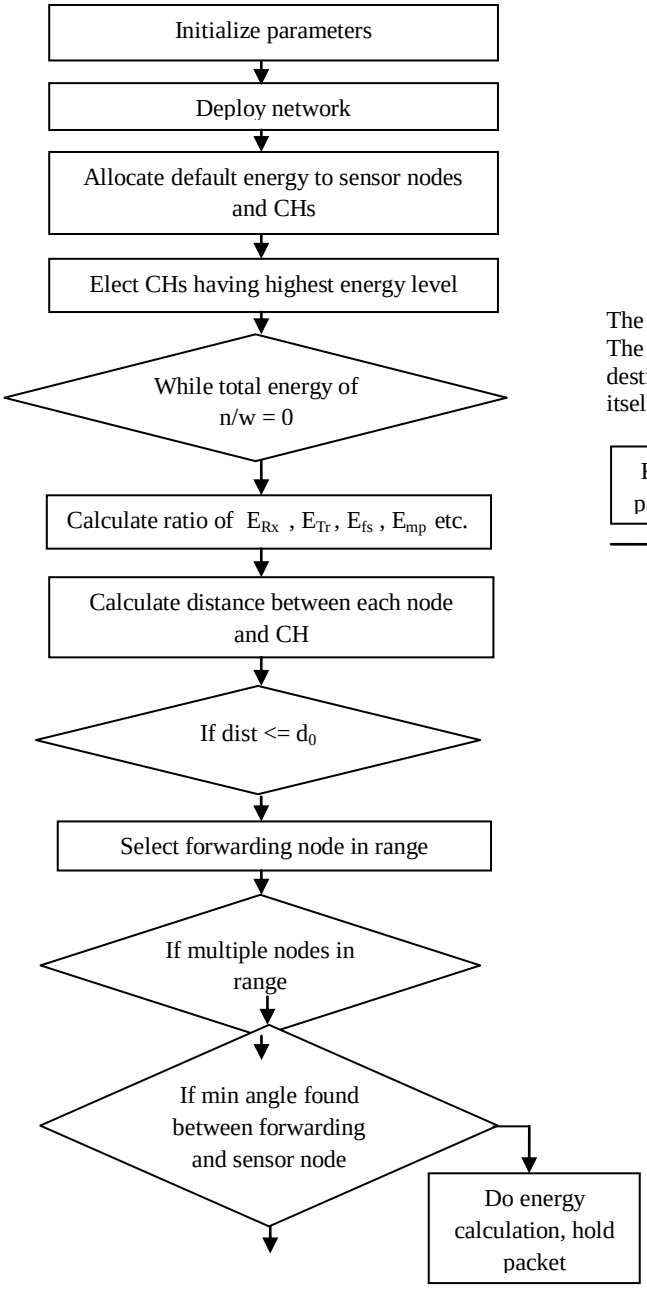
4.1.4. Schedule creation

After receiving the registration message from sensor nodes, CHs will make the TDMA schedule based on the number of nodes and broadcast to each sensor node in cluster.

4.2 Steady-State phase

After the cluster heads are decided and TDMA schedule is created, data transmission from sensor nodes to CHs will begin.

In CBR-mobile WSN [7], there was an unnecessary broadcast and collision due to the selection of same nodes within same transmission range. So, there is an urgent need to optimize the CBR-mobile WSN protocol. To overcome this issue, a new method is proposed in which collision and unwanted traffic will be reduced due to the selection of right forwarding/advanced nodes and reduction of unnecessary broadcast. This is achieved by calculating the angle between the nodes which are within the range of d_0 ratio [11]. This angle is considered if the angle between the sensor node and forwarding node is less than the threshold value. Node having minimum angle or less than 45° will get data from source node to forward. Plus sensor node will switches ON its radio transmitter, adjust the transmission power and send the data to CH. At the end, node will turns off its radio transmitter for minimum energy dissipation. But CHs must keep its radio transmitter ON to receive data from its member nodes, to send data request messages to its member nodes.



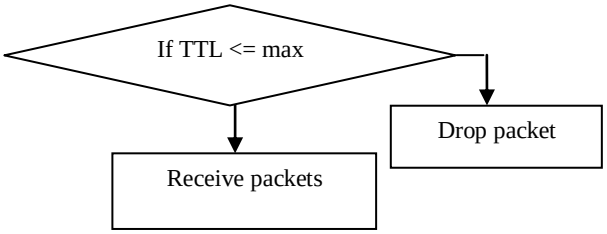


Fig 2: Flow chart of Improved CBR-Mobile

5. MOBILITY MODEL AND RADIO MODEL

In this paper, the mobility model used that is random waypoint model is similar to that model used in [7], where each mobile node picks its direction at random from (0, 2π] and moves in that direction from its current position to a new position for a distance d with a speed s between [Smin, Smax], where d is exponentially distributed.

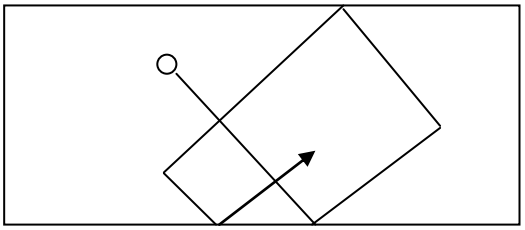


Fig 3: Random Waypoint Model

The node is reflected at the boundary, if it hits the boundary. The node pauses for a period of time on reaching the destination, based on random variables and the process repeats itself as shown in Figure 3.

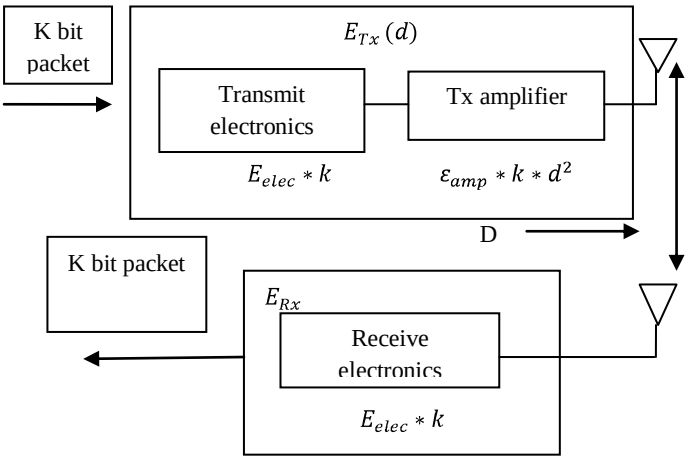


Fig 4: First Order Radio Model

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$$

$$E_{Tx}(k,d) = E_{elec} * k + \varepsilon_{amp} * k * d^2 \quad (1)$$

$$E_{Rx}(k) = E_{Rx-elec}(k)$$

$$E_{Rx}(k) = E_{elec} * k \quad (2)$$

In this paper, radio model is used in proposed protocol that is first order radio model which is described in [8],[9] to calculate the transmitting and receiving energy as shown in Figure 4.
In this model, transmitter and receiver dissipate Eelec = 50 nJ/bit to run the transmitter and receiver, with. The transmitter amplifier dissipating 100 pJ/bit/m [8][9]. Following Equations 1 and 2 calculate the amount of energy dissipated in transmitting and receiving k bits message through a distance d between the transmitter and receiver.

6. SIMULATION RESULTS AND DISCUSSION

We simulate Improved CBR Mobile-WSN and CBR Mobile-WSN using MATLAB to evaluate the performance of Improved CBR Mobile-WSN with the parameters shown in Table 1.

Table 1. Show the delivery ratio for both improved CBR Mobile-WSN and original CBR Mobile-WSN

Parameter	Value
Network Size (L*W)	100*100 m
Number of Sensor Nodes (N)	100
Sensor Node Deployment	Random deployment
Percentage of Cluster Head	5%
Percentage of Mobile Sensor nodes	5-100%
Data size	2000 bits
Sensing Range (R)	25m
Transmission Range	10-20m/s
Sensor Speed	1-20m/s
Mobility model	Random waypoint model
Radio Model	First order radio model

Figure 5 shows the average dealy for both improved CBR Mobile-WSN and original CBR Mobile-WSN. When numbers of nodes are less, then delay is low. This means the routing path are easily found and lots of collision avoided. A similar behavior is seen in improved delay ratio but it is performing better than original delay ratio using Improved CBR Mobile-WSN.
Figure 6 shows the delivery ratio for both improved CBR Mobile-WSN and original CBR Mobile-WSN. When the numbers of nodes are less, the packet delivery ratio is quite high. A similar behavior is seen in improved PDR but it is performing better than original PDR because of Improved CBR mobile-WSN.

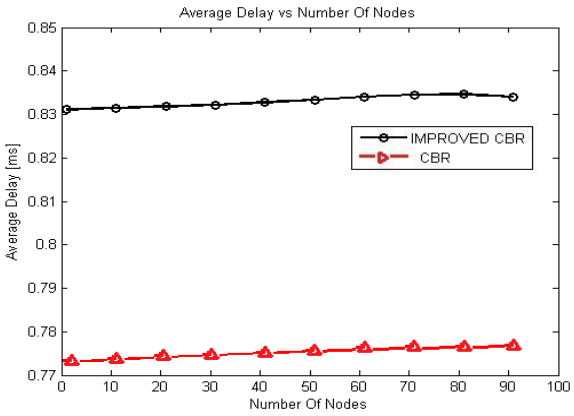


Fig 5: Comparison of average delay of original CBR Mobile-WSN and improved CBR Mobile-WSN

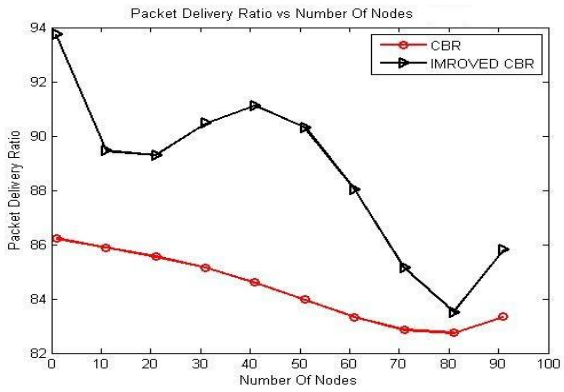


Fig 6: Comparison of packet delivery ratio of original CBR Mobile-WSN and improved CBR Mobile-WSN

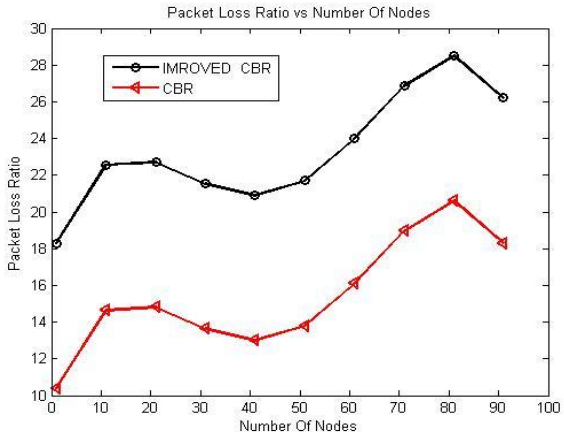


Fig 7: Comparison of packet loss ratio of original CBR Mobile-WSN and improved CBR Mobile-WSN

Figure 7 shows the delivery ratio for both improved CBR Mobile-WSN and original CBR Mobile-WSN. When the numbers of nodes are less, packet loss ratio is quite low. A similar behavior is seen in improved PLR but it is performing better than original PLR because of Improved CBR mobile-WSN.

7. CONCLUSION AND FUTURE WORK

In some environment, mobility in sensor nodes is very important. To handle the mobility in sensor nodes, routing protocol should be aware of packet loss. So, a new routing protocol is proposed called Improved Cluster Based Routing Algorithm for Mobile nodes in WSN. This is a routing protocol in which it reduces the unnecessary broadcast and collision of sensor nodes. The Improved Cluster Based Routing Algorithm shows the significant improvement in packet delay and unwanted traffic that cause collision in mobile nodes as compared to CBR-Mobile WSN protocol. Though improved CBR mobile-WSN works better than original CBR mobile-WSN, improved CBR is not completely efficient protocol. It is definitely an improvement over original CBR mobile-WSN, but still there are some improvements can be done in improved CBR mobile-WSN in terms of security of data. Data should be secure while travelling in mobile WSN.

8. REFERENCES

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