An efficient Qos-Balanced routing protocol in wireless sensor networks

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Abstract

Objective: Packet transferring in the wireless sensor nodes becomes increasingly popular in the real world environment where the usage of wireless devices like mobiles phones is increased considerably. The main goal of this work is to introduce a novel approach for providing an efficient environment to transfer the packets across different number of nodes without packet loss by considering the factors of energy load level, congestion level, interference level and the communication capacity.
Method: This work introduces a novel approach called Efficient QoS-Balanced Routing Protocol (EQBR) approach which is used to transfer the packets from the sensor nodes to base station node by establishing the proper connection between them. The routing tree would be constructed in every round for transferring the packet by selecting the proper parent nodes. The parent node selection would be done by calculating the factors called the energy load level, communication capacity, interference level, and the congestion level. By calculating these factors, efficient selection of the parent node with better network life time without congestion could be selected.
Results: The performance evaluation was conducted in the network simulator (NS2) environment to prove the improvement of the proposed approach than the existing protocols performance. The comparison has been made by using the parameters called the Delivery ratio, Routing load, End to end delay and Remaining Energy. The comparison made were proves that the proposed methodology provides an better environment to transmit the packets across different number of nodes successfully.
Conclusion: The findings of this work demonstrate that the proposed methodology provides better result in terms of successful transmission of packets with improved energy consumption ratio.

Keywords: Energy aware routing, Increased packet transmission, QoS consideration, Network life time

1. Introduction

Wireless sensor network is a non stationary environment where the mobility of the sensor nodes would vary in different time.WSN don't have an established communication path between them, so that transferring packet requires establishing the routing path establishment at every time. There routing path between the nodes would be changed dynamically due to dynamic movement present between the nodes. There requires to consider the lots of factors to select the proper nodes for transferring the packets which cannot be attained well in the existing scenario.

Energy is the main constraint that is present in the wireless sensor nodes which is limited in power that may lead to the resource failure which may cause the packet corruption while transferring. The energy consumption needs to be well monitored in the every sensor nodes to attain the successful transmission of packets across different number of nodes. Due to limited facilities of the sensor nodes, the communication capacity might also get reduced in the nodes due to which failure might arise in the environment.

Successful transmission of packet in the wireless sensor networks depends on the successful establishment of the routing path between the sensor nodes and the base station where all the nodes involved in the routing path should be good in their resources limitation. They need to assure the successful transmission of packets across different number of nodes present in the system. Various factors need to be considered while selecting the parent nodes for route establishment to achieve high packet delivery ratio.

The main contribution of this work is given as follows:

The proposed research of this work is concentrated to provide the efficient and better environment for the wireless sensor node users, so that they can transfer the packets across different number of nodes successfully. The successful deployment of routing path is done to increase a packet transmission ratio by limiting the drawbacks,

which may arise due to energy level, congestion level and the communication capacity. The working scenario of this work is given as follows:

- Construct the well efficient routing tree to achieve the successful transmission of packets.
- Transmit the packets to the base station through number of sensor nodes with the consideration of the various constrained factors like energy load, communication capacity, congestion level and the interference level
- Transfer a packets to the base station through established path between base station and sensor node or the root node and sensor node

The organization of this work is given as like follows: In this section I, detailed introduction about the data transferring in the wireless sensor node is given. In the section II, various previous researches that were conducted with the consideration of the energy factor is discussed detailed. In section III, proposed research methodology of this work is discussed and derived in the brief manner. In section IV, an experimental test of this work is done in the Ns2 environment between various existing protocols and the proposed research scenario. In section V, overall research of this work is concluded.

2. Related works

Zhao Han et al [1] introduced a tree based energy efficient routing protocol which will select the route path between the base station and the sensor nodes based on the energy factor. The route is constructed by considering the two situations. Those are, data received from multiple sensor nodes consists of same length where the data's collected from different sensor nodes consists of different length. If the data's from multiple nodes are having same length then the root node would be selected among the set of sensor nodes which will gather values from all nodes. The root node will aggregate the data values gathered from the multiple nodes which will then be sending to the base station. In the second scenario, the base station itself will act as the root node which will receive data packets of various lengths from different nodes directly.

Kemal Akkaya et al [2] discussed a various techniques that are introduced previously to attain an efficient routing performance in the wireless sensor networks. This research work discusses various techniques that are used to perform an efficient routing establishment in the cloud simulation environment. Based on the techniques that discussed previously, the routing establishment techniques are categorized into three types. Those are data-centric, location aware and the hierarchical manner. This survey analysis the route establishment in different scenarios with the consideration of the different factors like dynamic level of network, node usage level, energy consumption level, data delivery level, data fusion techniques and so on. This survey provides idea for establishment of the different factors which are used in the routing establishment concept.

Katayoun Sohrabi et al [3] discussed the self organizing behaviour of the sensor nodes present in the environment in terms of achieving and preserving the limited resources of wireless nodes. It is done based on the various parameter values which are preserved in terms of the most of working scenarios. This work concentrates on finding the better route between the different nodes in terms of the limitation factor such as energy conservation, communication capacity and so on. This work creates a static routing path through which communication would be established between the different numbers of nodes. This is used to avoid the various controller schemes in terms of the different functional scenarios.

Heinzelman, W.R et al [4] introduced a new type of protocol which is called as the LEACH. This protocol introduced in this work attempts to reduce the overall energy consumption of the network by transmitting and receiving the packets that are transmitted in the flexible manner. The energy dissipation of the network terminology depends on the fusion of various packets that are received from multiple nodes. It is often based on the dependency of the network nodes in terms of various packets that are fused together. The LEACH protocol of this work depends on the working scenario of fusion of multiple packets which are combined together to attain aconsiderable energy conservation by reducing the data transmission length. This protocol cannot support the transmission of the varying length data which can't be fused together.

Stephanie Lindsey et al [5] introduced a novel protocol named as PEGASIS which aims to reduce the total energy consumption of the wireless sensor nodes by transmitting the varying length of data's to the different number of nodes in terms of different set of packets. This work attempts to reduce the total energy consumption in terms of different number of protocols to reduce the varying length of power transmission capabilities. This methodology attempts to fuse the data's together to eliminate the needs of transmission different number of packets together.

This method also attempts to select the smallest path than the varying length of paths to avoid the wastage of resources. These nodes would communicate with the nodes those are most nearest to each other.

Jae-Hwan Chang et al [6] introduced as novel algorithm called the energy conserved route establishment program which attempts to establish the convenient route between the differential numbers of nodes in terms of various functional parameter values. This approach is based on enabling nodes to transfer the packet between different number of nodes until the energy get drained completely. And also, this mechanism attempts to change the routing path whenever the new transmission starts by changing the route path between different set of nodes. The various functionality features of the existing routing nodes are found to be established in terms of different parameter values. The computational delay also considered while selecting the route to forward the packets.

R.Prasanth et al [7] introduced the congestion and stability aware routing protocol which focus on establishing the well defined path between the source node to the destination node which in turn leads to the successful path trasnsmission. This approach focus on provisioning the resources in terms of different functional parameter values and it can tolerate the failure by establishing the path between different source and destination nodes.

A.Divia lakshmi et al [8] introduced a novel protocol which in turn leads to the effcieint path establishment process with the consideration of parameters called the authentication, randomization and distribution. This approach leads to the successful detection of the clone attacks in the wireless sensor networks through which improvement of the performance measures such as end to end delay, packet delievery ratio and the throughput is achieved.

The above research works introduced various research scenarios for establishing energy conserved route path establishment. In the following sections, proposed research scenario of this work is discussed in the detailed manner.

3. Efficient Qos balanced routing protocol to establish better routing path

Data transmission in the wireless sensor nodes is a most important task where there won't be any infrastructure present to share the data packets whenever it required. The sensor nodes need to establish the efficient routing path whenever they need to transfer the data's. The successful transmission of data packets depends on various factors in the sensor network, where the wireless nodes are limited in its resources. Some of the most important factors that are to be considered are the energy conservation level of nodes, communication capacity, congestion level and the interference level. These factors are required to be considered well before transmitting the packets to other nodes to avoid the packet loss.

One of the key approaches to complete the successful transmission is the establishing the well efficient key routing path when the node wants to send packets to the base station. The selection of parent node through which data's to be transmitted requires more concern for achieving successful transmission of packets. In this work, efficient QoS balanced routing protocol is introduced which attempts to establish the route which is much better to transfer the packets from sensor nodes to the base station. This work mainly considers the two scenarios that might arise in the wireless sensor network when forwarding the packets from sensor nodes to the base station. Those are given as follows:

1. Data can be fused
2. Data can't be fused

The above scenarios are considered in the network for achieving the better data transmission and the establishment of route path. The overall flow of this work is given in figure 1.

The figure 1 depicts the overall processing of this work. From this, we can divide the flow of the QoS balanced routing establishment asfollows:

- Initialize the network environment by calculating and informing their energy load level
- Constructing a tree for establishing route with the consideration of the QoS factors
- Transferring packets to the base station from the sensor nodes

All these processes would be done with the consideration of the two scenarios that are given previous for the efficient construction of nodes.

A. Initializing Network Environment

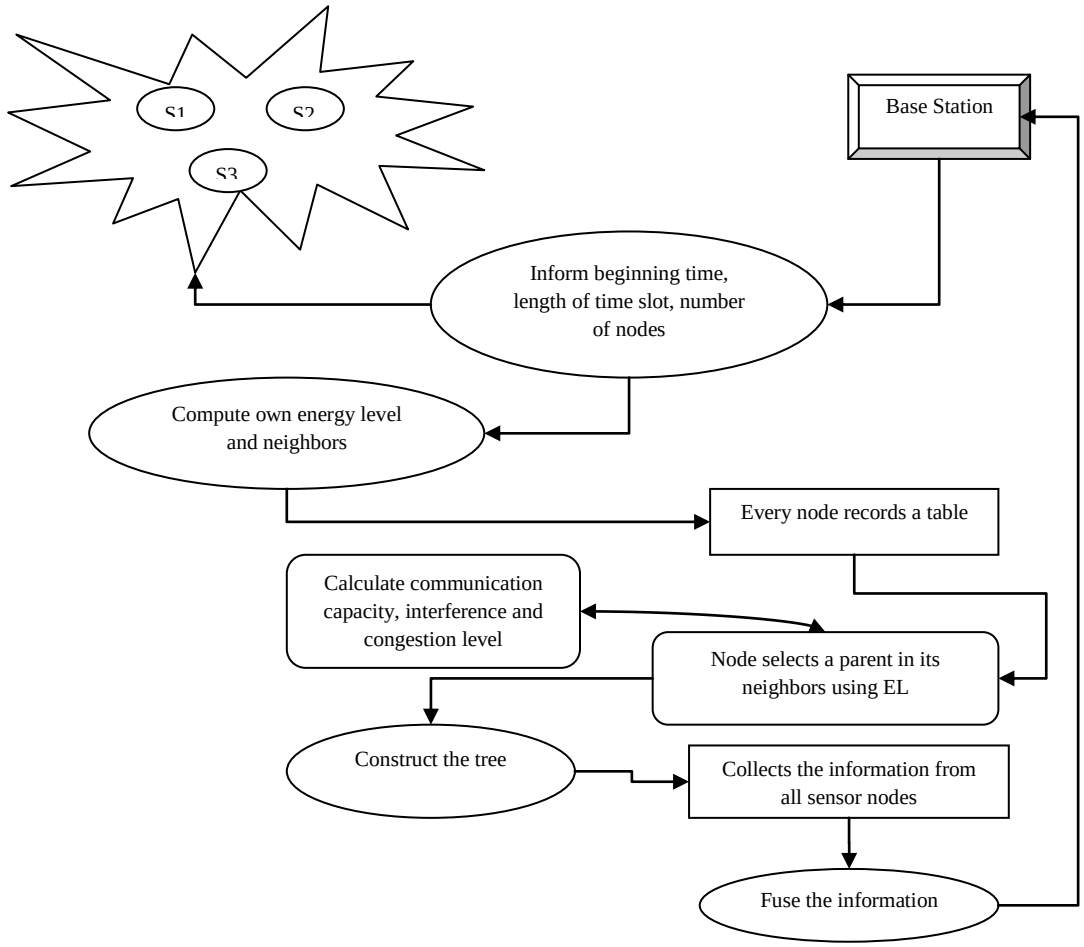
In this module, network module initialization would be done in terms of various constraints to limit the data packet failure rate. It is done by the base station which will wake up all the sensor nodes for transmission by sending

beacon packet. By receiving beacon packets from the base station all the sensor nodes present in the wireless sensor environment would start to calculate their energy load level in terms of their residual energy. The energy load calculation of each sensor node is done as like follows;

$$EL(i) = \left\lceil \frac{residual_{energy}(i)}{\alpha} \right\rceil$$

Where
EL = Energy load
α = constant parameter value

Figure 1. Overall flow of the routing establishment



This calculation will be done by each sensor node in their corresponding iteration level. For example, in ith iteration sensor node (i) will calculate and update their energy load level. After calculation node (i) will transfer the energy load level details to the other nodes which are nearest to each other. Thus the neighbouring node can update their table with the other nodes energy level calculation which would be more helpful at the time transmission of packets.

Likewise these processes would be repeated until every node updates their energy load level in terms of their remaining residual energy parameter value. Finally every node consist of the two table details; those are self table and the neighbour table.In the self table energy load information of the corresponding node would be stored and in the neighbouring table energy load information of the neighbouring node would be stored.After updation of energy load information about each sensor nodes then the packets would be transferred. For transferring packets, the proper route should be established which is explained in the detail manner in the following sub sections.

B. Constructing a Tree for Establishing Route with the Consideration of the QoS Factors

After updating the energy load level of the every sensor nodes present in the wireless sensor network, routing path would be established by constructing the tree. In this section, including the residual energy other factors are also considered for the parent node selection. Initially the base station will select the root node through which data

from all sensor nodes can be obtained. This root node selection process is done with the consideration of the two scenarios. Those are

- If the data from the entire sensor nodes are having equal length then the data fusion can be done. Thus the base station will select one of the node from the wireless sensor network consists higher residual energy as root node.
- If the data from the entire sensor nodes are having different lengths then the data fusion can't be done. Thus the base station will announce itself as root node for gathering the data from multiple sensor nodes.

After selecting the root node from the different set of sensor nodes, the information would be forwarded to other sensor nodes so, that the node which wants to transfer packet can establish the routing path by selecting proper parent node to reach the root node.

The parent node selection is the most important process in the routing establishment process where the failure parent node can down the entire performance of the network. In this work, parent node selection is done with the consideration of the QoS parameter where the node which satisfies all the mentioned QoS parameter values would be selected as parent node instead of transferring packets to the entire environment.

The QoS factors that are considered are

- Energy load level
- Congestion level
- Communication capacity
- Interference level

Each node tries to select a parent in its neighbors based on communication capacity of the nodes. Communication capacity defines the data handling capacity of the nodes in the real world. If the parent node has high communication capacity, it can handle more data. Real time Communication Capacity is computed by,

$$\mathrm{RTCC} = \mathrm{B} \sum_{\mathrm{x}} \mathrm{Ut}_{\mathrm{x}}\,(\mathrm{t})$$

Where,

$$\sum \mathrm{U\ tx(t)} = \sum_{\mathrm{P_i} \in \mathrm{Kx(t)}} \frac{\mathrm{T_1}}{\mathrm{D_i}}$$

Where, tx(t) = utilization factor, $\mathrm{D_i}$ is Distance of each node with respect to sink node, $\mathrm{T_i}$ is Transmission Time with each packet, B is Bandwidth utilization, i ratio of packet size and effective bandwidth.

For selecting the parent node, the interference of the node is computed.Given a transmission from node i to node j, the SINR value at receiver j is computed as follows:

$$\mathrm{SINR_{ij}} = \frac{\alpha_{\mathrm{ij}} \mathrm{P_i}}{\mathrm{N_j} + \sum_{\mathrm{k} \neq \mathrm{i}} \alpha_{\mathrm{kj}}\, \mathrm{P_k}}$$

Where αthe path loss is factor, $\mathrm{P_i}$ and $\mathrm{P_k}$ are the transmission powers for i and k, and $\mathrm{N_j}$ is the amount of ambient noise experienced by receiver j.

Finally, for choosing the parent node, the congestion level is determined based on the data rate of the node. Since congestion significantly reduces the effective bandwidth of a link, the effective link data-rate is given by,

$$\mathrm{D_{rate}} = \mathrm{D_{size}} / \mathrm{C_{delay}}$$

Where $\mathrm{D_{size}}$ is the data size and $\mathrm{C_{delay}}$ is the channel delay. So, based on these metrics the parent node is selected.

The node which satisfies all these parameter values would be selected as the parent node which will also called as the relay node that are used for forwarding the packets received from the sensor nodes to the base station.

If none of the nodes satisfies these parameters then the base station/ root node itself would be selected as the parent for the perfect data transmission. After establishing the perfect route path between sensor nodes to the base station, packets would be transferred which is explained detailed in the following sub section.

C. Transferring Packets to the Base Station

In this section, nodes would start the packets to the base station by considering the two scenarios.

In the first scenario, all the data packets received from different sensor nodes would be of equal length which will be transferred based on the Time Division Multiple Access and the Frequency Hopping Spread Spectrum methods. In this approach TDMA is used to decide the number of time slots for transferring the data packets to the sensor nodes. In each time slots, child node which is called as leaf node would attempt to transfer the packet to parent node. In this situation, three scenarios might occur. Those are

- None of the child nodes attempts to transfer packet
- Multi child nodes attempts to transfer packets
- Single child node attempts to transfer packets

In the first situation, all the parent nodes will go to sleep mode to save the energy consumption. In the second situation, control packets would be forwarded to the multiple child nodes which attempt to transfer the packets. The control packet will select the proper child for enabling data transferring process. In the third situation, acknowledgement would be send to the child node to allow them to transfer packets. Likewise in every iteration, leaf nodes will transfer the packet received from multiple sensor nodes in the fused manner to save the energy level.

In the second scenario, packet won't have an equal length where the each sensor nodes need to be transfer the packets to the base station individually. This is done by using the methodologies called the CDMA and FDMA which is used to schedule the packets to be transmitted in every iteration.

The proposed research scenario of this work assures that the successful delivery of the packet to the base station with the reduced packet loss rate which is proved by conducting the experimental evaluation. The performance evaluation conduced was discussed detailed in the following section.

4. Numerical results

In this section, performance evaluation was conducted in the network simulation environment to show the improvement of the proposed approach in terms of improved packet transfer rate with reduced packet loss rate. The performance evaluation was conducted under the different number of nodes and packet rate. The existing and proposed methods are named as follows:

- General Self-Organized Tree-Based Energy-Balance routing protocol (GSTEB) –existing
- Efficient QoS-Balanced Routing Protocol (EQBR) – proposed

The performance evaluation were conducted in terms parameters called the

- Delivery ratio
- Routing load
- End to end delay
- Remaining Energy

The comparison and evaluation were discussed in the detailed manner in the following sub sections

A. Delivery Ratio Comparison

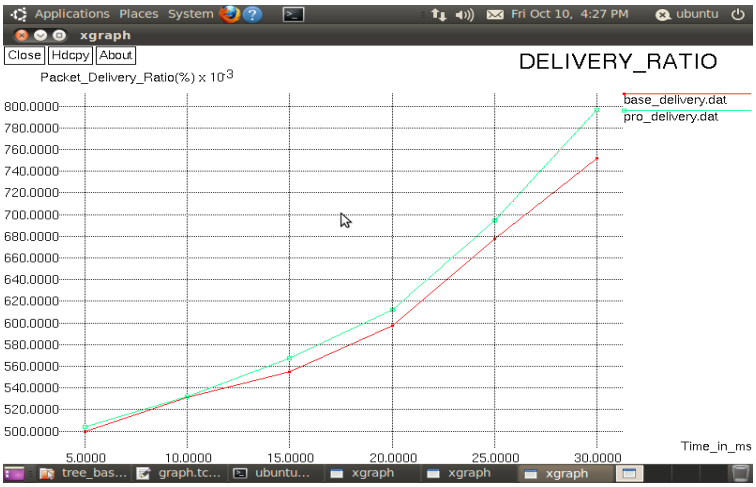
Delivery ratio is defined as the ratio taken between the numbers of packets that are transmitted and number of packets that are received. That is delivery ratio can be calculated by taking the ratio between the total packets that are sent and the total packets that are received. The formula for delivery ratio calculation is given as follows:

Delivery Ratio = ∑ Number of packet receive / ∑ Number of packet send

The comparison of delivery ratio parameter value of both existing and proposed system is depicted in the graphical representation (figure 2):

In the figure 2, delivery ratio comparison is depicted where the computation time is taken in the x axis and packet delivery ratio is noted in the y axis. The delivery ratio is calculated in the different time period nodes to predict the amount of data's that are transmitted successfully. The comparison graph proves that the proposed methodology provides better result than the existing approach in term of improved delivery ratio level.

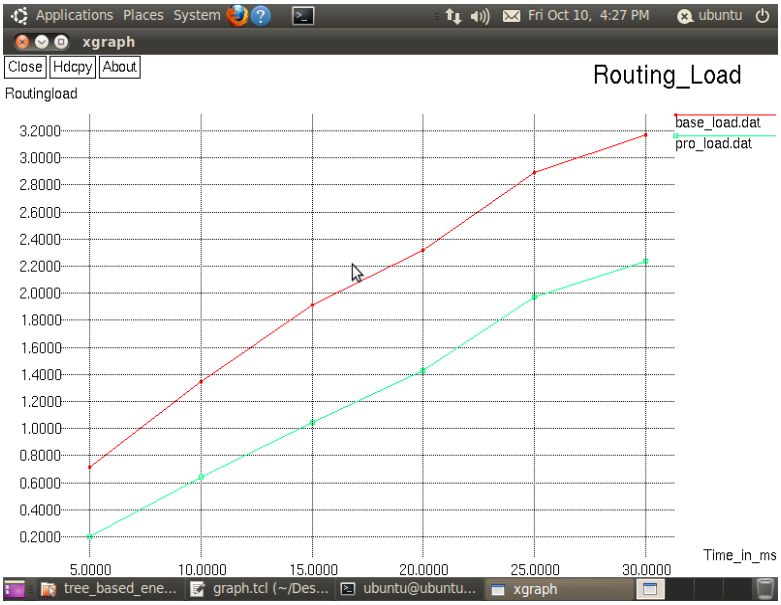
Figure 2. Delivery ratio comparison



B. Routing Load

Routing load is defined as the ratio of traffic that is transmitted from the source to the destination parameter. Routing load of the proposed methodology should be less than the existing approach which might considerably increase the packet loss rate. The graphical representation of routing load proposed and existing methodologies are depicted in figure 3.

Figure 3. Routing Load Comparison



In the figure 3, routing load comparison is depicted where the computation time is taken in the x axis and routing load is noted in the y axis. The comparison graph proves that the proposed methodology provides better result than the existing approach in term of reduced routing load level.

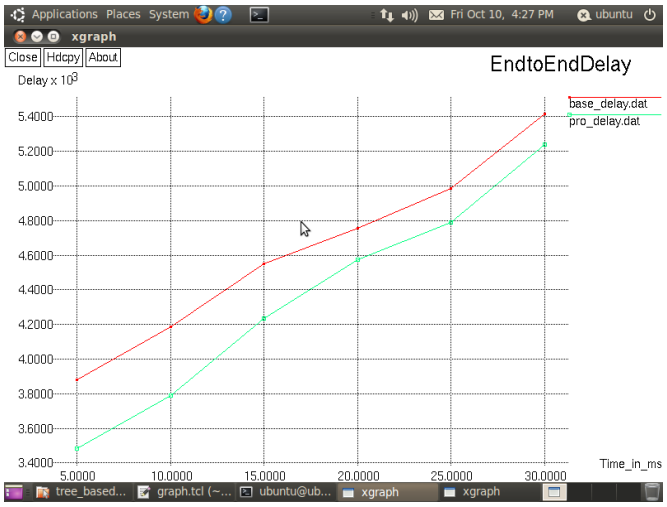
C. End To End Delay

The average time taken by a data packet to arrive in the destination is called as end to end delay. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that successfully delivered to destinations that counted.

$$\text{End to End Delay} = \sum (\text{arrive time} - \text{send time}) / \sum \text{Number of connections}$$

The graphical representation of end to end delay of both proposed and existing methodologies are depicted in figure 4.

Figure 4. End to End delay



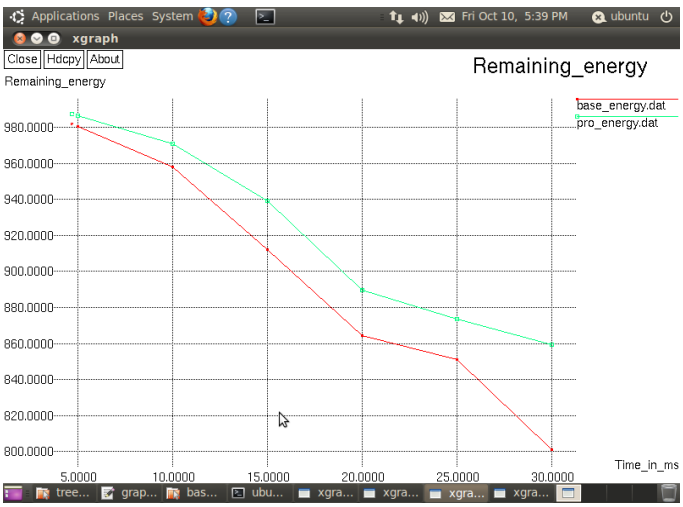
In the figure 4, end to end delay comparison is depicted where the computation time is taken in the x axis and end to end delay is noted in the y axis. The comparison graph proves that the proposed methodology provides better result than the existing approach in term of reduced end to end delay value.

D. Remaining Energy

The energy level of every node should be high in the every iteration for the better performance based on which failure of the nodes while transmitting packets can be avoided. The remaining energy is the parameter which is used to measure the available energy level after completion of packet transmission. The graphical representation of the energy level of the system is given as follows:

In figure 5, remaining energy comparison is depicted where the computation time is taken in the x axis and energy level is noted in the y axis. The comparison graph proves that the proposed methodology provides better result than the existing approach in term of more remaining energy level.

Figure 5. Remaining Energy



5. Conclusion

Data transmission in the wireless sensor nodes is most complex process where the packet loss rate might be increased considerably due to the limited energy resource factor of wireless sensor nodes. In this research work, successful transmission of data packets to the sensor nodes are done by introducing the novel mechanism called efficient QoS balanced routing protocol which attempts to transfer the packets in terms of the different QoS factors. The QoS parameters that are considered in this work are residual energy level, communication capacity, congestion level and the interference level. The experimental tests conducted were proves that the proposed methodology provides better result than the existing scenario in terms of the improved energy consumption level, decreased congestion ratio, decreased communication capacity an so on.

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