# Data Merge based Energy Efficient Routing Algorithm for Wireless Multimedia Sensor Networks

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**Abstract:** Many researchers worked on data aggregation and energy efficiency for Wireless Multimedia sensor networks. Now a days many web and mobile application frameworks are interconnected to get the data from an intended WSN to support the user requirements. These applications request the data from the base station of an intended WSN. The base station has to handle all the requests from various application users. It can forward these requests to specific sensor node to get the data. Multiple requests can be transferred to that sensor node, then sensor node can process those requests and send the replies back to the base station. This causes overhead at that sensor node as well as base station. We proposed a novel data merge based energy efficient routing algorithm (DMEERA) to utilize the bandwidth efficiently and to reduce the overhead on both sensor nodes and basestation. The simulation results shows that the increase of energy saving and network lifetime compared to the state of the art techniques.

***Keywords:*** *Data merge, energy efficiency, Routing, Bandwidth efficiency.*

## 1. Introduction

WMSNs are capable of sensing, processing and transferring both scalar and multimedia data. The multimedia data is large in volume and it needs to process before transmitting it. Depending on the type of application the multimedia data can be either real time or non-real time. Generally these WMSNs are similar to powerful distributed systems. The WMSNs have to face the challenges of multimedia communications to meet the energy processing capacities of the nodes, which suffers from limited power. These networks spend the energy on monitoring the environment, sensing the data and forwarding to sink. To transfer the data, routing algorithm is required for selecting an optimized path from sensor node to sink and vice versa in case of query/control packets transfer to a specific sensor node.Quality of Service (QoS) is one of the important requirement and it can be possible by the WMSNs routing algorithm[1]. Those QoS requirements include energy consumption, packet delivery ratio, end-to-end delay guarantee, bandwidth resource, and the lifetime of the network can be addressed.

Many researchers worked on wireless sensor networks and proposed solutions to routing problems in order to reduce the energy consumption of sensor nodes. A survey [2] presents that many applications getting benefits from the wireless sensor networks such as multimedia surveillance, industrial process control, environment monitoring, traffic avoidance, and enforcement and control systems.

In certain environmental applications the users are interested in knowing the present state of that environment with respect to time and space components. For this, different computational powered sensor nodes were deployed in the environment to monitor the events and as well as environmental conditions. Millions of users can send their request messages to the base station and base station has to forward these messages to the intended node to get the update. This causes a lot of consumption of the bandwidth and energy of the network.Typically, there are two important energy consuming tasks in WMSNs: sensing the fields and forwarding the data to the sink[3, 4].

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Data aggregation is the one of the most energy-saving mechanism. It improves the network lifetime by reducing the number of transmissions. It combines the data received from various sources and removes the redundant data before transmitting to the sink.Generally, aggregation is meant for doing statistical or algebraic operations like addition, multiplication, maximum, minimum, median and mean of data set. For this purpose aggregator nodes are considered in the WSNs. The aggregator nodes are also used for load balancing among the nodes in the network [5, 6].Node's energy consumption, data transmission delays can be reduced by performing data aggregation and packet scheduling at sensor nodes with a minimum latency [7]. Different types of packets can be scheduled based on the either real time requirement of data or not. This can cause the energy saving and reduce the end to end transmission delays [8, 9].

## 2. Related Work

The ant colony-based scheduling algorithm (ACB-SA) is proposed to solve the coverage problem [10]. It uses probability sensor detection model to solve efficient energy coverage (EEC) problem or optimize the coverage problem and it is similar to conventional ant colony optimization algorithm with extended solution to the coverage problem.

Bo Yu et al. [5] have proposed first distributed algorithm to minimize the time latency using a collision-free distributed scheduling based on maximal independents sets fordata aggregation in wireless sensor networks. The schedule is updated by adaptive strategy nature of the algorithm, in case of node failure or joining of new node in a network.The proposed algorithm outperforms the existing data aggregation techniques. However node failures causes the degradation of the performance of the algorithm.

ADynamic Multilevel Priority (DMP) packetscheduling technique is proposed[7], in this, all the nodes are arranged in a virtual hierarchical manner and each node maintainsthree levels ofpriority queues except thoseat the leaf level in the zone based topology ofWSNs. Real time data packets can be placed in the highest priority queue of a node and immediately the packets will be forwarded to its upper level. Non real time data packets can be kept in the low priority queue and wait for data aggregation to reach the maximum packet size.DMP packet schedulingtechniquereduces the average waiting time of a packet and also end-to-end delay of the packet.However the end-to-end delay can increase in case of deadlock situation happens in the process of scheduling the three levels of queues.

Anovel data aggregation without size reduction is proposed[11] and it reduces the number of transmissions and improves the bandwidth efficiency by appending the new packets to the buffered packets until the size of the packet becomes maximum.This technique shows gain up to56% in packet loss and 46% in energy consumption.

The TTCDA [12] is proposed to reduce the computation and communication cost by aggregating the data packets and also reduces the data redundancy and energy consumption. It used the additive and divisible aggregation functions and achieved the energy consumption reduction by 3.13% compared to other techniques.

EECDA protocol [13] proposed a technique of combining cluster based energy efficient routing and data aggregation for better lifetime of the network. They proposed a novel method for electing the cluster head and a path selection is based on the residual energy. In [14], BECDA technique presented a solution for effective data gathering by in-network data aggregation for heterogeneous network. It also used correlation of data in a packet to apply the aggregation functions and achieved better throughput.In [15], GKEERA is proposed to address the situation of selecting the data forwarder when the neighbours have less residual energy compared to the required energy. It has given solution for that situation and achieved optimized energy consumption and improved network lifetime.

In this work, we proposed data merge based energy efficient routing for WMSNs to reduce the consumption of both energy and bandwidth resources effectively.

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## 3. Data Merge based Energy Efficient Routing

We propose data merge technique to attain energy efficient routing for wireless multimedia sensor networks. The data generated and transferred by sensor nodes can be categorized into real-time and non-real-time data. The real-time data can be a high prioritized data in providing quality of service (QoS) to the multimedia applications. Non-real-time data can be low prioritized data, which doesn't required in real time. Based on the priority of the data, data merging can be applied separately to that data to reduce the overhead on base station and sensor nodes.

Generally data merging can be applied in case of overlapping of data in the packets. In this paper, the base station can perform the data merging on multiple packets, which are coming from various users intended or interested in particular sensor node. The base station is responsible for processing of user requests and gathering data from a sensor node. In this view, it receives all the request packets from users and verifies the interest of sensor node. BS can separate the requests intended to different sensor nodes and performs the data merging on each separated list of requests as shown in figure 1.

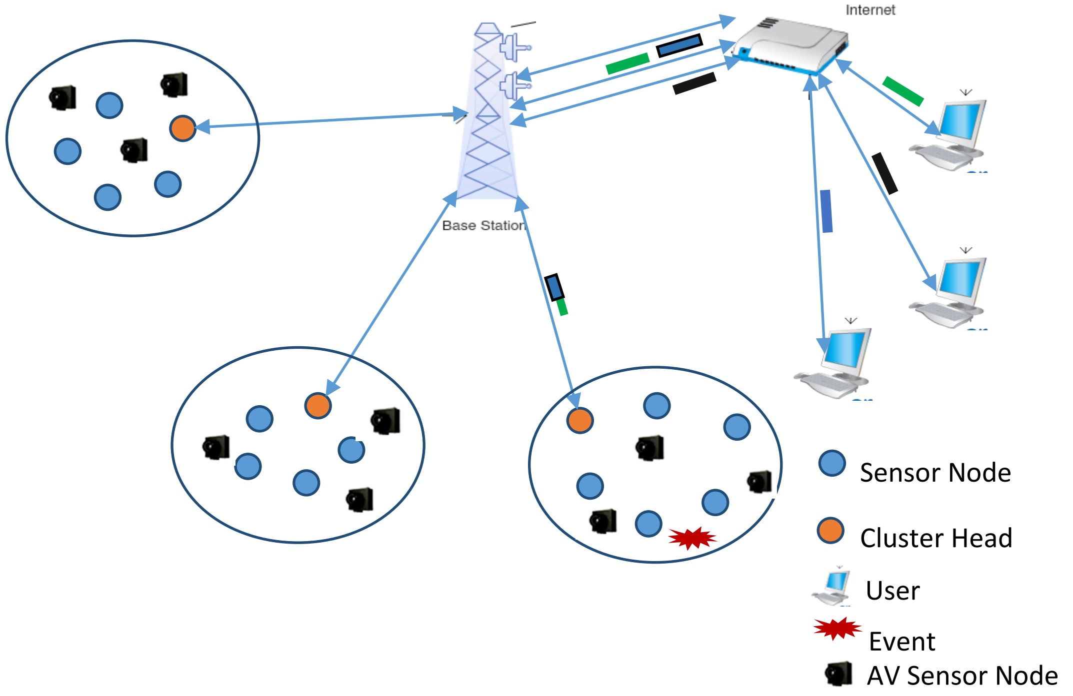


**Figure 1. Architecture of wireless multimedia sensor networks**

The architecture of the WMSN contains heterogeneity of sensor nodes like audio video sensor nodes (AV), cluster head (CH) and scalar sensor nodes (SN). The functionality of each node is differ from each other, Sensor nodes are continuously monitors and senses the scalar data of the environment. The data flow can happens in two ways: Event based data transmission and query based data transmission.

### 3.1 Event Based Data Transmission

The data from sensor node to user through the base station is called event based data transmission means any sensor node identifies abrupt change in the environment, immediately it activates the AV sensor node and AV node can capture the event details and forwards to the base station. Base station can process the received event details and forwards the data to the user.

Algorithm 1:

Input: Environment variables like temperature, humidity, pressure, smoke etc.
Output: severity of the event, event data transmission

1. Monitor and collection of scalar data by scalar sensors.

2. If any environment variable exceeds the respective threshold then
    a. Nearby scalar nodes activate the AV sensor nodes
    b. One or more AV sensor nodes captures the event details and forwards to the CH.
    c. CH invokes DMEERA
    d. CH transfers data merged packet to the base station
    e. Then base station can send alert signal to the intended users.
    f. Users take necessary actions to stop that event.
3. Otherwise goto step 1.

### 3.2 Query Based Data Transmission

In another direction, user to sensor node through the base station called query based transmission. Interested users, who wants to know the current state of the environment can send the request message to the base station and it can forward the request message to that sensor node.

Algorithm 2:

Input: Requests from users
Output: Data merged packets
1. Users can send their request messages to the base station
2. Base station groups the messages based on the destination
3. BS also maintains queues for different destinations based on the priority of the data
4. If two or more packets are intended to same destination then
    a. BS can invokes DMEERA and produces data merged packet
    b. BS can forward this data merged packet to the CH
    c. CH can send this packet to the intended sensor node.
    d. Sensor node can process that packet and send the requested details to the CH
    e. CH to BS and BS to user.
5. Else send them individually to the respective sensor nodes.
6. Go to step 1.

Algorithm 3: High level algorithm for DMEERA

Input: Multiple packets from various AV sensor nodes-
Output: Data merged packets
1. Group the incoming packets with respect to destination node
2. Initiate for wait signal
3. If waiting time of each group > average waiting time then
4. Apply data merging for the available data packets in each group
5. Forward the data merged packet to the CH
6. CH can transfer that packet to the destination
7. Destination node can process the packet and sends the reply back.

Algorithm 4: pseudocode for DMEERA

1:{
2: Id=Id_node;
3: If(Event occurred) then
4: Sense and Construct the datapackets P1,P2…Pk;
5: do
6: If(Id≠Id_sink) then
7: If ((Priority(Pi.Id))= High) then
8: Immediately forward the packet Pi to the next upper level node;

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```
Else If(Mergevalid(Pi.Id)) then
If(length(MergedPacket==0) then
Call for wait for time interval;
len1=length(MergedPacket+NewPacket);
If(len1<Maxlength) then
MergedPacket=Concatination (MergedPacket, NewPacket);
Else
len2=len1-Maxlength;
len3=length(NewPacket);
PPL=len3-len2;
RemP=len2(newpacket)
NewPacket1=Copy(PPL(NewPacket));
NewPacket2=Copy(Rem(NewPacket));
MergedPacket= Concatination (MergedPacket, NewPacket1);
Forward the MergedPacket to next node and call for newmergedpacket for the remp;
While(false);
}
}
}
```

### 3.3 Data Merging Process

From the figure 1, observe that user's request messages in terms of packets forwarded to the base station through the internet. Whenever these request packets received by the base station, immediately it can separate the packets with respect to the destinations. If two or more packets are intended to same destination then BS can performs the merge of data into a single request packet and forwards that packet to the intended sensor node. Sensor node can become active and senses the current state of the environment and applies the merging over the generated packets and forwards towards the basestation.In this case, data from different levels can be combined before being forwarded towards the base station.

The deployment of sensor nodes is in a static manner and all nodes are arranged in levels from low level to uppermost level and then to the base station as shown in the figure 1. Each level contains a set of clusters and each cluster contains heterogeneity of sensor nodes like scalar and AV sensornodes. The selection of CH can be done by the base station based on the residual energy of the sensor node. A node which has high residual energy will be declared as CH to that cluster. The newly selected CH information can be provided to all the sensor nodes in that cluster. In any level any event is occurred the scalar nodes activates the AV sensor nodes and AVs starts capturing of the event data. AV can forward the data to the CH in that cluster and the CH can verifies the priority if the data. CH maintains two queues, one for high priority data and the other for low priority data. Depending on the priority of the data either it starts forwarding or merging of those packets. If the data is high prioritized it can be immediately forwarded to the next upper level CH node. Otherwise the CH starts construction of merged packet by using the DMEERA algorithm.DMEERA can works in both directions from CH to BS and BS to CH.

### 3.4 Network Model

The proposed network model assumed that it contains heterogeneous nodes (Scalar nodes, AV nodes and a super node called CH) in terms of energy and computing capabilities. The network is divided into clusters of size 25 X 25 m and each cluster contains heterogeneous nodes. These clusters are considered as different levels of hierarchy from lower to upper. Each cluster is initially equipped with one cluster head (CH) and depending on residual energy the selection of CH can also be done by the sink. All heterogeneous nodes are randomly deployed with equal density and at one hop distance to each other in each cluster. Each CH is connected with other CH like in inter cluster routing.

The network model consists of heterogeneous nodes and these nodes can be formed as clusters such as C1, C2, C3, . . . Cn. The model can be represented as anadjacent graph G (V, E). Wireless connections between the nodes are edges and nodes can be represented as set of vertices V of a graph.The nodes are randomly deployed ones in a cluster. Each clustercontains a Cluster Head and members (nodes) and organized in a hierarchical manner by multi hop clustering algorithm.

### 3.5 Energy Model

The required energy consumption or energy consumptionto transmit 'K' data bits of a packet by the nodes to the CH is proportional to distance $d^2$as shown in [15] and is:

$$E_{TX}(K,d) = Eelec * K + eampc * K * d^2 \qquad d \le d_0 \qquad (1)$$

$$E_{TX}(K,d) = Eelec * K + eamps * K * d^4 \qquad d \ge d_0 \qquad (2)$$

where 'eampc' represents the energy consumed by nodes while transmitting the data packets to the CH and 'eamps' is the energy consumption of nodes in transmitting the data packets to thesink with in the cluster. The distance $d^2$ is from nodes to its CH and $d^4$ is the stance from nodes to sink. 'Eelec' is the energy dissipation per 'K' bits of data by the both transmitter and receiver circuitry. The '$d_0$' is a threshold distance of amplifier energy. In the similar manner the consumption of energy to receive 'K' data bits of the packet is represented by the following function.

$$E_{RX}(K,d) = (E_{DM} + E_{elec}) * K \qquad (3)$$

Where '$E_{DM}$' is the energy consumed by the data mergingalgorithm on the data packets at each CH and each cluster contains all the 'N/n' nodes, then energy consumed by the CH ($E_{CH}$) is the sum of both broadcast transmissions with in the cluster and reception energies from (N/n -1) nodes defined as follows,

$$E_{CH} = Eelec * K + eamps * K * d^2 + ((N/n-1)(E_{DM} + E_{elec}) * K) \quad (4)$$

Energy consumption by CH to transmit the data packets to sink with a group of 'm' members involved in the communication can be represented by the following

$$E_{CHP} = Eelec * K + eamps * K * d^4 + (((N/n)-m+1)\,(E_{DM} + E_{elec}) * K) \quad (5)$$

Energy consumption for each round is represented by

$$E_{rd} = (E_{CH} + E_{CHP}) / m \qquad (6)$$

## 4. Simulation Setup

We have implemented the proposed DMEERA in the Network Simulator-2 (NS2). The proposed DMEERA is implementedand analysed under different simulation parameters like priority of the packets, Queue Size, Packet Size and the performance of DMEERA is evaluated based on the metrics like energy consumption, delay and delivery ratio. The maximum length of the packet is 100 bytes and leaved 6 bytes for header. The data size of the newly generated packet is fixedat 4 bytes. To get the merged packet concerned incoming packets Maximum waiting time interval is predefined for the merged packet and it is considered as 500 ms. All the incoming packets are buffered until the waiting time interval expires. The sensor nodes are deployed in a 500 meter x 500 meter region and the simulation time is100 seconds. The transmission range of each node is 250 meters. Constant Bit Rate (CBR) is used for simulated traffic and some of the simulation details are presented in Table 1.

**Table 1: Simulation parameters**

| | |
|---|---|
| Size of deployment region | 500 X 500 |
| Number of sensor nodes | 20 –100 |
| Transmission Range | 250 m |

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| | |
|---|---|
| Transmission power | 0.6 J |
| Packet Size | 100 |
| Traffic Source | CBR |
| Initial Energy | 21.5 J |
| Bit Rate | 100 - 500 kbps |
| Receiving Power | 0.3 J |
| Simulation Time | 100 sec |

The performance of DMEERA is calculated under varying number of nodes such as 20, 40, 60, 80 and 100. The simulations for different transmission rates of data packets such as 100kbps, 200kbps, 300kbps, 400kbps and 500kbps. The CH can be selected as aggregation point in each level of routing tree and the leaf nodes simply forwards the data packets directly to the next level node in the routing tree. The priority of the packet is not only depends on the real-time of the packet and also depends on the source of the packet. Each node can maintains the ready queue and it holds a maximum of 50 tasks. In the following section the results were analysed.

## 5. Results and Performance Analysis

DMEERA is evaluated with respect to threeimportant metrics named throughput, energy consumption and delivery ratio. DMEERA is evaluated the energy efficiency and delivery ratio with respect to the existing techniques like TTCDA[12], EECDA[13], BECDA[14] and GKEERA[15].

### 5.1. Throughput

The following figure 2 shows the throughput details with respect to packet generation rate of the data.Initially, at the rate of 0.02 KB the throughput is around 500 bps and continuously increases the throughput of DMEERA with respect to increase in packet generation rate. DMEERA achieves maximum throughput of 6000 bps at the rate of 0.2 KB compared to BECDA, TTCDA and EECDA. This is possible because of date merging technique and also consumes less bandwidth.

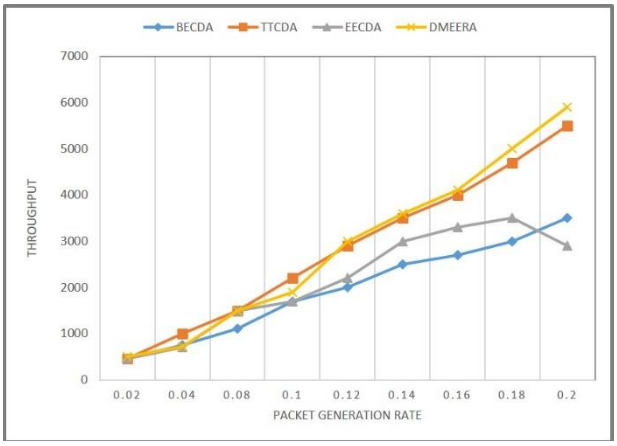


**Figure 2. Packet generation rate Vs throughput**

### 5.2. Energy Consumption

Figure 3 shows the details of the packet generation and energy consumption. At the rate of 0.2 KB the energy consumption is reduced by 2.66, 1.8, 1.5 and 1.1 times with respect to EECDA, TTCDA, BECDA and GKEERA respectively. The energy consumption of DMEERA is drastically reduced when compared with BECDA, TTCDA, EECDA and GKEERA. Along with bandwidth, energy consumption is optimized with DMEERA.

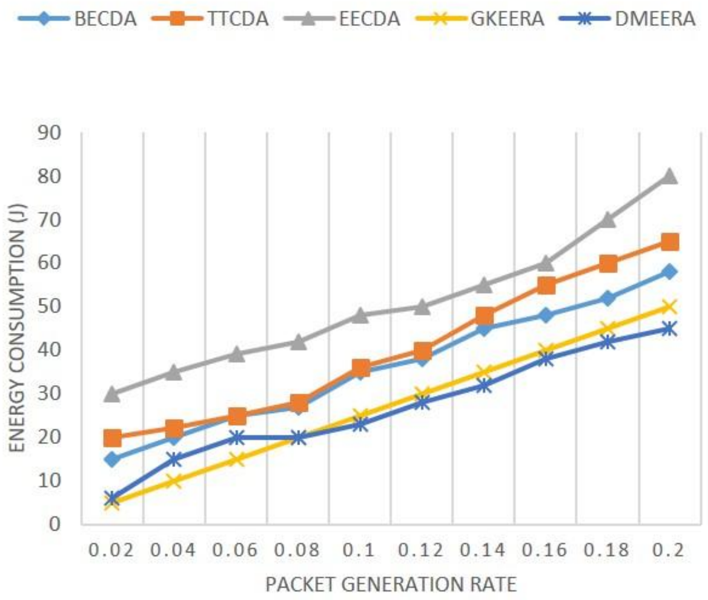


**Figure 3. Packet generation rate Vs Energy consumption**

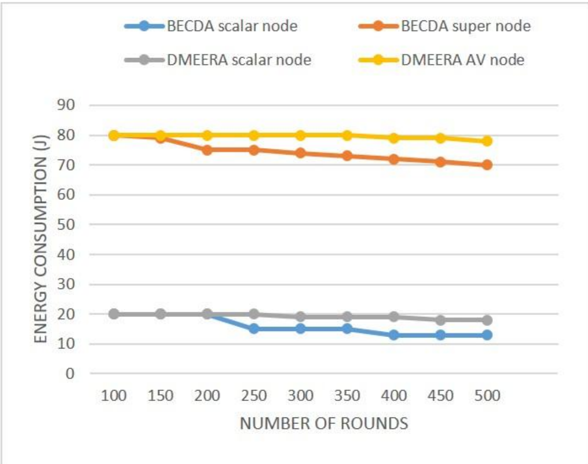


**Figure 4. Number of rounds Vs Energy consumption**

The Figure 4 shows the energy consumption with respect to network size. As network size grows, the energy consumption of scalar and AV nodes in DMEERA reduced a little after 400 nodes. When compared to BECDA, DMEERA consumed very less energy because of overhead reduction on the nodes.

### 5.3. Delivery Ratio

Delivery ratio is the ratio of the number of data packets successfully received by the sink and to the total number of data packets generated by all the nodes. In Figure 5, it is seen that DMEERA has good packet delivery ratio when compared to BECDA. Initially, the packet delivery ratio of DMEERA is maximum at the data rate of 100 KB and slowly decreases in increasing of data rate. At 500 KB of data rate, DMEERA achieves 0.35 delivery ratio.

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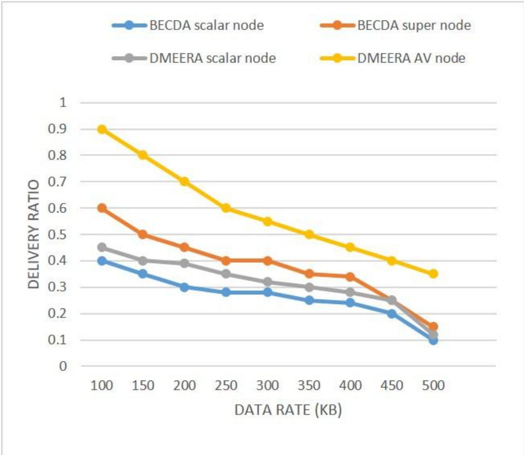


**Figure 5. Data rate Vs delivery ratio**

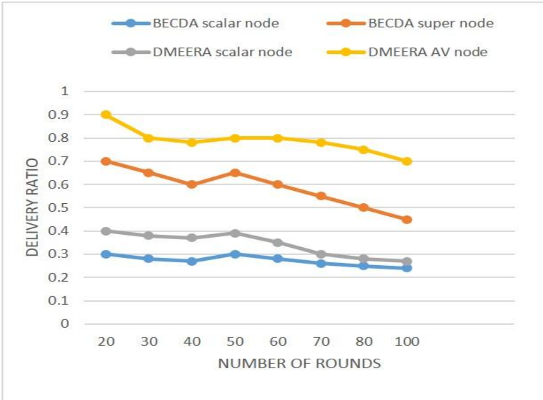


**Figure 6. Number of Rounds Vs Delivery ratio**

The figure 6shows the number of rounds with delivery ratio. As number of rounds increases in the network the delivery ratio is slightly decreased because of density of the nodes.

### 5.4 Network Lifetime

Figure 7, shows the network lifetime with various packet generation rates. The network life time of DMEERA is maximum, when compared to other techniques. The network life time is calculated on the available residual energy of each node.

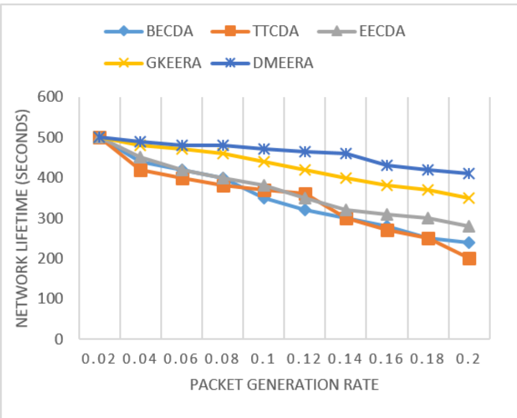


**Figure 7. Packet generation rate vs network life time**

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## 6. Conclusion

Data merge based energy efficient routing algorithm is proposed for wireless multimedia sensor networks to reduce the overhead on both the base station and sensor nodes. DMEERA reduced the energy consumption and bandwidth consumption in performing a lot of transmissions. This is happened because of efficient data merging technique. Simulation results shows that DMEERA is optimal for the energy and bandwidth requirements compared to other existing techniques.In future, we should work on security aspects to avoid misbehaving node's operations and also simplifying the complexity of the security algorithms in order to reduce the energy consumption of the network.

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