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A Reliable Energy Efficient Data Aggregation Algorithm for Wireless Sensor Network

Sudha R, Sasikala N, Senthil Kumar P, Jeganathan J

Abstract: One of the popular and emerging networks is wireless sensor networks (WSN), where it comprises of an unlimited number of sensors deployed dynamically and irregularly in a geolocation, for a specific purpose. Each sensor node in the network sense, collect and transmit the environmental data from one location to other location. All the nodes have the capabilities of transmitting and receiving the documents. The major problem in WSN is energy efficiency and network lifetime. By reducing the energy consumption, the network life time can be increased. Clustering, scheduling and other related methods are used to reduce the energy consumption, during the data transmission and receiving. This paper proposed a Reliable Energy Efficient Data Aggregation (REEDA) method for improving the energy efficiency. All the common nodes or the cluster head nodes gather, aggregate, and transmit the data where it reduces the energy consumption. The aggregation method is applied according to correlation of data packets generated by entire node. Simulations results prove that the proposed algorithm provides a good solution for minimizing communication and computation cost.

Index Terms: Energy consumption, Data aggregation, Communication cost, Wireless Sensor Network.

I. INTRODUCTION

A wireless sensor Network (WSN) is part of computer network that uses wireless connections for connecting network of nodes. To measure the physical quantities with help of sensors in the network. Normally sensors constitute with electronics and mechanics parts on separate microchips and it is packaged as high performance chip in earlier[1].In presently, sensors have evolved as smart sensors it comprises a nano processor, small amount of memory and transceiver packed as small scale factor powered by battery source (Figure:1). This smart sensor constitute a node in the wireless sensor network. Sensor nodes also called as a mote because of its performing nature. It is also a node in a sensor network capable of processing, gathering sensory information and communicating with other nodes in the network.

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***** Correspondence Author
Sudha R*, Assistant Professor, Deptartment of IT, PSNA College of Engineering & Technology, India.
Sasikala N, Assistant Professor, Deptartment of IT, PSNA College of Engineering & Technology, India.
Senthil Kumar P, Assistant Professor, Deptartment of IT, PSNA College of Engineering & Technology, India.
Jeganathan J, Assistant Professor, Deptartment of IT, PSNA College of Engineering & Technology, India.

In the wireless sensor network a mote can be node rather than a node is not always a mote.

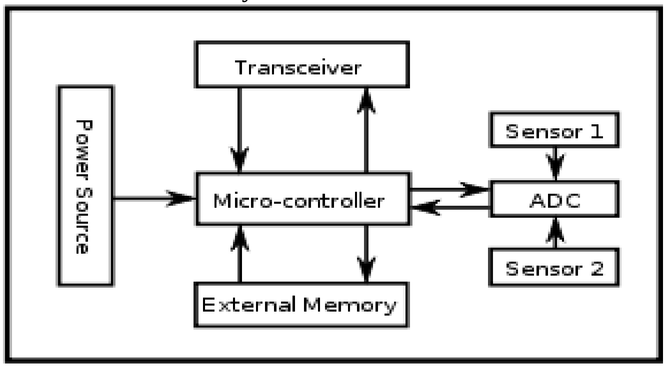

Figure: 1 The Architecture of the Sensor nodes

In presently, wireless sensor network is popularised in terms of its performing nature, because of its intelligence service it is used in many industrial and commercial applications. It can be used to monitor many environmental conditions such as temperature, pressure, humidity, etc. Also it can be used in many real time applications such as nearby node information discovery, intelligence way of sensing information and data collection, analysed, processed and stored.

The following characteristics of the sensor node in the wireless network used to evaluate the performance of WSN.

1. Fault tolerance: It is used to assist the network functionalities of each node in the network to unanticipated the network node failure.
2. Mobility of nodes: To improve the communication efficiency, the nodes roaming around within the sensor field based on the type of applications.
3. Dynamic network topology: The sensor network node follows the Dynamic network topology for
4. configure their network system as self.
5. Communication failures: Communication failures should be conveyed to the base station without any delay.
6. Independency: It will perform to work without any central control.

Data Aggregation

Data aggregation is the process of gathering and consolidating the needed data for storing the limited resources. Through can save energy efficiently among the sensor network nodes. The consolidated information send to nearby base station of each wireless sensor network.

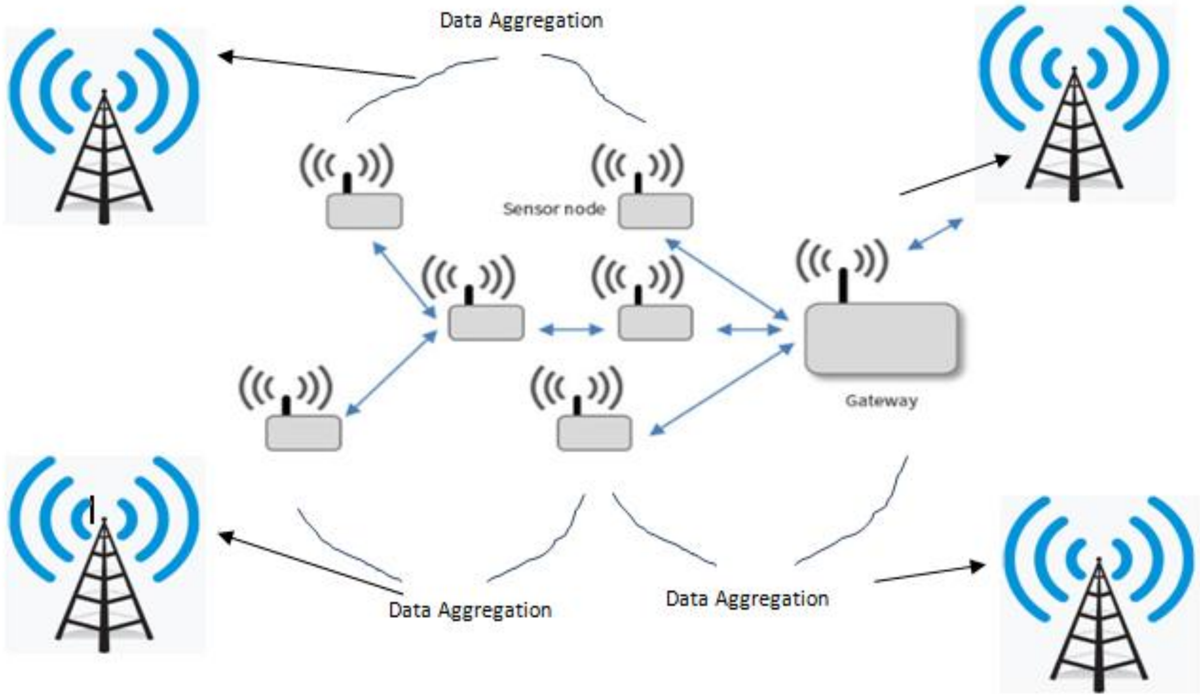

Figure: 2 Structural view of data aggregation

In some critical contexts, the sensor nodes are need to operate extended time of period. Indeed, sensor nodes are operated by battery power. It is stringent for sensors so it limit the energy resources in terms of energy. It is a need to enhance the energy efficient solutions to increase the network lifetime.

This paper uses the clustering method for data aggregation where it provides the scalability to stabilizing the topology of the network. A leader is selected among a group of sensors where the leader can do data aggregation and transmit the data packets to another hub or server. It eliminates the transmission energy of each sensor nodes, reduces the overall energy consumption of the network, and it increases the network lifetime. In order to save the energy this paper proposed a reliable energy efficiency data aggregation algorithm.

The leader node cumulates the data packets received from the other closer nodes who is transmitting the data packets through the leader node. From the implementation results, it is identified that the REEDA provides better performance for WSN discussed in the experimental results and discussion.

II. RELATED WORK

In recent decade, Many researchers are putting more effort and interest on wireless sensor network (WSN) . WSN standards and technologies are supporting on wide variety of applications. It provides a facility to monitoring the traffic, hospitals, fire in forest etc. at the same time WSN requires more development on its standards to support variety of applications [1].

Ad-hoc deployment nodes are preferred when the region is large and difficult to monitor and accessed by the humans. The number of nodes may be vary depends upon the environment which may be indoor or outdoor [2]. WSN uses to reduce the computational load and data redundancy of energy utilization by applying hierarchical approaches to combine the data's generated by the nodes. The cluster size nearer to a base station is reduced by using the cluster-based routing protocol for an extended network life time [3] and reducing the redundancy of data transmission, a new query processing technique to be used to identify duplicates among the detected events in the WSN [4].

Feng et all.(2015) proposed a new technique to improve the energy efficiency and increasing the network life time by introducing the coordinated and adaptive information strategy (CAICS) in clustered WSN [5]. Real time communication is one of the challenging issues in wireless networks based on the factors like fading, interference and quality of channel [6].

At the same time oliver et all (2020) discusses the various issues in the real time communication over the WSN [7]. Different data aggregation techniques has been identified to improves the network life time, reducing energy consumption and data accuracy by semantic correlation tree (SCT) based adaptive [8], based on the improved distributed [9] and latency[10] data aggregation techniques.

A new network architecture makes the network as distributed data base system by using the data centric protocol [11]. Maharajan et all [2019][12] discussed about a hierarchical model of cloud security which comprises of various emerging security methods. It provides a tightened security at various levels such as user level, data level and data transmission level.

III. NETWORK MODEL FOR PROPOSED SYSTEM

REEDA needs some assumptions on node over the network.

3.1 Node Assumptions

- All the node are arranged with different energy level.
- Each and every node has different DGR without knowing each other.
- Every node in the cluster has identification number.
- Data in the packets are generated by each node by using Random function.

Network Assumptions

- Every network has a stationary sink and the aggregation is performed by SL.
- All the nodes are randomly distributed where the nodes are heterogeneous.

3.2 Network Model

The connected graph G(V,E) where V and E represents set of vertices and connecting edges respectively. Based on the clustering algorithm, when s represent the clusters and node 'V{SN_1, SN_2….SN_V })present in network which is randomly distributed into the cluster otherwise the graph by G={ CA_1,CA_2…..CA_n }).
Now N nodes in the group, ' u, h € N' where u represents normal nodes and h represents advanced nodes and the nodes generated a variable set of fixed size packet datas {$r_1(t)$, $r_2(t)$, $r_3(t)$, ….. $r_{u,h}(t)$} .All the node generates correlation data packets and the cumulative and dissociative function at CH is f(A)= $\sum_{i=1}^{u,h} ri(t)$.

- The main design perceptive of REEDA for aggregation
- The packet count is reduced where the number of packets generated by the active node in the cluster by assigning aggregation function to the SL.
- The required energy and communication cost will be reduced as well as possible.

The proposed network model diagram given in figure 3 show that source node sensing the information where it creates variable number of packet and SL forward to sink after performing the aggregation .

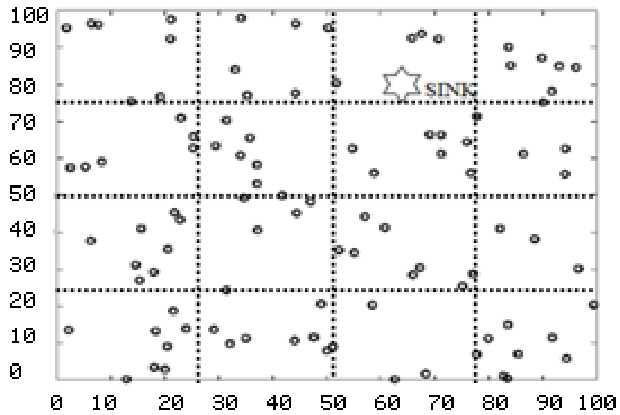

Figure: 3 Proposed Network Model

3.3 Energy calculations and Aggregate Functions

The aggregation value for the all the participating node is f(C_a)where the each node has variable DGR.

f (C_a) = $\sum_{i=1}^{L}(Xi)\ \forall(Xi)$= different DGR ….. (1)

Where i=1,2,….L.

The aggregation value for the all the participating node is f(D_a) where the each node has same DGR.

f (D_a) = $\frac{1}{M}\sum_{j=1}^{P}(Yj)$ = equal DGR…... (2)

Where P represents nodes generating equal number of data packets generated by nodes, ∑Yj represents the sum of the participating nodes.

The required total energy for SL (E) of k bit aggregation data packets at SL is

E_{sl}=K*E_e(N/s)+K*$E_s d^2$+((N/s)-1)*K*E_{DA}) …….. (3)

Where 'E_{DA}' is the energy requires for aggregation of data packets at SL, each cluster contain the 'N/s' nodes,

'E_e' represents of transmitter,

'E_s' represents energy consumed by node and

'd2' represents the distance of node to SL.

With the consideration of heterogeneity of nodes in the network the total initial energy of network is

E_i = N(αE_n + βE_a) …….. (4)

α =% normal node (u) with En = 30J, β = % super node (h) with Ea =50J, N = Total number of nodes.

IV. PROPOSED WORK

4.1 REEDA Algorithm

The REEDA algorithm works with on three phases named as sensing leader selection phase, package generation phase and aggregation phase as shown in figure 2.in the sensing leader selection phase, clusters has well arranged randomly distributed nodes and highest energy node has selected as SL. in the packet generation phase , based on the sensing node every node access the event with changeable data rates and transferred into the SL.

Finally, the aggregated data packets by SL are moved to sink.

4.2 Algorithm Details

Input: The graph G(V,E) with the cluster G={CA_1,CA_2…..CA_n}.

Output: An resulted aggregated data moved to sink.

1. For each cluster sensing leader receives data packets $r_i(t)$ from it member.
2. Find the correlation of the data packets at sensing leader.
3. If DGR of each node is same
4. Perform dissociative aggregation function D_a = (r1+r2…ru,h)/(number of nodes in cluster)
5. Else if DGR of each node is same
6. Perform cumulative aggregation function C_a = $r_1+r_2….r_{u,h}$
7. Else DGR is same for some node and different for some node
8. Perform both cumulative and dissociative function
9. Repeat step 1-8 until energy level of nodes becomes zero.

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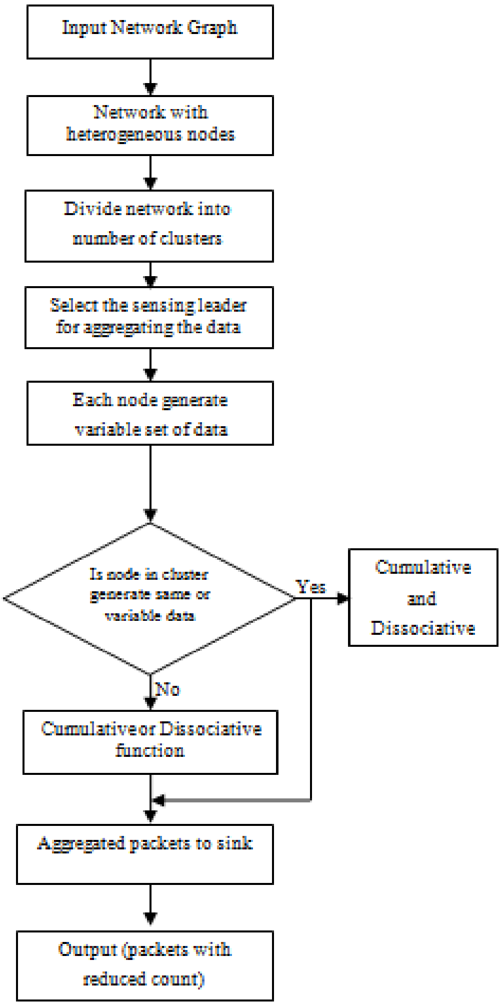

Figure: 4 REEDA Flow Diagram

4.3 correctness of the algorithm

From the experimental execution, the proposed algorithm delivers a cumulative and dissociative methods. It is observed that the network comprises on N number of sensor nodes and are interconnected using V number of links. The number of clusters is S and each cluster has L and P number of participating sensor nodes can receive and transmit various types of packets. The leader node "SL" gathers and aggregates the data packets under certain conditions. One of the numerical illustrations given below explains the topological structure of the network.

Example:

Number of cluster s = 3, Number of nodes V =10, packets generated by nodes in cluster are C1=(5,5,5), C2(1,5,4,6), C3(2,3,3).

CASE- 1: DGR of nodes is at Equal Rate (ER) in cluster area-1

S1+S2+S3/3 = 5

CASE- 2: DGR of nodes is at Different Rate (DR) in cluster area-2

S4+S5+S6+S7 = 13

CASE- 3: Nodes of DGR of nodes is at ER and DR in cluster area-3

S8+ (S9+S10)/2 = 5

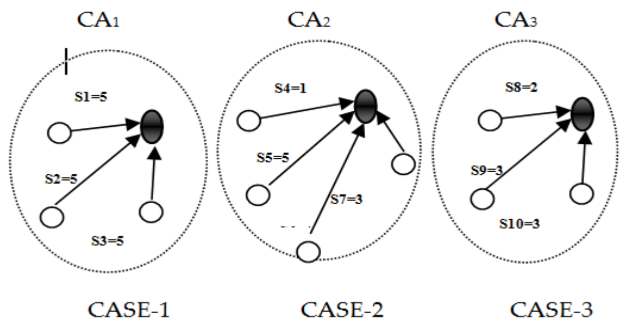

Figure: 5 Data packets generation within each cluster Numerical Illustration

Condition	*Case- 1 DGR of node is same L=0, P=3*	*Case- 2 DGR of node is different L=4, P=0*	*Case- 3 DGR of node is same & different L=1, P=2*	*Total packets received by sink*
Packets with aggregation	5	13	5	23
Packets without aggregation	15	13	8	36

V. SIMULATION RESULTS AND DISCUSSION

The REED Algorithm is simulated in Network Simulation software and the results are verified. By comparing its results with the other existing results, the performance of the REEDA is evaluated. To do that, some of the well-known performance parameters such as throughput, packet delivery ratio and average energy consumption. Throughput defines the total number data packets transmitted in the network.

Packet delivery ratio determines the number of data packets successfully received by the destination node. The amount of energy spent by all the sensor nodes out of the total amount of initial energy of the sensor nodes determines the energy consumption. The following figures show the simulation results obtained from the network considered in the proposed system.

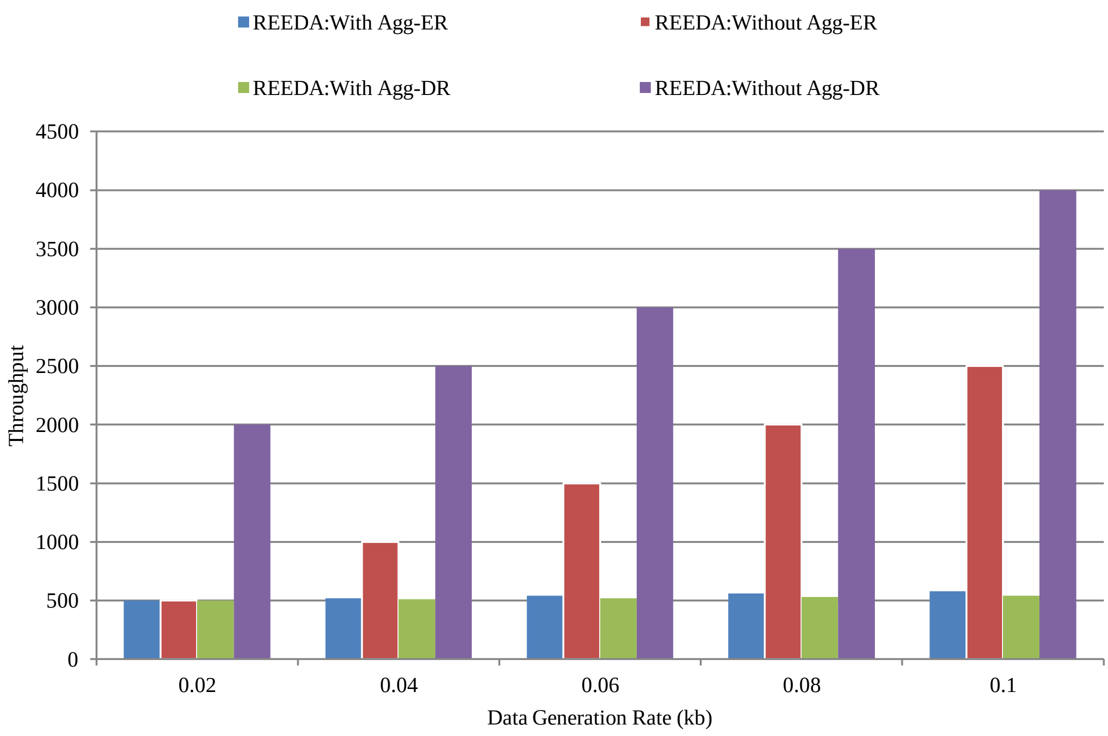

Figure:6. Comparison of throughput of REEDA (with and without Aggregation)

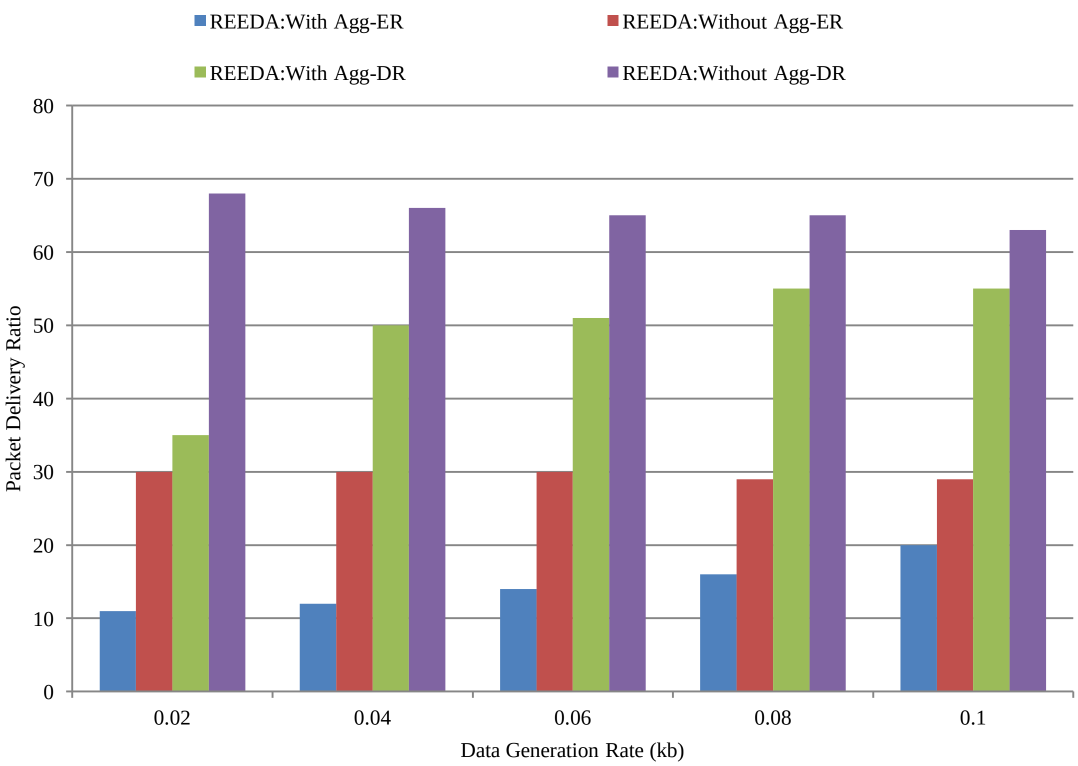

Figure:7. Comparison of Packet Delivery Ratio of REEDA (with and without Aggregation)

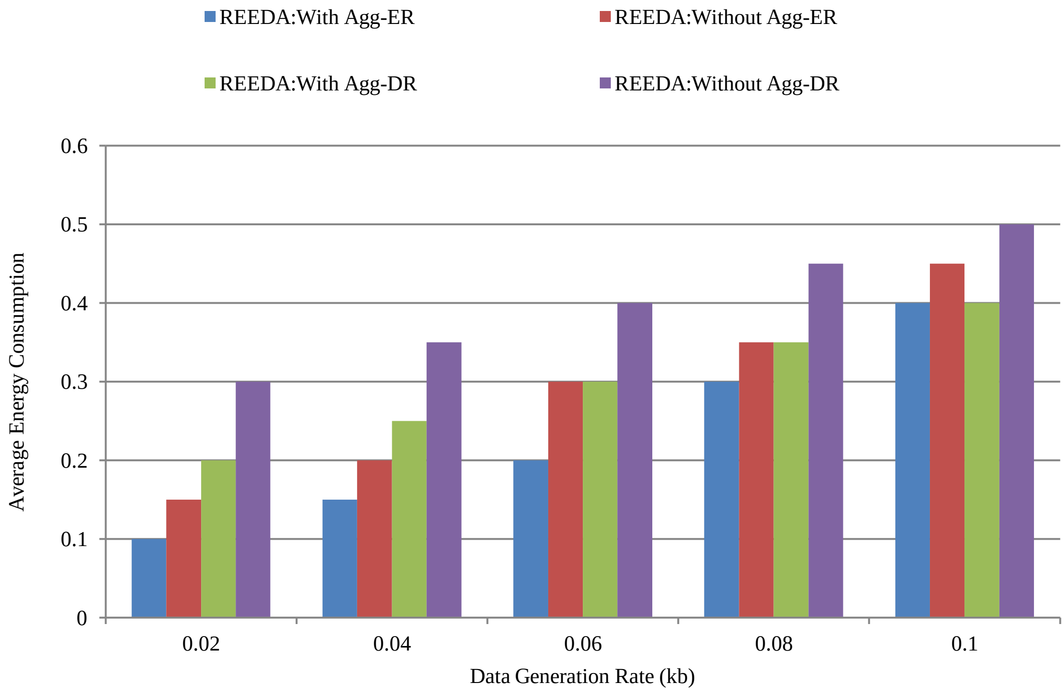

Figure: 8. Comparison of Average Energy Consumption of REEDA (with and without Aggregation)

VI. CONCLUSION AND FUTURE WORK

Cluster based REEDA algorithm improves an energy efficiency and life time of a network by using cumulative and dissociative functions. Based on the simulation result, the packet count has been decreased when it reaches the sink with aggregation.

In future, it is planned to develop a new algorithm considers both mobility and heterogeneity of nodes in the sink for improving the energy efficiency.

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