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Tdtd-Edr: Time Orient Delay Tolerant Density Estimation Technique Based Data Collection In Wireless Sensor Networks Using Energy Depletion Based Routing

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ABSTRACT

The problem of data collection in wireless sensor networks has been well studied in different schemes according to many factors like energy, latency, and throughput. Most of the methods suffer with the problem of energy depletion which affects the lifetime of the overall network. To solve the problem of energy depletion and routing problems, an time orient delay tolerant density estimation technique has been proposed which uses energy depletion based routing to perform data collection in wireless sensor networks. The sink node identifies the set of sensor data nodes at each region and estimates the density of sensor sink nodes using the current status of the network and performs the data approximation which specifies the amount of data present in the sensor data node. The data estimation technique is performed at each time interval and the sensor sink node decides the process of data collection based on the density estimation. Similarly the method chooses a route to collect the data using energy depletion routing (EDR). The proposed method collects the sensor data in most efficient manner and reduces the latency and time complexity. Also the proposed method improves the overall lifetime of the network.

Key Terms: *Wireless Sensor Network, Data Aggregation, Time orient delay tolerant density estimation, EDR.*

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I. INTRODUCTION:

The wireless sensor networks, which has movable sensor nodes, unmovable sinks and un movable data sensor with dynamic topology could be deployed at any location independent of location. The sensor nodes stores various information's about different concepts of any category. The modern world network stores various information's at different geographic locations which can be retrieved at later time using wireless protocols. The amount of information grows with day to day basis and need more sophisticated organized storage and representation scheme so that it could be referred and accessed easily. To provide such an access support and lookup , there are many approaches available in the literature but the association rule which shows the more exact information about the data locality.

The information in wireless sensor network is stored in different sensor nodes of the network and extracted at the time whenever required. In earlier approaches the sensor nodes are monitored or update the sink at periodic manner and it is not trustable that the sensor node updates the original information. Sometimes few nodes may provide fake information to get priority than other nodes which must be avoided. The agent system which supports movement of agents , where the system can generate N number of agents which can be moved between locations or sensor nodes. The agent can perform specified task whenever necessary and generate or update the rules generated.

The density measure shows the number of sensor data nodes present in any geographic region of the network. The density measure can be computed based on the number of mobile nodes present in the region and the number of sensor data nodes present. By computing the density measure we can infer the amount of recent data available at each sink can be estimated. The time orient delay tolerant density estimation is the process of computing the density of data available at any specific region and the amount of delay could incur in collecting the data. By computing this measure, the data collection can be measured for its effectiveness which overrides the problem of unnecessary energy depletion of all the nodes involve in data collection.

The EDR-Energy depletion routing is the process of identifying a single route from large set of available routes. For each route available, the energy depletion could occur by collecting the data can be estimated and a least depletion route can be selected which improves the lifetime of the network and increases the efficiency of data collection.

II. RELATED WORKS:

There are many approaches has been discussed in the literature for the data collection in wireless sensor networks and we discuss few of them here in this section.

An Efficient Data Aggregation Scheme in Wireless Sensor Networks [1], proposed an automatic time series modeling based data aggregation scheme in wireless sensor networks. The main idea behind this scheme is to decrease the number of transmitted data values between sensor nodes and aggregator by using time series prediction model. Its can effectively save the precious battery energy of wireless sensor node while keeping the predicted data values of aggregator within application defined error threshold. We show through experiments with real data that the predicted values of our proposed scheme fit the real sensed values very well and fewer messages are transmitted between sensor node and aggregator.

A Graph-Center-Based Scheme for Energy-Efficient Data Collection in Wireless Sensor Networks [3], propose a data collection scheme for the WSN, based on the concept of the center of the graph in graph theory. The purpose of the scheme is to use less power in the process of data collection. Because it is mostly true that the sensors of WSN are powered by batteries, power saving is an especially important issue in WSN. In this paper, we will propose the energy-saving scheme, and provide the experimental results. It is shown that under the energy consumption model used in the paper, thescheme saves about 20% of the power collecting data from sensors.

Approximate Self-Adaptive Data Collection in Wireless Sensor Networks [4], propose an Approximate Self-Adaptive data collection technique (ASA), to approximately collect data in a distributed wireless sensor network. ASA investigates the spatial correlations between sensors to provide an energy-efficient and balanced route to the sink, while each sensor does not know any global knowledge on the network. Based on our synthetic experiences, we demonstrate that ASA can provide significant communication (and hence energy) savings and equal energy consumption of the sensor nodes.

A Feedback-Based Secure Path Approach for Wireless Sensor Networks Data Collection [8], propose to use a novel tracing-feedback mechanism, which makes full use of the routing functionality of WSN, to improve the quality of data collection. The algorithms of the approach are easy to be implemented and performed in WSN. We also evaluate the approach with a simulation experiment and analyze the simulation results in detail. We illustrate that the approach is efficient to support secure data collection in wireless sensor network.

Optimizing Data Collection for Object Tracking in Wireless Sensor Networks [9], proposed to optimize an algorithm of object tracking in wireless sensor network (WSN). The task under consideration is to control movement of a mobile sink, which has to reach a target in the shortest possible time. Utilization of the WSN resources is optimized by transferring only selected data readings (target locations) to the mobile sink. Simulations were performed to evaluate the proposed modifications against state-of-the-art methods. The obtained results show that the presented tracking algorithm allows for substantial reduction of data collection costs with no significant increase in the amount of time that it takes to catch the target.

Data collection is one of the main research topics of wireless sensor networks in recent years, and, data collection research outside users through wireless sensor networks to collect perception data from the monitoring area. Formal concept analysis is a data analysis tool, especially for investigation and treatment can be given information to discover important information hidden in the data behind. The Design of Data Collection Methods in Wireless Sensor Networks Based on Formal Concept Analysis [11], proposes the data collection methods in Wireless Sensor Networks based on formal concept analysis. Experiments show that the proposed FCA-based data collection algorithm in WSN more effective than the traditional algorithm.

Data Collection with Multiple Sinks in Wireless Sensor Networks [12], consider Multiple-Sink Data Collection Problem in wireless sensor networks, where a large amount of data from sensor nodes need to be transmitted to one of multiple sinks. We design an approximation algorithm to minimize the latency of data collection schedule and show that it gives a constant-factor performance guarantee. We also present a heuristic algorithm based on breadth first search for this problem. Using simulation, we evaluate the performance of these two algorithms, and show that the approximation algorithm outperforms the heuristic up to 60%.

A Multi-objective Approach for Data Collection in Wireless Sensor Networks [13], addresses the problem of data collection using mobile sinks in a WSN. We provide a framework that studies the trade-off between energy consumption and delay of data collection. This framework provides solutions that allow decision makers to optimally design the data collection plan in wireless sensor networks with mobile sinks.

All the above discussed approaches has the problem of energy depletion and latency which has to be reduced to maximize the lifetime and energy of the sensor nodes.

III. PROPOSED METHOD:

The proposed time orient delay tolerant density estimation technique based data collection has different functional components namely Time Orient Density Estimation, Time Orient Delay Estimation, Route Discovery, Energy Depletion Routing and Data Collection. We discuss each of the functional component in this section in detail.

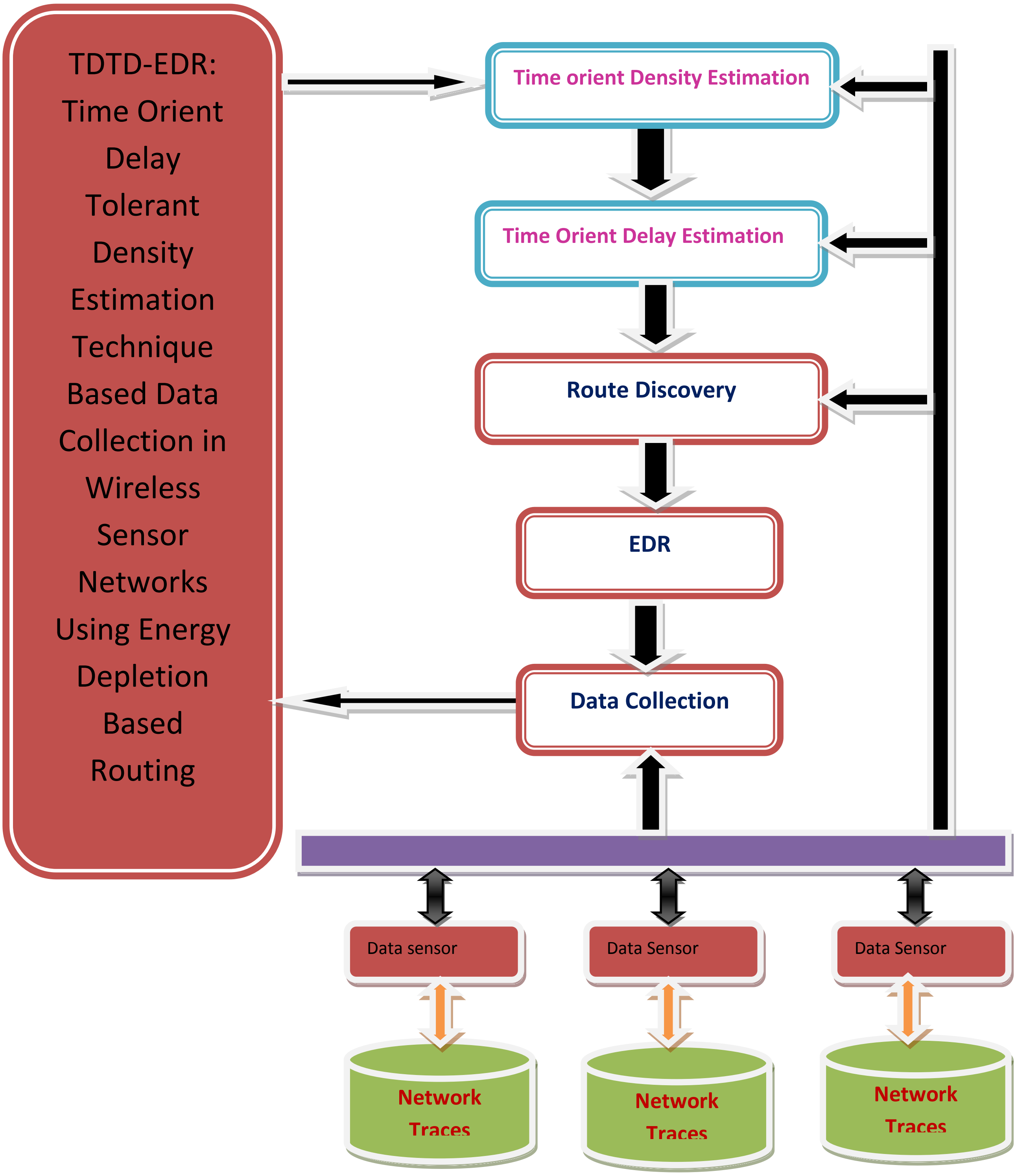


Figure 1: Proposed System Architecture

The Figure 1 shows the architecture of the proposed approach and it shows the functional components of the proposed data collection model.

3.1 Time Orient Density Estimation:

The time orient density estimation is performed at regular time interval. The method identifies the set of data sensor nodes present in each region where the whole geographic region is split into number of small regions. For each of the region being split, the method computes the number of data sensor presents and the number of sensor nodes present in current time. The sink node maintains different details about the data reception from each of the data sensor in the previous time window. Based on all these informations, the method computes the possible data density to be stored in the data sensors at the current time window. The computed density value will be used in the next stage of data collection.

Algorithm:
Input: Geographic detail GD, Network Trace NT.
Output: Density Estimation Set DES.
Step1: start
Step2: split the geographic region into many small scale regions.
GR = $\sum_{i=1}^{x} Split(GA)$
Step3: for each region Ri from GR
Compute Number of data sensors Ds.
DS = $\sum Data\ Sensors \in Ri$
Compute Number of sensor nodes present in Ri.
SN = = $\sum Sensor\ Nodes \in Ri$
Extract the trace belongs to the region Ri.
Trace T = $\sum_{i=1}^{Tw} \sum Traces(t) \in NT$
for each time window Ti from Tw
compute average data density value.
ADDV = $\sum_{j=1}^{size\,(TW)} \sum \frac{Payload\ \ (Tl \in Tw(j))}{Number\ \ of\ traces\ \ at\ Tw(j)} \times Number\ of\ sensors$
end.
Density Estimation DES = $\frac{ADDV}{Number\ \ of\ sensors}$
End
Step4: stop.

3.2 Time Orient Delay Estimation:

The delay estimation is performed at each time interval by the sink node. As like the density estimation, the method splits the geographic region into number of small parts and for each region the delay incur will be estimated. From the network trace generated at the previous data collection, the method identifies the set of routes has been used to perform data collection. The method computes the average hop count and average delay incur in collecting the data using the data density score. Based on the both the measure computed the process of data collection will be initiated by the sink node in the final stage.

Algorithm:
Input: Network Trace NT, Geographic Details GD.
Output: Delay Estimation Score DS.
Step1: start
Step2: split the geographic region into many small scale regions.
GR = $\sum_{i=1}^{x} Split(GA)$
Step3: for each region Ri from GR
for each time window Ti from TW
Extract the trace belongs to the region Ri.
Trace T = $\sum_{i=1}^{Tw} \sum Traces(t) \in NT$
Identify distinct routes used.
Route Set RS = $\sum Distinct\ Routes \in T$
compute average hop count AHP.
AHP = $\sum_{i=1}^{size\,(Rs)} \sum \frac{Hopcount\ \ (Ri)}{size\,(Rs)}$
compute average delay ADL.
ADL = $\sum_{i=1}^{size\,(Rs)} \sum \frac{Delay\ (Ri)}{size\,(Rs)}$
Compute Estimated delay score DS.
DS = AHP×ADL
End.
End

Step4: return DS.
Step5: stop.

3.3 Route Discovery:

The method discovers available routes according to the geographical status of the network. The method employs popular AODV route discovery procedure to collect the available routes. The method generates route discovery request by sending the route request packet which is performed on demand. And the sink will wait for the route reply and when the reply s being received from the neighbor nodes then the sink arranges the routes according to the hop count. The rearranged route set will be given to the EDR to perform route selection and data collection.

3.4 Energy Depletion Routing:

The energy depletion based routing procedure compute energy depletion factor for each of route discovered at the early stage. From the routes being identified, the method computes the energy depletion factor using the time orient density estimation and time orient delay estimation factors. For each route being available, the method computes the energy depletion measure which represents the possible energy loss could occur at the intermediate sensor nodes. Based on the depletion measure a single route will be selected to perform data collection.

Algorithm:
Input: Delay Estimation Score DS, Density Estimation Score DES, Route Set Rs
Output: Selected route SR.
Step1: start
Step2: for each route Ri from Rs
Identify the region of the data sensor DSR = $Region \in Sensor$
Identify the Delay score from Ds.
Delay = $DS(DSR)$
Identify Density value from DES.
Density = $DES(DSR)$
Compute current Delay Estimation of region DSR.
CDelay = Time-Orient-Delay-Estimation(DSR).
Compute current Density Estimation of region DSR.
CDensity = Time-Orient-Density-Estimation(DSR).
Compute Number of hops NH.
NH = $\sum Hops \in Ri$
Compute Energy Depletion Rate EDR.
EDR = $\left(\frac{Delay}{CDelay} \times \frac{Density}{CDensity} \times NH\right) \times \mu$
Here µ- the value of energy depletion incur in transmitting single byte stream.
End.
Step3: Choose the least depletion route.
Step 4: Perform data collection request through the route selected.
Step5: stop.

3.5 Data Collection:

At this stage, from the route selected at the previous EDR phase, the query will be transferred and the intermediate sensors forward the request to reach the data sensor. the data sensor replies with the most recent data available with it towards the sink. In this way, the data collection is performed at regular time interval also if the estimated density value is less than the specific thresholds then the data collection for the time window will be skipped but included in the next time slot to minimize the energy depletion occur by unnecessary data collection.

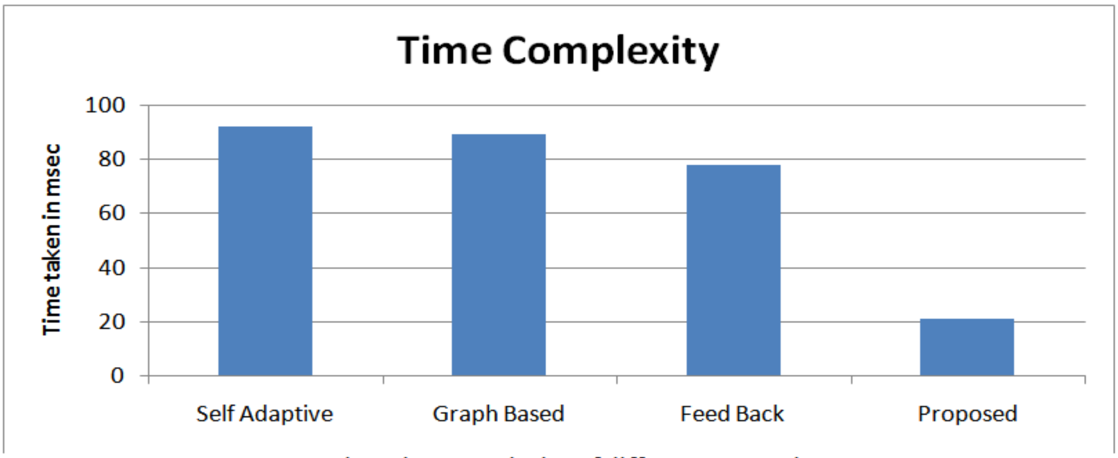
IV. RESULTS AND DISCUSSION:

The proposed time orient delay-density estimation based data collection approach has produced efficient results in data collection as well as in other factors like time complexity, latency and energy efficiency with lifetime maximization. The proposed method has been evaluated with various input parameters and various geographic constrains and different network scenarios has been used. The method has been evaluated with various simulation parameters and implemented with the help of Advance Java development Environment.

The time complexity is the factor which is computed based on the number of nodes available in the sensor network and total time required to collect the data which is computed using the following formulae.

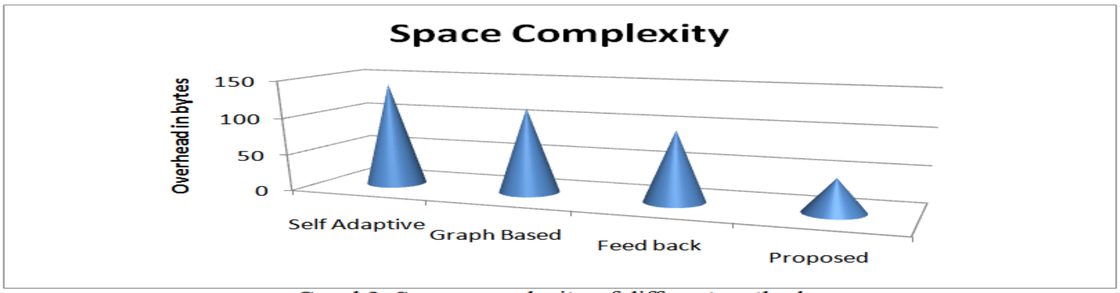
Time complexity Tc = $\int_{i=1}^{N} \sum Time(x)$ -- (1)

The formulae (1) shows how the time complexity of rule generation could be computed where N- specifies the number of nodes in the network , x shows the time taken to collect the data from each node.



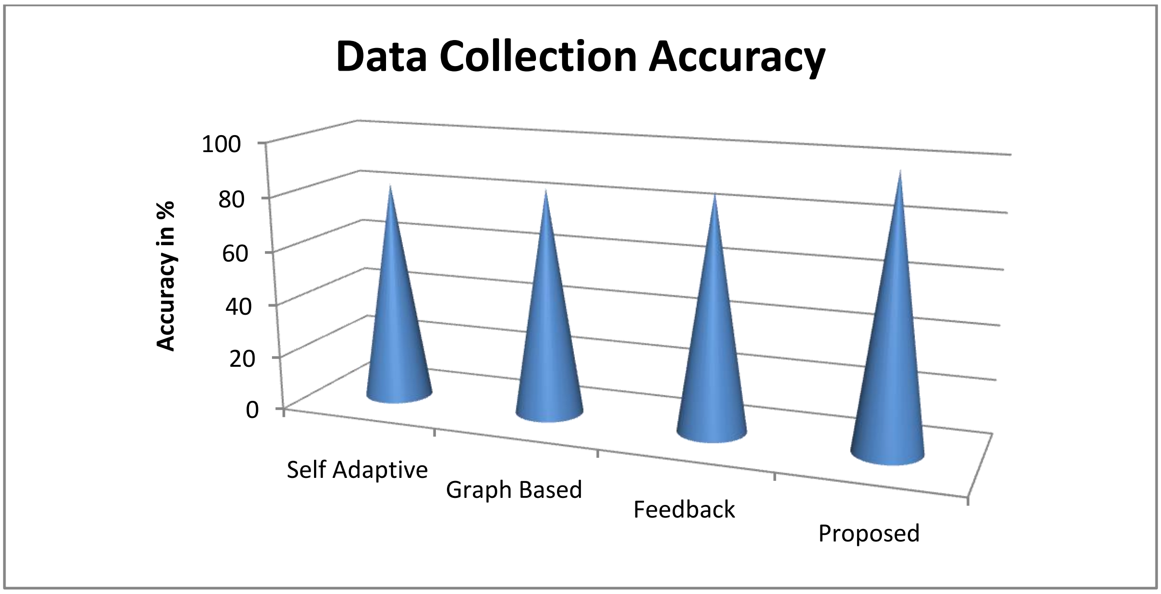
Graph1: Time complexity of different approaches

The graph1 shows the time complexity produced by various methods in data collection where the number of data sensors is 10 and it shows clearly that the proposed approach has produced less time complexity than other methods.



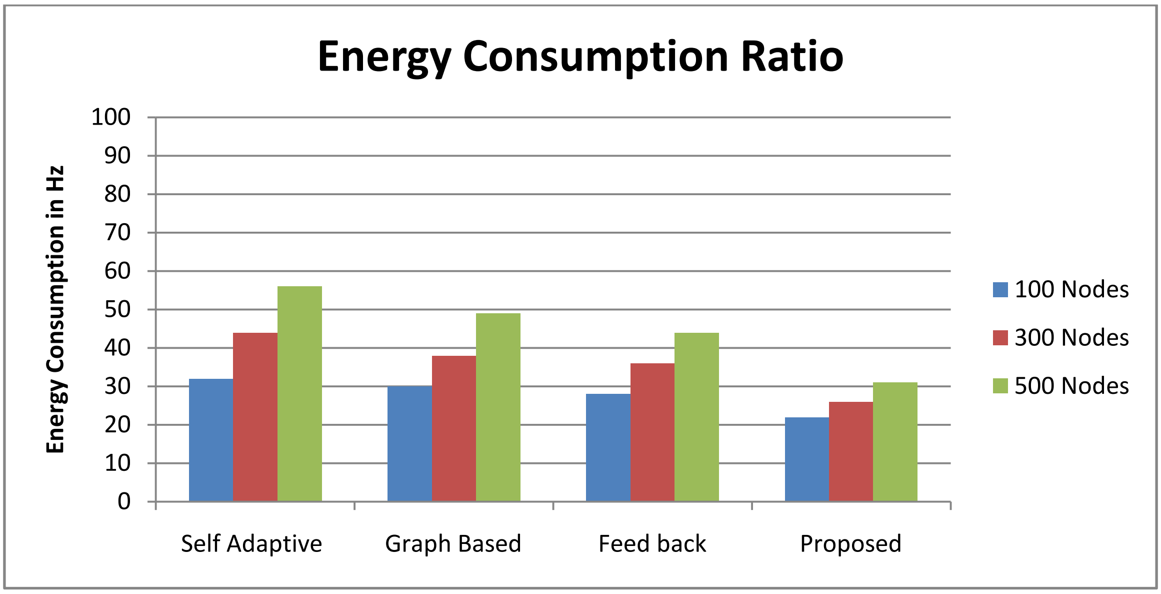
Graph2: Space complexity of different methods.

The graph2 shows the comparison of different methods in bytes occupied. It shows clearly that the proposed method has occupied less space in bandwidth and produced efficient results.



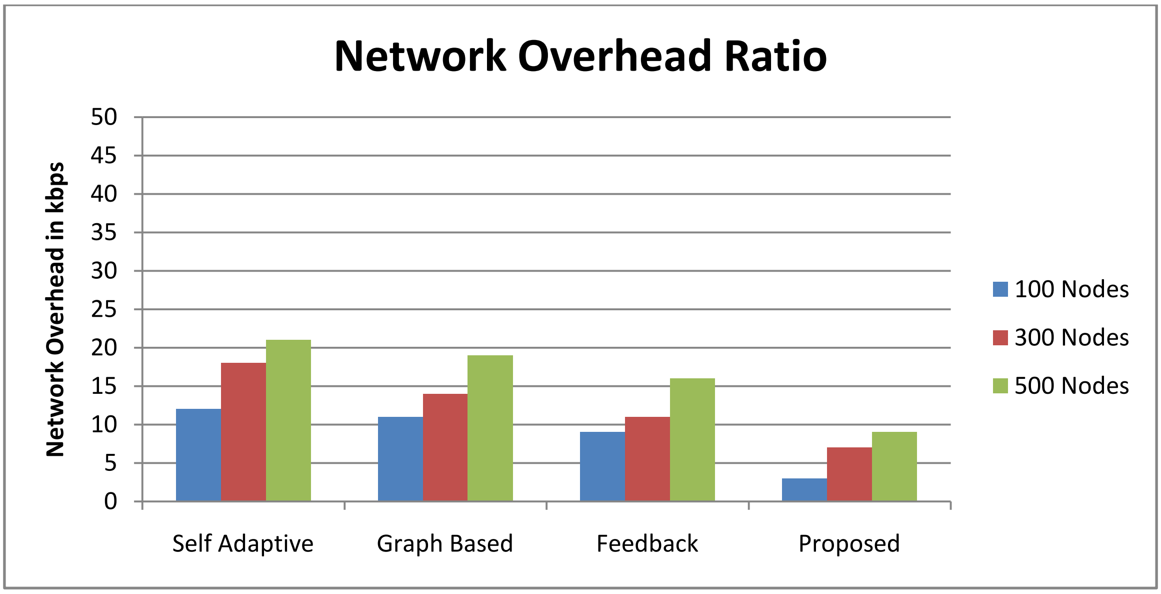
Graph3: Comparison of rule generation accuracy

The graph3, shows the accuracy of data collection, where it clearly shows that the proposed approach has performed data collection with higher accuracy than earlier methods.



Graph4: Comparison of Energy depletion occurred

The graph4 shows the energy depletion occurred in data collection according to number of nodes available in the network. The graph shows that the proposed approach has less energy consumption in generating rules with different number of nodes.



Graph5: Comparison of network overhead

The graph5 shows the comparison of network overhead introduced by different methods in collecting the data from the data sensor nodes. The graph shows that the proposed approach has produced less overhead than other approaches.

V. CONCLUSION:

We proposed a novel time orient delay tolerant data density estimation based data collection scheme for wireless sensor networks using energy depletion based routing EDR. The proposed method collects the set of data sensor present in each region considered and for each region the method computes the delay estimation and density estimation at each time window considered. Then the method discovers the routes available and for each of the route available in the network, the method computes the energy depletion ratio using which a single route will be selected to perform data collection. The proposed method has produced efficient results in all the factors considered and reduces the energy depletion and improves the lifetime and data collection accuracy. Also the proposed method reduces the time complexity of the network also.

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