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Mobile Agents based Energy Efficient Routing for Wireless Sensor Networks

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ABSTRACT

Energy Efficiency and prolonged network lifetime are few of the major concern areas. Energy consumption rated of sensor nodes can be reduced in various ways. Data aggregation, result sharing and filtration of aggregated data among sensor nodes deployed in the unattended regions have been few of the most researched areas in the field of wireless sensor networks. While data aggregation is concerned with minimizing the information transfer from source to sink to reduce network traffic and removing congestion in network, result sharing focuses on sharing of information among agents pertinent to the tasks at hand and filtration of aggregated data so as to remove redundant information. There exist various algorithms for data aggregation and filtration using different mobile agents. In this proposed work same mobile agent is used to perform both tasks data aggregation and data filtration. This approach advocates the sharing of resources and reducing the energy consumption level of sensor nodes.

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Introduction

Extended network life time and energy efficiency are major challenges lies in the field of MWSN [1]. Clustering is the key solution for offering energy efficient network. In clustered network [2, 3, 4, 5, 6] nodes are organized in form of groups and grouping is done on the basis of common properties of sensor nodes. Each group or cluster consists of fixed or varying number of sensor nodes depending upon the mobility behaviour of sensor nodes. Communication among the clusters taken place through a gateway. Each cluster has its own cluster head (CH) which is elected n the basis of any of the desired criteria. Various researchers have offers numerous algorithm for cluster head election. CH has assigned the responsibility of establishing communication among the sensor nodes within the cluster through collection and aggregation of the data. Aggregation and filtration of data reduces the chances of data loss thereby aggregating data to small fixed size. As aggregation reduces data size, filtration helps to reduce the noise if any in the data packet. Aggregation and filtration both reduces the congestion, contention and noise in network.

Result sharing among the nodes highlighted by [own paper] allows the sensor nodes to permit the sharing of data within the cluster that saves large amount of energy. This work focuses on the use of agents for data aggregation and filtration in sensor networks.

The current work considers that the sensor network is already clustered and follows hierarchical topology [7]. A clustered network offers significant advantages such as expandability, scalability and robustness over other network topologies. Although clustering in sensor networks offers an energy efficient solution but it is poses numerous challenges [8] like redundant data aggregation and noise in aggregated data at cluster head and high communication cost. Latest research indicates that mobile agents [9] are proving significant for providing the solution to above issues. Mobile agents move around the network autonomously to carry out the desired operations and return to the source triggering them. However deployment of mobile agents in sensor nodes is very sensitive as it also adds the overhead of consuming the energy of host nodes and hence must be dealt carefully. In order to get the optimum results, mobile agents should be placed at high density locations (maximum sensor nodes). The current work proposes to deploy mobile agents at the cluster head level from where it is originated and triggered to perform data aggregation as well as result sharing.

The paper is structured into five sections. Section 2 acknowledges the work of authors who had been putting efforts to improve the life of a sensor network. Section 3 express the proposed work in detail Section 4 represents the implementation results and finally section 5 concludes the paper.

Related Work

It is evident from the literature that managing energy of mobile sensors is one of the biggest hurdles in the field of MWSN [10, 11]. A clustered network seems to a promising solution towards an energy efficient solution,

but data aggregation performed at cluster head is an overhead. A reliable data aggregation scheme offers the prolonged network life time along with lowest communication cost. Mobile agents can also play the role of data collector for providing energy efficient network. Various researchers have offered numbers of ways for data aggregation scheme in sensor networks. An efficient and flexible data aggregation approach by Dirk & Mithun [12] suggests to initially conceal the sensed data and later aggregate the data by applying encryption transformations. Charalampos et al. proposed a greedy approach for data collection [13] from nearby nodes that includes itinerary mechanism keeping the low cost itinerary. The approach offers effective performance over the alternatives. An event based scalable and efficient data aggregation [14] uses semi-structured with dynamic forwarding. Different types of data aggregation schemes such as Spatial Temporal Correlation, Scale Free Aggregation in Sensor Networks, Energy Efficient Clustering Scheme, Energy Efficient Spatial Correlation Based Data Aggregation etc. [15] highlights the importance of data-diffusion for flat networks. Data-diffusion process starts with defining the route discovery process. A Comprehensive energy consumption model proposed by [16, 17, 18] is based on energy efficient clustering scheme. This proposed model discusses the level of energy consumption for clustered networks i.e. during transmission, cluster head movement etc. An energy efficient spatial correlation scheme for data collection is available in [19]. The approach utilizes clustering as the founding algorithm where clusters are formed on the basis spatial correlation between the nodes in network. The algorithm reduces the level of communication between source and sink. IN Structure Free and Energy Balanced Scheme proposed by [20] is two phase process in which dynamic aggregator mechanism is used to gather the data and also balance energy during data aggregation.

A vital information grilled from the literature presented above is that researchers have been putting efforts towards data aggregation in WSN, but very few have considered MWSN and also less attention has been paid to utilizing the mobility of mobile agents for data aggregation. Further, to the best of our knowledge, data sharing at lowest level nodes has inadvertently being ignored and hence the motivation to take up this research work.

Non linear extended Kalman filter [21] uses interlacing multiple model (IMM) for tracking mobile stations.Coordinated turn model is used to improve the tracking performance of proposed scheme.

False report detection and dropping mechanism proposed by [22] uses key based authentication code attached with each event report.Each node verifies the authentication code that was attached with progressed report gives efficient results in terms of reducing the energy consumption level and dropping out bogus reports but still there are chances of data loss at compromised node. This scheme is not suitable for shared data nodes.

Bandwidth efficient Cooperative Authentication (BECAN) [23] scheme is used to detect injected false data in sensor field. ID based authentication scheme is proposed that allows batch verification of multiple signatures for identifying the false injection of data. It has been observed that ID based scheme offers good results as compare to BECAN but ID generation and assigning to all nodes is a time consuming process.

Cluster based false data filtering scheme [24] works on early stage of data collection and identifies the false data earlier thus saves energy. Rekey management technique is used to identifythe injected false data and improves the system life time. It also increases the security of the network however in case of cluster head failure results are not as per expectations.

Command based filtering mechanism [25] is designed here for accepting and rejecting the human interventions by making the use of Petri nets. Petri nets approach is used to analyze the operated behavior and commands for synthesizing the filters, request for stopping the unrestricted commands and command supervision events needs to be handled separately in different environments.

Use of Kalman filtering for under water sensors using cross layer and time synchronization is proposed by [26]. It controls the Doppler shift caused due to mobility of sensor nodes. This scheme offers optimized results in terms of accuracy and energy efficiency. However, its practical implementation for under water environment is left as future work.

Event driven approach proposed by Xiaohua and Qing [27] is used to analyze the sensor behavior for data transmission over the network. Transmission behavior of each sensor node is analyzed on the basis of its filtering error measurement. Performance of proposed mechanism is analyzed on basis of various filtering parameters. Each sensor node transfers the data packet only when its local error value exceeds the threshold value.

Nonlinear filtering mechanism using channel fading is being proposed by [28] that ensure the stability of Unscented Kalman Filter (UKF). Due to channel fading there are chances of transmission failure and fluctuation of signal. This proposed approach reflects that channel gain will be uncorrelated over the time and space.

Effective signal to noise ratio estimation using Kalman filter is proposed by [29] that includes signal to noise ratio along with link quality indicator. This proposed

approach reduces the energy consumption level and utilize thefull capacity of all channels that will further improve the accuracy of estimation. But the method proposed for link quality indicator computation is not accurate in terms of link margins, because it takes only few inputs for link quality indicator estimation and ignored some important parameters.

Localization based data filtering mechanism proposed by [30] estimates the location of sensor using filtering mechanism. An Eigen vector based approach is offered to estimate the location of sensor where position is specified as the integration of various positional parameters and acceleration data values. Major hurdle for implementation of this method is that positional parameters need to be highly accurate for getting the efficient results.

GRPEF (Grouping-Enhanced Resilient Probabilistic En-Route Filtering) [31] is an efficient distributed algorithm uses location aware scheme for detecting nodes without splitting them in extra grouping that will further improve the network efficiency and reduce the energy consumption level.

Prediction based data transportation scheme proposed by [32] uses partial omission of network for improving the network life time, reduces network traffic and the energy consumption levels.

Application based Extended kalman filtering approach is used by [33] for evaluating efficient information processing by making the use of extended kalman filtering in sub surfaces as kalman filter can be applicable in both theory and practical and it also reduces the level of errors.

Proposed Work

Literature reveals that data aggregation is one of the key solution for offering energy efficient network that prolongs the network lifetime. Usage of Mobile Agents for data aggregation with result sharing proposed by [own paper reference] conserve the energy by removal of redundant data among sensor nodes and thereby reducing the energy consumption rate of sensor nodes. In this proposed work mobile agents are deployed at each cluster head. After fixed TDMA slot CH invokes associated agent and sent it for collection of data from its cluster members. Mobile agent follows hop to hop approach for data collection from member nodes. Each node transfers its data to mobile agent which shares this data with neighbouring nodes so as to remove redundant data. Agents perform two types of operations one after another; firstly collects the data from member nodes and apply filters the data and then forwards the fresh copy of data to the CH. At each CH other MA called Head Mobile Agent (HMA) is there to filters the data aggregated from various CH within same network.

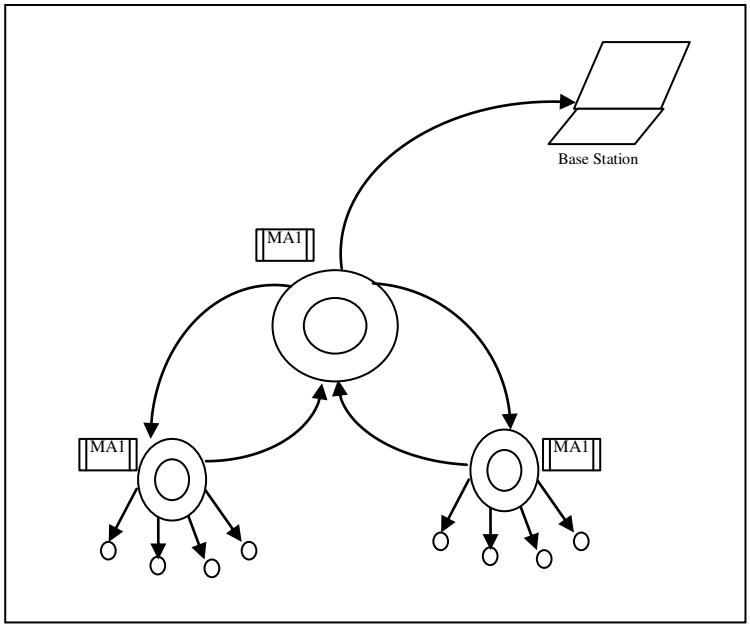

Figure 1.1 High Level View of Proposed Approach

The proposed approach comprises of two phases, in first phase mobile agent collects the data the member nodes,

After which fresh and updated copy of data is forwarded to base station.
followed by second phase where filtration process is applied on the aggregated data so as to reduce the redundancy from aggregated data.
The working both modules is discussed below

Algorithm*: *Data Aggregation and Filtration

CH invoke MA

MA visits member nodes in hop to hop manner

member nodes share data

if $Data(n1) == Data(n2)$

then MA filters the redundant data

else aggregate data( )

send the Data to CH

Results and Discussions

For evaluating the performance of the proposed work, MATLAB platform is used. Network consists of 100 numbers of mobile nodes that are organized in clustered form. Mobile agents are installed at each cluster head and CH triggers an event for MA to collect data from its member nodes. Before executing the data aggregation module mobile agent goes for various checks for

redundant data and on the basis of that further decision about data aggregation process and filtration is taking place. Implementation of this algorithm reflects that deployment of MA at relevant places gives outstanding performance than the random deployment and offers energy efficient data aggregation and filtration process that executes at each level of clustered network. Data aggregation removes the redundant information and prolongs the network life time. Filtration process reduces the noise level and also reduces the delay in represented in the figure 1.2 and 1.3.

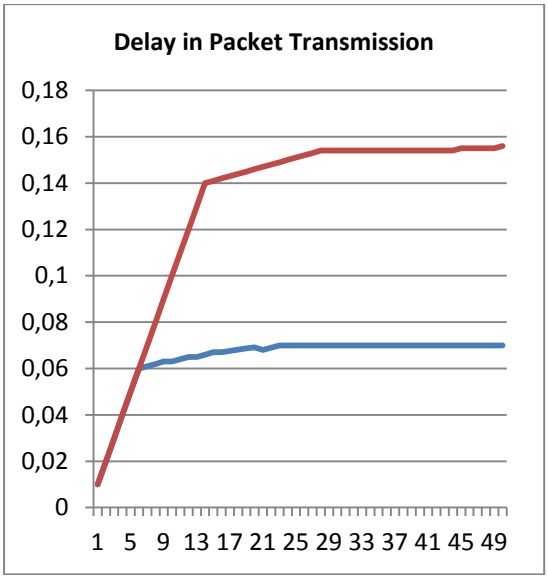

Figure 1.2 Delay in Packet Transmission

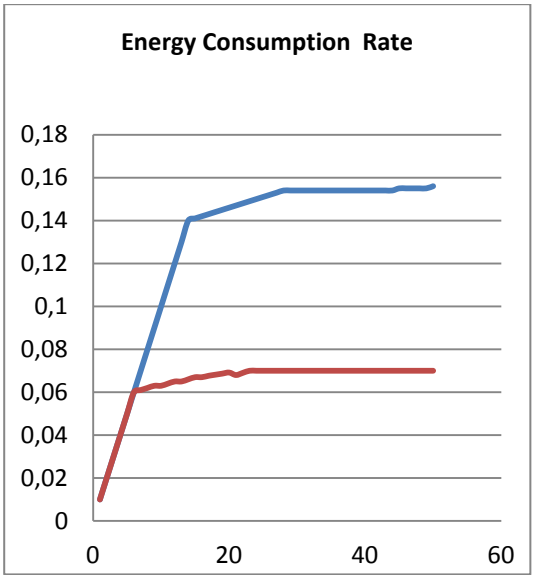

Figure 1.3 Energy Consumption rate

Conclusion

Scarcity of efficient algorithms in the field of data aggregation and filtration especially has formed the basis of this research work. Moreover, the desire to have minimal hop traversals and maximum data collection demands for efficient modules. The complete framework can not only reduce the number of nodes being traversed but can also provide more accurate and non-redundant data. The strategy uniquely contributes an amalgamation of data aggregation and filtration but it also offers autonomy to the modules. The partial results achieved so far are highly significant and motivating for further research. Comparison of proposed approach with existing approaches is left for future work.

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