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A study on Various Techniques handled for Data Aggregation Process in Wireless Sensor Network

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Abstract--Wireless Sensor Network (WSN) consists of many sensor nodes that are all connected to a network. In WSN we have used huge no. of applications such as Area monitoring, Smart office monitoring, Health monitoring, Forest fire detection and eic.,. The data aggregation is the main challenge in the WSN. In this paper, the survey is made on hierarchical based data transmission, Cluster based, Tree structure based, Structure Free data aggregation, layered and Grid based data aggregation and related concepts. This type of structure based data aggregation process uses various algorithms and protocols. When the data transmission speed is high, then the energy utilization is reduced, increasing the high throughput and packet delivery ratio. So, this paper it concentrates on different data aggregation process and also different algorithms are explained and compared.

Keywords**:** WSN, Structure Free, Hierarchical structure, Cluster based, Tree structure, Data aggregation.

I. INTRODUCTION

Wireless sensor network is a collection of sensors interconnected by wireless communication channels. Each sensor node is a small device that can gather data from its surrounding area, carry out simple computations, and communicate with other sensors or with the controlling authorities of the network. Long distance communications are achieved in a multi-hop fashion (Yunzhu peter chen et.al 2006).

In WSN, sensor units are deployed at various locations in the network, and they continuously measure the physical parameters such as temperature, humidity, pressure etc (Ramesh patil et.al 2016). Typically, a sensor node is a small device that includes four main components namely a sensing unit, microcontroller unit, communication unit and a power source. The major advantage of such network is the deployment of nodes at any location and exchange of data via supportive intermediate nodes which act as routers to switch data from one to other node. Due to wireless mode of communication, sensors could be deployed at any corner and could be easily monitored from different locations (Mohamed et.al 2012).

The WSN finds its applications in various domains such as agriculture or environmental sensing, object tracking, wild life monitoring, health care, military surveillance, industrial control, home automation and security. Since the WSNs are deployed in an unattended environment, the WSN applications require high reliability.

(Prabhudutta Mohanty et.al 2014) Data aggregation protocols could be categorized into two groups they are structure free and structured data aggregation. For efficient data aggregation, structured approaches employ either hierarchical, tree based, cluster based structure and etc., where much more energy overheads is associated with construction and maintenance. (Nandhini et.al 2010) The main goal of data aggregation algorithm is to gather and aggregate data in energy efficient manner so that network lifetime is enhanced. Wireless sensor offers an increasingly good-looking method of data gathering in distributed system architectures and dynamic access via wireless connectivity. The data aggregation protocol aims to eliminate redundant data transmission and this improves the lifetime of energy constrained in WSN.

II. RELATED WORKS

(Yuanzhu Peter Chen et.al) proposed an Energy-Efficient Protocol for Aggregator Selection(EPAS). Then, we generalize it to an aggregation hierarchy and make longer EPAS to a Hierarchical Energy-Efficient Protocol for Aggregator Selection (hEPAS). This also derives the optimal number of aggregators with generalized compression and power-consumption models, and present fully distributed algorithms for aggregator deployment. Simulation results significantly reduce the energy consumption for data collection in wireless sensor networks. Furthermore, the algorithms do not rely on particular routing protocols, and are thus relevant to a broad spectrum of application environments.

(Shangwei Duan et.al) Suggested Hierarchy architecture is based on wireless sensor network’s two distinct features: centralization and task orientation. Based on hierarchy architecture also developed a lightweight and task oriented clustering algorithm to reduce the granularity of wireless sensor networks. The simulation demonstrates its effectiveness in wireless sensor network based on energy analysis.

(Prabhudutta Mohanty et.al) improved a Hierarchical Energy Efficient Reliable Transport Protocol (HEERTP) for the data transmission within the WSN. In this protocol maximizes the network lifetime by controlling the redundant data transmission with the co-ordination of Base Station (BS) and also achieves end-to-end reliability using a hop-by-hop acknowledgement scheme.

(Manal AL-Bzoor et.al) improved hierarchical coordination of data gathering (HCDG) routing schema is based on WSN's multi-level chain formation with data aggregation. This method provides an analytical model for energy utilization in WSN to compare the performance of proposed HCDG schema with the near optimal energy reduction methodology, PEGASIS. The proposed routing schema provides relatively lower energy consumption with minimum delay for large scale WSNs.

(Kun-Hsien Lu et.al) presents a hierarchical ring-based data gathering (HRDG) scheme for thick wireless sensor networks. A hierarchical grid structure is constructed, and only some sensor nodes are chosen as grid heads for collecting data, after reducing the total energy consumption per round. Grid heads are then organized into hierarchical rings to decrease the transmission delay of a round. The HRDG scheme focuses on reducing the *energy* × *delay* cost in a round of data gathering HRDG is analyzed. the proposed HRDG technique out performs other data gathering schemes are the provisions of the number of rounds, the *energy* × *delay* cost and coverage ratio.

(Mikel Larrea et.al) developed three hierarchical algorithms for data aggregation in wireless sensor networks where sensors can crash and recover. The network is divided in several regions. The algorithms ensure (i) the selection of a common data aggregator sensor within each region, in charge of the collection of local data, and (ii) the selection of a unique super-aggregator sensor, in charge of the collection of global data, among all the aggregators. Both selections are achieved by implementing the Omega failure detector, which provides a self-organizing and fault-tolerant leader election service. This is also introduces a battery depletion threshold to provide wireless sensor network QoS.

(Ammar Hawbani et.al) provided a Sensor Grouping Hierarchy Structure (GHS) to split the nodes in wireless sensor network into groups to assist the collaborative, dynamic, distributed computing and communication of the system. This idea is to partition the nodes according to their geographical maximum covered regions such that each group contains a number of nodes and a number of leaders. To evaluate the performance of proposed grouping structure has implemented a Group based routing and Group based object tracking. The proposed grouping structure gives a better performance in energy consumption and energy dissipation during data routing and it generates a little redundant data during object tracking.

(Yuanzhu Peter Chen et.al) proposed an Energy-Efficient Protocol for Aggregator Selection (EPAS) protocol. Then, they generalize it to an aggregation hierarchy and extend EPAS to Hierarchical EPAS. The optimal number of aggregators with generalized compression and power–consumption models was derived, and fully distributed algorithms for aggregator selection were presented. Simulation results significantly reduce the energy consumption for data collection in wireless sensor networks.

(Hu Yanhua et.al) developed a data aggregation algorithm based on constructing a data aggregation tree. After give a formalism description of the problem proposed, this is also a data aggregation tree constructing algorithm. By minimize the maximal energy consumption of nodes and algorithm can prolong the lifecycle. In data aggregation scheduling algorithm, we select the number of communications carefully to get the trade-off between low weighted delay and high network lifecycle. The simulation result gives algorithm consumes less energy while aggregating data from sensor nodes and thus can prolong the network lifecycle.

(Duc Tai Le et.al) suggested a novel data aggregation scheme that minimizes the data aggregation delay in duty-cycled WSNs. Proposed algorithm takes the sleeping delay between sensor nodes into account to construct a connected dominating set (CDS) tree in the first phase. The CDS tree is used as a virtual backbone for efficient data aggregation scheduling in the second phase. The scheduling assigns the fastest available transmission time for every sensor node to deliver all data collision-free to the sink. The simulation tool give the results in reduces data aggregation delay by up to 72% compared to previous work. To achieve this data aggregation delay reduction, every sensor node has to work shorter and the network lifetime is prolonged.

(Cheng Feng et.al) developed that an algorithm based on dynamic programming in the shortest path tree of the wireless sensor network. Shortest path tree approach classifies conflicts into two types, tree-inside conflicts and tree-outside conflicts with the aggregating tree. First, scheduling transmission time utilizes a dynamic programming algorithm. Then, transmissions with tree-outside conflicts are removed with maximum weight independent set in tree-outside conflict graph. As the scheduling performance depends on the aggregation tree and propose another idea for simultaneous execution of aggregation tree construction and scheduling. In this proposed work greedy algorithm is used to maximize the number of scheduled nodes in every time slot from deadline to time slot 1 in WSN. Greedy algorithm is give the results in wireless sensor networks outperforms dynamic programming in the shortest path tree and naive algorithm in terms of the effectiveness and the average delay.

(Elham Mohsenifard et.al) suggested a cuckoo optimization algorithm (COA) which is a data aggregation tree which can optimize energy consumption in the network. The proposed method was compared with genetic algorithm (GA), Power Efficient Data gathering and Aggregation

Protocol- Power Aware (PEDAPPA) and energy efficient spanning tree (EESR). The results of simulation tool is conducted in matlab indicated that the proposed method had better performance than GA, PEDAPPA and EESR algorithm in terms of energy consumption. Consequently, the proposed method was able to enhance network lifetime.

(Priti K. Hirani et.al) proposed that an energy-efficient cluster for wireless sensor network which suits better for periodical data gathering from the application. Proposed Energy Efficiency Clustering and Data aggregation for sensor Networks are classified into four phases: cluster head, cluster head selection, data aggregation and maintenance. Important issues in wireless sensor network is to minimize the total energy consumption required to collect data.

(Jun Yue et.al) proposed EEBCDA technique addresses, problem in cluster-based and homogeneous WSNs in which cluster heads transmit data to base station by one-hop communication, and proposes an energy efficient and balanced cluster-based data aggregation algorithm (EEBCDA). It divides the network into rectangular grids with unequal size and makes cluster heads rotate among the nodes in each grid respectively, the grid whose cluster head consumes more energy has more sensor nodes to take part in cluster head rotation and share energy load, by this way, it is able to balance energy dissipation. Besides, it adopts some measures to save energy. The simulation results are show that EEBCDA can remarkably enhance energy efficiency, balance energy dissipation and prolong network lifetime.

(Siva Ranjani. S et.al) developed an Energy efficient Cluster Based Data Aggregation scheme for sensor networks (ECBDA) has four phases: Cluster formation, Cluster head election, Data aggregation and Maintenance. Cluster members send the data only to its corresponding local cluster head. Data generated from neighboring sensors are often redundant and highly correlated thus the cluster head performs the data aggregation to reduce the redundant packet transmission. In this scheme, clusters are formed in a non-periodic manner to avoid unnecessary setup message transmissions. ECBDA approach effectively reduces the energy consumed and it helps to increase the network lifetime**.**

(Prabhudutta Mohanty et.al) proposed ESDAD protocol, waiting time for packets at each intermediate node is calculated very sensibly so that data can be aggregated efficiently in the routing path. The sensed data packets are transmitted judicially to the aggregation point for data aggregation. The proposed protocol computes a cost function for structure-free, next-hop node selection and performs near source data aggregation. The buffer of each node is partitioned to maintain different types of flows for fair and efficient data delivery. The transmission rates of the sources and intermediate nodes are adjusted during congestion. The simulation results reveal that it outperforms the existing structure-free protocols in terms of energy efficiency, reliability and on-time delivery ratio.

(Avneet Kaur et.al) suggested that the Energy efficient structure-free data aggregation and de-livery (ESDAD) is the protocol which is hierarchal in nature and it ESDAD protocol can be further improved to increase lifetime of wire-less sensor networks. The base station localizes the position of each sensor node and defines level of each node for the data transmission. In the ESDAD protocol, the next hop node is selected based on cost function for the data transmission. In this research work, improved in ESDAD protocol is proposed in which gateway nodes are deployed after each level for the data transmission. The sensor node will sense the information and transmit it to gateway node. The gateway node aggregates data to the base station and simulation results show that improved ESDAD protocol performs well in terms of energy consumption and number of throughput.

(Chih-Min Chao et.al) developed a structure-free and energy-balanced data aggregation protocol (SFEB). The two-phase aggregation and dynamic aggregator selection of SFEB enable both efficient data gathering and balanced energy consumption. Extensive simulations verify the superiority of our SFEB.

(Hamed Yousefi et.al) improved on designing a structure-free Real-time data Aggregation protocol, RAG, using two mechanisms for temporal and spatial convergence of packets – Judiciously Waiting policy and Real-time Data-aware Anycasting policy. To get extensive simulations in NS-2 results of RAG in terms of aggregation gain, miss ratio, energy consumption, and end-to-end delay for WSNs.

(Kai-Wei Fan et.al) suggested a design techniques and protocols that lead to efficient data aggregation without explicit maintenance of a structure. As packets need to converge spatially and temporally for data aggregation, we propose two corresponding mechanisms—Data-Aware Anycast at the MAC layer and Randomized Waiting at the application layer. We model the performance of the combined protocol that uses both the approaches and show that our analysis matches with the simulations

(Chih-Min Chao et.al) proposed a structure-free and energy-balanced data aggregation protocol, SFEB. SFEB features both efficient data gathering and balanced energy consumption, which results from its two-phase aggregation process and the dynamic aggregator selection mechanism. Analysis, extensive simulation, and real system implementation results verify the superiority of the proposed mechanism.

III. DATA AGGREGATION APPROACHES

Data Aggregation is a process of aggregating the sensor data and to eliminate the redundant data transmission and thus improve the life time energy saving. There are many types of data aggregation approaches, some of the aggregating methods are listed below.

3.1 Hierarchical data aggregation

Consider a more general framework that organizes the aggregators in a hierarchy. To begin all the sensor nodes in a hierarchy level is 0. From those sensors, select a subset as aggregators for level 1. From level 1 aggregators, select a subset to act as level 2 aggregators. Similarly, In this hierarchy select a subset of the aggregators at each level to act as aggregators at the next higher level. Finally, the sink (which may not be an aggregator of any of the other levels) is the only aggregator of level N + 1. Once the data aggregation hierarchy is established, sensors collect data and send it to the nearest level 1 aggregator. The level 1 aggregators collect this data from their sensor nodes, aggregate it, and forward it to the nearest level 2 aggregator. This process continues until the level N aggregators forward the data to the sink.

Hierarchical network data aggregation has to be done at special nodes, with the help of these special nodes can reduce the number of number of data packets transmitted to the sink. So, this network improves the energy efficiency of the whole network. Various types of hierarchical data-aggregation protocols and algorithms are as follows

3.2 Tree-Based Data Aggregation

In a tree-based network, sensor nodes are controlled into a tree where the data aggregation is performed at an intermediate node along the tree and a concise representation of the data is transmitted to the root node.

(Hu Yanhua et.al) The construction of aggregation tree is the preparation of the whole data aggregation process, and there are two reasons to build the aggregation tree. On one hand, there is only one base node in the whole sensor network, so the tree structure is suitable to this condition. On the other hand, the tree structure can reduce the overhead of communication in the whole network, and this is necessary for energy limited wireless sensor networks.

(Priti K. Hirani) The process of aggregation is included in leaf node aggregation, intermediate node aggregation and leader node aggregation.

- **Leaf node aggregation:** Data aggregation starts from th**e** leaf node in the aggregation tree toward the BS. Leaf node doesn't need to do any aggregation it simply sends its ID, data and count value to its parent.
- **Intermediate node aggregation:** The intermediate node receives an aggregate from a child node, first checks the flag. If the value of the flag is 0, it keeps a local copy of the aggregate otherwise the node directly forward the packet to its parent node. For a packet received from child node with flag 0. The node first decrypts the data using its pair wise key shared with child nodes.
- **Leader node aggregation:** Intermediated node ha**s** processed the aggregation from its child node and find that group leader node based on the condition H (sg /x) < fg(c). a regular intermediate node, it also computes a new aggregate, keep local copies of these packets with flag 0,and corresponding MAC uses its individual key. Regular intermediate node, it changes the flag to 1 in its aggregation packet and encrypt the new aggregated with its individual key shared with BS.

3.3 Structure Free

Framework for an energy efficient data aggregation and delivery in structure free WSNs. The first subsection presents the procedure to construct the logical topology. In the next subsection, we present the approach to select the sensors that are eligible to transmit the sensed data depending on the required reliability of the occurred event. The judicial waiting policy for efficient data aggregation and data forwarding is presented in the next subsection. In the last subsection, we present an efficient congestion control mechanism to reduce the packet loss and the local recovery of the lost packets (Prabhudutta Mohanty et.al).

Structure-free data aggregation scheme is event-driven reporting in sensor networks. Since there is no established data gathering structure, each node with event data to report sends an any cast RTS first to determine the next hop to the sink. Any node that receives this RTS is a next hop candidate. To achieve better aggregation efficiency, a node that has the same event data to report or is closer to the sink have higher priority to respond a CTS. To reduce the number of transmissions, a randomized waiting scheme is introduced (Chih-Min Chao et.al).

When the logical topological is constructed cluster heads are selected in the network. The cluster heads select its next hop in the step of judicial data transmission. In the IESDAD protocol, gateways are deployed after each hop to for-ward data to next hop. The cluster head select its nearest gateway using Euclidian distance. The cluster heads need not do next hop for the data transmission which reduce routing overhead and also improve network lifetime **(Avneen Kaur et.al)**. The three phases of structure free data aggregation processes are the following i.e 1.logical topology construction 2.Judicial data transmission 3.Gateway node selection

1. **Logical topology construction**: The problems that have been caused due to the redundant number of nodes and their deployment in dense manner can be minimized with the help of topology control.
2. **Judicial data transmission:** Large amount of co-related and redundant data is generated due to the dense deployment of sensor nodes within the sensing field When the sensed data is selectively forwarded to the aggregation point, there is a possibility of reducing the energy consumption of WSN.
3. **Gateway node selection:** In the last phase of the algorithm, the gateway nodes are deployed in the network. The gateway node depends upon the total number of nodes which is described by the Equation G nodes = n /4. Here, G stands for Gateway node. The total numbers of nodes are denoted by n. The gateway nodes are the forth part of the total nodes. The best node is selected from the all gateways nodes to send data to the base station.

3.4 Cluster Based Approaches

Sensor nodes are grouped into a number of clusters with a cluster head that has the responsibility of routing from the cluster to other cluster heads or base stations. Data travel from a lower clustered layer to a higher one. Although, it hops from one node to another, by the hops from one layer to another it covers larger distances. This moves the data faster to the base station. Clustering provides inherent optimization capabilities at the cluster heads. In cluster based data aggregation approaches, each cluster has a cluster head based on distance or nodes energy which is selected among the cluster members. Cluster heads perform the role of aggregator which aggregates the data received from cluster members locally and then transmit the result to base station (Nandhini.S. Ptil.).

3.5 Centralized Approach and Decentralize approach

Only one sensor node plays in this technique of a role in aggregator node and all remaining sensor nodes are connected to that aggregator node. All remaining sensor nodes are sensing the data and transmit to the aggregator node, which is called centralized node. There are grouping of loads on that aggregator node, so there is a need of more energy and security on that aggregator node because all data is on the centralized aggregator node (Youssef Emhemmad et.al,2016). All sensor nodes play aggregator function to the sensed data. Here single centralized aggregator node is not obtainable, but all nodes have the same priority to aggregate the sensed data. Also, all sensor nodes are connected to their neighbor node. This methodology has the benefit of more scalability, dynamic change node failure in the (WSNs) (Jyoti Rajput *et al,* 2014).

IV. DATA AGGREGATION AND COLLECTION IN WSN

- **Sensor node:** Sensor node is the most important working factor that performs various activities like cluster formation, data collection, transfer data among switching centers and so on.
- **Sensors Parameters:** The parameters like bandwidth, memory, time-to-live, radio signal strength Indicator (RSSI), MRIC are detection factors for WSN architecture.
- **Newly Arriving Node:** Current numbers of nodes present in the cluster and newly incoming nodes are managed by functional parameters used in cluster creation parameters.
- **Cluster Formation:** Collection of nodes that satisfy the parameter requirements ultimately form a cluster
- **Cluster Head selection:** An individual cluster head is selected by evaluating the minimum cost and minimum distance of that node who will serve as the head.
- **Threshold battery power:** Threshold battery power is checked or evaluated against the present status of battery of the cluster head.
- **Collection of Data:** Data is collected from various nodes participating in the communication and stored in a remote location for further access.
- **Query Processor:** User defined queries are accepted and generated at user end and data is retrieved from the database for a specific query.
- **Aggregation:** Aggregation technique like data cube collection approach has been used for storage of node parameter values and cluster locations (Base Station). Data cube approach supports various phases in a graphical format that is easy to understand and access.

4.1 Table 1 Comparison of Existing Work

Authors & year	**Structure**	**Technique**	**Findings**
Yuanzhu Peter Chen et.al, 2006	Hierarchical	hEPAS – hierarchical Energy Efficient Protocol for Aggregator Selection	Maximum Energy consumption in WSN and Reduced by the employing.
Prabhudutta Mohanty et.al, 2014	Hierarchical	HEERTP- Hierarchical Energy Efficient Reliable Transport Protocol	HEERTP is achieving better end to end reliability and outperforms existing technique for the terms of Energy efficiency and Packet delivery ratio.
Kun-Hsien Lu et.al, 2010	Hierarchical	HRDG – Hierarchical ring Based Data Gathering	It reduces the data transmission delay and minimizes the energy consumption.
Shangwei Dun et.al, 2006	Hierarchical	Light Weight task oriented clustering	This algorithm reduced the granularity and effectively save the energy to compare existing.
Ammar Hawbani et.al 2015	Hierarchical	GHS – Grouping Hierarchy Structure	GHS result of maximize the lifespan of nodes by minimizing the energy consumption, balancing energy and generating redundant data.
Hu Yanhua et.al 2016	Tree	Data aggregation Scheduling Algorithm	Minimizes the Maximal energy consumption of a node, Improve the energy Utilization and Ignore the security and Lifecycle.
Chen Feng et.al, 2017	Tree	Shortest path tree and Naive	Data aggregation is effectiveness and average time delay is increased.
Duc Tai Le et.al 2018	Tree	Delay aware tree construction and First fit aggregation scheduling(DTC&FAS)	DTC&FAS is reduce the data aggregation delay by upto 72% compare to previous work and network lifetime is prolonged.
Elham	Tree	COA – Cuckoo Optimization Algorithm	Energy consumption of the network reduced

Mohsenifard et.al 2016			significantly and network lifetime is consequently enhanced.
Prabhudutta Mohanty et.al 2016	Structure free	ESPAD – Energy Efficiency Structure Free Data aggregation Delay	ESPAD outperforms the packet delivery ratio, less traffic load and loss recovery.
Avneet Kaur et.al 2018	Structure free	I ESPAD – Improved Energy Efficiency Structure Free Data aggregation Delay	In this scheme overall performance by upto 15 to 20 % of previous ESPAD protocol.
Chih-Min Chao et.al 2009	Structure free	Structure Free Energy Balanced method	It enhances the data aggregation efficiency and reduces the energy consumption.
Hamed Yousefi et.al 2012	Structure free	RAG – Real time Data Aggregation	RAG reduce the energy consumption and prevent congestion.
Priti K et.al 2015	Cluster based	Energy efficiency Clustering and Data Aggregation	In this method, it collects the required data and minimizes total energy consumption.
Jun Yuea et.al, 2011	Cluster based	EEBCDA - Energy efficiency Balanced Cluster based Data Aggregation	EEBCDA technique is improve the energy efficiency and enhanced the network lifetime.
Siva Ranjani et.al 2012	Cluster based	ECBDA - Energy efficiency Cluster Based Data Aggregation	It conserve more energy and it can be enhanced by addressing the reliability and security issues
Dilip Kumar et.al, 2011	Hierarchical Cluster based	EECDA – Energy Efficient Clustering and Data Aggregation	EECDA has better network lifetime, Stability and energy efficiency when compared with existing protocol.

V. CONCLUSION

In this paper, different types of structures and various algorithms used for data transmission are relatively surveyed based on related Knowledge in the wireless sensor network using data aggregation technique. The data aggregation techniques are very helpful in the field of wireless sensor network. It reduces the data redundancy and improves the network lifetime for the network. The various techniques that are used in data aggregation is the most essential problem in WSN literature. In this survey, it consider most important parameter like packet delivery ratio, time delay, throughput, energy consumption, data loss rate, alive node, round calculation are compared between the sender and receiver.

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Authors Profile

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