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An Optimal Energy Efficient Spatial-Temporal Correlation Method for Data Aggregation in Wireless Sensor Networks

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Abstract: A (WSN) Wireless Sensor Network is a vital application to monitor the environmental and to track the particular target. For measuring the parameters of the node wireless sensor networks (WSN) interconnected with huge amount of nodes. By using these tiny nodes with inhibited ability to sense the data, collect, and spread information. Many new protocols are intended in wireless sensor networks which are mainly designed for wireless. Some factors such as power consumption, communication capabilities, mobility are needed at time of designing the sensor networks. In wireless sensor networks energy-efficient data gathering is a widespread method but it is significant process in many applications. In this paper a survey is given regarding the architecture design of sensor networks. The paper explores with research issues for the realization of networks.

Keywords: *Wireless Sensor network, Data aggregation, WSN application, Security Goals and Challenges, Adhoc network, Attacks, Architecture design and Design issues.*

1. INTRODUCTION

In modern era Wireless Sensor Networks may contains many sensor nodes linked with another node in a sensor network. A sensor network is environments which consists of measure or sense, compute and communicate the elements. The environment depends upon the framework it may be an information technology (IT), biological system or physical world. In modern networks these are bi-directional in nature and also facilitate to control action of the sensor. The advancement of wireless sensor networks was aggravated or motivated with the help of military application like as battlefield surveillance; now a day these networks are used in many other applications depends upon consumer and industrial based. This industrial process used for monitoring and controlling, health monitoring, and so on. The Wireless Network includes huge number of "sensor nodes" it may be in the form of hundreds or may be thousands, in which every node is linked to more than sensors. Every connected node retrieves data or information from further sensor nodes and then spread it to the sink. Wireless sensor networks may include numerous sensors based upon its types, like visual, infrared, seismic, thermal, acoustic, and radar, which can observe pressure, temperature, moving vehicle, humidity, noise levels etc. Figure 1 shows Energy utilization is the most essential aspect in the wireless network as each sensor node based upon

battery. If data gathering is not performed in proper way, then lot of traffic is their and more energy consumption will occur So, sensors battery will be discharged easily and existence time of the sensors will be so small *i.e*. life time. A simple structure of WSNs shows in the Figure 1.

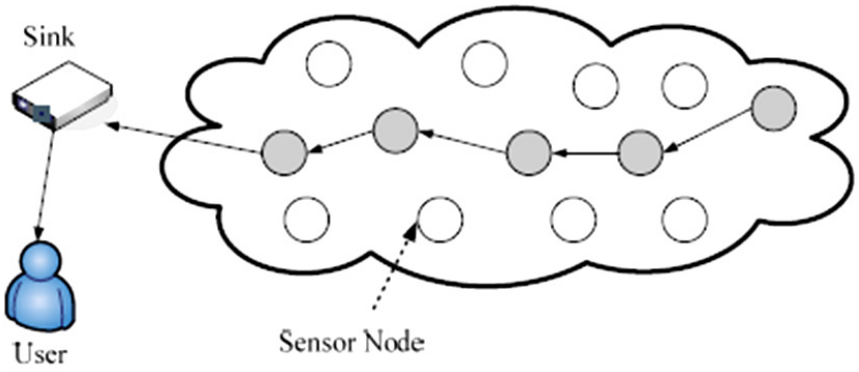

Figure 1: Wireless Sensor Network

In the network area, sink sends the information request to all other sensor nodes, from all of them sensor nodes one of the sensor node search the information or data then it try to retransmit this by using other nodes towards to the Sink. Data gathering is the way of collection to sensed data from different sensors towards the base station. As sensor nodes depends on power constrained and have less energy transmission range, so this is not possible that all of the sensors to send the information straightforwardly to the sink.

Information gathering from other sensor nodes can be correlated and redundant. The sum of data produced from huge network area is generally large for its own base station. So, we are using different ways for merging data into the premium information that is useful at the intermediate nodes and send the packets to the sink due to the consumption of energy. This process can be done by using data aggregation. Data aggregation is defining as the process of collecting information from different sensor nodes to remove the unnecessary data diffusion or transmission. *Data aggregation* collects the most significant data from different sensor nodes and sends it to the sink in energy well-organized way.

In this survey paper we focus on data management and data aggregation. In techniques of data aggregation, we used different ways or methods to route the packets for combining the data comes from different sources then move towards the sink. Data aggregation standard by recognizing the actual problems and converse hypothetical concert limits of data aggregation method. We also talk about data-aggregation protocols depends upon network structural design and distribute their current solutions, and also explain its merits and demerits. At last we review the data aggregation techniques and give guidelines and inspiration for future work related with research. Sensor network node includes several components such as microcontroller, radio transceiver, an electronic component; these are use to interface with all other sensors, energy source like battery power. Some limitation on assets such as computational speed, power, bandwidth and memory depend upon the size and expenditure of the sensor nodes. WSN topology may vary from star to mesh network. Routing used as a transmission technique in between the huge number of nodes in a network.

Wireless Sensor Networks have come out as a considerable new area in wireless technology. Wireless sensor network also used in ad-hoc network to measured some physical parameters such as humidity, pressure, temperature sound etc.

To improve the power efficiency, Data Aggregation is an important technique in sensor network. The aim of Data Aggregation protocol is to summarize and merge data packets of numerous sensor nodes so that amount of data transmission to be reduced. In sensor networks, sensor nodes collected the data from its neighboring sensors, and further it to the sink for improving the bandwidth and energy consumption in the network, where

it is progressed, examine, and used by the request. Data produced from different sensors can be progressed together and then send in the direction of the sink, e.g. firstly we combine the sensor readings of a same event then forward it or transmit further. In a network, data aggregation size of the data reduction shall not hide the information that is statistical regarding the observed event. For example, if various sensors monitoring the same event again, the nodes will report it and the report timings may release the event's size.

1.1. WSN applications

WSN applications can be categories in two ways: monitoring and tracking (see Figure.) Monitoring applications consist of environmental monitoring, Public/Industrial monitoring, and structural monitoring. Tracking applications includes tracking of objects *e.g*, vehicles, animals, human being, etc. Some of important real-applications of WSN are given below:

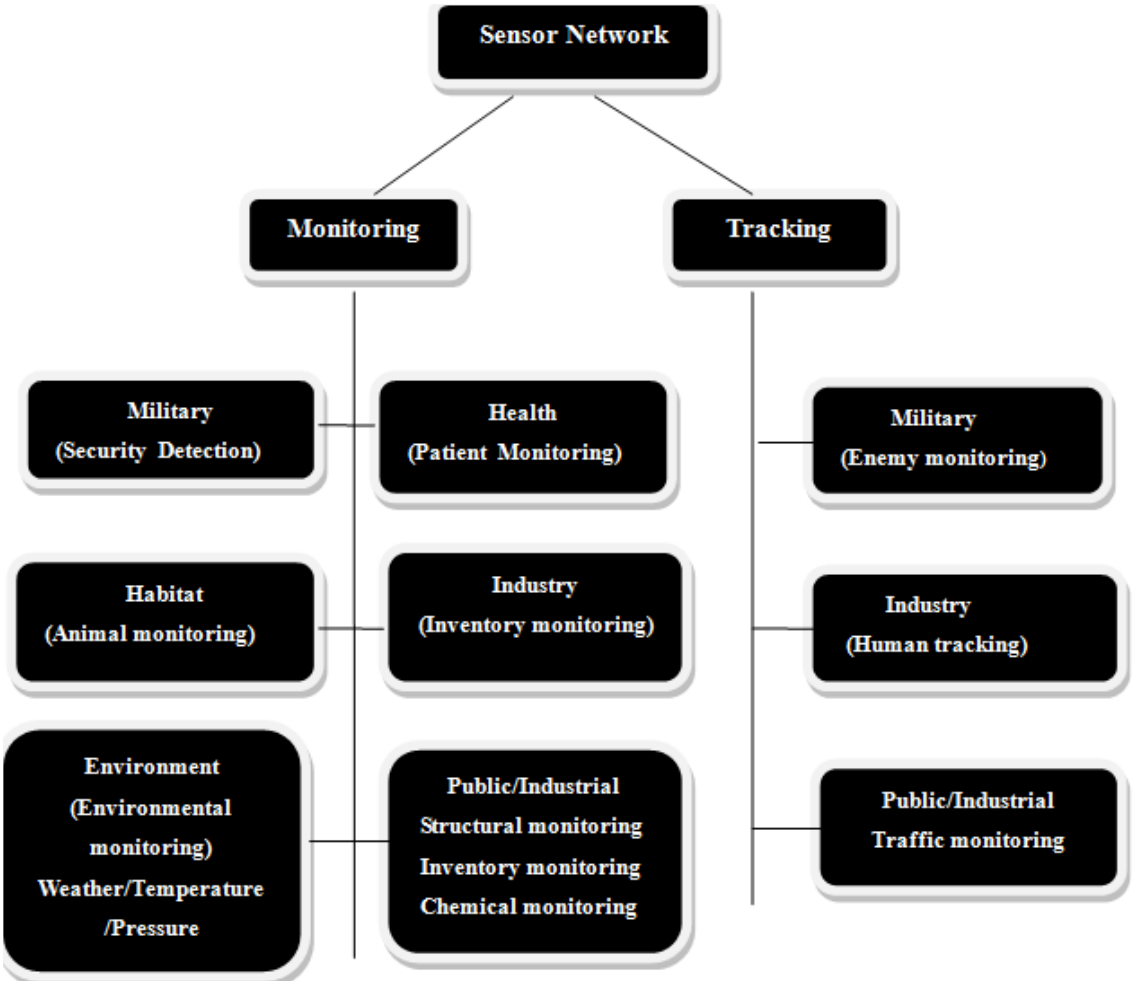

Figure 2: Applications of Wireless Sensor Network

Some more applications are there:

1. **Application based on Disaster relief :** Wireless sensor networks are also helpful for detecting the different disasters such as earthquake, forest fire etc. Whenever any of an event detected by the sensor nodes they send that particular information to their neighboring nodes in-network data aggregation. A sink node take a decision on the disaster happening with the help of information received from different sensor nodes. So this collaborative decision improves the reliability of entire network.

2. **Investigation in Scientific area :** Sensor networks are also used for different scientific investigation.
3. **Precision agriculture:** WSN also allow fertilizing and precise irrigation insert the sensors into the fields that have the mixture soil/humidity composition.
4. **Threat-Identification:** Sensors can also be used to recognize prospective threats *e.g* chemical contamination of water circulation system at various locations.
5. **Pollution monitoring:** WSN also helpful to monitor the Pollution, it may be air pollution, water pollution, etc.

1.2. WSN challenges

There are many challenges occur in the WSN are as given below:

1. **Energy-efficient based process:** In energy-efficient process, all nodes are depends upon energy which support long lifetimes of these nodes. In Energy-inefficient network will decrease the lifetime of the sensor nodes.
2. **Lifetime:** The lifetime is the essential factor in Wireless Sensor Network. In many situation, nodes will have limited power (using batteries) so change such batteries will time wastage process and cost also have major issue due to recharging of batteries which will decrease the lifetime. To increase the battery lifetime of sensor nodes we need to decrease the number of transmissions, so it will increase the sensor lifetime also.
3. **Fault tolerance:** In the transmission process it might be possible to damage the nodes, or we can say the communication in between nodes can be permanent broken up, so due to this WSN need to tolerate this type of faults.
4. **Maintainability:** Depends upon such situation of a WSN and the WSN itself modify the system has to adjust.
5. **Scalability:** WSN includes a huge amount of sensor nodes, the protocols and architectures must be scale the sensor nodes.

1.3. Comparison of Sensor nodes with ad hoc sensor nodes in WSN

1. Sensor nodes have inadequate computation energy, assets, memory and bandwidth as compared to ad hoc network.
2. Sensor nodes are easily cooperation with ad hoc nodes.
3. Sensor nodes are flat to failure due to energy constraints & insensitive exploitation environments as compared to ad hoc nodes.
4. Amount of sensor nodes can be numerous orders of degree superior than the nodes in an ad hoc network.
5. Ad hoc nodes may have inclusive recognition as compared to sensor nodes.
6. The topology of sensor nodes varies commonly due to the failure of node as compared to ad hoc network.
7. Sensor nodes are compactly organized in most of the environment as compared to ad-hoc network.

1.4. Security Goals

Whenever we talk about security for wireless sensor network, we primarily focus on some security services which are following as below:

1. **Availability:** The survivability services of a network to authoritative party whenever required although (Dos) Denial-of-service attacks ensure by availability [1].
2. **Confidentiality:** The main purpose of confidentiality or Secrecy required information not accessible by unauthorized users [1], [2].
3. **Authentication:** Authentication ensures the identity of a node for communicating purpose[1], [2].
4. **Non-repudiation:** Non-repudiation indicates that sensor nodes cannot send the redundant information.
5. **Integrity:** Integrity measuring the received information is not misused in transfer by an opponent [1], [2].
6. **Authorization:** In authorization authoritative sensor nodes can be right to use network services and resources.

1.5. Security Challenges

In this we define some security challenges for wireless sensor networks from [3], [4], [5] are as following:

1. Network topology may be dynamic due to adding and failure new node in sensor network.
2. For processing in a network involvement of an intermediate sensor nodes transfer the information in end-to-end way.
3. Maximizing performance of security and minimizing the consumption of resources.
4. Due to mobility of nodes and large scale of nodes make the network situation more complex.
5. In sensor network deployment provide huge no. of link attacks comes from passive eavesdropping to active interfering.

1.6. Threats and Attacks

Security Problems commonly comes from an attack. Most of the research studies security issues regarding different sensor nodes. No need to require security if no one attack is there. The possibility of an attack in sensor networks is more than the wireless LANs, depends upon their exploitation situation and assets limitations [3].

Attacks are categorized in two ways: External attacks and internal attacks.

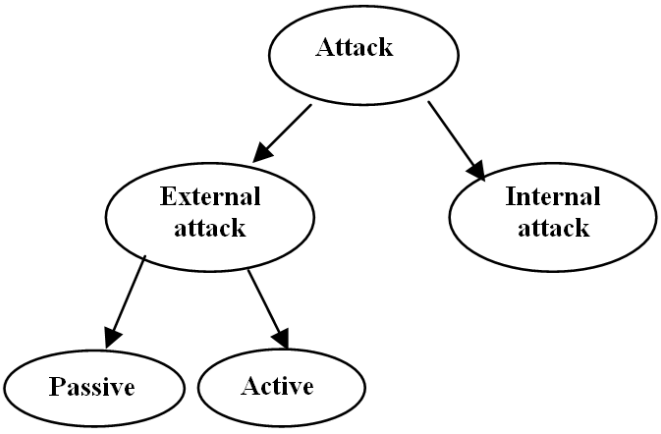

Figure 3: Types of Attacks

In an External attack, the attacker node is not an authorized sensor node in a network [3]. External attacks also categorized into two ways: Passive and Active. Passive attacks for routing packets includes unauthorized 'listening'. This attack can be used encryption security method. Active external attacks interrupt network utility with the help of denial-of-service (DoS) attacks, *e.g* jamming [6]

Table 1
Some more attacks on sensor network [7]

Passive Information Gathering attack	*The attacker just simply chooses the data stream and listen data at the time of communication between different nodes.*
Black hole attack	It will disrupt the communication process between sink and other WSN.
Sinkhole attacks	It attracts almost all of the traffic to a specific node, and also changes the base station position.
Sybil attacks	A single node represents multiple identities and also exploiting the routing race condition.
Wormhole attacks	It gives the False routing information, effect on topology,and also changes the normal messages stream
Hello floods	An attacker may be sends a routing protocols hello packets with more energy to confuse the network routing process
Jamming Attack	Denial of service (DoS) attack comes under Jamming attack in which the attacker is to jam communications process between the sensor nodes.

2. SENSOR ARCHITECTURE DESIGN IN WSN

According to above diagram that a WSN includes various numeral sensor nodes. The communication architecture for (WSNs) has shown in figure.1on the upper side. The important thing is that construct the architecture [16]: In Sensor network contains different sensor nodes. The main objective is to communicating over a wireless channel, collect the information then route particular data to the sink. The Base Station or sink communicates with the client through internet or satellite which is placed nearest to the sensor network.

2.1. Design Issues

Based upon their performance of a routing protocol which is nearest to the design model, in this section we define the design issues & also define their implication.

1. **Node Deployment :** In this network sensors are placed manually and pre determined paths are define.
2. **Network dynamics:** In sensor network based upon three main components. These are the sink, sensor nodes, event detected.
3. **Energy Consideration:** Energy consideration is also main concept used in design issue. During this we consider the transmission power based upon the routing path. Direct routing path perform well as compare to multi hop transmission by nodes because these are very close to the sink.
4. **Data Delivery Models:** According to the application of the sensor network, the data delivery model to the sink possible to be event- driven, hybrid or continuous. In event driven model, when an event occurs the transmission of data is produced by the sink. Sensor sends data periodically in continuous delivery model [8].

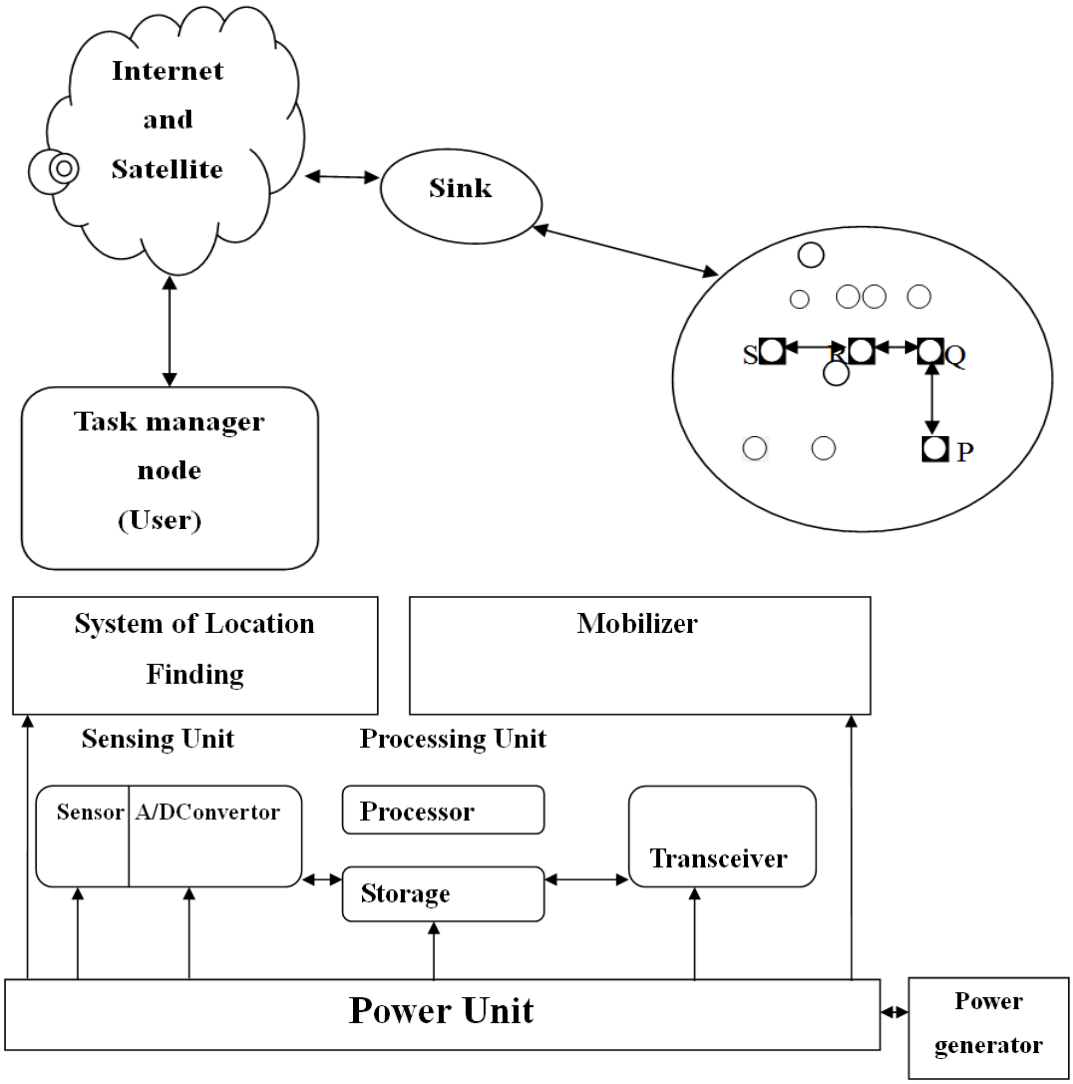

Figure 4: Sensor nodes spread in a sensor field and components of a sensor node

3. LITERATURE REVIEW

B. Baranidharan and B. Santhi, "An Evolutionary Approach to improve the life time of the Wireless sensor network". In this paper, they work on the Genetic algorithm approach to improve the energy effectiveness or efficiency in the wireless sensor. Genetics operators are used to reduce the unnecessary information to the base station and save its power efficiency, so which increases the nodes lifetime. [9].

Sanaz Naziri, Majid Haghparast and Somayeh Hasanpoor, "Improving Lifetime and Reliability in Routing Real-Time Wireless Sensor Networks based on Hybrid Algorithm". In this paper, they work on a hybrid algorithm for enhancing the network lifetime and reliability. In MATLAB software using above algorithm simulation results display that has a considerable enhancement in compare with its previous one. [10].

Bhasker, proposed **"**A secure cluster-based data aggregation in WSN". In this paper, firstly select the Cluster Heads (CHs) depends upon the connection of different node and used as a data aggregator. Clustering process occurred with the help of genetic algorithm. Whenever a cluster head sends the data to data aggregator using data encryption technique which provides integrity, authentication, and confidentiality. To reduce the power consumption, this technique to be used which ensure to reduce redundant transmission and security also.

Azzedine Boukerche, "An energy aware spatio-temporal correlation mechanism to perform efficient data collection in wireless sensor network". In this paper (2013), this works on new algorithm defined which named as Efficient data collection aware of spatio-temporal correlation (EAST), which used the shortest path to send data towards the sink or base station. and both correlation perform real-time data collection in Wireless sensor network.

Jiang et al, Proposed "An energy-efficient framework for clustering-based collection in wireless sensor network"(2010). In this paper data-aggregation technique are use which is based on statistical information and also used expectation-maximization algorithm for accurate estimation of sensory data parameters. This techniques is not reduced the communication cost but it gives the valuable statistical information

Sarangi & Thankchan, proposed Energy constrained WSN deployed over a region were considered in (2012). The important purpose of these networks is to collecting data from sensor nodes and sends it to the sink or base stations for further processing. In this paper we use a Particle Swarm Optimization based Routing protocol (PSOR) in which energy efficiency is a major reason to perform routing and find out optimal path to send and process the data to sink or base station. PSOR generated a new path which has less energy consumption than that of other routing paths. The experiments performed with the help of simulator. This paper shows the comparison in between the proposed algorithm PSOR and Genetic Algorithm and showed that PSOR gives better results as compared to Genetic Algorithm.

Yoon and Shahabi [11], proposed a new method for spatial correlation in WSNs. In this method, define the Clustered Aggregation Technique (CAG), which build cluster nodes that sensing same values. These cluster nodes send the readings to the sink whereas the other nodes ignore their readings. This CAG algorithm based on: query and response method. The authors proposed mechanism which reduce the number of transmissions. Flooding-based protocol to distribute the query to all other sensor nodes author use CAG algorithm.

4. PROPOSED WORK PLAN

We know that Wireless sensor networks (WSNs) [12–15] based upon small sensor device, battery-operated, sensor nodes whose main purpose is to monitor their environment for collecting the data and to send towards to a sink node. One of the main limitations of wireless network is battery-operated device, many protocols are used to avoid or delay communication [16-22].Our proposal needs to extend some of current publication [23-25], which provides many WSN applications, data are to be correlated in both time and space nearby the nodes. In this literature, we categorized data correlation protocols in two ways: (*i*) Spatial correlation (*ii*) Temporal correlation. We define the different correlation methods:

Spatial correlation : Whenever change the pattern of the data; we expect data sensed by nearby node is similar or same. In spatial correlation, when information is to be detecting from different sensor nodes which are very close to each other and get same information then send towards the sink, this process will consume energy due to more transmission. So, for reducing the transmission we choose a few representative nodes. The working of these representative node reports the occurring event of a particular area on behalf of a group of nodes that gather same information of an event.

Temporal correlation: Whenever change the pattern we expect the previous observed readings equal or similar to the current sensor readings. On a different time interval data collected from a particular sensor may be similar. This is also called as temporal correlation. e.g in a day we measure the temperature at each minute, the temperature may not change extensively. So, In this case, no need to send report at each minute since we consider the last noted reading corresponds to the actual one.

4.1. A new Optimal Energy Efficient Algorithm for spatial–temporal correlation

In this section, we define spatial –temporal correlation then we proposed the OEEA (Optimal Energy Efficient Algorithm) for spatial-temporal correlation. In this algorithm, dynamically changed the threshold value and depends upon the size of the correlation area, we can reduce the energy consumption with the help of eliminating redundant data. The main objective of this algorithm to reduce redundant transmission, preserving data accuracy and real time reporting. Some nodes perform important role in this network:

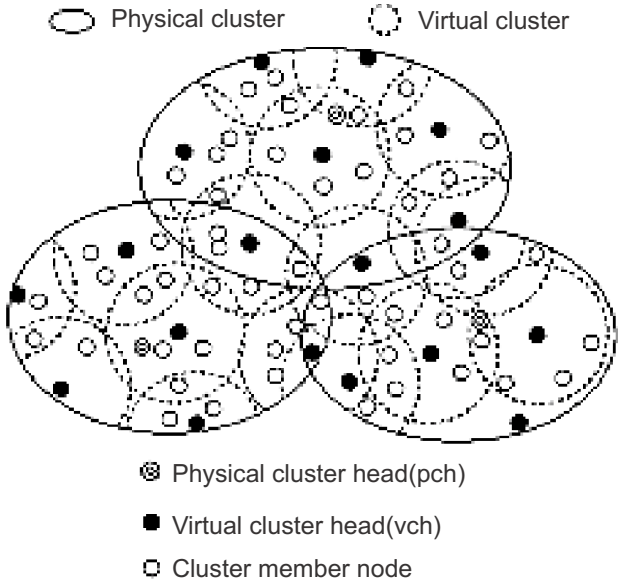

Figure 5: Deployment of different nodes

Cluster member node: Cluster member nodes detecting one or more than one events. These nodes just sensed the data, it may be redundant information.

Virtual cluster head: Virtual cluster head nodes represent as a **representative node** which detects an event occurring. It contains the information of all neighboring node with similar value or readings.

Physical cluster node: Physical cluster head nodes represent as a **coordinator node**, its function is to detect an event and collect all data comes for representative nodes and next process to send this data towards to the sink.

Relay Nodes: The main function of relay nodes is to transmit data towards to the sink.

Sink node: Sink node is used as the Base station which is the gateway between the WSN and monitoring event.

The OEEA algorithm uses the shortest path in a particular region (S), in which sensor nodes ($s_{i,j}$) sense the data and forward it to virtual cluster head ($H_{i,j}$) further it will send the data towards to physical cluster node ($S_{i,j}$) and this sensor data (F_i) forward it to the sink (S_k). In this section we define node localization, in which physical cluster node's (coordinator node) position (i_n, j_n), Each and every node represented with structured pair (i_c, j_c). The central location of an event represented with (i_e, j_e). C and C/2 will represented with cell size and radius.

Step 1: Begin

Step 2: While sensor node $s_{i,j}$ senses data in region S

Step 3: For each sensor node $s_{i,j}$ in region S **do**

S_k broadcast REQ signal requesting location, node ID, and energy level of each node $X_{i,j}$.

$S_{i,j}$ send message having location information, node ID, and energy level to S_k.

Step 4: For each nodes $s_{i,j}$ in the region S **do**

new_head = get_nexthead()

transfer_info (new_head)

new_head.build_connections()

notify zone head

notify predecessor and successor

if have_data() then

transfer_data(successor)

endif

Step 5: For each occurrence of event in the region S **do**

$ic \leftarrow 0$ [ordered pair of cell]

$jc \leftarrow 0$

if $(i_n - i_e) > 1$

***c*/2**

$ic \leftarrow [(i_n - i_e) - c/2] + 1$ C

jc $\leftarrow [(i_n - i_e) - c/2] + 1$ C

End if

if $(i_n - i_e) \leftarrow 1$

***c*/2** $ic \leftarrow [(i_n - i_e) + c/2] - 1$ C

$jc \leftarrow [(i_n - i_e) + c/2] - 1$ C

End if

End while

End for

Step 6: For each node $S_{i,j}$ in region S

Calculate the shortest path from $s_{i,j}$ to $z_{i,j}$

$H_{i,j} = s_{i,j}$

$S_{i,j} = H_{i,j}$

End for

Step 7: For each sensor data F_i in the S **do**

Send the data to the sink

Step 8: For each querying Q_i in the S **do**

Send Q_i to node $S_{i,j}$ in region S

End For

End while

End

According to this algorithm, if the value of C = 0 then no spatial correlation method to be occur in between the nodes then all nodes becomes as representative nodes so number of transmission more. But if the value of C > 0 then spatial correlation method will occur in which representative node gathering the data from other member nodes and then sensed data further send to the coordinator node.

5. CONCLUSIONS

This paper proposed OEEA, in which this algorithm based upon optimal energy efficient data transmit towards the sink in WSNs. Both spatial and temporal correlation method to be used for saving energy. We already studied about current literature of spatial and temporal correlation algorithms, in which energy dissipation not consider at the time of data gathering it only choose the representative nodes at each correlation region which observe or collect the redundant information. So it provides the less transmission and energy will be save.

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