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Improvement Performance of Clustered Shortest Geopath Routing Protocol Using Data Aggregation in Wireless Sensor Network Environments

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Abstract. The wireless sensor network is one of the wireless networks which consists of many sensor nodes placed in a particular region for a certain specific functionality. Sensor nodes are generally small and have limited memory, processing resources, energy and lifetime. Limitations of sensor nodes on the energy side can affect network performance such as network lifetime and delay on the event detection. There are many methods that have been done to increase network lifetime, one of which is Clustered Shortest Geopath Routing protocol (CSGP). CSGP is a method to increase network lifetime, this method the development of the shortest geopath routing protocol (SGP) and Low Energy Adaptive Clustering Hierarchy (LEACH). the cluster formation is based on the geographic information of the network while the cluster head selection is based on the position of the node closest to the clusters center point and the data sensing obtained by sensor node will be sent to the cluster head which will forward them to the sink using SGP. However, this method has the limitation on the cluster head selection which is not optimal and the density of network transmission on the SGP line so that the energy consumption of nodes in the path is greater than other sensor nodes. This research proposes a schema selection and maintenance of the cluster head to determine the adaptive path, then aggregation data to reduce the number of network transmission. The data aggregation is the process of collecting and combining useful information in a particular region. Implementation of the stages will be performed in the simulation environment by utilizing SIDNet SWANS simulator, a simulator that used for simulating the wireless sensor network.

1. Introduction

At this time where technological developments occur very rapidly, many human activities are greatly helped by the existence of technology. One of the most widely used and utilized wireless sensor networks (WSN), which can be implemented in many areas such as in the military, agriculture, environmental monitoring, health and so on [1]. WSN is one of the distributed wireless networks consisting of sinks and collections of sensor nodes scattered in certain areas, used as a medium to process the sensors, collect sensing data which then produce information according to certain characteristics so that it can be used to monitor a certain condition such as temperature, radiation, pressure, humidity, vibration, and others [2]. Each sensor node is equipped with communication system equipment so that nodes can be connected to other sensor nodes [3].

Sensor nodes have some limitations on the energy side, this limitation can affect network performance such as on the network lifetime and delay event detection. Several studies have been

done to increase network lifetimes such as Low Energy Adaptive Clustering Hierarchy (LEACH) and Clustered Shortest Geopath Routing Protocol (CSGP). LEACH is one of the algorithms developed to improve network performance on the network lifetime side. The algorithm was first introduced by Heinzelman by utilizing a hierarchical or cluster-based Routing protocol [4]. Clusters can be formed by clustering. This process classifies data into multiple clusters, so data in one cluster has a high degree of similarity [5]. A shortest geopath routing protocol is one of the location-based routing protocols, forward the message to the sink with the closest distance to the sink[6].

CSGP is the development of shortest geopath routing protocol(SGP) and LEACH, the formation of clusters is based on the geographic information of the network and the selection of cluster head selection based on the position of the node closest to the center point of the cluster, the sensing data obtained by the sensor node will be sent to the cluster head, then cluster head will forward to sink data with shortest geopath routing protocol [7]. However, CSGP has not conducted further research on the selection and replacement of the cluster head so that further research is needed for the selection process and the change of cluster head, on the other hand, the transmission of data from the centralized cluster head using the nearest line to the sink can cause its solid transmission on the path so that the energy consumption of nodes in the path is greater than other sensor nodes. To reduce the number of network transmission can be done with the data aggregation process[8]. Data aggregation to reduce packet size as well as redundancy and then send packets to the required location [9]. In LEACH method the cluster head selection based on the highest residual energy, CSGP method cluster head selection based on the closest distance to the cluster center and without data aggregation that caused the high density of network traffic.

Therefore, this research proposes a schema cluster head selection to determine the adaptive path, then aggregation data to reduce the number of network transmission. Data aggregation is the process of collecting and combining useful information in a particular region [10]. Effective data collection techniques can improve energy efficiency and network life [11]. Implementation of the stages will be performed in the simulation environment by utilizing SIDNet SWANS simulator, a simulator that used for simulating the wireless sensor network [12].

2. Methodology

This method called Clustered Shortest Geopath Routing Protocol with Data Aggregation (CSGP-DA), divided by 2 phases, cluster head selection phase and data aggregation phase. Cluster head selection phase is a phase where each node performs cluster head selection based on the highest number of neighbors in a cluster. Data aggregation phase is a phase where cluster head received data from node sensor and temporarily accommodated data where priority data is medium and low priority data and then collected data will be average.

The cluster head is the selected node sensing that is responsible for forwarding messages from the cluster member to the sink. the cluster head is required in order to reduce the number of network transmission, because with the cluster head then the transmitting message will become centralized where the cluster member or sensor node does not need to forward the message directly to the sink that can cause its high transmission in the network. Sensing results from the sensor nodes will be sent to the selected cluster head which then passes the received message to the sink through the shortest path to the sink.

Firstly, the cluster head selection is performed after the heartbeat is completed, the selection parameter is based on the node that has the largest number of neighbors in a cluster. Each sensor node will find out the number of its own neighbors and the number of neighbors in a cluster, if the number of neighbor nodes is greater than the number of neighbors of each neighbor then that node will be chosen as cluster head, but if the number of neighbor's neighbor node more than the node's, then the neighbor node that will be chosen as cluster head.

To reduce the number of network transmission can use data aggregation in the cluster head so that with the reduced number of transmissions will increase network lifetime. For network scenarios that scan data such as temperature, humidity or other data that sometimes do not need to be sent at any time, data aggregation techniques can be used and then sent adaptively according to the priority of the scanned data. In this research, the experiment will be conducted on fire scenario with data temperature.

After the neighbor information and the sink are stored in the table, then the sensor nodes will periodically perform the sensing in accordance with the specified sampling interval, the sensing results will be grouped into several priorities according to a certain range of values that is the high priority, medium priority, and low priority. The priority data is to recognize the condition of an area where if fire condition then it is considered as a high priority and required handling faster than other priorities. Medium Priority is being considered as abnormal conditions and low priority considered as normal conditions. As for the data priority according to temperature, there is three range such as fire temperature range 40 - 110 celsius, abnormal temperature range 33-43 Celcius and normal temperature range 18-32 Celcius.

Furthermore, data aggregation phase is performed by a cluster head while the aggregation process is based on data priority level. Cluster head reduces the amount of transmission by collecting some data from the lower node and aggregate it before send to the sink node. High data priority (P1) will be sent directly to sink using SGP, whereas data with medium and low priority will be temporarily accommodated in the cluster head to a certain limit. Medium data priority (P2) are collected until the collected data reach a certain number. In this case, we use 10 data as the limit. Low data priority (P3) will be collected until collected data is equal to 20. Figure 1 shows the flowchart of the aggregation process in cluster head.
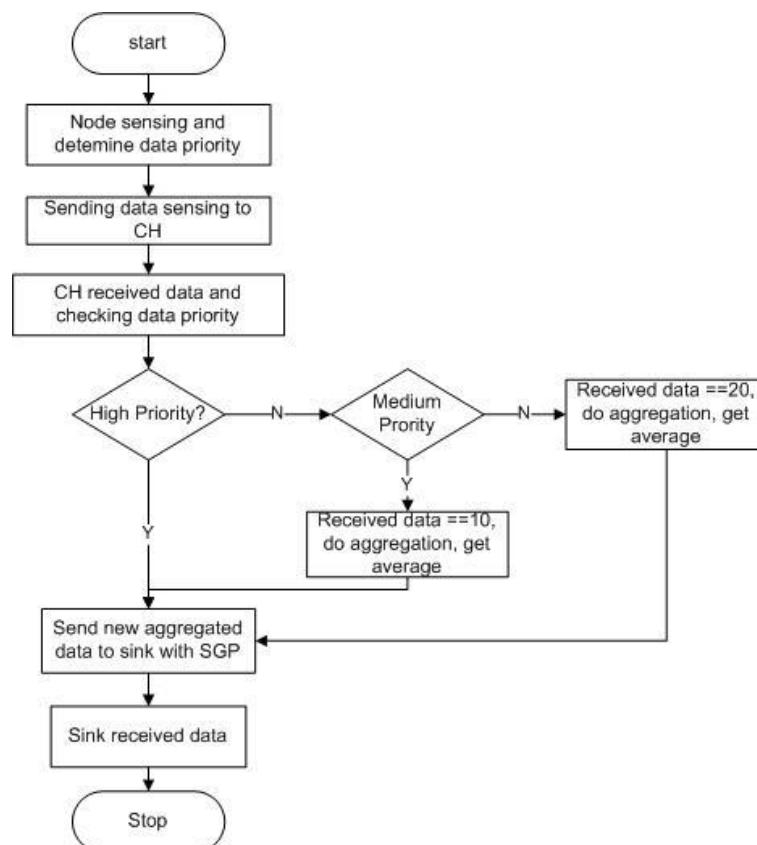

Figure 1. Flowchart of Aggregation Process in Cluster Head

3. Result and Discussion
The experiment carries out by SIDnet-SWANS simulator with 400 m2 area, 200 nodes that randomly place and 60 hours of monitoring. The power source is limited to source node battery with 3 volts and 40 mAh capacity and node sink battery with 3 volt and 80 mAh. Another experiment parameter using the default setting from SIDnet-SWANS simulator. The proposed method Clustered Shortest Geopath Routing Protocol with Data Aggregation (CSGP-DA) will be compared to the Clustered Shortest Geopath Routing Protocol without data aggregation (CSGP-WA) method and Shortest Geopath Routing Protocol without data aggregation(SGP-WA). The experiment will be run for 3 times and all result will be calculated for average value and then compare it to the other method. Proposed method CSGP-DA

is tested for 3 times by using all parameter and pre-build scenario that already determined. Network lifetime is a parameter where how long lifetime of a network from nodes deployed until one of the nodes run out of power source, greater value is better. Delay event detection is a parameter to determine how long from event happens until event detected by the sink node, a lower value is better. Table 1 depicts Experiment result of CSGP-DA.

Table 1. Experiment Result of CSGP-DA

Experiment		1	2	3	Average
Network Lifetime(Minutes)		2635	2633	2650	2636
Delay Event Detection(ms)	P1	72	72	72	72
	P2	83	83	83	83
	P3	77	77	77	77

Then we need to compare proposed method CSGP-DA with CSGP without adaptive path and data aggregation (CSGP-WA) and SGP without data aggregation (SGP-WA) to know the performance of CSGP-DA. It also tested for 3 times by using same parameter and pre-build scenario. Table 2 depicts Experiment result of CSGP-WA, Table 3 depicts Experiment result of SGP-WA.

Table 2. Experiment Result of CSGP-WA

Experiment		1	2	3	Average
Network Lifetime(Minutes)		2223	2193	2218	2211.3
Delay Event Detection(ms)	P1	97	97	96	96.6
	P2	105	105	105	105
	P3	106	106	106	106

Table 3. Experiment Result of SGP-WA

Experiment		1	2	3	Average
Network Lifetime(minutes)		1159	1160	1792	1370.3
Delay Event Detection(ms)	P1	98	99	101	99.3
	P2	103	105	111	106.3
	P3	176	105	96	125.6

From the third experiment, we could compare the other performance base on average result of network lifetime and delay event detection based on data priority. Table 4 shows each average result comparison.

Table 4. Comparison Average of Network Lifetime and Delay Event Detection

Method		CSGP-DA	CSGP-WA	SGP-WA
Network Lifetime(minutes)		2636	2211.3	1370.3
Delay Event Detection(ms)	P1	72	96.6	99.3
	P2	83	105	106.3
	P3	77	106	125.6

As shown in table 4, CSGP-DA has better performance than other methods, average network lifetime of CSGP-APA is 2636 minutes that is 19,2% better than CSGP-WA that has 2211.3 minutes and 92,22% better than SGP-WA has 1370,3 minutes.

Average delay event detection of CSGP-APA is the lowest compared to other methods. This happens since with data aggregation the number of network transmission can be reduced without ignoring high data priority. Comparison Average of network lifetime shown in figure 2 and average of delay event detection shown in figure 3.
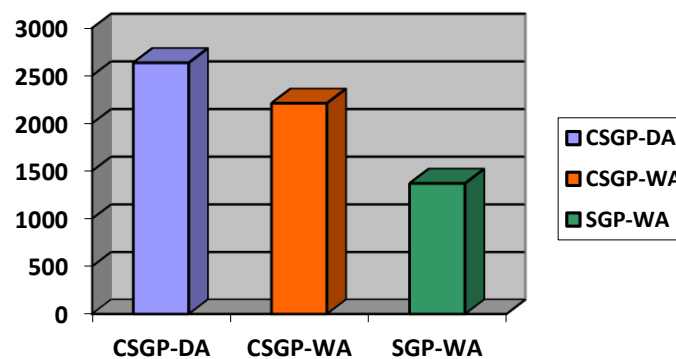
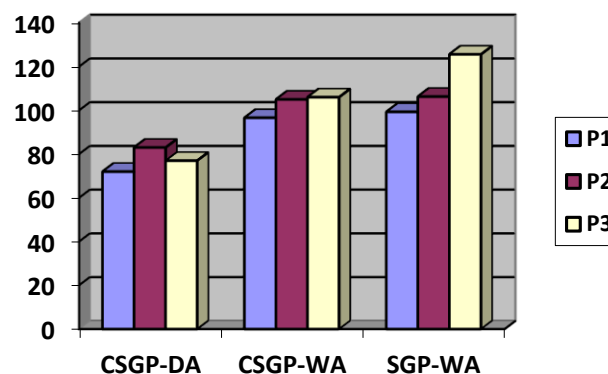Figure 2. Comparison average of network lifetime

Figure 3. Comparison average of delay event detection

4. Conclusions

The results CSGP with data aggregation (CSGP-DA) method proved to increase network lifetime 19,2% compared to CSGP without data aggregation (CSGP-WA) and 92,22% compared to SGP without data aggregation (SGP-WA), then decrease delay event detection compared to CSGP without data aggregation and SGP without data aggregation. CSGP-DA is 7 ms lower than CSGP-WA and 26,3 ms lower than SGP-WA. Further research is required to handle the hole conditions in the sgp line.

5. Acknowledgment

6. References

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