Adaptive Data Aggregation for Shortest Geopath Routing Protocol in Wireless Sensor Network

I Gusti Ngurah Ady Kusuma[1] and Waskitho Wibisono [1]

***Abstract*— Wireless sensor network is a network that contains many nodes in each nodes with limited power source and ability to send a sensing data to a cordinator node that called sink node. Every data that sent through network, will cost amount of energy for transmitting and draw energy each time a data transmitted from power soucve. To extend the network lifetime, we should optimize the data that transmitted. In this research author propose an adaptive method that using in network data aggregation with cluster and tested in SIDnet-SWANS. This method collecting the data at Cluster Head node before it forward to sink node rather than forwarding every data that arrive at cluster head to next hop. This method has better performance than other method, average energy left after 48 hours sensing is 17.23% and 78818.67 second to first node dead. This method giving more efficiency of energy use better than non-aggregation method.**

Keywords— **Aggregated Route, cluster routing, shortest path route, wireless sensor network**.

***Abstrak*— *Jaringan sensor nirkabel adalah jaringan yang berisi banyak node pada masing-masing node dengan sumber daya terbatas dan kemampuan untuk mengirim data penginderaan ke node cordinator yang disebut sink node. Setiap data yang dikirim melalui jaringan, akan menghabiskan jumlah energi untuk mentransmisikan dan menarik energi setiap kali ada data yang dikirimkan dari soucve daya. Untuk memperpanjang umur jaringan, kita harus mengoptimalkan data yang ditransmisikan. Dalam penelitian ini penulis mengajukan suatu metode adaptif yang menggunakan agregasi data jaringan dengan cluster dan diuji pada SIDnet-SWANS. Metode ini mengumpulkan data pada node Cluster Head sebelum meneruskan ke sink node daripada meneruskan setiap data yang sampai pada cluster head ke hop berikutnya. Metode ini memiliki kinerja yang lebih baik daripada metode lainnya, rata-rata energi yang tersisa setelah 48 jam penginderaannya adalah 17,23% dan 78818,67 detik untuk simpul pertama yang mati. Metode ini memberikan efisiensi penggunaan energi lebih baik daripada metode non agregasi*.**

Kata Kunci— *jalur terpendek, jaringan sensor nirkabel.*

I. Introduction

Wireless sensor network is one of the wireless communication that contains some of small devices with a low weight and included to a low-cost network [1]. Every node that form a wireless sensor network operated with a limited source of power that usually from a small battery and has a sensing ability to monitoring an environment also wireless communication [2].

Network lifetime is amount of data that received until some percent of node is dead [3]. In some case, wireless sensor network very relying on network lifetime to functioning and more specific at some node. Lifetime is defined by time of first sensor node that dead because run out of power. In other means, if we talk about energy efficiency it also talks about network lifetime, because more efficient also bring more lifetime.

Because its limited power, network lifetime very critical in a wireless sensor network. Network lifetime defined by amount from data aggregation until percentage of α from total node that died because lost its power [3]. In some case, wireless sensor network put its ability of long time sensing very critical in each node. Lifetime defined as a time where first node from a wireless sensor network died. When transmitting a data to another node, it will cost amount of energy. Because of that, every node should optimize amount of transmission that happen in network so the network life could increase.

Data aggregation in a network called with in-network data aggregation that defined as a aggregation method that happen to all data that collected at router network that passed in multi-hop network, processing data in intermediate node to achieve a better network lifetime [4].

In the architecture of wireless sensor network that use data aggregation is divided by 2 type, there are flat network architecture and hierarchical network architecture [3]. On flat network, every node has same amount of initial energy. The advantages of flat network that is easy to setup because all node have same functionality. Flat network has same task for all node which is, closer with sink node will have more task to do and more energy consumption. On hierarchical network, there is node that has special ability and more power that running as intermediate node with special task. Special task like aggregation data will be run at intermediate node. With intermediate node, sink node will have less task to do so the energy consumption will have distributed to intermediate node. Intermediate node also reduces the amount of transmission by collecting some data from lower node and aggregate it before send to sink node. Figure 1 show the example of hierarchical network architecture.

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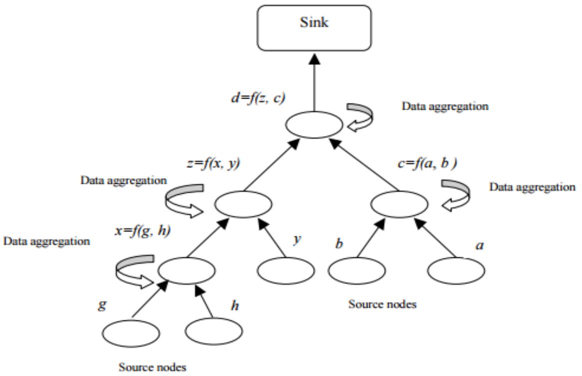

Figure 1. Hierarchical network example [3]

In this research, author propose a method to reduce amount of transmission in a wireless sensor network with a data aggregation method that applied with a shortest path routing. This method adaptively could choose amount data that aggregated based from condition. The experiment will carry out by a SIDnet-SWANS, a simulator that used to simulating the wireless sensor network [5].

II. Method

This method called Aggregated Shortest Geo Path (ASGP), divided by 2 phase, query spread phase and sending sensor value phase. Query spread phase is phase where sink node creates a control message that tell source node to do monitoring task for some duration and giving information which region will be monitored. Sending sensor value phase is phase where source node start sending the sensor value data that generated from censoring value. Query spread phase will apply broadcast system and sending sensor value will apply proposed method (ASGP).

A. Query spread phase

In this phase, sensing query is created on sink node that already chosen in wireless sensor network. Sensing query is a message that contain control message about which location that will be monitor and how long it will be. Message will be spread with broadcast technique to all node in network. When a node receives the message it will check if receiver node in the right position of monitoring area. If node is in the right place, it will be doing sensing job and sent sensor value to sink node, but if it's not, node only broadcast to another node and will ignore if it gets same sensing query message again. This process will be repeated until all node receive sensing query message.

In this phase also repeated when there is more than one region that will be monitored. Each monitored region has their own query identity. Every node only spread the same query once, and each query that has been sent to neighborhood node, node register query identity to mark that query already processed. Just in case to stop infinite loop from rebroadcasting same query. It is because, when a sender node broadcast a query to another node, after received by another node, another node also broadcasting again and it possible sender node will receive again. With register and mark every query that has been processed, sender node will ignore the query message when received.

B. Sending sensor value phase

In this phase, data sensor generated from source node will be sent to neighborhood node. With normal Shortest Geo Path (SGP), next hop usually chosen by closer location to sink node, but in this method (ASGP) it will be send to next hop node that has many other neighborhoods. This selection means the next hop is the cluster head node that will be as intermediate node to collecting sensor data from another source node. Figure 2 show data flow on network in this phase.

Aggregated Shortest Geo Path (ASGP), divide a region by create a small cluster. Each node in region will find the most node in their neighbor that has many neighbor nodes that become a cluster head aggregator. After that, node sent data to cluster head, and cluster head will be aggregating the data and send it to sink node with Shortest Geo Path routing (SGP).

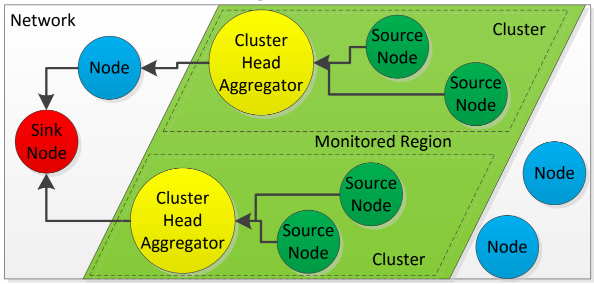

Figure 2. Data flow in network when phase 2

The minimum constraint of amount data to aggregate adaptively change based on condition (priority level) that marked on data that send by source node to cluster head aggregator. If data received with higher priority will reduce minimum constraint of amount data to aggregate which means it will faster to forward to the sink node and reverse if priority is low. Every data that received by cluster head will be divided by sensor type and priority level. Figure 3 show flowchart of aggregation process in cluster head aggregator.

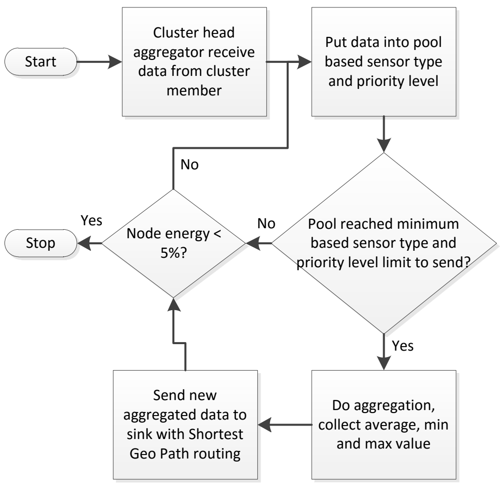

Figure 3. Flowchart of aggregation process on cluster head node

Priority level is determined by source node by measuring and classifying the result of sensor value. It classified by divided temperature into 3 range. Into normal condition where 10 – 40 Celsius, Suspicious condition 41 – 48 Celsius and Emergency 49 – 100 Celsius. Each priority level has different minimum constraint. More minimum constraint will be make slower data flow on network and less minimum constraint will make faster data flow on network. Normal level has 5 minimum data to be aggregated before it sends to sink node, suspicious level has 3 minimum data and emergency have 1 minimum data. Normal priority has higher value because in normal condition, we do not need faster data flow to do monitoring, but when it increased to suspicious level, it reduce to 3 minimum data to faster data flow. And when it is on emergency level, the minimum constraint reduces to 1, it means every data that received will be forwarded instantly to sink node.

III. Results and Discussion

The experiment carries out by SIDnet-SWANS simulator with 500 m^2 area, 200 nodes that randomly place, and 48 hours of monitoring. Monitoring running on 3 different regions and there is only one sink node for all region. Power source is limited to battery with 3 volt and 75 mAh capacity. Another experiment parameter using the default setting from SIDnet-SWANS simulator. ASGP, the proposed method will be compared to SGP method. Experiment will be run for 3 times and all result will be calculated for average value and then compare it to each other method. Figure 4 show how simulation running.

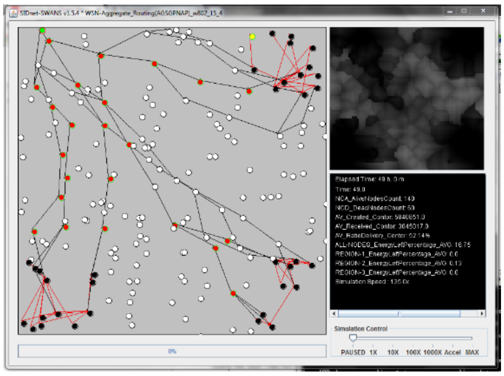

Figure 4. How simulation run on SIDnet – SWANS

Simulation is running by scenario case that already build for all 3 regions. Using pre build scenario will make it easier to see if the method could detect any activity changes at every region and we could detect delay between the activity happen at each region and the activity detected on sink node. Figure 5 show scenario graphic that will be used.

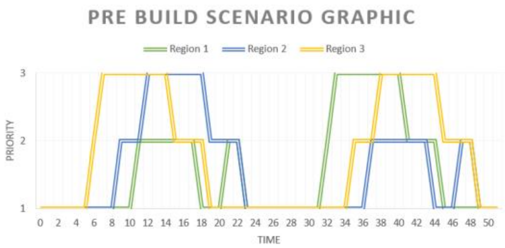

Figure 5. Pre build scenario graphic that will be used on experiment

All different region that will be monitored will have fix place base on simulation area. Region placed on each corner with fix place. Region 1 will take up right corner, region 2 down right corner and region 3 left down corner. Sink node will be at top left corner and selected from 1 node to be sink node for all region. Figure 6 show how is region placement on simulator.

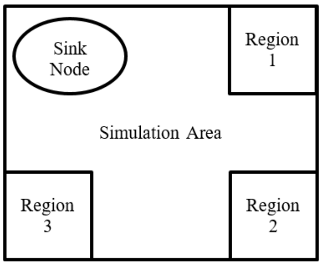

Figure 6. Sink Node and Region location for experiment

Analysis aspect that used are percentage of average energy left to determine average battery percentage value after monitoring finished, greater value is better; undetected event to determine how many activity change that doesn't detected by sink node, lower value is better; delay event detection to determine how long sink node will know if there is activity at each region base on pre build scenario, lower value is better; time to first node dead to determine how long lifetime of network until there is a dead node that run out of power source, greater value is better; and total dead node to determine how many dead node in network after simulation, lower value is better.

A. *ASGP experiment*

Proposed method ASGP is tested for 3 times by using all parameter and pre build scenario that already determined. From ASGP experiment we get a result on Table 1.

Table 1.
Result of ASGP Experiment

Analysis Aspect	Value	Average Result
Average Energy Left (%)	16.75	17.23
	16.85	
	18.10	
Undetected Event	7	8.33
	9	
	9	
Delay Event Detection (sec)	16.63	18.77
	20.19	
	19.5	
Time to First Node Dead (sec)	78849	78818.67
	78848	
	78759	
Total Dead Node	60	58.67
	60	
	56	

B. *SGP experiment*

To know how ASGP perform, it will be compared to unmodified SGP method. It also tested for 3 times by using same parameter and pre build scenario. From SGP experiment we get a result on Table 2.

TABLE 2.
RESULT OF SGP EXPERIMENT

Analysis Aspect	Value	Average Result
Average Energy Left (%)	2.94	3.14
	2.74	
	3.74	
Undetected Event	18	18.67
	19	
	19	
Delay Event Detection (sec)	817.43	311.81
	63.33	
	54.67	
Time to First Node Dead (sec)	42002	42390.67
	43162	
	42008	
Total Dead Node	170	168.33
	170	
	165	

C. *ASGP vs SGP*

From both experiment, we could compare each other performance base on average result for each analysis aspect. Table 3 show each average result comparison.

TABLE 3.
RESULT OF COMPARISON OF ASGP AND SGP EXPERIMENT

Analysis Aspect	Average Result Comparison	
	ASGP	SGP
Average Energy Left (%)	17.23	3.14
Undetected Event	8.33	18.67
Delay Event Detection (sec)	18.77	311.81
Time to First Node Dead (sec)	78818.67	42390.67
Total Dead Node	58.67	168.33

As we can see from Table 3, the proposed method ASGP has better performance than SGP method. Average energy left of ASGP is 17.23% that 5 times better than SGP method that has 3.14%.

Undetected event from ASGP method is 8.33 of 25 event occur which is means 33.32% of activity did not detected with 18.77 second delay for each detection, and SGP method has 18.67 of 25 undetected event which is 74.68% of activity did not detected with 311.81 second delay for each detection. It is means SGP has lower performance from ASGP from activity detection.

ASGP method could hold lifetime network until one of its node dead at 78818.67 second with total dead node at the end 58.67. SGP method could hold lifetime network until one of its node dead at 42390.67 second with total dead node at the end of experiment 168.33 node. From aspect lifetime, ASGP have better performance than SGP method. ASGP method could hold 1.86 times longer lifetime than SGP method and reduce total dead node significantly.

IV. CONCLUSION

Aggregated Shortest Geo Path (ASGP) has better performance than Shortest Geo Path (SGP) because it could reduce transmission count and extend the network lifetime. ASGP has 17.23% average energy left, better than SGP it is because ASGP does not forward all data that received by some node instantly to sink node, but waiting at cluster head until some data has minimum requirement to be sent as one new data. It means ASGP could sent 5 data sensor with 1 times transmission rather than SGP that sent 5 data sensor with 5 timer transmission for normal condition of lowest priority.

ASGP with its efficiency, also could make the data that flow on network does not overflowed. It is because it can control the data flow by holding forwarding time to waiting another data to be collected. It means reduce amount of network traffic and also reduce collision and congestion on network so data sensor will be having better chance to arrive at sink node. That is why ASGP has better at activity detection and lower delay detection rather than SGP method.

Because ASGP could sent data efficiently and reduce network flow, it could hold longer lifetime than SGP method. As you can see on experiment section, ASGP could hold 1.86 times longer lifetime than SGP method because its aggregate method.

ASGP still have weakness at some point where it only holds lifetime for 78818.67 of 172800 second total simulation time. It means only hold 45.61% from total duration of simulation. After first node is dead, network reability will also reduce overtime. So we need another efficiency method that could hold longer than ASGP method because, in the real place, monitoring event could longer than 48 hours even 1 month.

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