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Author Index

Comparative Analysis of Routing Protocol on Wireless Sensor Network (WSN) with Gradient Based Approach and Geographic Based Approach Method

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***Abstract*— Wireless Sensor Network (WSN) is a wireless network device that consists of a lot of sensor node, computation or data processing device, and also communication device to send or receive data. WSN might be used for communicating, monitoring, tracking, and controlling.**

This research analyzed the comparison of the simulation result from routing protocol on WSN using Gradient based approach and Geographic based approach.

From the result of the simulation, it was compared the most efficient routing from hop, distance, and energy that was used at the data sending from 100 node to BS. The most efficient from the result is Gradient based approach with the total hop of 375, distance 4414.3822 meter, and the used energy 0.0767189 Joule. The simulation result of Geographic based approach is the total hop of 411, distance 4588.4049 meter, and the used energy 0.0836362 Joule.

Keywords; Wireless Sensor Network (WSN), Gradient based approach, Geographic based approach

I. INTRODUCTION

Wireless Sensor Network (WSN) is a wireless network device that consists of a lot of sensor node, computation or data processing device, and also communication device to send or receive data. WSN might be used for communicating, monitoring, tracking, and controlling.[1]

Most routing protocol on WSN is based on flooding or random-walk, which will cause bigger communication cost because of the many route that is found and unidirectional sending. And also, the problem that most often arise on WSN was large energy using to send and receive data that was used for each node, while the energy that each node had was limited. To solve that problem, many kind of routing algorithm that use a variety of method appeared to get different goals. Some routing algorithm or method that was developed are gradient based approach and Geographic based approach.

Because of the many routing method that was developed, it must be known the most effective method and what are the advantage and disadvantage of each method. Because of that, this research will analyzed the comparation of the routing method on WSN.

II. TEORY

A. Wireless Sensor Network (WSN)

Wireless Sensor Network (WSN) is a wireless network device that consists of a lot of sensor node, computation or data processing device, and also communication device to send or receive data. WSN might be used for communicating, monitoring, tracking, and controlling.[1]

Generally WSN consist of three important parts. Sensor network; is for detecting an area and sending it to base station through wireless. Base station, or sink; is usually put not very far from the sensor area. User; is the manager of data that base station got from sensor node.

Sensor node receive and send data through wireless to network center. Many application of WSN need hundreds or thousands of sensor node and is often placed in secluded area, or in hard environment such as desert, ocean, forest, etc. Each node will send information to sink to know the condition at that place.

Sensor node communicate not only to each other but also to base station (BS) through wireless on each sensor node.

Sensor node ability on WSN varies, from the simple sensor node that can monitor single physical phenomenon, to complex device that can combine different sensors (such as acoustic, optic, magnetic). [2]

Sensor node is also different in communication ability, for example using ultrasound, infrared, or radio frequency with a variety of data speed and latency. Simple node can only collects and communicates data about the observed environment, but there is also another node that has broad ability from the side of data process, energy, and storage capacity.

WSN is often used on large geographic area and radio transmission power has to be saved and used minimally to save energy, so multi-hop communication is e very effective way to be used. In multi-hop communication, sensor node not only captures and spreads its own data, but also functions as relay to other sensor node. They have to cooperate to spread data from source data until the data reach base station.

The problem on multi-hop network is route searching or routing from sensor node to the base station.

B. Routing Protocol pada WSN

Based on indicator difference, routing algorithm protocol is divided into three subclass which is: [4] Flat-Based; all node has the same task on network. Flat routing protocol send and receive affordable data on sensor network. Each routing protocol in this category has ways to decide its own route to get the best route based on hop. Hierarchical-Based; manages the node in cluster. Nodes in cluster send data to cluster head and this CH forward the data to sink. Location-Based; Most protocol routing needs location information from sensor node. In most cases, location information that is needed to count the distance between two nodes so energy consumption can be predicted for each data sending, because there is no addressing scheme for sensor network like IP address.

C. Gradient Based Approach

Gradient based approach is a routing protocol included in flat-based category. It will send data only to other nodes still within reach. This routing protocol use relative distance between nodes. Relative distance shows the data flow direction from sender to data. The idea of gradient based approach is to know the source distance to base station based on total hop when data pass through network.

There are some stage in route searching with this method. In the beginning stage, it will be searched the cost of each node. That cost is the value of jump or the minimum hop to send packet to base station. So, each node can count total minimum hop to get to BS. After each node has its cost, the route or neighbor that will be passed for data sending is decided. With requirement, a packet is forwarded on node that has smaller cost than that node.

$$Cost_{source} = Cost_{onsumed} + Cost_{current\_node} \quad (2.1)$$

Where :

$Cost_{source}$ = Cost source node
$Cost_{consumed}$ = Cost for sending the data
$Cost_{current\_node}$ = Cost destination node

D. Geographic based approach

It is a routing protocol that is included in location-based category. This routing protocol will send data by noticing geographic position on sensor node. This method promise to give efficiency especially for energy on WSN. [5]

Geographic routing protocol only needs local information so is very efficient on WSN. First, node only needs to know its direct neighbor location information to forward the packet and because of it the state that is saved is minimum. Second, protocol saved the energy and bandwidth because flooding is not needed. Third, in mobile network with the topology often changing, geographic routing has quick respond and can find new route quickly only using local topology information.

In routing mechanism study, it uses these assumptions: [5]

- Each node knows geographic location using some localization mechanism. Location awareness is very important for many wireless application, so it is expected that node will be completed with localization technic. Some technic are for sensor location based on closeness, or triangulation using radio signal, acoustic, or infrared. These technics are different in their granularity localization, reach, spreading complexity, and cost. Generally, many system localizations are already proposed in literature such as GPS, infrastructure based localization system, and ad-hoc localization system.
- Each node knows neighbor location. This information can be gotten by node periodically or with the request broadcasting their location to their neighbor.
- Source knows the destination.

In geographic routing, each node knows direct neighbor location (neighbor in radio's reach). Source enters destination in the packet. While forwarding packet, each node use its neighbor location and destination information to forward packet to the next hop. Forwarding can be to single node or some node. Forwarding to some node is stronger and direct to some route to destination, but can waste a lot of power source (energy and bandwidth), so forwarding to single node is more efficient.

Each node forwards packet to the nearest neighbor to destination until finally packet reach the destination. Distance calculation on each sensor node use Euclidean calculation :

$$R = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \quad (2.2)$$

Where: R = Distance between nodes
x_1 = Source node position on x axis
y_1 = Source node position on y axis
x_2 = Destination node position on x axis

y_2 = Destination node position on y axis

E. Calculation of Energy Use in Routing Protocol

Has been described by Wendi Rabiner Heinzelman [6], where:

Transmitter Energy:

$$Etx(k,d) = \begin{cases} k.Eelec + k.Efs.d^2 & d < d' \\ k.Elec + k.Emp.d^4 & d > d' \end{cases} \quad (2.3)$$

Receiver Energy:

$$Erx(k) = Erx\sim elec(k) = k.Eelec \quad (2.4)$$

$$Etotal = Etx + Erx + Eidle \quad (2.5)$$

Etx is the energy used to transmit data. Erx is the energy used to receive data. K is the number of data bits. Eelec is the energy used for operation of the circuit on the radio device. Efs is energy for signal transmission. d is distance from transmitter to receiver. Emp is energy to amplify the signal. Eidle is energy when the sensor turn on but does not perform activities.

III. SIMULATION

This research use two different scenarios. That is gradient based approach and geographic based approach. Where each scenario will be using the same input parameters and at the end of this simulation, it will be compared the simulation result of both method. The parameters to be compared is, jump or hop, distance, and energy used in each method for sending data.

On this simulation, several assumptions are used, as follows:

- Data transmission is done from all nodes as the source and the base station as destination.
- Data transmission is done one by one from node 1 to 100 as the source and the base station as the destination.
- There is no obstacle.
- Does not pay attention to the process after the data in the BS.
- Only focus on power consumption.
- Do two scenarios, gradient based approach and geographic based approach.
- Simulation using MATLAB R2012b.

A. Gradient based approach

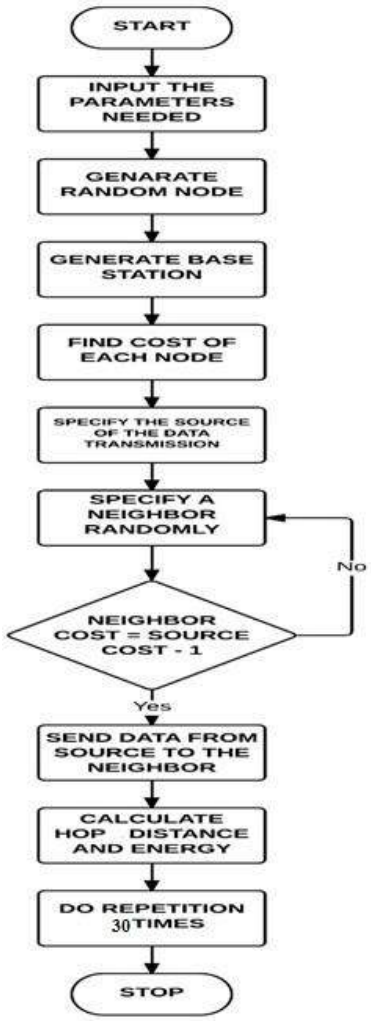

FIGURE 3.1 FLOWCHART GRADIENT BASED APPROACH

Figure 3.1 illustrates a flowchart of gradient based approach. Where in the initial stage input parameters are needed. Because the result of the simulation output of both method will be compared, then the input parameters is same for both method. And then nodes will be generated randomly in position, node as a source of data transmission, which will transmit data in multi hop. Then base station will be generated as the final destination from the data source.

Then the route searching step is based on gradient based approach. After the route is obtained, process will be repeated 30 times in order to see which the most efficient route is. The result of the simulation desired are the number of jump or hop at the time of transmission data, the distance of sending data, and energy needed in data transmission.

After choosing one of the most efficient route, the route then would be compared with the output of the geographic based approach simulation.

B. Geographic based approach

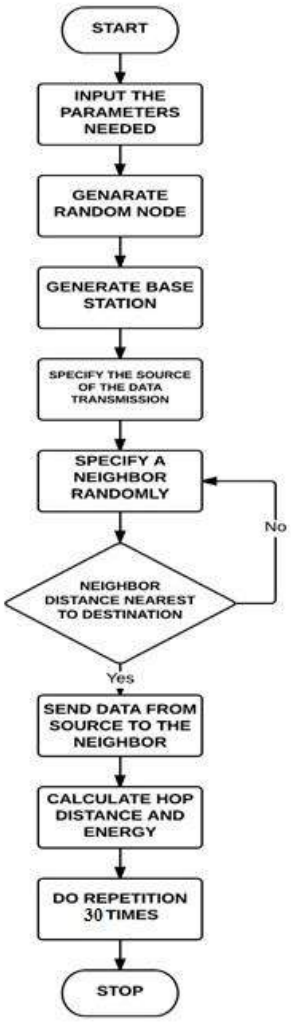

FIGURE 3.2 FLOWCHART GEOGRAPHIC BASED APPROACH

Figure 3.2 illustrates a flowchart of geographic based approach. The process is the same as before until the nodes and the base station are generated.

After that the route searching step is based on geographic based approach. After the route is obtained, process will be repeated 30 times in order to see which the most efficient route is. The result of the simulation desired are the number of jump or hop at the time of transmission data, the distance of sending data, and energy needed in data transmission.

After one of the most efficient route is chosen, then the route would be compared with the output of the gradient based approach simulation.

IV. RESULT

On this research, searching the route on both method was done 30 times to find the most efficient route for sending data.

A. Gradient Based Approach

a. Analysis of the number of hop on the gradient based approach

Figure 4.1 shows total hop, that was gotten for 30 times of searching the route, which is the same, 375 hop. Total hop that was gotten is the same because cost was already decided at beginning and the route searching followed the hop. So, although the founded route were a lot and data passed through different route, total hop would be the same.

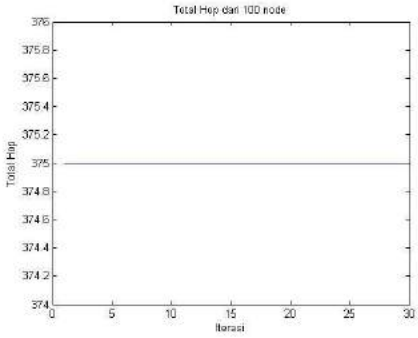

FIGURE 4.1 TOTAL HOP OF 100 NODES WITH GRADIENT BASED APPROACH

b. Analysis total distance on gradient based approach

On each data transmission that used a different route, the total distance of the data transmission would be different. Even though the gradient based approach had the same hop value, the route will be different, which then made the total distance different.

Figure 4.2 show the total obtained distance on 30 times route searching, which are 4454.1341 meter, 4449.9674 meter, 4443.2785 meter, 4503.5617 meter, 4443.0947 meter, 4480.2794 meter, 4434.5927 meter, 4468.2002 meter, 4465.3837 meter, 4438.1564 meter, 4435.7183 meter, 4430.4826 meter, 4536.7737 meter, 4469.6565 meter, 4478.8051 meter, 4414.3822 meter, 4442.9927 meter, 4491.4607 meter, 4470.6525 meter, 4461.3205 meter, 4440.4461 meter, 4439.8887 meter, 4451.4223 meter, 4446.9294 meter, 4487.6047 meter, 4462.5364 meter, 4479.5069 meter, 4469.8172 meter, 4436.0256 meter, and 4466.6088 meter. With the average distance is 4459.7893 meter. And minimum distance is on the sixteenth search, which is 4414.3822 meter.

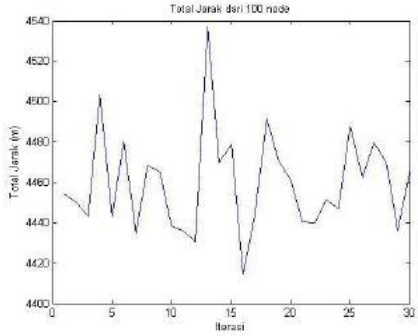

FIGURE 4.2 TOTAL DISTANCE OF 100 NODES WITH GRADIENT BASED APPROACH

c. Analysis energy consumption on gradient based approach

From the formula developed by Wendi Rabiner Heinzelman, it was proven that energy is also influenced by hop and distance. The more hop and the farther distance data transmission, the energy needed will be greater.

Figure 4.3 shows the energy for sending data from each node to the base station on 30 times route searching, which are 0.0767346 Joule, 0.0767367 Joule, 0.0767331 Joule, 0.0767575 Joule, 0.0767336 Joule, 0.0767489 Joule, 0.0767293 Joule, 0.0767456 Joule, 0.0767456 Joule, 0.0767314 Joule, 0.0767276 Joule, 0.076731 Joule, 0.0767726 Joule, 0.076743 Joule, 0.0767456 Joule, 0.0767189 Joule, 0.0767323 Joule, 0.0767542 Joule, 0.0767474 Joule, 0.0767421 Joule, 0.0767332 Joule, 0.0767333 Joule, 0.0767345 Joule, 0.0767333 Joule, 0.0767535 Joule, 0.0767411 Joule, 0.076747 Joule, 0.0767446 Joule, 0.0767311 Joule, 0.076744 Joule.

With average energy is 0.0767402 Joule. And minimum energy is on sixteenth search, which is 0.0767189 Joule.

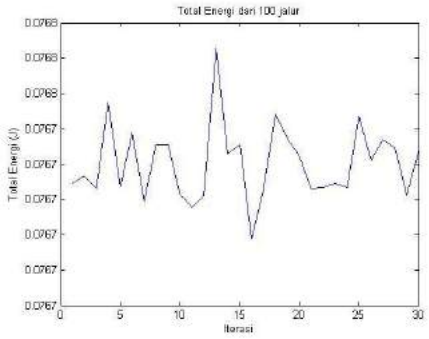

FIGURE 4.3 TOTAL ENERGY OF 100 NODES WITH GRADIENT BASED APPROACH

B. Geographic Based Approach

a. Analysis of the number of hop on the geographic based approach

From simulation result, it was obtained that total hop from sending the data from node 1 to node 100 to base station is 411 hop on 30 times route searching. On geographic based approach, the same hop was obtained because the route that was gotten on 30 times route searching was the same. Figure 4.4 shows total hop, that was gotten on 30 times route searching, which is the same, 411 hop.

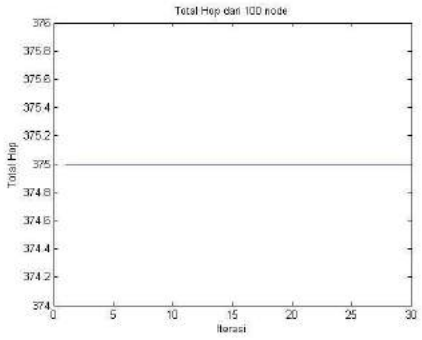

FIGURE 4.4 HOP TOTAL OF 100 NODES WITH GEOGRAPHIC BASED APPROACH

b. Analysis total distance on geographic based approach

Figure 4.5 shows the same distance of 30 times route searching. The same total distance was caused by route searching only finding one route with geographic based approach method. Total distance when data were transmitted from 100 node to the base station is 4588.4049 meter.

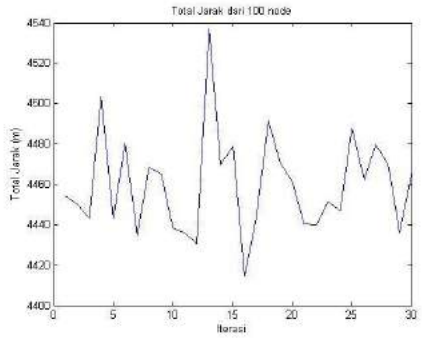

FIGURE 4.5 TOTAL DISTANCE OF 100 NODES WITH GEOGRAPHIC BASED APPROACH

c. Analysis energy consumption on geographic based approach

Figure 4.6 shows energy from 30 times route searching, which is the same, 0.0836362 Joule. That energy was same because the route that was gotten was the same,. While energy was affected by hop and distance.

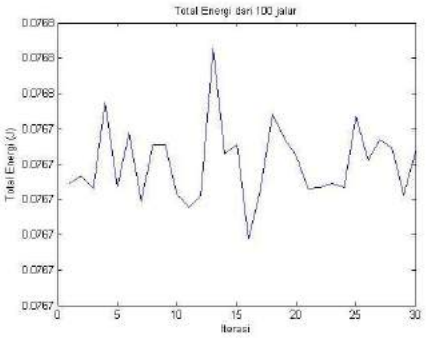

FIGURE 4.6 TOTAL ENERGY OF100 NODES WITH GEOGRAPHIC BASED APPROACH

C. *Comparison of Gradient Based Approacn and Geographic Based Approach*

FIGURE 4.7 COMPARISON OF GRADIENT BASED APPROACH AND GEOGRAPHIC BASED APPROACH

This both method used the same input parameter and the same simulation result parameters, but there were differences on simulation output, which is shown in Figure 4.7. In gradient based approach method, after 30 times route searching, the most efficient route was in on the sixteenth. So, the result of the sixteenth route searching was compared with geographic based approach. The result of the sixteenth route searching were, 375 of total hop, 4414.3822 meter of total distance, 0.0767189 Joule of total energy.

In geographic based approach, after 30 times route searching, the result on hop, distance and energy was the same on each route searching, because the route that was founded was just one route. The result were 411 of hop, 4588.4049 meter of distance, and energy needed was 0.0836362 Joule. So, from the comparison result of hop, distance, energy, gradient based approach had more efficiency more than geographic based approach.

Each routing protocol have advantages and disadvantages. Gradient based approach had more efficiency than geographic based approach on total hop, total distance, and total energy. But on gradient based approach, calculating the cost must be done at beginning, so it had more step on route searching. Also, gradient based approach had no information of geography location of node coordinate.

On geographic based approach, efficiency of hop, distance, and energy was not better than gradient based approach. But geographic based approach did not need to calculate hop for route searching. It only needed to know distance of each node to the base station and could be gotten from geography information that was saved on each node. Also, geographic based approach had information of node coordinate that can be used for many applications.

V. CONCLUSION

On this research, it can be concluded as folows:

1. Gradient based approach method is more efficient on total hop, distance, and used energy for packet sending than geographic based approach. With gradient based approach, total hop is 375, distance is 4408.4449 meter, and energy is 0.07671612 Joule. With geographic based approach total hop is 441, distance is 4586.404914 meter, and used energy is 0.0836362 Joule.
2. Gradient based approach can be used for network that do not consider geography location important, but need energy as minimum.
3. Geographic based approach can be used for network that need geography information for a node sensor.

From the research that has been done, there were some difficulties, such as design of simulation and doing the simulation, so the suggestion for next research are:.

1. Use another simulator such as NS, Omnet, etc, to see whether it will has the same result.
2. Gradient based approach should be used for network that need large power efficiency but do not consider location important, for example on indoor WSN applicant such as temperature.
3. Geographic based approach should be used on outdoor network that need enough power efficiency and need coordinate information. For example on military to detect enemy, using this routing protocol can know where the enemy is and is not on the coordinate.

VI. ACKNOWLEDGMENT

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