Comparative Analysis of Leach-C and Pegasis Routing Algorithms in a Wireless Sensor Network using Network Simulator-2

Dimas Setiawan Saputro, Siti Ummi Masruroh, and Nashrul Hakiem
Department of Informatics, Faculty of Science and Technology, UIN Syarif Hidayatullah Jakarta, Indonesia.
hakiem@uinjkt.ac.id

***Abstract*—Since 2001, the development of Wireless Sensor Networks has generated an increased interest from the perspective of the industry and research. Sensors collect data from the environment and then send the data to the actor node that processes all the incoming data and takes action. The usefulness of wireless sensor networks in an unobstructed field of computing and sensing capabilities is limited. Optimization of the energy consumption in the network is done by implementing an efficient routing algorithm that uses less energy. PEGASIS and LEACH-C are two types of algorithm that are identified as energy efficient and lifetime friendly. In this research, simulation and analysis comparisons of the performance of both types of routing algorithm have been performed with parameters, such as energy efficiency, node lifetime and throughput using Network Simulator 2 (NS-2) in areas of 100 m×100 m, 300 m×300 m and 600 m×600 m. In the analysis of the performance in terms of energy efficiency, node lifetime and throughput, the results lead to the conclusion that the performance of the PEGASIS algorithm is superior in an area of 100 m×100 m, while the LEACH-C algorithm is superior for areas of 300 m×300 m and 600 m×600 m.**

***Index Terms*— Efficiency; LEACH-C; Lifetime; PEGASIS; Routing Algorithm; Throughput; Wireless Sensor Network.**

I. INTRODUCTION

The utilization of sensors is now widely applied in various fields. The use of sensors in vehicles, factories and even smartphones provides growing evidence that sensor technology is vital to the modern lifestyle. Although it may appear that the sensor has been in use for a long time; in fact, research in wireless sensor networks (WSN) only began in the 1980s, and since 2001 the development of WSN has generated increasing interest from the research and industry perspective. This is because such devices are generally available with cheap and powerful components, especially as the processor, radio, and these sensors are often integrated onto a single chip (system on a chip (SoC)) [1].

In the communication architecture of a wireless sensor network, several devices are interconnected through the use of radio waves. The sensor includes the environment, a collection of sensor nodes and a node actor. All the sensor nodes are connected to a particular node actor. The sensors collect data from the environment and then send that data to the actor node that processes all the incoming data and takes appropriate action. The data collected are sent from the sink through the gateway to the task manager. Users only need to interact with the task manager and process the incoming data [2].

A wireless sensor network has some limitations, such as limited of energy supply, computing power, and bandwidth that connects the sensor nodes. One of the main design goals of wireless sensor networks is to carry out data communications while extending the lifetime of the network and preventing degradation connectivity by using aggressive energy management techniques [3].

Research in routing algorithms is an aspect of wireless sensor networks. Compared with traditional wireless networks, the node energy is limited and cannot be replenished, thus using an energy efficient node becomes the first factor to be considered [4]. To optimize energy consumption in the network is to implement a routing algorithm that defines a set of rules to determine how to transfer the message packets from the source to the destination in the network efficiently and with less energy consumed [5].

PEGASIS and LEACH-C are two kinds of hierarchical routing protocols in a wireless sensor network [6]. Hierarchical routing is an efficient method to reduce energy consumption within a cluster and to perform data collection and fusion in order to limit the number of transmitted messages to the Base Station [7].

In PEGASIS, each node communicates only with the closest neighbor by adjusting its power signal to be only heard by this closest neighbor [8]. The centralized LEACH (LEACH-C) protocol can produce better performance by distributing the Cluster Head throughout the network. The sink (Base Station) runs a centralized cluster formation algorithm to determine the clusters for a round [9].

The remaining of this paper is organized as follows. Section II describes works related to this research and Section III briefly reviews the research methodology. Section IV describes the experimental results on these findings while Section V provides the conclusion of this paper.

II. RELATED WORKS

The previous research related to a wireless sensor network was conducted, for example in [5]. This paper compares some features of LEACH protocol variants. It reviews the taxonomy of WSN routing protocols and also highlights issues in LEACH protocol along with disadvantages. The objective of this paper is to provide brief detail of some LEACH improved versions.

There is also another research [10] which evaluates the performance of PEGASIS routing algorithms. This study completed experiments over areas of 100 m×100 m and 300 m×300 m, with a number of nodes 75, 100, and 150 and performance parameters of consumption energy and node lifetime by using Network Simulator-2. The study resulted in a comparison chart of energy consumption and the lifetime of nodes taken from six different simulation scenarios. It showed that each PEGASIS node only communicate with the nearest neighbor node and transmit to the base station, therefore it reduces energy consumption per session i.e. longer lifetime node.

Based on this background, the authors raised the title "Comparative Analysis of LEACH-C and PEGASIS Routing Algorithms in a Wireless Sensor Network using Network Simulator-2" to be studied more deeply. The purpose of this paper is to simulate the LEACH-C algorithm in a wireless sensor network using Network Simulator-2 and to compare it with the PEGASIS algorithm based on the parameters of energy efficiency, throughput, and node lifetime taken from each scenario.

III. METHODOLOGY

Figure 1 shows the research method which has been used.

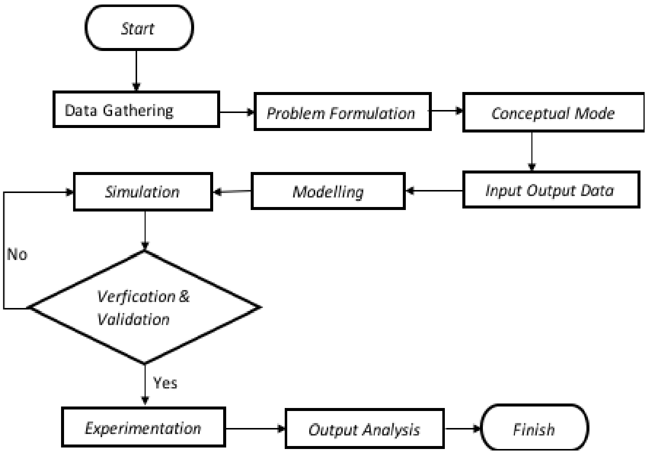


Figure 1: Research Method

The conceptual mode consists of several provisions as discussed in the previous literature as depicted in Table 1.

Table 1
Simulation Parameters

Scenario	Area (m)	Nodes
1		75
2	100 × 100	100
3		150
4		75
5	300 × 300	100
6		150
7		75
8	600 × 600	100
9		150

1) *The area of the simulations are 100 m×100 m, 300 m×300 m and 600 m×600 m.*
2) *The number of nodes is 75, 100, and 150.*
3) *The simulation duration is 600 seconds and the given energy is 2 Joules.*
4) *Only one node actually transmits data to the base station, and this is called the cluster head.*
5) *The regional deployment of nodes is created with random coordinates.*

The performance is measured with parameters of energy efficiency, node lifetime, and throughput. The detail of the parameters are as follows.

A. Energy Consumption

Energy consumption is the result of the total amount of energy between the energy transmitted, received, and when idle. The equation is as follows:

$$E_{total} = E_{receive}(n) + E_{transmit}(n) + E_{idle}(n) \tag{1}$$

$E = Energy$
$n = number\ of\ nodes\ to\ be\ passed$

B. Node Lifetime

Node Lifetime is the age of the node. Energy expenditure has a very large impact on the lifetime of a node.

C. Throughput

Throughput can be calculated using Equation (2) [11]. Total data is the amount of data (bytes) received by the base station.

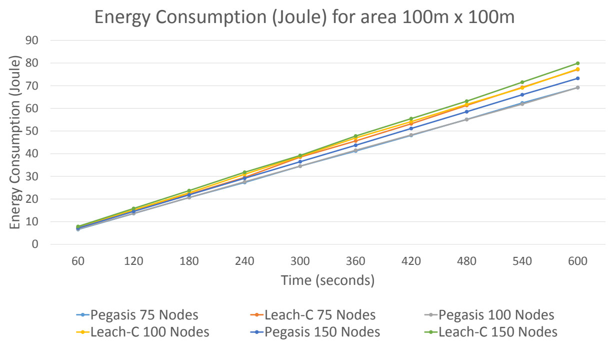
$$Throughput = \frac{number\ of\ bytes\ received}{time} \tag{2}$$

IV. EXPERIMENTAL RESULTS

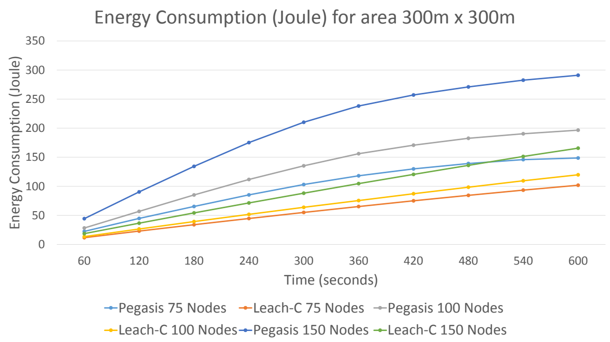
The simulation was conducted using NS-2 after setting the input parameters according to each scenario with the duration of 600 seconds and a given energy of 2 Joules.

A. Energy Consumption

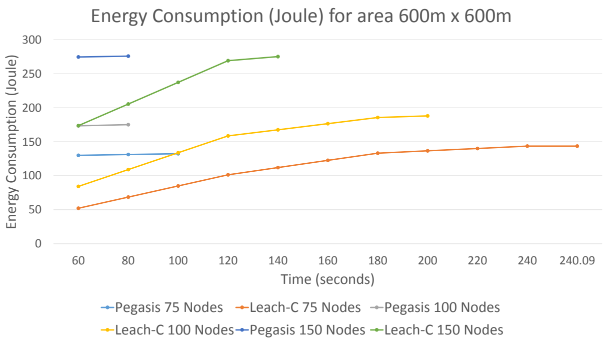
Figure 2 (a, b, and c) shows the energy consumption result of the simulation which was an area of 100 m×100 m, 300 m×300 m, and 600 m×600 m with 75 nodes, 100 nodes, and 150 nodes.



(a)



(b)



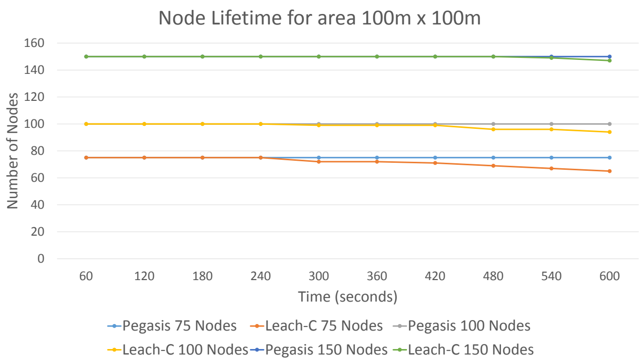
(c)

Figure 2: Simulation result for Energy Consumption; (a) Comparison of Energy Consumption for an area 100 m×100 m, (b) Comparison of Energy Consumption for an area 300 m×300 m, (c) Comparison of Energy Consumption for an area 600 m×600 m

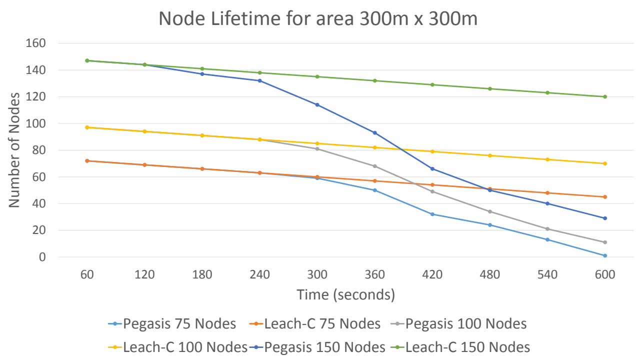
The resulting energy consumption for LEACH-C was greater than for PEGASIS for an area of 100 m×100 m and 600 m×600 m, while for the area of 300 m×300 m the energy consumption of LEACH-C was less than PEGASIS.

B. Node Lifetime

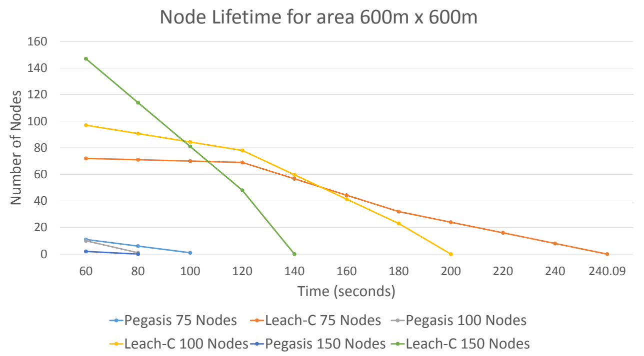
Figure 3 displays the node lifetime of the simulation assumed to be an area of 100 m×100 m, 300 m×300 m, and 600 m×600 m with 75 nodes, 100 nodes, and 150 nodes.



(a)



(b)



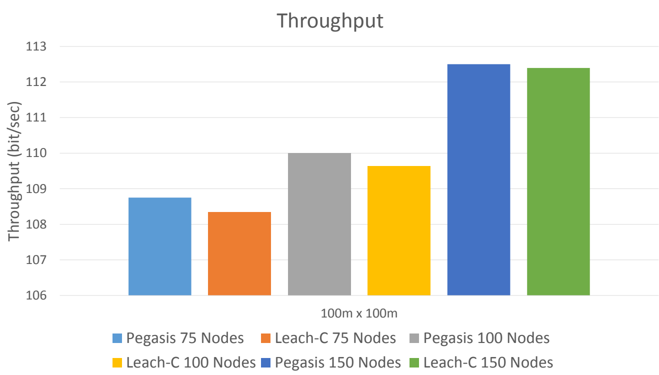
(c)

Figure 3: Simulation result for Node Lifetime; (a) Comparison of Node Lifetime for an area 100 m×100 m. (b) Comparison of Node Lifetime for an area 300 m×300 m, (c) Comparison of Node Lifetime for an area 600 m×600 m

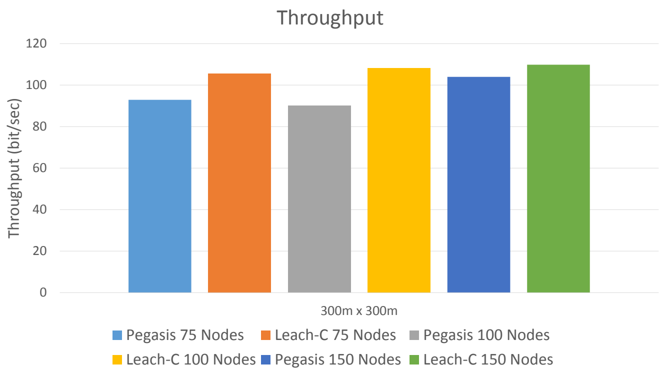
For node lifetime parameter that shows the parameter of node lifetime, the PEGASIS routing algorithm indicates no node is dead at the end of the simulation for all experiments (75, 100, and 150 nodes) for the area of 100 m×100 m. However, the LEACH-C routing algorithm has a better node lifetime parameter than PEGASIS for areas of 300 m×300 m and 600 m×600 m.

C. Throughput

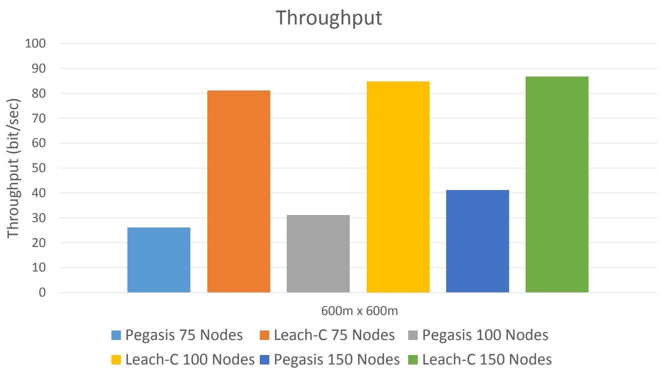
Figure 4 demonstrates the last parameter i.e. throughput for an area 100 m×100 m, 300 m×300 m, and 600 m×600 m with 75 nodes, 100 nodes, and 150 nodes.



(a)



(b)



(c)

Figure 4: Simulation result for Throughput; (a) Comparison of Throughput for an area 100 m×100 m, (b) Comparison of Throughput for an area 300 m×300 m, (c) Comparison of Throughput for an area 600 m×600 m

Figure 4 shows that for the parameter of throughput, the PEGASIS routing algorithm indicates better value for the area of 100 m×100 m. However, the LEACH-C routing algorithm has a higher throughput parameter than PEGASIS for areas of 300 m×300 m and 600 m×600 m.

V. Conclusion

The results of the comparative analysis of the performance of the LEACH-C and PEGASIS routing algorithms show that, the PEGASIS routing algorithm indicates the least value for the area of 100 m×100 m and 600 m×600 m for the parameter of energy consumption. However, the LEACH-C routing algorithm has a lower energy consumption parameter than PEGASIS for areas of 300 m×300 m. A lower value of energy consumption indicates better performance from the routing algorithm, i.e. higher energy efficiency.

For the node lifetime parameter, the superior performance belongs to the PEGASIS routing algorithm for the 100 m×100 m area, where no node is dead at the end of the simulation. For the area of 300 m×300 m and 600 m×600 m, the node lifetime for LEACH-C is greater than the node lifetime for PEGASIS. The greater the node lifetime indicates a better performance of the routing algorithm.

The resulting throughput for LEACH-C is smaller than PEGASIS for an area of 100 m×100 m, while for the area of 300 m×300 m and 600 m×600 m the throughput of PEGASIS is less than LEACH-C.

Overall, the performance of the PEGASIS algorithm is superior over an area of 100 m×100 m, while the LEACH-C algorithm is superior for areas of 300 m×300 m and 600 m×600 m.

References

[1] S. Yinbiao, K. Lee, P. Lanctot, F. Jianbin, H. Hao, B. Chow, and J.-P. Desbenoit, “Internet of Things: Wireless Sensor Networks,” 2014.

[2] H. Kaur, “A Review on Wireless Sensor And Networks Actor,” *Int. J. Adv. Res. Comput. Sci. Softw. Eng.*, vol. 4, no. 5, pp. 863–867, 2014.

[3] P. Kumar and M. Challa, “Predicting and Extending of Sensor Lifetime in Wireless Sensor Networks using Fuzzy Logic,” *Int. J. Sci. Res. ISSN (Online Index Copernicus Value Impact Factor*, vol. 14, no. 6, pp. 2319–7064, 2013.

[4] L. Tian, H. Du, and Y. Huang, “The simulation and analysis of LEACH protocol for wireless sensor network based on NS2,” in *2012 International Conference on System Science and Engineering (ICSSE)*, 2012, pp. 530–533.

[5] H. Dhawan and S. Waraich, “A Comparative Study on LEACH Routing Protocol and its Variants in Wireless Sensor Networks: A Survey,” *Int. J. Comput. Appl.*, vol. 95, no. 8, pp. 975–8887, 2014.

[6] S. Parvin and M. S. Rahim, “Performance Evaluation of LEACH and PEGASIS: Two Prominent Routing Protocols for Wireless Sensor Networks.” University of Rajshahi Bangladesh, Rajshahi, 2007.

[7] S. Vhatkar, J. Rana, and M. Atique, “Performance Evaluation and QoS Analysis of EEPB and PDCH Routing Protocols in Wireless Sensor Networks,” *IOSR J. Comput. Eng.*, vol. 17, no. 5, pp. 2278–661, 2015.

[8] L. Almazaydeh, E. Abdelfattah, M. Al-Bzoor, and A. A. Al-Rahayfeh, “Performance Evaluation of Routing Protocols in Wireless Sensor Networks,” *Int. J. Comput. Sci. Inf. Technol.* , vol. II, no. 2, pp. 64–73, 2010.

[9] P. M. Dave and P. D. Dalal, “Simulation & Performance Evaluation of Routing Protocols in Wireless Sensor Network,” *Int. J. Adv. Res. Comput. Commun. Eng.*, vol. II, no. 3, pp. 1405–1412, 2013.

[10] S. Saputra, “Evaluasi Kinerja Efisiensi Algoritma Routing Pegasis pada Wireless Sensor Network menggunakan Network Simulator-2,” UIN Syarif Hidayatullah Jakarta, 2012.

[11] N. Sharma, “Impact of varying packet size on multihop routing protocol in Wireless Sensor Network,” *Int. J. Adv. Stud. Comput. Sci. Eng. IJASCSE*, vol. 3, no. 9, pp. 10–16, 2014.