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Development of the Multi-Channel Clustering Hierarchy Method for Increasing Performance in Wireless Sensor Network

Robby Rizky , Zaenal Hakim , Sri setiyowati, Susilawati , Ayu Mira Yunita
Universitas Mathla'ul Anwar, Banten, Indonesia

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ABSTRACT

Wireless Sensor Networks are technologies that make it possible to observe phenomena. The problem is data delays in covering the distance from the origin to the destination. Packet Loss is a condition that shows the number of lost packets and the total queue length caused by data processing time. **This research aims** to develop a cluster-based protocol. **This research used a multi-channel hierarchical clustering method** and added odd-even by dividing the network into several channels and forming a cluster head for each channel. **The research results** were Channel 1 with a throughput value of 1.88, channel 2 with a throughput value of 21.68, channel 3 with a throughput value of 1.62, and channel 4 with a throughput value of 42.44. This study concluded that the throughput results are smaller than the Multi-Channel Clustering Hierarchy method because not all nodes are active.

Corresponding Author:

Robby Rizky +6285722996564,
Faculty of Technology and Informatics,
Universitas Mathlaul Anwar, Banten, Indonesia,
Email: robby.rizky@unmabanten.ac.id.

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1. INTRODUCTION

The problem with Wireless Sensor Networks (WSN) is delay, which is the time needed for data to travel the distance from origin to destination. Delay can be affected by distance. Packet loss is a parameter that describes a condition that shows the number of packets lost, and packet loss can occur due to congestion on the network. A jitter is a variation in queue length, resulting in data processing time and packet reassembly time at the end of the jitter journey. Throughput is the data transfer speed caused by a bottleneck, which is caused by a data flow jam, resulting in decreased WSN performance [1]. Another problem that often occurs in WSNs is slow data transmission, which decreases WSN performance [2]. Another problem is data collisions, where collisions are physical segments that can collide between data nodes [3]. Sensor nodes have limited energy resources. Recharging the battery is generally not possible because the position of the sensor nodes is in extreme conditions [4]. As with natural disaster locations, the lifetime of the WSN needs to be increased so that the benefits of the WSN can be felt longer [5]. One model that can be used to improve performance, namely geographic routing (GR) or route determination based on geographical position, was introduced to overcome the limitations of topology-based routing protocols [6]. The geographic routing protocol relies on the physical location information of the nodes in the WSN obtained from the location service [7]. By utilizing geographic position information, GR does not need to perform routing table maintenance and can even run without a routing table at all [8]. Several GR protocols in WSN development have been introduced, such as greedy routing, which was developed to improve performance on WSN by calculating all paths based on the Euclidean distance from the sensor node to the sink node [9]. The latest protocols are generally a development of the Greedy Routing protocol by adding certain modifications according to delay and throughput considerations. Another model in developing WSN protocols to improve WSN performance is shortest path routing (SGP). It is an extensively researched protocol on WSN because it promises a low packet delivery ratio with a low delay time [10]. In addition, the SGP protocol does not require complicated computations. So, it is suitable for WSNs with limited computational capabilities [11]. A method for developing protocols to improve performance on WSNs has been carried out previously under the name energy-efficient - multiple - cluster - head - selection routing protocol (EEMCHRP) [12] that handles low-performance and stray nodes on WSN. This is done to reduce the amount of direct communication to the sink. However, in EEMCHRP, the one hope communication model is still used, and outside the simulated area, it is relatively small, namely 100 x 100m, with unlimited radio transmission power to a node [11]. The Zigbee protocol is a protocol developed by the Zigbee Alliance where this protocol can improve the performance of the WSN [13]. By using MAC and PSY layer-based communication. However, this protocol is equipped with several features, one of which is that nodes using this protocol can become three types of nodes: end device at router and coordinator [14]. Previous researchers have developed the multi-channel model by forming four channels with a clustering technique called multi-channel clustering hierarchy (MCCH) [15]. MCCH has four stages: determining humidity temperature data, forming four channels, determining the closest node to the cluster head, and grouping the process using a single linkage HAC [16]. The model used in this study is the multi-channel model. This model can divide several channels to overcome the problems in WSN [17]. Several researchers have used this multi-channel model to improve WSN performance. This multi-channel model can divide several channels and divide several nodes to overcome traffic jams on WSN lines [18]. Previous research related to improving performance [19]. An energy-efficient architecture of high-performance FIR adaptive filter design using approximate distributed arithmetic (DA), which is integrated with canonic signed digit-based triangular common sub-expression elimination (CSDTCSE) and carry-resist adder-based Booth recorder adder (CRABRA) is proposed for noise removal in sensor nodes. Each networks output is considered input to the Optimized Recurrent Neural Network (ORNN) for predicting the ending superiority of the whole IoT network. Here, parameter tuning in the RNN is done using the Self Adaptive Honey Badger Algorithm (SA-HBA) [20]. An improved Ant Colony Optimization (ACO) algorithm is proposed to acquire UAVs spot-checking flight trajectories [21] efficiently. The proposed method comprises two stages: the training stage, where the neural network is trained with appropriate models, and the execution stage, where the trained network suggests the cluster heads location based on the sensors conditions. The results demonstrate that the proposed method can accurately identify suitable locations for cluster heads in a sensor network and can adapt to new models despite environmental changes and variations in input configurations [22]. The positioning of this research is a multi-channel model, and this research develops a method to improve WSN performance. This research develops the MCCH method, which previous researchers carried out by adding one stage by inserting odd and even, which can provide new contributions. In this study, the MCCH method was developed by adding odd-even steps to the MCCH method. The development of the MCCH method has five steps: determining temperature and humidity data, forming four cluster heads, determining the closest node to CH, determining active and inactive nodes using the odd-even technique, and grouping process using single linkage HAC. In the odd-even technique on the node, if the even node is active, then the odd node dies. Conversely, if the odd node is on, then the even node is dead; this technique is believed to be able to break down the traffic density on the WSN route. Smart irrigation systems cannot be separated from wireless sensor network technology, so they are connected to one another. Various types of sensors can help the performance of this smart irrigation. The sensor can describe the system built by applying a fuzzy logic algorithm to describe temperature and humidity variables, resulting in more optimal watering.

Problems occur when delays often occur. A delay is a queue contained in the WSN protocol line that can reduce performance and make the irrigation system suboptimal [23].

The gap between this research and previous research is that this research uses a multi-channel model and odd-even techniques. When the even node is active, the odd node is turned off to improve performance on WSN. **The difference between previous research and the multi-channel model is the addition of** stages that previous researchers have never done, namely the addition of odd-even steps that can improve performance on WSN. To overcome the problems that exist in smart irrigation systems, it is necessary to develop WSN protocols so that irrigation system performance can work optimally. The main factor in optimizing the irrigation systems performance is to improve the performance of the WSN in terms of data exchange. To improve the performance, a protocol for WSN must be developed, and the performance must be tested. If WSN performance is good, the irrigation system will work optimally [**?**].

This research aims to develop a cluster-based protocol. The development of the MCCH method answers all problems in WSN in the form of delay, Packet Loss, jitter, and Throughput. This method can improve WSN performance by increasing the Throughput value. Clustering is a tool used for analysis. This is related to the process of grouping data so that groups with a strong degree of relationship between cluster members are formed. Clustering can be said to be a discovery tool because this method can find information relationships through existing structures. Data that is not yet clear turns into a new relationship in the form of useful information that makes sense when found, for example, for the needs of certain pattern analysis, grouping, machine learning, document retrieval, image segmentation, and pattern grouping. This study uses an odd-even technique to improve WSN performance [**?**]. This research contributes to the formation of cluster heads using retrieval probability, the formation of cluster heads and cluster members that are close to each other, the odd-even process, and the grouping process using proximity or similarity techniques using distance matrices.

2. RESEARCH METHOD

This research tests the development of the MCCH method with simulation using QoS parameters. To test the development of this method, the data used was the same as the original MCCH method. This research uses quantitative. Figure 1 explains that the blue nodes are the cluster heads as channel references, the red nodes are odd, and the green nodes are even. This research develops the MCCH method by adding an odd-even technique, where the even node is sleeping when the odd node is active. Conversely, the odd node is sleeping if the even node is active.

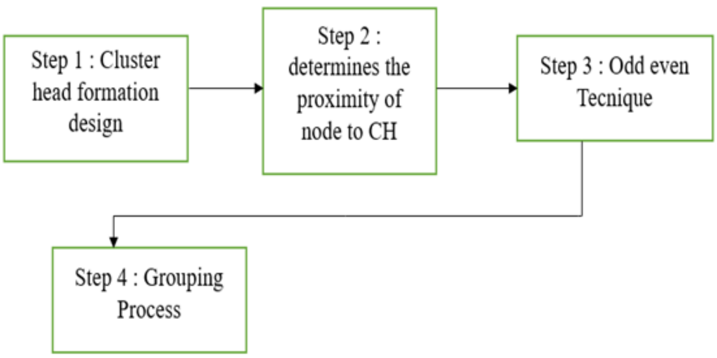

Figure 1. Protocol

Figure 2 explains the research flow process, starting with the node distribution process with initial energy, probability, and energy delivery parameters. The next step is forming a cluster head (CH) with several nodes becoming cluster members / non-CH, where several nodes are dead and several nodes are active to minimize the energy in the WSN. The final result is a throughput value on the WSN to measure performance.

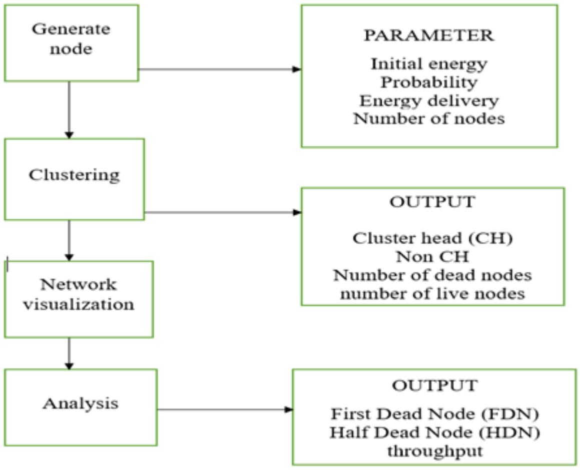

Figure 2. Research flow

Table 1 describes the steps of the method used in this study. This study has four steps: the first is the formation of a cluster head, the second step is the design between cluster heads and adjacent cluster members, the third stage is the odd-even process, and the final stage is the clustering hierarchy process. Table 1 explains the parameters used in the simulation in this research with a node distribution of 100, energy 100, X_{max} 300, Y_{max} 300, and Velocity 10000.

Table 1. Parameter Simulation

Parameter	Value
Number of nodes	100
Energy	100
Xmax	300
Ymax	300
Velocity	10000

2.1. Formation of Cluster Heads

The formation of Cluster heads in this research uses the concept of probability, which is the chance or possibility of an event, a measure of the possibility or degree of uncertainty of an event. The probability range is between 0 and 1; a value of 0 indicates cluster membership, while a value of 1 indicates becoming a cluster head. In this research, 100 nodes were randomly distributed and designed to form cluster heads and members. The task of the cluster head is to accommodate data from cluster members and send data to the base station/server. The task of cluster members is to send data to the cluster head. The formula for forming cluster heads uses a probability process by selecting variables as nodes on the WSN, as shown in Equation 1. At At this stage, to form a cluster head, use a probability formula: a value of 1 indicates becoming the cluster head, while a value of 0 indicates becoming a cluster member $T(n)$. The threshold per round node will be the cluster head if $m > T(n)$, P Applied Cluster head probability, r Round, N Nodes are grouped.

$$T(n) = \left\{ \frac{P}{10 - P(rmod\frac{1}{p})} \right\} \quad (1)$$

2.2. Calculation of the distance of each node and cluster head

The formation of cluster members and cluster heads so that they are close to each other uses Euclidean theory, where, this theory calculates the distance between two points. Calculate the distance between two points to determine the relationship between angle and distance. This second process is designed to form cluster heads and cluster members so that they are close together and transactions between nodes can be as efficient and more optimal. The formula for determining the Cluster head and cluster members are close to each other using Equation 2. At this stage, it forms between adjacent nodes using a Euclidean approach, D Node point, X1 Nodes on the X axis (CH), X_2 Nodes on the Y axis, X_{1j} X axis figure (CH), X_{2j} Y axis figure.

$$D(x_2, x_1) = \sqrt{\sum_{j=1}^{d}(x_2, x_1)^2} \tag{2}$$

2.3. Odd-even process

The odd-even technique in this study is designed to reduce leech traffic density in the WSN protocol. When the even nodes are active, the odd nodes will die, and conversely, when the even nodes die, the odd nodes will live. This concept is applied to reduce density and energy efficiency in WSNs to increase WSN performance. The formula for determining node variables when odd nodes are active and then even nodes are off is used with equation 3. At this stage, the odd calculation process is used to streamline work on the WSN node. While the increase in the Y coordinates for each point in the column position is 0 or even, the value (y) has the same value in the same row and increases $^*R_{cy}$ in the same column. The formula for determining odd nodes is given by Equation 4. At this stage, the calculation process even streamlines work on the WSN node. In odd-column positions, the value of M(y) is the same in the same row and increases by $^*R_{cy}$ in the same column but is higher by Rcy when compared to the value of M(y) in the even-column position. The formula for determining even nodes is provided in Equation 5. At this stage, the odd calculation process is used to streamline work on the WSN node. While the increase in the Y coordinate for each point in the column position is 0 or even, the value (y) has the same value in the same row, and increases $^*R_{cy}$ in the same column.

$$M(currentx) = M(previousx +^* R_{cx})_{even} \tag{3}$$

$$M(currenty)_0 = M(previousx +^* R_{cy})_{Odd} \tag{4}$$

$$M(currenty)_0 = M(previousx +^* R_{cy})_{even} \tag{5}$$

2.4. The process of forming a WSN channel using a Multi-Channel Clustering Hierarchy (MCCH)

The final step is the grouping process after all the stages have been carried out. A multi-channel clustering hierarchy is a protocol development on WSN that has a process to overcome problems, namely in the form of low throughput values. The first step is to determine the temperature criteria in the form of very cold, cold, moderately cold, cool, moderately hot, hot, and very hot and determine the criteria for humidity in the form of dry, moderately dry, moderate, humid, and wet. The second stage is the formation of cluster heads, which become channel references for node members to use. The third stage is to determine the closest node point using the Euclidean approach when looking for the closest member node to the cluster head. The fourth stage is determining the node members by grouping single linkage and looking for proximity to the cluster head. The clustering process uses the single linkage clustering technique by looking for similarities or closeness to fellow nodes. The similarity search process in this study uses a distance matrix for each similarity or closeness, which will then be grouped. So, after being grouped, a new axis is formed and entered into each cluster. How the development of the MCCH method works is the initial process of determining the cluster head using the LEACH algorithm, determining the member nodes with the cluster head. The grouping process uses a distance matrix to determine the closest grouping formula using Equations 6. At this, the grouping process uses a hierarchical single linkage approach: d Channel or CH, h node member, I node member, and J node member. Figure 3 explains that each cluster member sends data to the cluster head, and the cluster head sends data to the base station by forming four channels to handle WSN problems and explains the development protocol for the MCCH algorithm where if the odd node is active, then the even node will be inactive and vice versa. The method used in this research was successfully carried out by inserting an odd-even process, and better results were obtained, proving the analysis of the development of the MCCH method using the QoS parameter.

$$d_{(h,i,j)k} = min(d_{hk}, d_{jk}, d_{jk}) \tag{6}$$

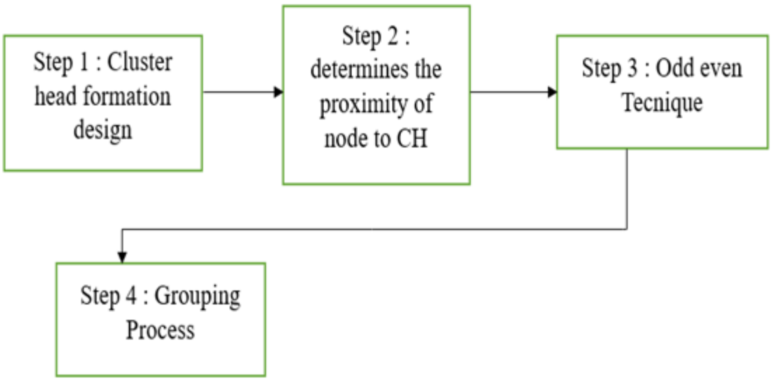

Figure 3. MCCH Algorithm development model

3. RESULT AND ANALYSIS

Figure 4 explains the simulation results of forming cluster heads and cluster members, where the red nodes are cluster heads and the blue nodes are cluster members. The simulation uses the Matlab application with 100 nodes and is processed using Qos parameters. Figure 4 explains the process of grouping cluster heads and cluster members by designing four channels, channels by forming cluster heads as shown in the red cluster heads, and cluster members in blue. So, when designing the node closest to the cluster head, that node will enter that channel group. The simulation uses the Matlab application with 100 nodes and is processed using Qos parameters. Throughput is the average data speed a node receives within a certain observation interval. Throughput describes the condition of the data rate in a network. The higher the throughput value generated, the routing protocol has better performance, throughput = number of packet sent shared package delivery time. The results of this study are in the form of developing a multi-channel clustering hierarchy / MCCH method and producing throughput values in WSN. This studys results align with the study entitled Improved Performance on Wireless Sensors Network Using Multi-Channel Clustering Hierarchy [1]. Clustering in the form of nodes on WSN in this study was developed using odd-even techniques, to make the performance of the WSN more efficient, when the odd node is active, the even node is off conversely when the even node is on, the odd node is off, it can save WSN performance and improve performance on WSN. the results of the throughput value in this study are lower than previous studies due to several reasons, in this study the detected nodes are not all nodes because they use odd-even techniques. When the even node is active, then the odd node is dead, and vice versa, making the node not detected active, only a few nodes are active.

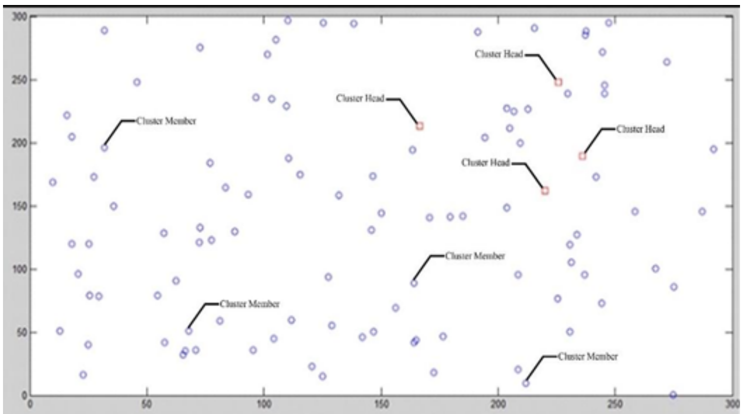

Figure 4. Cluster head formation

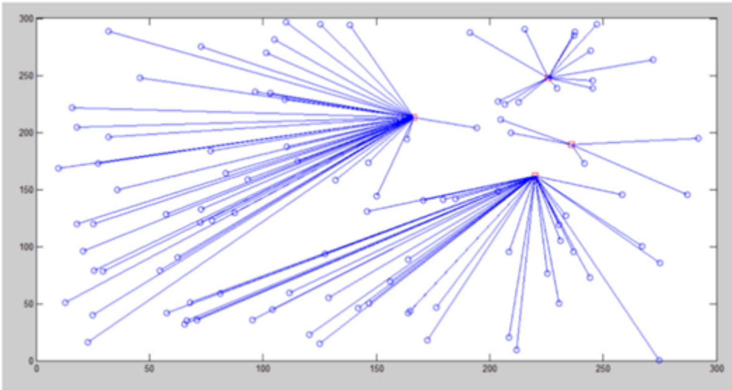

Figure 5. Cluster head formation

Packet loss is measured as the percentage of packets lost when packets are sent between source and destination nodes. Packet loss occurs when one or more data packets passing through a network fail to reach their destination. Packet loss = packets that experience loss shared shared package sent. Delay is the time needed to send data. Factors affecting delay are the time the protocol needs to find a route. Delay = sending time receiving time. Figure 6 describes the graph of data loss parameters in this study. Each parameter will be explained. This image comes from the Matlab application with the results: number 1 describes channel 1, number 2 describes channel 2, number 3 describes channel 3, and number 4 describes channel 4. The results can be seen in Table 2.

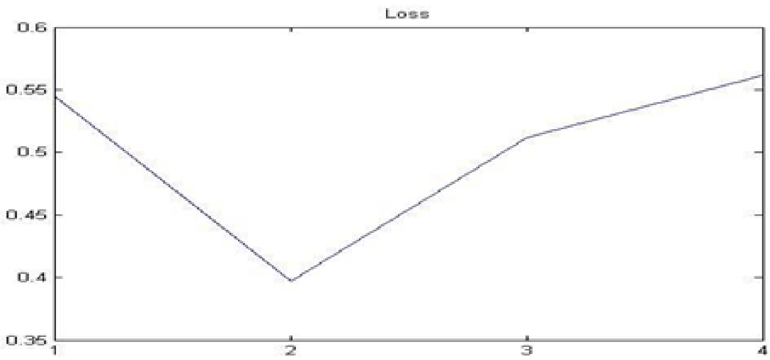

Figure 6. Loss parameters

Table 2 explains the data loss for each channel in this research, explaining in detail each channel and the results of the data loss. The bigger the number in Table 2, the bigger the data loss. From the data in Table 2, channel 4 has the largest data loss, which was 0.616. Figure 7 explains the graph of the delay parameters in this study, and each parameter will be explained. This image comes from the Matlab application with the results: number 1 describes channel 1, number 2 describes channel 2, number 3 describes channel 3, and number 4 describes channel 4. The results can be seen in Table 3, which explains the delay data on each channel and the delay for each channel in detail. The higher the number in Table 3, the greater the level of delay. In Table 3, the largest delay figure is on channel 2 with the number 39, which is the slowest in delivery data.

Table 2. Data Loss

Channel	Parameter
Channel 1	0.5455
Channel 2	0.3968
Channel 3	0.5120
Channel 4	0.5616

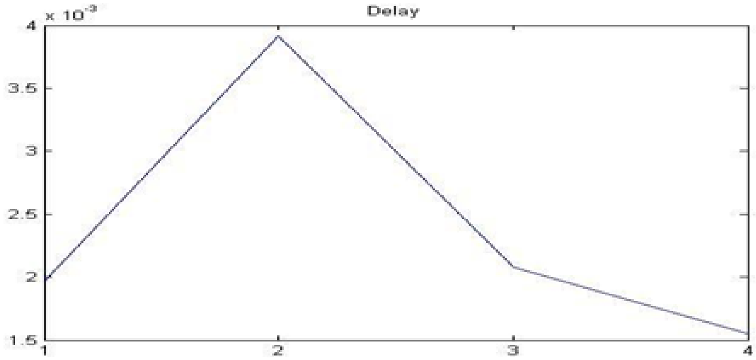

Figure 7. Delay parameter

Table 3. Delay

Channel	Parameter
Channel 1	0.0020
Channel 2	0.0039
Channel 3	0.0021
Channel 4	0.0015

Figure 8 explains the odd-even throughput graph, and the throughput data is explained in Table 4. This image comes from the Matlab application, with the number 1 describing Channel 1, number 2 describing Channel 2, number 3 describing Channel 3, and number 4 describing Channel 4. The results can be seen in Table 4. Table 4 describes the throughput parameter data, which is explained in detail for each channel. In this result, the throughput value differs from the previous table; the larger the number, the better the channel performance. In the data shown in Table 4, Channel 4 has the best performance with the number 2.22.

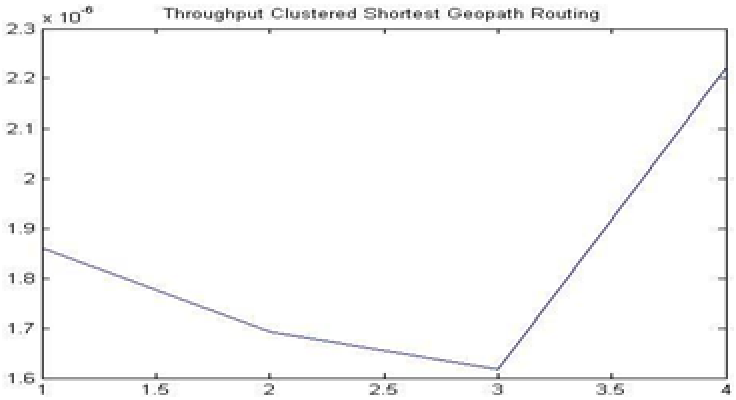

Figure 8. Odd-even throughput parameters

Table 4. Odd Even Throughput

Channel	Parameter
Channel 1	1.88
Channel 2	1.68
Channel 3	1.62
Channel 4	2.22

Figure 9 explains the throughput graph of the original MCCH [15]. In this research, we developed the MCH method by adding odd-even stages to the original MCCH. Number 1 describes channel 1, 2 describes channel 2, 3 describes channel 3, and 4 describes channel 4. Data can be seen in Table 5. explains the original MCCH throughput parameter data and explains each channel in detail. The original MCCH data from previous research is very large because the data entered is complete, and there are no odd or even numbers in the research. The throughput is small because data is entered when odd is on, then even is off, and vice versa, which makes performance better. In this research, modifying MCCH by adding an odd-even technique produces better performance because when the odd node is active, the even node is off, and vice versa. When the odd node is off, and the even node is on, it can save energy, speed up the data transfer process, and further minimize loss. Data and delay are due to a few active nodes.

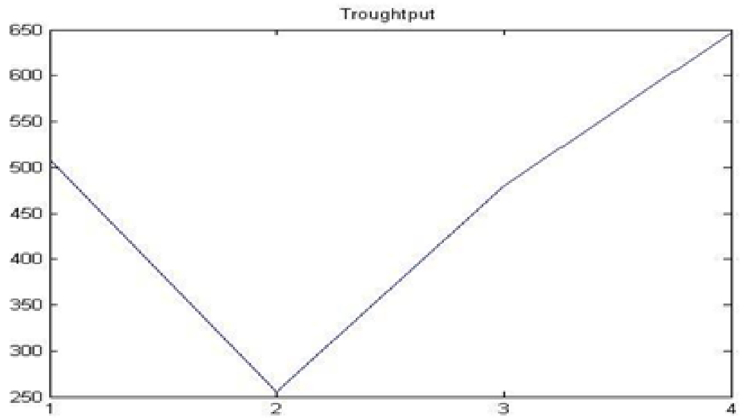

Figure 9. Throughput MCCH original

Table 5. Original MCCH Troughput

Channel	Parameter
Channel 1	5.085.165
Channel 2	2.555.661
Channel 3	4.798.289
Channel 4	6.465.618

This research was developed to save energy when exchanging data because when even nodes are active, then odd nodes are dead. This process does not directly save the transaction process and the energy used. The MCCH development process can solve several problems in the form of delay, data loss, jitter, and low throughput. This method can also improve WSN performance and overcome traffic congestion on WSN protocol lines. The nodes used are 100 nodes distributed, and a traffic density of 100% in one path is broken down into 20% per path and 5% active and dead nodes. Thus, the traffic density on the WSN path can be achieved with the proposed MCCH development method. The results of this study have been compared with previous studies using the original MCCH method [1]. There are several reasons for the smaller throughput value compared to the original MCCH method, such as the fact that the development of the MCCH method by adding this odd-even technique does not include all active nodes. Only active nodes are detected by throughput. When the odd node is active, the even node dies and vice versa, making the detected nodes not all.

4. CONCLUSION

The main finding in this research is the development of a multi-channel clustering hierarchy (MCCH) algorithm by adding an odd-even process, where when the even node is on, then the odd node is off. So, this process can improve WSN performance and save power on the energy used. The limitations of this research are only improving WSN performance and developing WSN protocols by adding odd-even processes. The contribution of this research is the formation of cluster heads with probability by forming cluster heads and cluster members that are close to each other, the odd-even process, and the grouping process using proximity or similarity techniques using a distance matrix.

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6. DECLARATIONS

AUTHOR CONTIBUTION

Robby Rizky : Conceptualization, Methodology, Validation. **Zaenal Hakim** : Formal analysis, Resources, Writing original draft. **Sri setiyowati** : Writing review & editing. **Susilawati** : Visualization, software. **Ayu Mira Yunita** : Formal analysis, Investigation, Data curation.

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COMPETING INTEREST

The authors declare that we have no known competing financial interests or personal relationships that could have appeared to influence reseach in this paper.

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