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Improved Performance on Wireless Sensors Network Using Multi-Channel Clustering Hierarchy

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Abstract: Wireless sensor network is a network consisting of many sensor nodes that function to scan certain phenomena around it. WSN has quite a large problem in the form of delay and data loss which results in low WSN performance. This study aims to improve WSN performance by developing a cluster-based routing protocol. The cluster formation is carried out in several stages. The first is the formation of the cluster head which is the channel reference to be used by node members by means of probability calculations. The second determines the closest node using the Euclidean approach when looking for the closest member of the node to the cluster head. The third is determination of the node members by means of single linkage grouping by looking for proximity to CH. The performance of the proposed MCCH method is then tested and evaluated using QoS parameters. The results of this research evaluation use QoS parameters for testing the MCCH method, channel 1 throughput 508.165, channel 2 throughput 255.5661, channel 3 throughput 479.8289, channel 4 throughput 646.5618.

Keywords: enhancement; performance; wireless sensor network; multi-channel clustering

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1. Introduction

Wireless sensor network is a collection of wireless sensor devices (sensor nodes) which are generally used to record data about phenomena in an area [1]. Sensor nodes have limited computing and communication capabilities [2]. The general communication pattern in the wireless sensor network (WSN) is sending data from the scanning (sense) phenomena to the base station or a number of nodes that have been determined as data collectors [3]. The data collector or base station makes a request to the sensor node which contains a query about the phenomenon to be collected, the sampling interval, and the total sampling time [4].

There are several causes of poor performance on wireless sensor networks, including delay. It is one of the problems that can reduce performance of WSN and the high number of delays is very disturbing for data exchange transactions in WSN. Another cause of poor performance of WSN is data loss, which is loss of data during data exchange transactions in WSN due to heavy traffic on the WSN [5].

The high delay rate is due to the dense traffic on the protocol line on the WSN which will reduce the performance of the WSN. The high delay rate results in increased data loss/data loss which can reduce the performance and quality of the WSN. Therefore, we need a method that can solve these problems to reduce delay and data loss [6].

This intelligent irrigation system cannot be separated from Wireless Sensor Network technology to be connected to one another [7]. With various types of sensors that can help the performance of the intelligent irrigation, the sensor can work by describing the system that has been built by applying a fuzzy logic algorithm to describe the temperature and humidity variables so that watering becomes more optimal [8]. The problem is that data collisions often occur [9]. Collision is a physical network segment where data packets can collide with each other on a shared medium [10]. One humidity sensor and one temperature sensor are data that will be sent to the server; therefore, with many sensors it can cause a data collision. When the data has collided, the tool will not work optimally [11] even making the tool blank data and turns off instantly and the irrigation system will automatically die too [12].

Geographic routing (GR) or routing based on geographic position was introduced to overcome the limitations of topology-based routing protocols [13]. The geographic routing protocol relies on information on the physical location of nodes in the wireless sensor network (WSN) obtained from location services (e.g., Global Positioning System or GPS). By utilizing geographic position information, Geographic Routing (GR) does not need to perform routing table maintenance, and can even run without routing tables [14]. Several GR protocols have been introduced, which calculates all paths based on the Euclidean distance and sensor node to the sink node, then selects the appropriate path [15]. The latest protocols are generally.

Several clustering protocols for WSN have been developed, and one that has a high success rate is the LEACH (Low-Energy Adaptive Clustering Hierarchy) algorithm. The LEACH algorithm divides the WSN into several clusters, each of which is a cluster head, and the cluster head forwards the data to the base station [16,17]. The LEACH algorithm does not use geographic information as the basis for determining routes, forming clusters, or searching for neighbor nodes [18]. The advantages of LEACH in this case are using clustering techniques to increase throughput [19]. However, it is necessary to introduce some modifications to the clustering technique so that it can be implemented in the multi-channel clustering protocol [20]. The Wireless Sensor Network consists of many spatially distributed sensors [21,22]. These sensors are used to monitor various environmental conditions such as temperature, humidity, weather, and so on [23]. Observational data are transformed into electronic signals [24]. A sensor is equipped with a radio transceiver, microcontroller, and energy source [25]. In general, the sensors used are small and cheap.

The multi-channel in this study only formed 2 channels with cluster head selection. Two channels can parse the traffic density that exists on the WSN protocol path; the problem in this study is the distance between the cluster head and cluster members which are still random and far apart. Subsequently, transactions between nodes require enormous energy [26,27]. However, in this study, the cluster head and cluster members are very far apart, which makes transactions between nodes ineffective.

This study discusses the formation of channels in WSN to improve performance by forming two channels with the MAC algorithm by designing the cluster head as a reference channel to be used. The formation of this multi-channel can improve performance of WSN because it can overcome WSN problems such as delay and data loss [28].

The formation of multi-channel in this study using a scheduling system which is close to the base station will be used as a cluster head. However, the distance between the cluster head and the cluster members is considerable and random, which results in transactions between data not being maximized [29].

From several literature reviews in theory, this method can improve performance of WSN. However, various models of throughtput increase are not so significant because they still have several shortcomings such as the formation of nodes that are far apart from each other, specifically for the multi-channel model, because this has only been done to design two channels.

This research combines the LEACH, Euclidean and HAC single linkage approaches in order to be able to group nodes on the WSN so that these nodes can be positioned close between cluster heads and cluster members.

The performance improvement method in previous studies has not been able to design nodes between the cluster head and cluster members close to each other. Formation of nodes between the cluster head and cluster members are far from each other, which causes transactions between nodes to require a lot of energy and a very high rate of delay [8].

In this study, the cluster head and cluster members are positioned close together so that transactions between nodes do not require a lot of energy.

The performance of small sensors is usually not as good as that of large expensive sensors, but with their small size and low price, the observed area becomes wider because the number of sensors installed can be very large [30]. Sensors on the WSN network send data to the base station but can also communicate with each other [31]. Nodes in WSN have limited energy, and it is often impossible to recharge the battery [32]. As with computer networks in general, WSN can also be implemented in several topologies, namely:

- Point-to-point Topology,
- Star Topology,
- Mesh Topology,
- Hybrid Technology,
- Tree Topology.

Point-to-point network topology is the simplest form of network topology [33]. In this topology, the two end devices are directly connected to each other. This point-to-point topology physically connects the two nodes directly via cable or other media. Point-to-point topology is used to determine the structure of different telecommunication networks. Point-to-point logical topology defines the way in which data will actually flow in the network. As for the point-to-point physical topology, it defines the way in which nodes are placed in the network [34].

Star topology is a method or way to connect two or more computers with a star-shaped network, where the network topology comprises of convergence from the middle node to each node/user so that all nodes or points are connected to the middle node. The star topology has a working principle with a centralized control, or control where all links go through the center and then data is routed to all nodes or certain nodes. information technology terms, the central node is referred to as the primary station, while the other connected nodes are referred to as secondary or client stations.

Mesh topology is a group of computer devices that are directly connected to each other in a network so that they can communicate with each other. This topology is also referred to as a mesh topology because the shape of the circuit resembles a mesh shape. Mesh topologies are mostly made for medium-sized networks that require fast communication between devices and otherwise use a lot of cables which is quite difficult to manage [35].

Hybrid topology can be interpreted as a new topology model on a computer network that is created from a combination of two or more network topologies of different types. Because it is a combination of various types of topologies, the hybrid topology design looks more complicated and does not display certain characteristics.

In this study, researchers used a tree topology. In this topology, there is a device that is rooted or occupies the top level and is the main center of communication for all connected nodes [36]. Then, at the level below it, there are devices that are the center of connections to other devices that make up the star topology [37]. In this study, the lowest level is the cluster member, the middle level is the cluster head, and the highest level is the sink.

Clustering on Wireless Sensor Network

Clustering techniques in WSN are generally used with the aim of saving energy resources [38]. One of the most popular clustering protocols is LEACH (Low-Energy Adaptive Clustering Hierarchy). This is a routing protocol that aims to improve energy conservation [39].

Figure 1 shows the blue nodes representing the cluster head, the white nodes representing the cluster members, and the red nodes representing the sink or server. The main idea of LEACH is to divide the network into several clusters based on signal strength and use the cluster head as a router to send messages to other clusters or base stations [40]. Data processing is also carried out in the cluster head [41]. The dynamic nature of LEACH divides time into several intervals [42]. At the beginning of the interval, the cluster head is determined randomly from several nodes that retain energy above a certain level [43]. In the next interval, each sensor n takes a random number x such that $0 < x < 1$ and compares it with a certain threshold T(n). If $x < T(n)$, then the node becomes the cluster head in that interval.

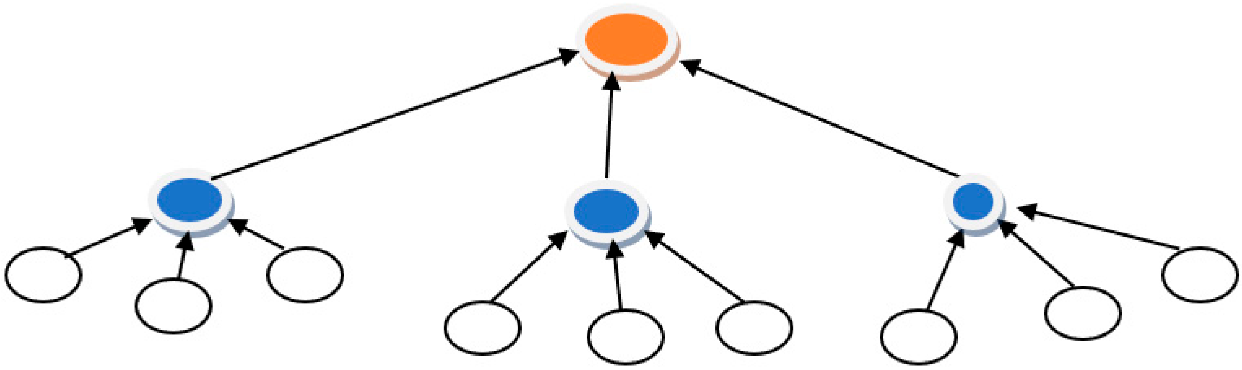
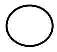


Figure 1. Protocol architecture protocol architecture.  = Cluster head,  = Cluster member.

After being selected as the cluster head, the node broadcasts to neighboring nodes. Then, the neighboring nodes will attribute themselves to being members of the cluster head that has the strongest signal [44]. Then, the cluster is formed, and the cluster head will arrange a sampling schedule and send it to all member nodes. The member node will perform the scan according to the schedule and send the scan result to the cluster head [45]. Towards the end of the interval, the cluster head will send the collected data to the base station [46]. Although it saves network energy, LEACH also has the disadvantage of uneven distribution of sensor nodes. The selected cluster head can be at the edge of the cluster, so it cannot reach all member nodes directly [47,48].

2. Multi-Channel Clustering Hierarchy (MCCH)

Multi-Channel Clustering hierarchy is an approach that offers a process to overcome the problems that exist in WSN technology, namely the low throughput values. The first stage is the formation of a cluster head that is the reference channel used by node members. The second stage is to determine the closest node using the Euclidean approach when looking for the closest member of the node to the cluster head. The third stage is to determine node members by grouping single linkage by looking for proximity to the cluster head.

Figure 2 below shows the method used in this study where there are four steps that can solve the problem of delay and data loss in WSN.

Table 1 is the parameter used in this study by using the MATLAB application in conducting simulations.

Table 1. Simulation parameters.

Parameter	Value
Number of nodes	100
Energy	100
Xmax	300
Ymax	300
Velocity	10,000

Figure 3 below shows nodes that are spread over 100 nodes using matlab simulation. The next process is to determine CH as the channel reference used by node members.

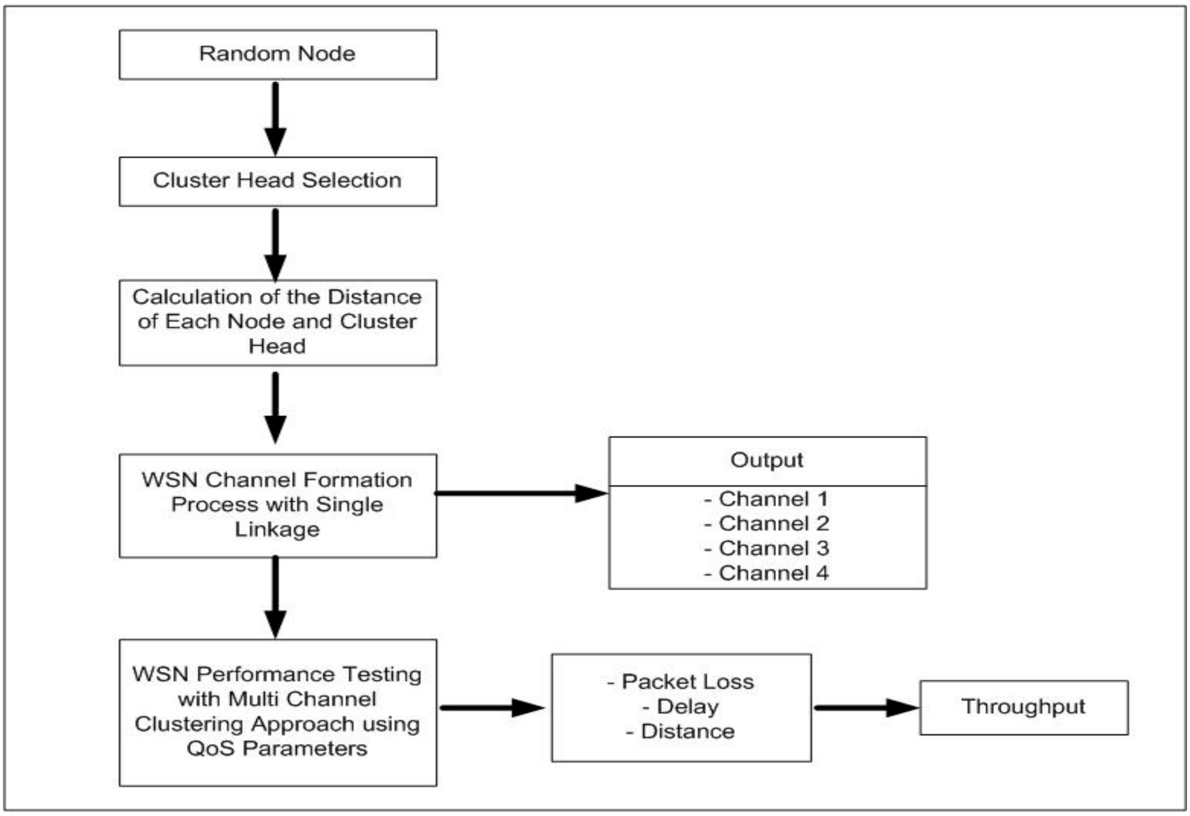


Figure 2. Protocol.

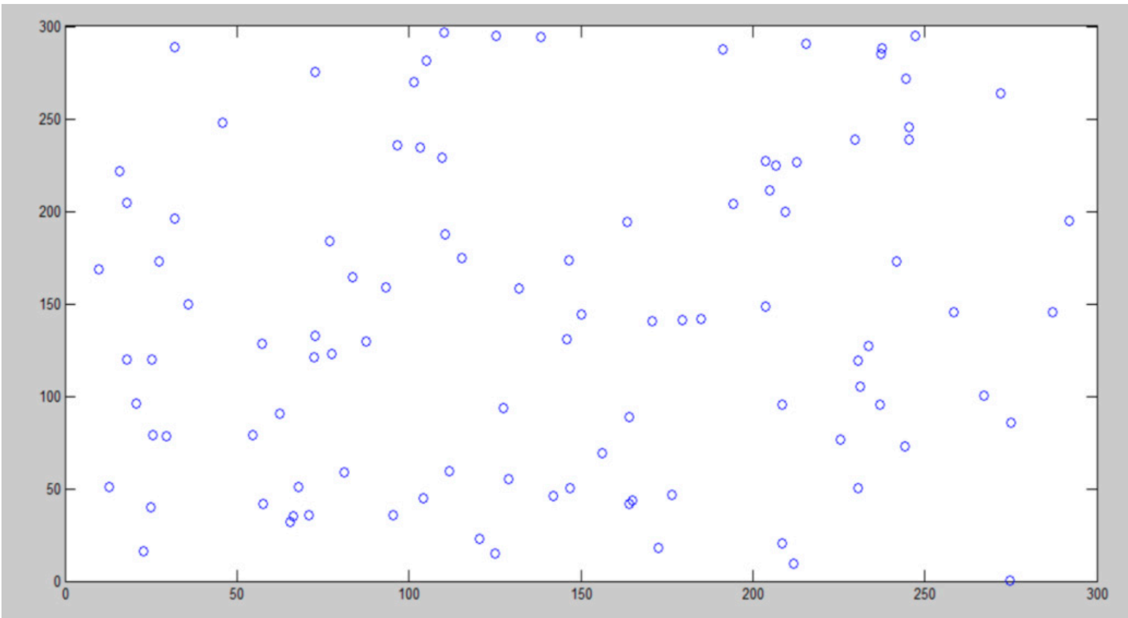


Figure 3. Node.

Table 2 is the initial algorithm in the form of random nodes that will be processed with the next algorithm process.

Table 2. Algorithm 1.

Algorithm 1: Temperature and Humidity Criteria Algorithm

```
n = 100;
N = 4;
energy = 100;
temp_top = 26;
temp_bot = 20;
humi_top = 100;
humi_bot = 0;
huma_top = 100;
huma_bot = 0;
freq_top = 50;
freq_bot = 10;
xmax = 300;
ymax = 300;
velocity = 10,000;
for i = 1:n
node(i).id = i;
node(i).xd = (xmax).* rand(1,1);
node(i).yd = (ymax).* rand(1,1);
node(i).energy = energy;
node(i).temp = (temp_top − temp_bot).* rand(1,1) + temp_bot;
node(i).humi = (humi_top − humi_bot).* rand(1,1) + humi_bot;
node(i).huma = (huma_top − huma_bot).* rand(1,1) + huma_bot;
node(i).freq = (freq_top − freq_bot).*rand(1,1) + freq_bot;
axis([0 xmax 0 ymax])
plot(node(i).xd,node(i).yd,'o');
hold on
end
clear energy temp_top temp_bot humi_top humi_bot huma_top huma_bot freq_top freq_bot
```

2.1. Cluster Head Selection

The initial random node process that must be carried out in this study is to find the Cluster Head to determine the channel.

1. Several sessions depending on the desired amount of CH and the period of observation are carried out.
2. The CH position for each node for one session is ensured.
3. The position of CH becomes unstable or alternates so that a Cluster has a dynamic formation or changes every session.

The algorithm begins by deciding in advance the cluster along with the desired percentage of CH and the active period of the node as long as it becomes CH. After that, each node decides whether to be CH or not during the session based on its remaining energy level [49]. Decision making is carried out by node n choosing a random number between 0 and 1. If the number is less than the threshold, then the node becomes CH for that session [50].

$$T\ (n) = \left\{ \begin{array}{l} \dfrac{P}{1 - P \times \left(r \bmod \frac{1}{p} \right)} \quad if\ n\ \in\ G \\ 0 \quad otherwise \end{array} \right\}. \tag{1}$$

Notes:
$T(n)$ = threshold each round node will be cluster head if $m > T(n)$,
P = the initial probability selected,
R = Round,
N = Node,
G = A set that is not yet a cluster head.

Figure 4 below, the blue node is a member node while the red node is a CH with an illustration using matlab.

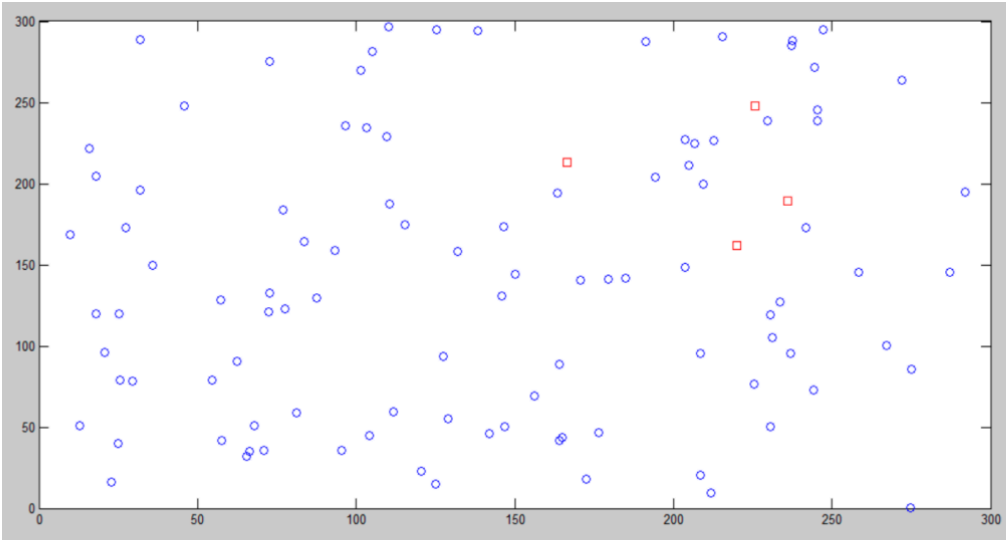


Figure 4. CH Selection.

Table 3 is the next step is the cluster head selection algorithm which is designed into four cluster heads.

Table 3. Cluster head selection.

Algorithm 2: cluster head selection

```
cent = struct();
hold on
for k = 1:N
cent(k).x = (b − a).* rand(1,1) + a;
cent(k).y = (b − a).* rand(1,1) + a;
plot(cent(k).x,cent(k).y,'s red');
hold on
end
figure(2)
for k = 1:N
plot(cent(k).x,cent(k).y,'s red');
hold on
end
dis = struct();
for i = 1:n
plot(node(i).xd,node(i).yd,'o');
hold on
for k = 1:N
dis(i).cent(k).id = k;
dis(i).cent(k).distance = pdist ([node(i).xd, node(i).yd; cent(k).x, cent(k).y],'euclidean');
end
end
clustering_channel = struct();
count = 0;
for k = 1:N
for i = 1:n
if node(i).cent == k
count = count + 1;
clustering_channel(k).node(count) = node(i).id;
end
end
count = 0;
end
```

2.2. Calculation of the Distance of Each Node and Cluster Head

At this stage, the process of determining the distance between the nodes scattered on the WSN is initiated. Next, the point closest to CH will be searched. In calculating the distance of all sensors to the cluster head, the distance formula used is the Euclidean approach. In mathematics, the Euclidean distance is the distance between two objects or points. Euclidean distance can be used to measure the similarity (matching) between objects. The information collected is in the form of the Euclidean distance between nodes and neighbors. Euclidean distance is the length of a line connecting two points on a coordinate plane. If the coordinates used are two-dimensional planes, then the Euclidean distance between the two nodes (X_1, X_2) and (y1, y2) can be calculated using the following equation:

$$D(x_2\ ,\ x_1) = \sqrt{\sum_{j=1}^{d} |x_{2\ j} \quad - \quad x_{1\ j}|^2}. \tag{2}$$

Notes:
d = Node point,
X_1 = Node on axis X (CH),
X_2 = Node on axis Y,
X_{1j} = axis number X (CH),
X_{2j} = axis number Y.
Table 4 is the next step, namely the third algorithm, which is to calculate the distance between the cluster head and cluster members so that they are close together.

2.3. The Process of Forming a WSN Channel

If the distance between the member and CH nodes has been obtained, the next step is the clustering analysis process.

Single linkage is a clustering technique that produces a series of decreasing numbers of clusters at each stage. The clusters contained in each stage are obtained from the previous stage by combining two clusters that display similarities. This technique is carried out using two methods, namely matrix theory and graph theory.

This single linkage does not require a specific number of clusters in the grouping process, so we do not need to determine the number of clusters that will be formed at an early stage. However, for certain cases it is possible to determine the number of clusters

Using this technique, so that when grouping occurs there will be hierarchical cuts at certain points according to the initial conditions of the grouping.

The following is a solution algorithm using Single linkage.

1. contains a single entity and a symmetric matrix of the distance (similarities)
2. Find the distance matrix for the closest (most similar) cluster pair. For example, the distance between clusters U and V that is most similar is d u v.
3. Merge the newly formed cluster U and V cluster labels with (UV). Then, update the entries in the distance matrix in the following way:
4. Delete rows and columns corresponding to clusters U and V.
5. Add rows and columns giving the distances between the cluster (UV) and the remaining clusters.
6. Repeat steps 2 and 3 (N − 1) times. All objects will be in a single cluster after the algorithm ends. Note the identity of the merged cluster and the level (distance or similarity) at which the merger occurs.

$$\mathrm{d}_{\,(\mathrm{h,\,i,\,j})\ \mathrm{k}} = \min\,(\mathrm{d}_{\,\mathrm{hk},}\ \mathrm{d}_{\,\mathrm{ik},}\ \mathrm{d}_{\,\mathrm{jk}}). \tag{3}$$

Notes:
d = Channel or CH,
h = node member,
I = node member,

J = node member.

Table 4. Calculation of the distance between each node and cluster head.

Algorithm 3: Calculation of the distance between each node and cluster head

```
for k = 1:N
for i = 1:size(clustering_channel(k).node,2)
p = clustering_channel(k).node(i);
hac(k).ch(i).id = node(p).id;
for j = 1:size(clustering_channel(k).node,2)
hac(k).ch(i).d(j).id = clustering_channel(k).node(j);
end
end
[~,index] = sortrows ([hac(k).ch(i).d.dis].');
hac(k).ch(i).d = hac(k).ch(i).d(index);
clear index
end
iter = 0;
x = zeros();
for i = 1: size(node,2)
if node(i).cent
end
end
y = pdist(x);
Y = squareform(y);
z = linkage(y);
figure()
dendrogram(z)
title(strcat('Channel-', num2str(k)))
D = 0;
for i = 1:size(z,1)
D = D + z(i,3);
end
HAC(k).distance = D;
sc = size(clustering_channel(k).node,2);
F = 0;
for i = 1:size(z,1)
n1 = z(i,1);
n2 = z(i,2);
if n1 <= sc && n2 <= sc
F = F + 1;
end
end
I = inconsistent(z);
loss = 0;
for i = 1:size(I,1)
loss = loss + I(i,4);
end
end
```

Figure 5 describes the process of grouping member nodes and cluster heads using a single linkage approach by looking for proximity to the cluster head [36].

Table 5 is the final algorithm which is the grouping process between the four cluster heads and cluster members.

Figure 6 is a single channel that exists in the current WSN technology. Each node will send data directly to the server/sink which results in a lot of data queues and data density, therefore a WSN protocol with the MCCH method has been developed which can divide the protocol channel so that it can reduce traffic congestion in WSN.

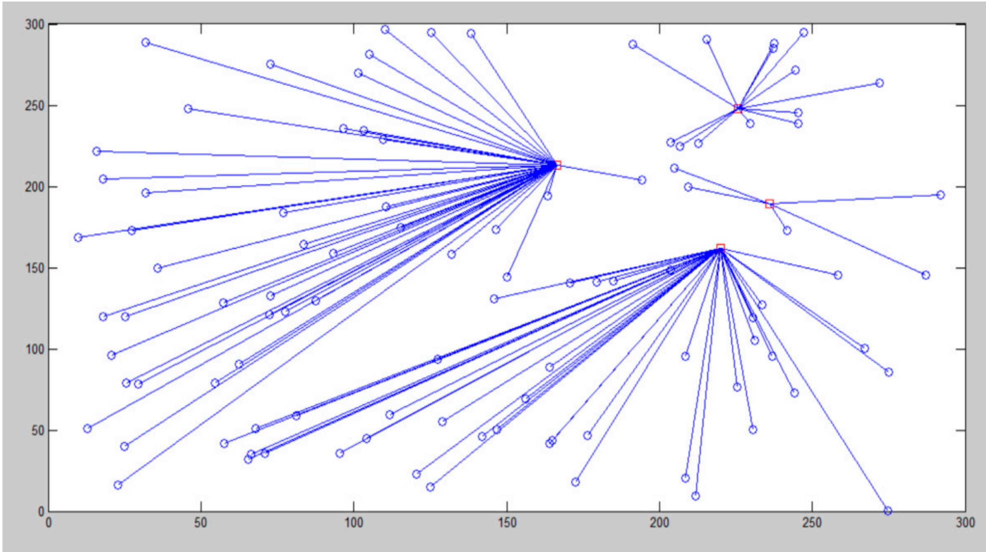


Figure 5. Multi-channel grouping process.

Table 5. The proces of forming a WSN channel.

Algorithm 4: The process of forming a WSN channel

```
for k = 1:N
for i = 1:size(clustering_channel(k).node,2)
end
end
xx = 1:1:N;
for i = 1:N−1
end
for i = 1:N−1
end
title('Delay')
for i = 1:N−1
plot ([xx(i) xx(i + 1)], [HAC(i).throughtput HAC(i + 1).throughtput])
hold on
end
for i = 1:N−1
end
```

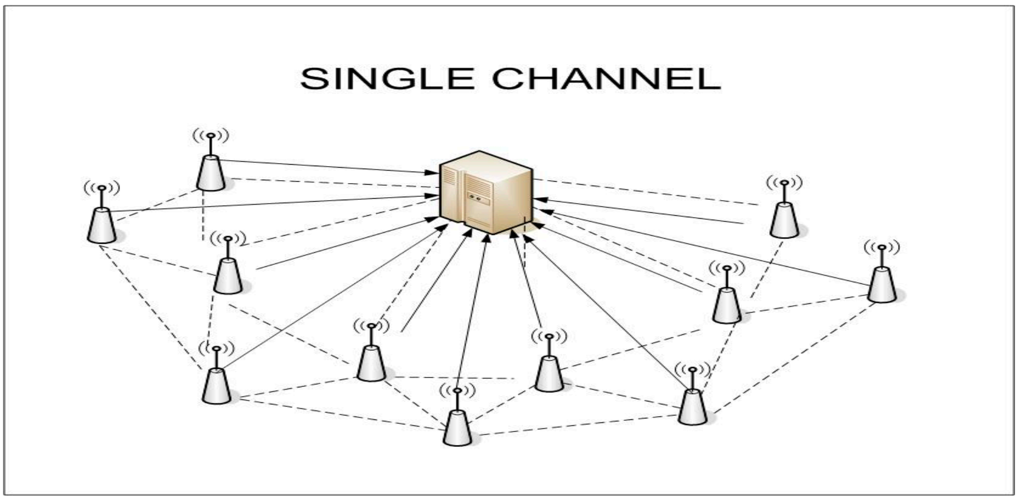


Figure 6. Single channel WSN.

Figure 7 below shows the results of MCCH research by dividing 4 channels which can overcome problems such as of delay and data loss in WSN technology and can parse the density of data transactions in WSN. The concept of multi-channel clustering hierarchy (MCCH) is believed to be able to increase the throughput value of WSN and maximize the performance of intelligent irrigation systems.

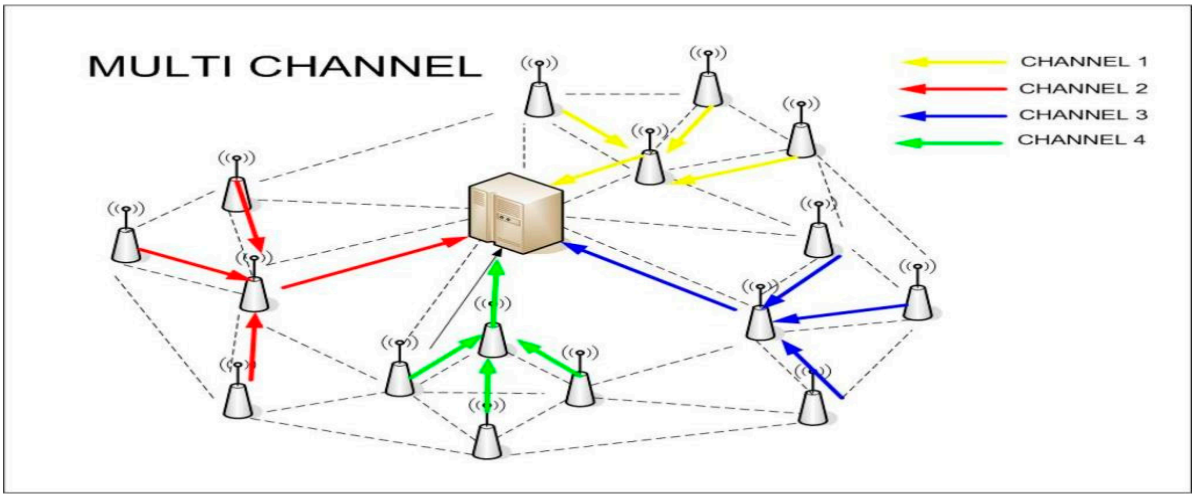


Figure 7. Multi-channel clustering hierarchy (MCCH).

Figure 8 describes the nodes that belong to channel group 1 using a single linkage approach.

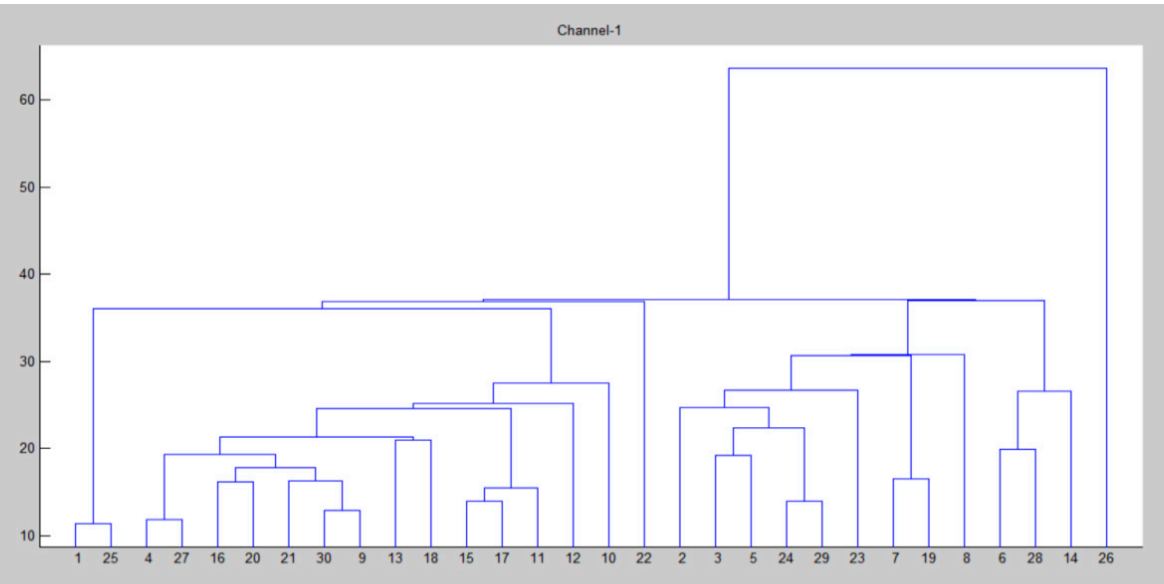


Figure 8. Channel 1 node gruping.

Table 6 is a node that enters channel group 1.

Table 6. Node channel 1.

Channel 1	Node
	6, 7, 11, 12, 13, 14, 15, 17, 24, 25, 26, 29, 31, 33, 37, 38, 40, 43, 47, 50, 57, 67, 68, 71, 74, 76, 78, 82, 83, 85, 87, 89, 90, 91, 94, 95, 97, 98, 99, 100

Figure 9 describes the nodes that belong to channel group 2 using a single linkage approach.

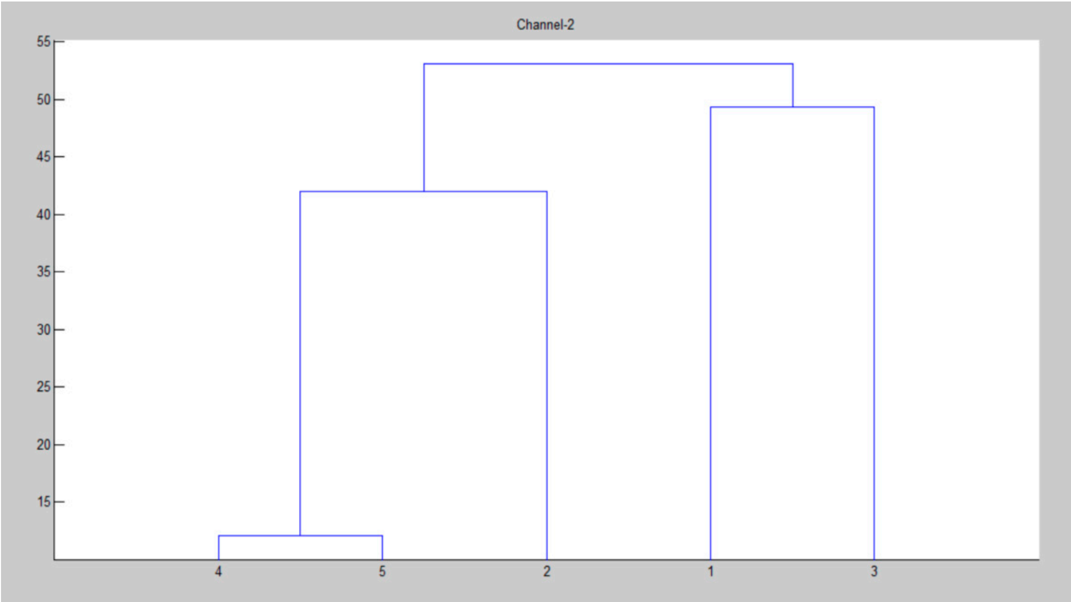


Figure 9. Channel 2 grouping.

Table 7 is a node that is included in the channel group 2.

Table 7. Node channel 2.

Channel 2	Node
	3, 49, 53, 60, 93

Figure 10 describes the nodes that belong to channel group 3 using a single linkage approach.

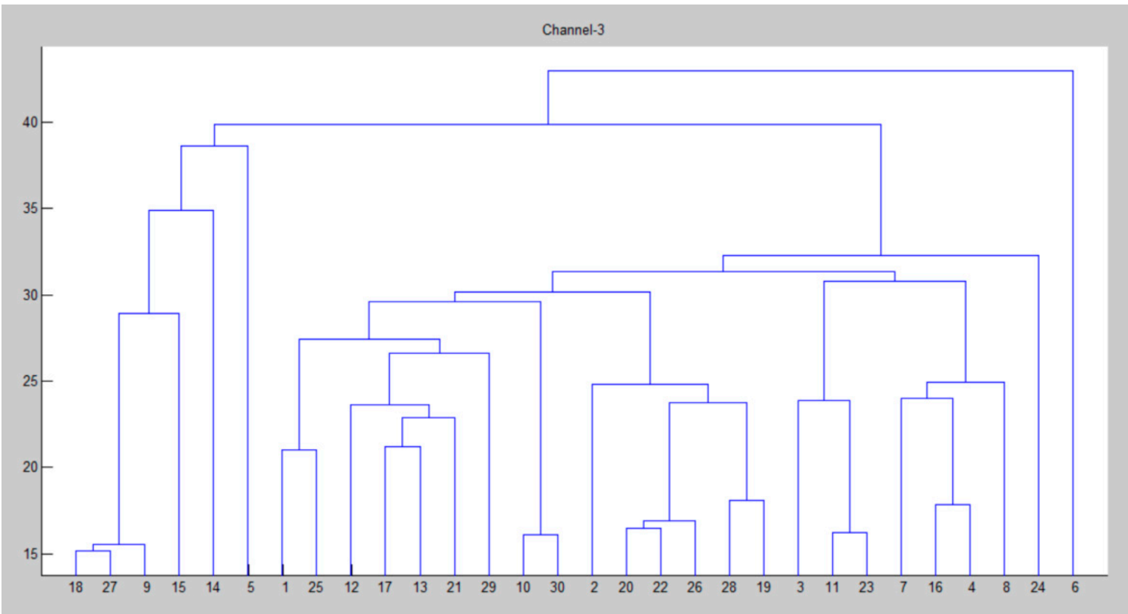


Figure 10. Channel 3 grouping.

Table 8 is a node that enters the channel group 3.

Table 8. Node channel 3.

Channel 3	Node
	2, 10, 16, 18, 20, 21, 22, 23, 27, 28, 30, 32, 35, 36, 39, 41, 42, 44, 45, 46, 48, 51, 54, 55, 56, 58, 59, 61, 62, 63, 64, 69, 72, 75, 77, 79, 80, 81, 84, 86, 88, 92

Figure 11 describes the nodes that belong to channel group 4 using a single linkage approach.

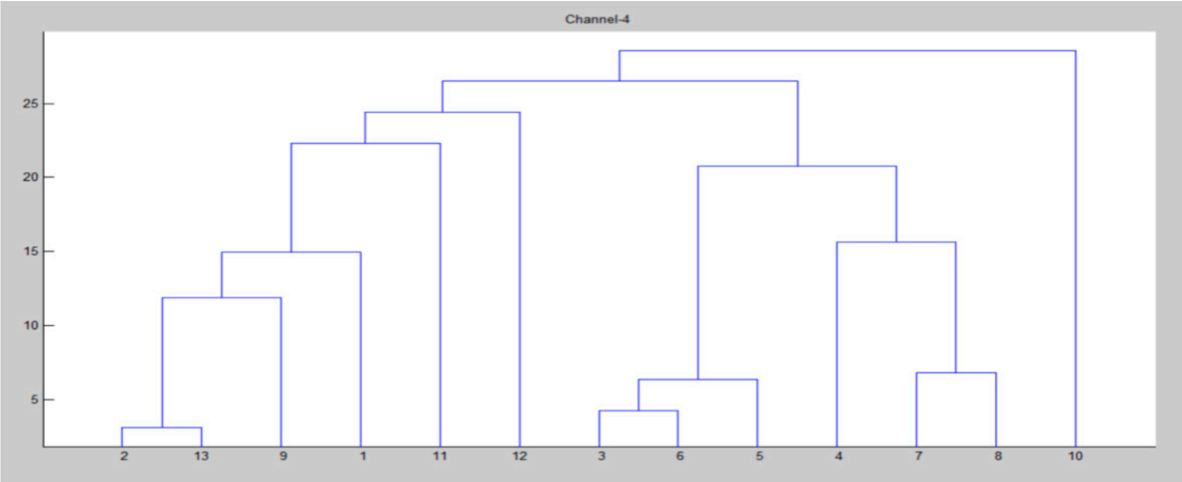


Figure 11. Channel 4 Grouping.

Table 9 is a node that enters the channel group 4.

Table 9. Node channel 4.

Channel 4	Node
	1, 4, 5, 8, 9, 19, 34, 52, 65, 66, 70, 73, 96

3. Measurement of WSN Performance Using QoS Parameters

1. Throughput

Throughput is the average speed of data received by a node in a certain observation time interval. Throughput describes the condition of the data rate in a network. The higher the throughput value.

$$\text{Troughput} = \frac{\text{number of packet sent}}{\text{package delivery time}}$$

2. Packet Loss

Packet Loss is measured as the percentage of packets lost with respect to packets sent between source to destination nodes. Packet loss occurs when one or more data packets passing through a network fail to reach their destination.

$$\text{Packet loss} = \frac{\text{packet experiencing loss}}{\text{package sent}}.$$

3. Delay

Delay is the time it takes to send data. The factor affecting delay is the time it takes the protocol to find a route.

$$\text{Delay} = \text{delivery time} - \text{acceptance time}.$$

Figure 12 describes the loss parameters, number 1 indicates channel 1, number 2 indicates channel 2, number 3 indicates channel 3, and number 4 indicates channel 4.

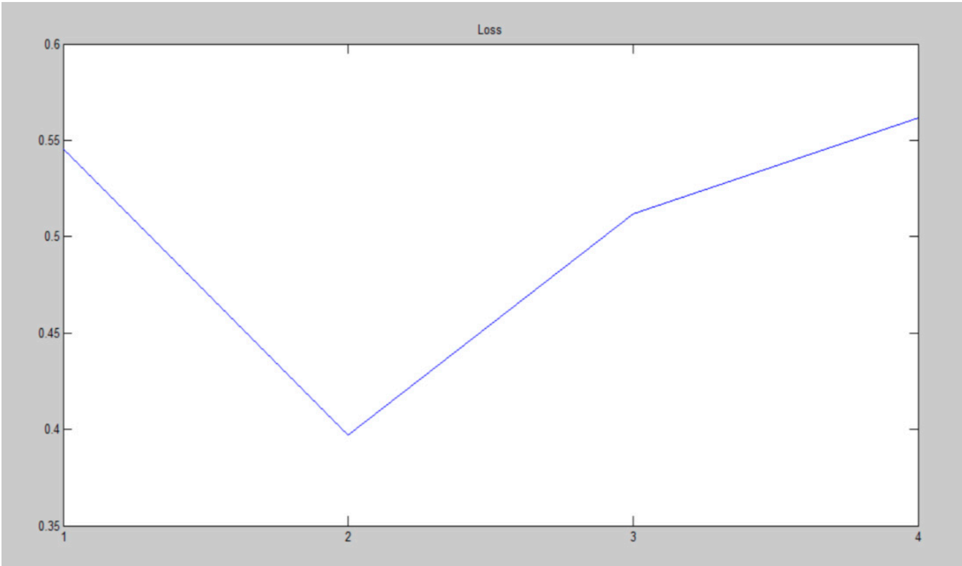


Figure 12. Loss parameters.

Table 10 is an explanation of data loss on each channel.

Table 10. Loss parameters.

Channels	Parameters
Channel 1	0.5455
Channel 2	0.3968
Channel 3	0.5120
Channel 4	0.5616

Figure 13 describes the delay parameters, number 1 indicates channel 1, number 2 indicates channel 2, number 3 indicates channel 3, number 4 indicates channel 4.

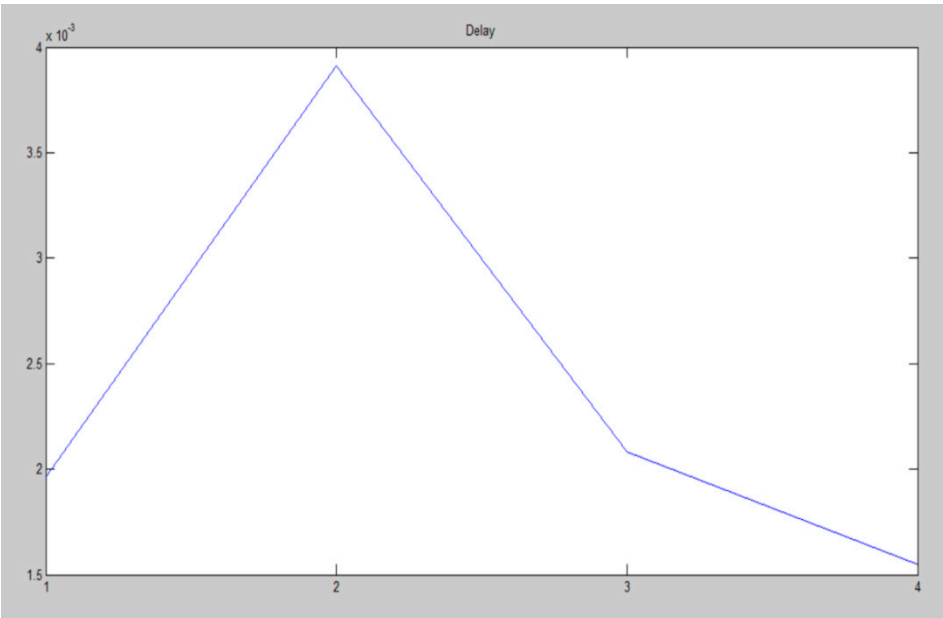


Figure 13. Delay parameter.

Table 11 is the number of delay on each channel.

Table 11. Delay parameter.

Channels	Parameters
Channel 1	0.0020
Channel 2	0.0039
Channel 3	0.0021
Channel 4	0.0015

Figure 14 shows the distance parameters, number 1 indicates channel 1, number 2 indicates channel 2, number 3 indicates channel 3, and number 4 indicates channel 4.

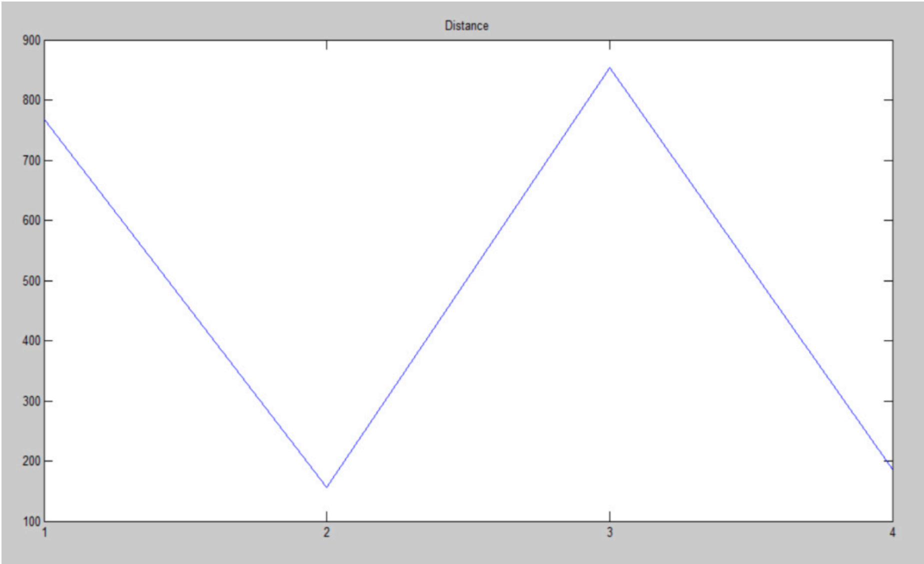


Figure 14. Distance parameters.

Table 12 is the distance number for each channel.

Table 12. Distance parameters.

Channels	Parameters
Channel 1	766.9368
Channel 2	156.5153
Channel 3	854.4712
Channel 4	185.5971

Figure 15 describes the throughput parameters of the MCCH algorithm, number 1 indicates channel 1, number 2 indicates channel 2, number 3 indicates channel 3, and number 4 indicates channel 4.

Table 13 is the result of the Throughput of the MCCH algorithm.

Table 13. Throughput parameters MCCH.

Channels	Parameters
Channel 1	508.5165
Channel 2	255.5661
Channel 3	479.8289
Channel 4	646.5618

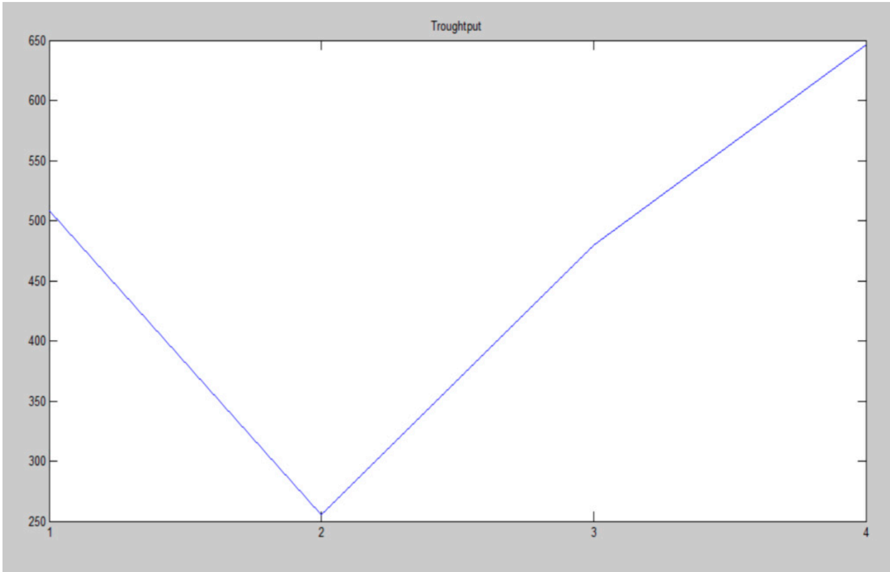


Figure 15. Throughput parameters MCCH.

Figure 16 describes the throughput value of a previous study entitled Adaptive multi-channel in IEEE.802.11s Wireless mesh networks [26].

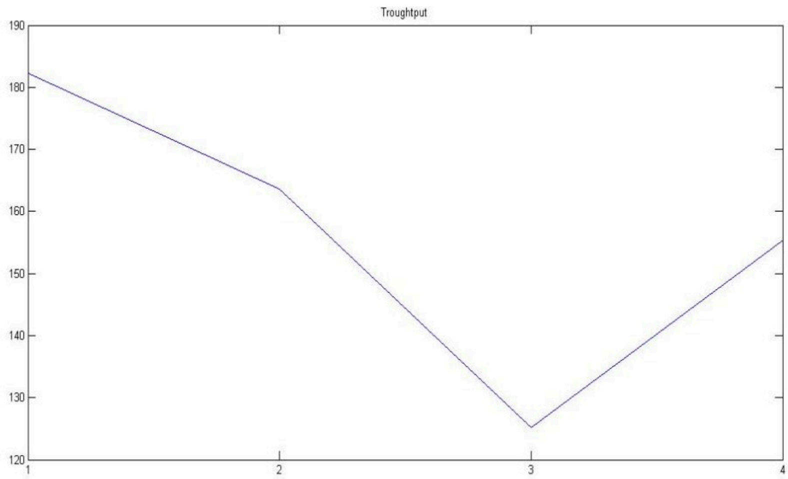


Figure 16. Multi- channel.

Table 14 is the result of conventional multi-channel throughput.

Table 14. Throughput parameters multi channel.

Channels	Parameters
Channel 1	190
Channel 2	165
Channel 3	125
Channel 4	158

4. Discussion

This study presents a methodological approach to the development of wireless sensor networks. The WSN protocol in this study is developed to form a cluster head, where the cluster head is used as a reference channel that will be followed by cluster members. The distances between the cluster head and cluster members are designed to be small in order to save energy when exchanging data. The next step is the process of grouping between cluster heads and cluster members by looking for similarities or proximity that will enter the channel group. The development of a protocol on WSN by applying the multi-channel clustering hierarchy (MCCH) method is believed to be able to solve problems such as of delay and data loss.

Compared to the previous WSN protocol development method, the main contribution of the proposed method is the formation of 4 channels on the WSN by grouping them between cluster heads and cluster members by looking for the closest similarity between node members and cluster heads. The divide of the WSN channel into 4 channels increases the throughput value of each channel and can reduce delay and data loss. Next, an analysis of the performance of the multi-channel clustering hierarchy method by using QoS parameters such as delay, data loss and throughput is required. The results of the MCCH research are 4 channels in WSN which can improve performance of WSN and optimize the performance.

The MCCH method can overcome traffic congestion on the WSN protocol path. This describes the path that was originally 100 nodes with 100% traffic density on one lane broken down to 25% per lane. Thus, the existing traffic density on the WSN path can be overcome by the proposed MCCH method.

5. Conclusions

From a series of research activities, the following can be concluded:

The development of the MCCH protocol is done by modifying the routing protocol. Modifications are made by dividing the network into several clusters by selecting the cluster head as a channel reference. The selection of the cluster head is done by spreading 100 nodes and randomly selecting it with the probability formula. The distance between the cluster head and cluster members is designed not to be far apart so that the data transmission process can be as effective as possible and require little energy. The formation of distance between cluster heads and cluster members is performed using the Euclidean approach. The process of grouping cluster heads and cluster members is performed using a single linkage approach, by looking for proximity and similarity to cluster heads and cluster members as well as finding the distance matrix for the closest (most similar) cluster pair and merging the newly formed clusters. The results of the grouping are 4 channels in WSN which can improve performance: channel 1, 508.165. channel 2, 255.5661. channel 3, 479.8289. channel 4, 646.5618.

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Data Availability Statement: The data in this study uses matlab simulation.

Conflicts of Interest: The authors declare that there is no conflict of interest.

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