

## CHAPTER 7

### CONCLUSIONS AND FUTURE WORK

#### 7.1 Introduction

This research proposed a new 3D Euclidean Distance method for enhancement clustering algorithm in WSN. The enhancement clustering algorithm proposed was tested with parameters such as energy consumption, packet, and distance. The 3D Euclidean Distance refers to a clustering algorithm that considers the energy between the neighbour node of correlated degree and the topological features, mainly to enhance the network connectivity in WSNs. Hence, the distance between the nodes determines the degree of correlation. Due to high distance in the network topology, sensor observations are highly correlated with the degree of correlation, which increases with the decreasing internode separation.

#### 7.2 Research Contributions

This study aims to gain an understanding of the issues related to clustering algorithm for an improved network connectivity in the WSNs of correlated node behaviour. This literature review aims to present clustering algorithm method as the initial phase of a significant development of clustering approach in WSNs. Such as LEACH, TL-LEACH, EEC, Load Balancing, Fault-Tolerance, Highest-Connectivity, Weighted Clustering Algorithm, R-HEED, PEGASIS, LCA, GROUP clustering algorithm methods. This review result highlighted the parameters such as energy, packet, and distance for performance network connectivity measurement and the factors of network critical condition. Network connectivity is influenced by mobility prediction of the node, which estimates the future locations. The definition of location is based on the link of wireless networks. In infrastructure networks, location refers to

the access points to which static terminal is connected. To illustrate, the mobility of the nodes could affect the outcome of the wireless network. In the group mobility wireless network, when the nodes move from cluster head groups, the mobility of the nodes in the same cluster head group depends on the mobility of the cluster head groups.

Static node may be the most ideal solution in connecting two clusters in a highly dynamic environment. To deploy static nodes in place of critical nodes, the cost of static node deployment must be considered. When the nodes are placed, maximised network connectivity and minimum cost must be prioritised. Energy consumption is the key challenge in energy conservation for a prolonged network lifetime due to the network connectivity constraints. Provided that energy is the most valuable resource in network connectivity, its condition should constantly be monitored after network deployment.

The sensor nodes behaviour is the main issue in wireless sensor network, especially network connectivity due to dynamic nature of the network. To establish a network connectivity, nodes are required to be in a cooperative behaviour state to perform data transmission. However, the changes of nodes' behaviours may occur from cooperative to misbehaving, which directly affects the network's connectivity. It was found that network connectivity practices were still focused on theoretical works, with significant number of studies ensuring that network connectivity of the nodes maintained network performance. However, the studies conducted on enhanced network connectivity were scarce, despite its notable impact on the clustering algorithm in WSNs. Moreover, the constant development of wireless technology keep growing lead to more challenges to be addressed. Therefore, the key points in resolving this issue are the reduction of network connectivity effect, advanced method to improve network connectivity, and the reliable transmission of field information.

Several clustering algorithms aim to find a cluster based on 3D Euclidean distance algorithm. In this research, correlation network clustering algorithm based on parameters such as distance, packet, energy-consumption, and network connectivity using 3D Euclidean distance based on the correlated degree to overcome correlation network clustering algorithm has been developed. The specific contributions of the present work are highlighted in the preceding section. This study will focus on the correlation degree of the cluster algorithm to improve network connectivity through correlated node behaviours in these networks, such as distance, packet, network connectivity and energy consumption.

A new formulation on the correlated degree using 3D Euclidean distance to achieve higher network connectivity under correlated node behaviour. The key idea behind the 3D Euclidean distance in network clustering is to identify a set of sensors whose sensed values present some data correlation referring to correlated degree. The correlated degree is formulated based on three-point distance within a correlation region to identify the level of node correlation within neighboring nodes. In addition, the correlated degree also be able to detect the same group of node behaviour which is grouped in correlated regions. 3D Euclidean distance is shown in mathematical analysis and how the new formulation calculates correlated degree is also discussed. It is also expected that the new 3D Euclidean distance formulation may help correlation region to change its cluster formation dynamically to achieve the required network connectivity.

The research examines the possibility of enhancement clustering algorithm that provides adequate performance for correlation clustering algorithm in WSN network connectivity and energy consumption problem. The simulations use experimentation with four different scenarios namely, cooperatives node, selfish node, malicious node and failure node were carried out to gauge the performance of the enhancement clustering algorithm. Nodes behaviour in WSN network usually have limited on board processing and wireless

communication capabilities, and are equipped with batteries with limited power and thus energy saving techniques needs to be deployed in order to prolong the network lifetime. However, if all the node behaviour simultaneously operated, redundant sensing data, corresponding wireless communication collision and interference will cause much energy to be wasted. The question arising is that how does all sensing node get correlated with the least active nodes so that no blind-point exists and connectivity kept is significant. Cluster becomes a serious problem in large scale sensor networks where hundreds and thousands of nodes are randomly deployed.

An enhancement clustering algorithm for clustering algorithm WSN main parameters (such as distance, packet, energy consumption, and network connectivity) using 3D Euclidean distance method is proposed, enhancement clustering algorithm developed and tested. The algorithm is explained thoroughly and verified using simulation tests. The results from the algorithm show a great improvement and superior enhancement clustering algorithm/ improve network connectivity in WSN parameters leading to the control of energy consumption and network connectivity along with a good connection over correlated and cluster area. The enhancement clustering algorithm has been tested on experimental with four different scenarios namely, cooperatives node, selfish node, malicious node and failure node data and yet to be tested using 3D Euclidean distance based on correlated degree WSN. Thus, the next step is to evaluate the performance of the energy-consumption, and network connectivity of the enhancement clustering algorithm compared with LEACH, EEC, R-HEED, PEGASIS, and LCA algorithms. From the present work, the following can be noted.

An improved correlation network connectivity of the clustering algorithm using 3D Euclidean Distance based on the correlated degree has been analysed, ECA algorithm compared with LEACH, EEC, R-HEED, PEGASIS, and LCA algorithms. An enhancement clustering algorithm of four different scenarios of behaviour node on clustering algorithm that

improve network connectivity using 3D Euclidean Distance based on the correlated degree was carried out to evaluate the network performance energy-consumption, and network connectivity on the enhancement clustering algorithm. The tests were carried out in 3D Euclidean Distance based on the enhancement clustering algorithm to evaluate performance results.

### 7.3 Recommendations and Future Work

Despite the performance of the research, an exhaustive investigation may not be realistic within the present time frame and resources. Therefore, future pertinent work includes the following:

Firstly, research considered correlation cluster algorithm on 3D Euclidean distance to find the cluster head (CH). The research, that studied the joint effects of the correlation degree, distance, and network distance on forming optimal network connectivity that require less energy than conventional approaches. That showed that unlike most of the existing clustering approaches produce uniform clusters throughout the whole network, network connectivity *measurement* are more energy efficient in WSNs with correlation degree. For future work, it may be interesting to implement the algorithm where the placements more involve 3D Euclidean distance algorithm to assess if the clustering algorithm would not significantly different from that obtained in the present work.

Secondly, a possible extension is the dynamic allocation of energy relative to cluster further from the sink are larger in radius clustering network. In this research, that further study can be done on the correlated region, establishing Trust method in a clustering network can provide numerous advantages, such as supporting a CH to detect failure node or malicious nodes on the clustering network. The approach defines a weight for each sensors node when send their data which depends on the distance from the cluster head to the target sensor node.

In the case of the correlation clustering, a trust method system aids in obtain correct data aggregation.

Which consider also defines a self-adaptive weighted method is defined for Trust method aggregation at cluster head. Thus, correlation region can be defined as an area where the Trust method sensed by the sensor nodes are considered similar for the region. Therefore, a single reading within this region is sufficient to represent it. When a node send data to another node an initial correlation which receives no acknowledgement will increase the correlation range till the minimal amounts of neighbours are discovered. For events whose parameters change significantly at short range, the sink node should decrease the size of the correlated region, this event needs to be notified by closer nodes. For events whose parameters do not change significantly at short range, the sink node can increase the size of the correlated region. A cluster head in a cluster network is that the trust method can better monitor the status of the nodes and also improve the clustering network.

Thirdly, the research focused the method of correlated degree as a network connectivity for the sensor nodes having a strong correlation degree in their correlated region, the network cluster is a stable position. Currently, the algorithm only cater stationary distribution of nodes in WSNs. However, a possibility that may need to be evaluated is the scenarios possible with static networks where some of the nodes are not fixed and thereby the distance between nodes varies dynamically.

Fourthly, as future work that intend to consider the trust method to improve the clustering network of the sensor node about the observed phenomenon and further reduce energy consumption. To achieve these objectives, behaviour nodes can estimate the values such as minimum, mean and maximum of their region of correlation taking into account the time and recent readings. In addition, that intend to consider correlation regions of different sizes for a network clustering. As the future work efficient clustering algorithms can be implemented

in every cluster to make few nodes to active at a time and hence more data fidelity can be acquired. Along with this clustering algorithm good routing algorithms can be integrated to get better results.

