

**ENHANCEMENT OF CLUSTERING ALGORITHM USING 3D
EUCLIDEAN DISTANCE TO IMPROVE NETWORK CONNECTIVITY
IN WIRELESS SENSOR NETWORKS FOR CORRELATED NODE
BEHAVIOURS**

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Thesis Submitted in Partial Fulfillment for the degree of
DOCTOR OF PHILOSOPHY IN SCIENCE AND TECHNOLOGY

Faculty of Science and Technology
UNIVERSITI SAINS ISLAM MALAYSIA

2021

AUTHOR DECLARATION

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

I hereby declare that the work in this thesis is my own except for the quotations and summaries which have been duly acknowledged.

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ACKNOWLEDGEMENTS

In the name of Allah, most gracious, most merciful

All praises is due to all, the Lord of the World, the Entirely Merciful and the Especially Merciful. May His peace, blessings and choicest benediction be upon the noblest of mankind, the Prophet Muhammad (PBUH) and his entire family, his companions and all who follow in their footsteps till the day of reckoning.

Words are indeed inadequate to express my profound gratitude to my supervisor and mentor, Associate Professor Dr Azni Haslizan Ab Halim, for her relentless efforts in motivating, guiding and supporting me in every form morally possible during the course of this study. This work would not have been accomplished without her conscientious guidance and support. May Allah reward her abundantly and grant her long life in good health, Ameen.

I would also take to thank my co-Supervisor Associate Professor Dr Farida Hazwani Mohd Ridzuan for her support.

I am also indebted to all my colleagues who have in any way offered some form of motivations, assistance, tips, or materials, all of which were handy in making this research a reality. You are too numerous to provide an exhaustive list. My heartfelt gratitude should also go to the staff and lecturers of the Faculty of Science and Technology, staff of the Centre of Graduate Studies, staff of library in USIM for their friendly cooperation in the whole period of my study.

Finally, would like to thank my family. They were always there cheering me up and stood by me through the good and bad times.

ABSTRAK

Tingkah laku nod memainkan peranan penting untuk rangkaian berkluster bagi meningkatkan prestasi dalam rangkaian sensor tanpa wayar. Rangkaian berkluster adalah salah satu teknik terpenting yang digunakan dalam rangkaian sensor tanpa wayar untuk mengurangkan penggunaan tenaga untuk memanjangkan jangka hayat nod. Idea utama rangkaian berkluster adalah, nod tidak perlu menghantar data dengan kuasa maksimum tetapi nod secara kolaboratif menentukan nod tetangga mereka dengan membentuk hubungan kejiranan yang bersekutu di bawah kriteria tertentu, dengan tujuan mengekalkan sambungan. Sambungan nod bergantung kepada nod yang baik dimana tenaga di setiap nod memainkan peranan penting untuk menjaga nod dalam keadaan baik untuk masa yang lebih lama. Kebanyakan penyelidikan dalam rangkaian berkluster digunakan untuk meminimumkan setiap kaedah penggunaan tenaga nod dengan menyesuaikan kuasa penghantaran nod dan mengimbangi penggunaan tenaga untuk memanjangkan hayat rangkaian. Walau bagaimanapun, penggunaan tenaga dalam rangkaian nod sensor sebahagian besarnya dipengaruhi oleh aktiviti tambahan yang dilakukan oleh nod yang tidak baik di mana penyelidikan sebelumnya gagal diatasi. Aktiviti nod yang tidak baik seperti nod yang egois dan berniat jahat cenderung untuk melakukan tingkah laku yang berkorelasi yang mampu memisahkan rangkaian. Apabila pemisahan rangkaian berlaku, sambungan rangkaian akan hilang dan keseluruhan prestasi rangkaian akan merosot. Oleh itu, kajian ini mencadangkan algoritma kluster baru untuk mengurangkan kesan tingkah laku nod berkorelasi pada rangkaian nod sensor. Objektif penyelidikan ini adalah untuk meningkatkan algoritma kluster yang sedia ada untuk meningkatkan kesalinghubungan rangkaian di bawah keadaan tingkah laku nod berkorelasi. Penyelidikan ini akan merumuskan jarak *Euclidean* 3D untuk mengukur kadar kolerasi. Kadar kolerasi akan mengukur parameter yang dicadangkan untuk mengoptimumkan penggunaan tenaga untuk mengelakkan perpisahan rangkaian. Jarak *Euclidean* 3D dengan kadar berkorelasi akan menyumbang kepada sambungan nod jiran dan ia dirumus berdasarkan jarak tiga titik dalam rantau korelasi. Kemudian, algoritma kluster yang berkorelasi baru akan dibina berdasarkan kepada kadar kolerasi yang dipilih sebagai ketua kluster untuk berfungsi sebagai penyambung antara nod individu dan jirannya bagi membentuk rangkaian berkluster. Kajian ini menggunakan simulasi berasaskan eksperimen menggunakan pengaturcaraan NS-2 dan C ++. Eksperimen ini menggunakan empat senario yang berbeza iaitu nod baik (*cooperative*), nod yang egois (*selfish*), nod jahat (*malicious*) dan nod yang gagal (*failure*). Algoritma berkluster akan dibandingkan dengan algoritma lain iaitu LEACH, EEC, R-HEED, PEGASIS, dan LCA untuk menilai prestasi rangkaian. Dapatan penyelidikan adalah berdasarkan tingkah laku senario nod yang berbeza menunjukkan bahawa algoritma kluster baru yang dibina oleh jarak *Euclidean* 3D menggunakan kadar berkorelasi memberikan prestasi rangkaian yang lebih baik berbanding dengan algoritma ECA, LEACH, EEC, R-HEED, PEGASIS, dan LCA. Sambungan rangkaian menggunakan algoritma kluster meningkat ECA sebanyak 11%, sebanyak 17% untuk LEACH, EEC sebanyak 20%, R-HEED sebanyak 23%, PEGASIS sebanyak 14%, dan LCA sebanyak 15%. Dapatan ini menunjukkan algoritma kluster baru dapat memanjangkan hayat rangkaian dan nod boleh berkomunikasi dengan nod jiran dengan cekap. Ia juga dijangkakan bahawa algoritma kluster baru dapat membantu rantau korelasi untuk mengubah pembentukan kluster secara dinamik untuk mencapai sambungan rangkaian yang diperlukan dan meningkatkan prestasi rangkaian.

ABSTRACT

Node behaviour plays an important role for network clustering to increase performance in wireless sensor networks. Clustering is one of the most important techniques used in wireless sensor networks for energy consumption reduction to prolong node lifetime. The main idea of clustering is that, instead of transmitting with the maximal power, nodes collaboratively determine their neighboring node by forming the proper neighborhood relation under certain criteria, with the purpose of maintaining connectivity. The connectivity of nodes relies on cooperative node where energy in each node plays an important role to keep the node in cooperative state longer. Most of the research in clustering minimizes energy consumption per node by adjusting nodes transmission power and balancing energy consumption to prolong network lifetime. However, energy consumption in ad hoc network mostly affected by extra activities performed by misbehave node in which previous research failed to address. Misbehave activities such as selfish and malicious node tends to perform correlated behaviour which is capable to partition the network. When partition occurs, network connectivity will be loss and degrade the entire network performance. Thus, this research proposes enhancement on clustering algorithm to mitigate the impact of correlated node behaviour on network performances. The objective of this research is to enhance the existing clustering algorithm to improve network connectivity under the event of correlated node behaviour. This research will formulate 3D Euclidean distance to measure the correlated degree. Correlated degree will measure the proposed parameters to optimize energy consumption to prevent partitioning. The 3D Euclidean Distance with a correlated degree will contribute to the connectivity of the neighboring nodes and it is formulated based on three-point distance within a correlation region. Then, the enhancement clustering algorithm will be constructed based on correlated degree which is selected as a cluster head to serves as a link connectivity between individual node and its neighbor to form network clustering. This research uses an experimental based simulation using NS-2 and C++ programming. The experiment uses four different scenarios namely, cooperatives node, selfish node, malicious node and failure node. The clustering algorithm will be compared against LEACH, EEC, R-HEED, PEGASIS, and LCA algorithms to evaluate the network performance of WSN. The results based on different scenarios behaviour node show that the enhance clustering algorithm built by 3D Euclidean Distance using correlated degree provides better network performance compared with LEACH, EEC, R-HEED, PEGASIS, and LCA algorithms. When compared with other algorithms, the connectivity of network using the clustering algorithm increased by 11% for ECA, 17% for LEACH, 20% for EEC, 23% for R-HEED, 14% for PEGASIS, and 15% for LCA. This finding shows that the enhancement of the existing clustering algorithm prolongs its network lifetime and the node may communicate with neighboring node efficiently. It is also shown that the enhancement for the clustering algorithm may help correlation region to change its cluster formation dynamically to achieve the required network connectivity and increase network performance.

مخلص البحث

يلعب سلوك العقدة المترتبة دورا مهما في ادا شبكت الاستشعار اللاسلكية، قد تغير العقدة سلوكها من السلوك العادي إلى سوء السلوك ، مما يؤدي إلى سلوك العقدة المترتبة التي قد تؤثر على اتصال العقد. ارتفاع عدد العقد سوء السلوك ، وارتفاع حركة المرور للعقدة لأنها تستقبل كميات الطاقة التي أحيلت في الأصل من قبل عقدة سوء السلوك. في الأساس ، تؤدي العقد التي تم إساءة تصرفها إلى تقسيم الشبكة مما يؤدي إلى انخفاض أداء الشبكة بسبب عدم توفر العقد. في هذا الصدد ، يتمثل مفتاح حل هذه المشكلة في إيجاد أفضل خوارزمية للتجميع يتم تنفيذها من أجل اتصال العقد في حالة سيناريو سلوك الإيماء المترابط. الهدف من هذا البحث هو تحسين خوارزمية التجميع الموجودة لتحسين اتصال الشبكة في حالة سلوك العقدة المترتبة. سيقوم هذا البحث بصياغة مسافة إقليدية ثلاثية الأبعاد لقياس درجة الارتباط. وهناك درجة مترابطة قياس المعلمات المقترحة لاستهلاك الطاقة الأمثل لمنع التقسيم. يستخدم البحث في محاكاة تجريبية قائمة على خوارزمية التجميع المترابط. باستخدام البرمجة هذا التجربة مع أربعة سيناريوهات مختلفة وهي عقدة التعاونيات ان اس تو و سي بلس بلس. يستخدم والعقدة الأناية والعقدة الخبيثة والعقدة الفاشلة. ثم يتم تحليل ومناقشة النتائج. بعد ذلك ، سوف تساهم هذه المسافة الإقليدية ثلاثية الأبعاد مع درجة ارتباط في خوارزمية التجميع في توصيل العقد المجاورة. تتمثل المسافة الإقليدية ثلاثية الأبعاد في تجميع الشبكات في تحديد مجموعة من المستشعرات التي تعرض قيمها الحسية بعض ارتباط البيانات في إشارة إلى درجة مترابطة. يتم صياغة درجة الارتباط على أساس مسافة ثلاث نقاط داخل منطقة الارتباط لتحديد مستوى ارتباط العقدة داخل العقد المجاورة. بالإضافة إلى ذلك ، فإن الدرجة المترتبة هي أيضاً قادرة على اكتشاف نفس مجموعة سلوك العقدة التي يتم تجميعها في المناطق المترتبة. تُظهر النتائج المستندة التي صُنعت بواسطة مسافة إقليدية ثلاثية الأبعاد إلى سلوكيات سيناريوهات مختلفة أن خوارزمية التكتل المترابط من زيادة اتصال الشبكة باستخدام .و باستخدام درجة مترابطة توفر أداءً أفضل للشبكة مقارنةً بخوارزميات على التوالي. يوضح هذا الاكتشاف أن خوارزمية المجموعات المترتبة كانت والقيمة حيث القيمة هي والقيمة تطيل عمر الشبكة وقد تتواصل العقدة مع العقدة المجاورة بكفاءة. من المتوقع أيضاً أن يساعد التقييم القطري المشترك منطقة الارتباط على تغيير تكوين الكتلة بشكل ديناميكي لتحقيق اتصال الشبكة المطلوب.

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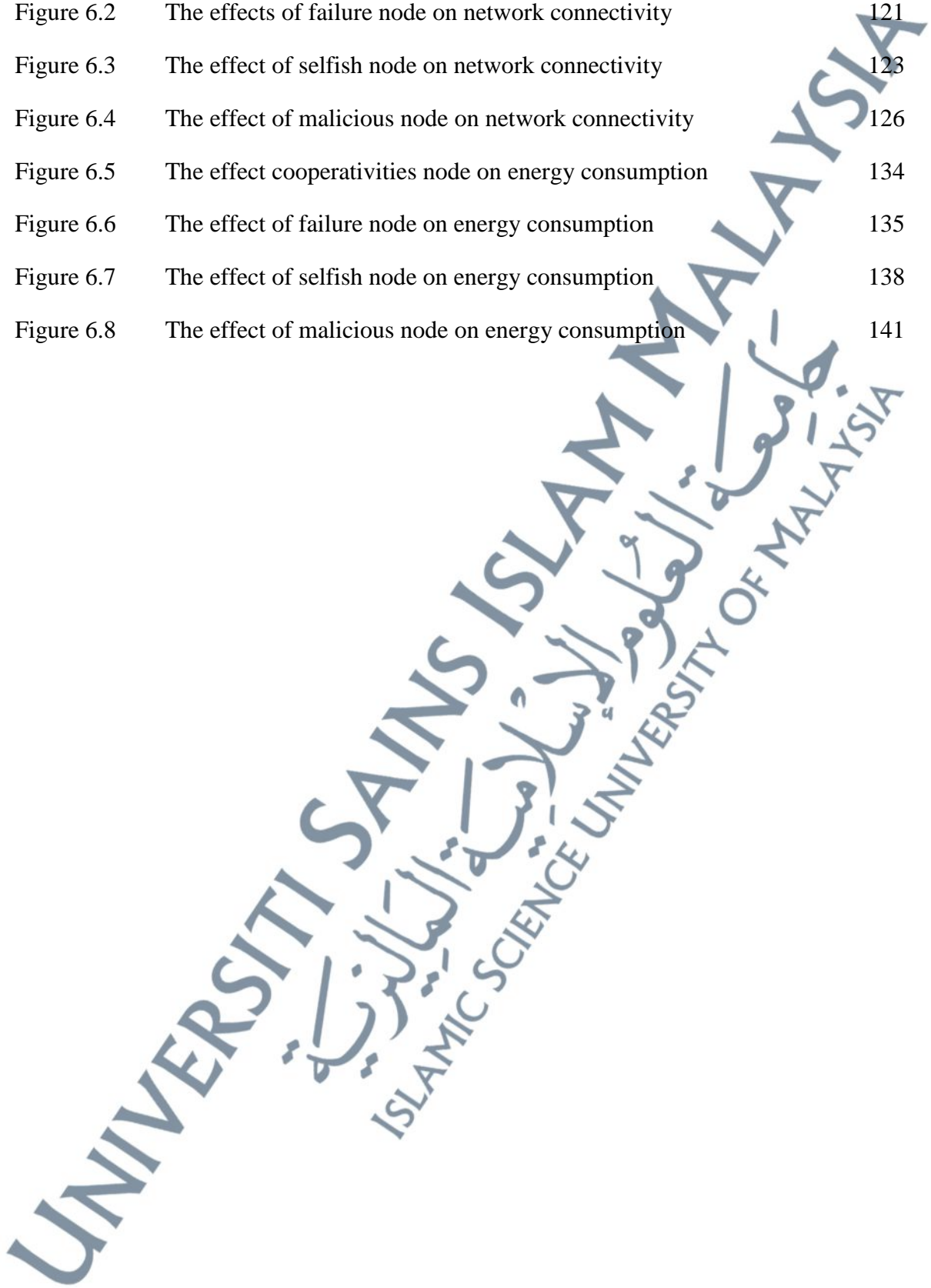
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LIST OF ABBREVIATIONS

WSNs	Wireless Sensor Networks
LCA	Linked Clustering Algorithms
DoS	Denial of Services
LEACH	Low-Energy Adaptive Clustering Hierarchical
TL-ELACH	Two-Level Low-Energy Adaptive Clustering Hierarchy
TDMA	Time-Division-Multiple access
CH	Cluster Head
LCA	Linked Cluster Algorithm
WCA	Weighted Clustering Algorithm
CDMA	Code-Division Multiple Access
MAC	Medium Access Control Protocol
R-HEED	Rotated Hybrid Energy-Efficient Distributed Clustering
PEGASIS	Power-Efficient Gathering in Sensor Information Systems
GS	Grid Seed
GROUP	A Grid-Clustering Routing Protocol
QoS	Quality of Service
CD	Correlated Degree
RSSI	Received Signal Strength Indicator
3D	3D Euclidean Distance
2D	2D Euclidean Distance
CC	Correlation Coefficient
TCP	Transmission Control Protocol
AODV	Ad hoc On-Demand Distance Vector Routing