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EFFECT OF MOBILITY ON DEVICE-TO-DEVICE CLUSTERING USING SELF-ORGANIZING MAP (SOM) ALGORITHM

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***Abstract*— In this paper, the effect of mobility on device-to-device clustering using self-organizing map (SOM) algorithm is presented. About 50 mobile devices were considered and the state of each of the 50 devices was considered in two instances, at an interval of one (1) hour. The x-y coordinate data and the hardware capacity of the mobile devices were generated with a random distribution technique using the 'rand' command in MATLAB for each of the 50 devices occupying an area of 1500 m by 1500 m with the base station (sink) at the center (750 m to 750 m) of the region. The SOM algorithm was used to do the selection of the cluster heads and the clustering of the devices in each of the two hours. The results show that nine (9) cluster heads were selected by the SOM algorithm in the first hour and in the second hour. Also, according to the results, the first cluster head (which is mobile device 2 with device capacity of 4.5290) had 5 clusters slaves in the first hour and 9 clusters slaves in the second hour. This implies that during the second hour the position of the second device was closer to the base station than it was in the second hour. On the other hand, the ninth cluster head (which is device 39 with device capacity of 4.7511) had 4 cluster slaves in the first hour and one (1) cluster slave in the second hour. This implies that during the second hour the position of the 39th device was father away from the base station than it was in the second hour. Similar variations in the number of cluster slave for each cluster head were observed in each of the nine cluster heads. Such variations in the number of cluster slaves per cluster head due to the spatiotemporal variations in the mobile device locations are indicators of the effect of mobility on the D2D cluster.**

Keyword: Clustering, Self-Organizing Map, Device-To-Device, Base Station, Base Station

I. INTRODUCTION

Today, wireless communication technologies have dominated the communication industry [1,2,3,4,5]. The growing demand for more bandwidth and improved quality of services drive researchers to explore ways to meet such stringent demands. Efficient handoff mechanisms [6,7,8,9], more accurate propagation loss estimation [10,11,12,13,14,15], and other strategies like the device to device (D2D) communication technologies [16,17,18] are among the approaches adopted in the wireless communication industry to meet the challenges caused by the growing demand. As regards D2D communication, most of the available studies embarked on clustering of mobile devices with the assumption that the devices are stationary [19,20,21,22,23,24]. With the knowledge of the hardware capacity of the devices and their distance from the base station, it was possible to cluster the weak and afar devices to the selected relay device to ensure efficient inter signal transmission [16,17,18, 25]. However, since some of the devices considered are mobile, the results achieved when the devices are assumed static will be considered inadequate. Accordingly, this paper studied the effect of device mobility on the clustering outcome based on the Self-Organizing Map (SOM) clustering algorithm [26,27,28,29].

II . METHODOLOGY

In this paper, Self-Organizing Map (SOM) was used to study the effect of mobility on D2D clustering of nodes in wireless network. The SOM algorithm-based procedure used to study the effect of mobility on D2D clustering is shown in Figure 1. About 50 mobile devices were considered and the state of ach of the 50 devices was considered in an interval of one (1) hour. The x-y coordinate data and the hardware capacity of the mobile devices were generated with a random distribution technique using the 'rand' command in MATLAB for each of the 50 devices occupying a region of 1500 m by 1500 m with the base station (sink) at the center (750 m to 750 m) of the region. The random data generation was conducted twice at varying x-y coordinate positions of the mobile devices with the position of the sink being the same. Table 1 shows the x-y coordinate position of the mobile devices which was assumed to have occurred at 1hour interval with the same hardware capacity of the mobile devices. The SOM algorithm was used to do the clustering of the devices in each of the two hours considered and the results of the clustering reveal the effect of the mobility of the devices on the D2D clustering.

In Table 1, the same 50 mobile devices were projected for two hours in order to account for the changes in position. The graphical view of the data in Table 1 can be seen in Figure 2 and Figure 3.

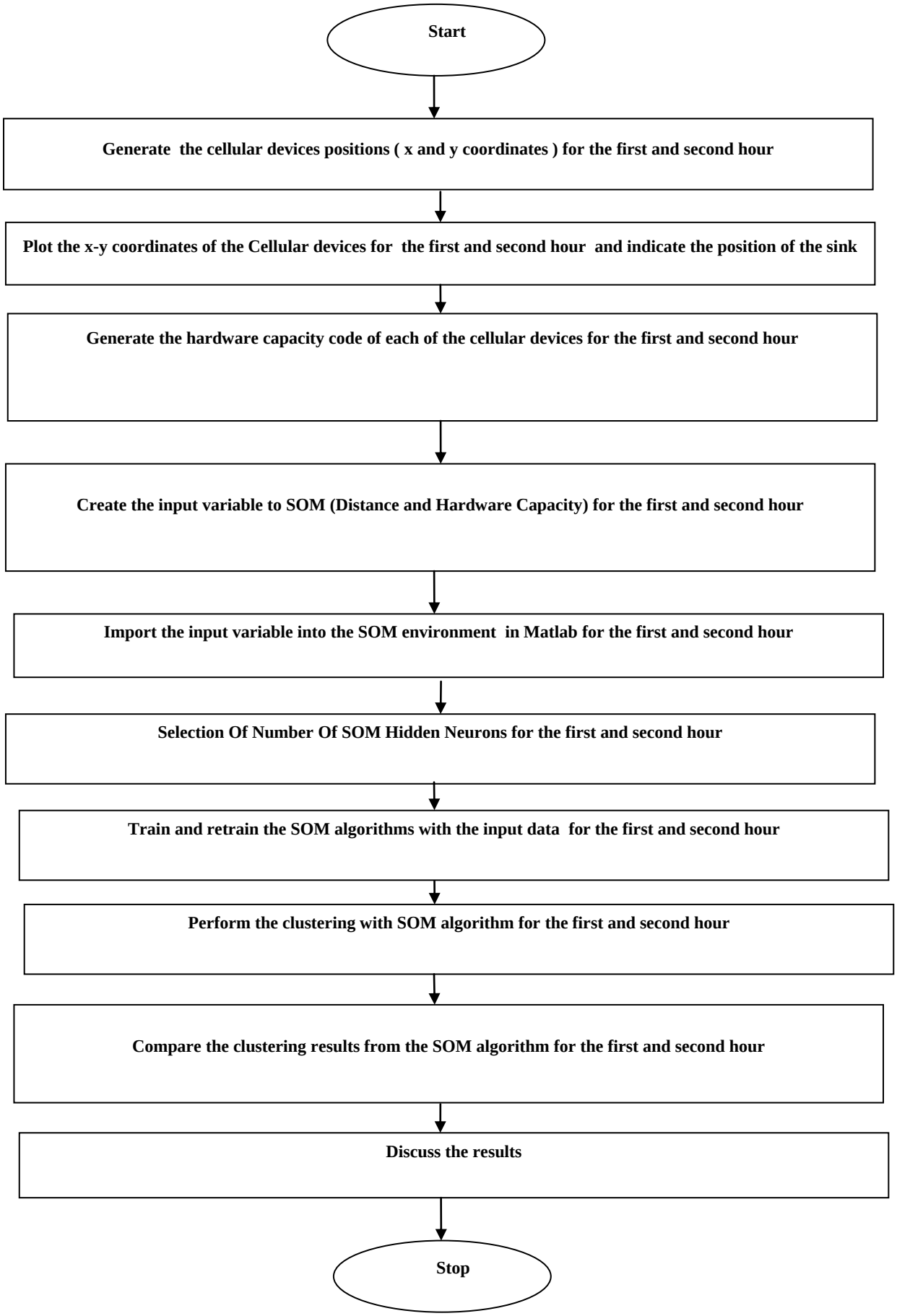

Figure 1: The SOM algorithm-Based Procedure Used To Study The effect of Mobility On D2D clustering

Table 1: The x-y coordinate position of the mobile devices which were assumed to have occurred at 1hour interval with the same hardware capacity of the mobile devices.

Device number	Hardware capacity	Coordinate for first hour		Coordinate for second hour	
		x	y	x	y
1	2.0736	414.04	243.27	625.9	966.48
2	4.5290	1019.6	1191.4	74.482	567.91
3	0.6349	982.65	466.82	1354.1	1217.4
4	3.5669	243.92	792.8	1417.2	799.24
5	3.1618	178.5	248.47	736.3	526.09
6	0.4877	747.55	902.97	733.88	1408.5
7	1.3925	1439.6	394.46	506.58	1313.9
8	2.7344	510.58	981.12	1350.1	825.23
9	4.7875	877.9	1033.8	553.87	933.71
10	1.8244	335.72	1122.2	166.8	880.57
11	0.7881	1126.9	675.81	1170.4	311.61
12	2.8530	382.64	125.73	584.61	451.87
13	4.7858	758.94	343.47	362.54	706.39
14	2.4269	1048.6	1370	605.87	345.73
15	4.0014	1336.4	228.57	144.68	1266.5
16	0.7094	1438.9	1238.7	197.96	292.15
17	2.1088	820.82	807.51	1413.1	338.88
18	4.5787	207.94	1494.2	1434.2	256.06
19	3.9610	223.94	117.26	862.81	341.5
20	4.7975	386.26	664.02	89.669	653.55
21	3.2787	1261.1	159.98	352.17	466.65
22	0.1786	381.42	1442.8	529.74	1385.1
23	3.2456	1221.4	6.9513	1231.8	645.31
24	4.6700	365.29	1162.4	23.105	277.22
25	3.3937	1393.9	1226	64.536	1357.3
26	3.7887	524.98	1303	253.49	1469.6
27	3.7157	294.89	126.65	973.67	658.3
28	1.9611	376.63	599.67	1097.6	166.68
29	3.2774	924.07	389.81	971.62	387.1
30	0.8559	709.93	1200.1	676.39	613.08
31	3.5302	527.49	647.12	820.51	892.34
32	0.1592	1246.2	1366	444.48	393.32
33	1.3846	877.9	272.77	1117	904.26
34	0.2309	824.59	395.7	283.43	1066.8
35	0.4857	1375.8	218.31	1030.2	332.62
36	4.1173	428.76	204.1	275.27	176.13
37	3.4741	1135.8	1303.9	552.73	445.01

38	1.5855	1130.6	869.56	938.43	478.17
39	4.7511	570.67	824.79	1170.3	636.25
40	0.1722	851.73	217.43	121.69	761.79
41	2.1937	113.78	1279.5	1394.1	128.27
42	1.9078	80.925	933.08	1163.6	393.72
43	3.8276	796.2	526.43	730.19	1201.5
44	3.9760	1168.8	769.87	653.79	43.83
45	0.9344	1401	602.71	670.18	1393.3
46	2.4488	194.86	113.95	459.52	1095.5
47	2.2279	853.24	359.87	762.76	732.91
48	3.2316	704.09	184.98	766.16	867.79
49	3.5468	17.853	275.86	1226.4	355.93
50	3.7734	505.68	359.93	1192.2	688.27

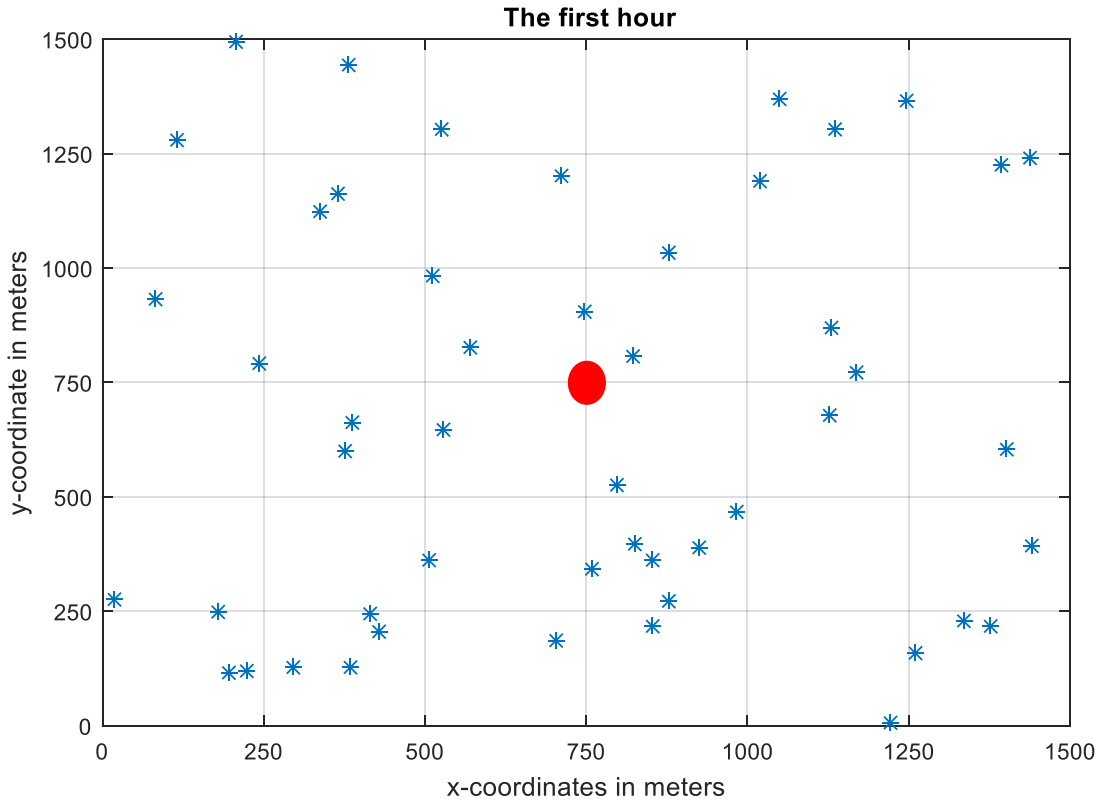

Figure 2: The x-y coordinate position of the mobile devices in the first hour

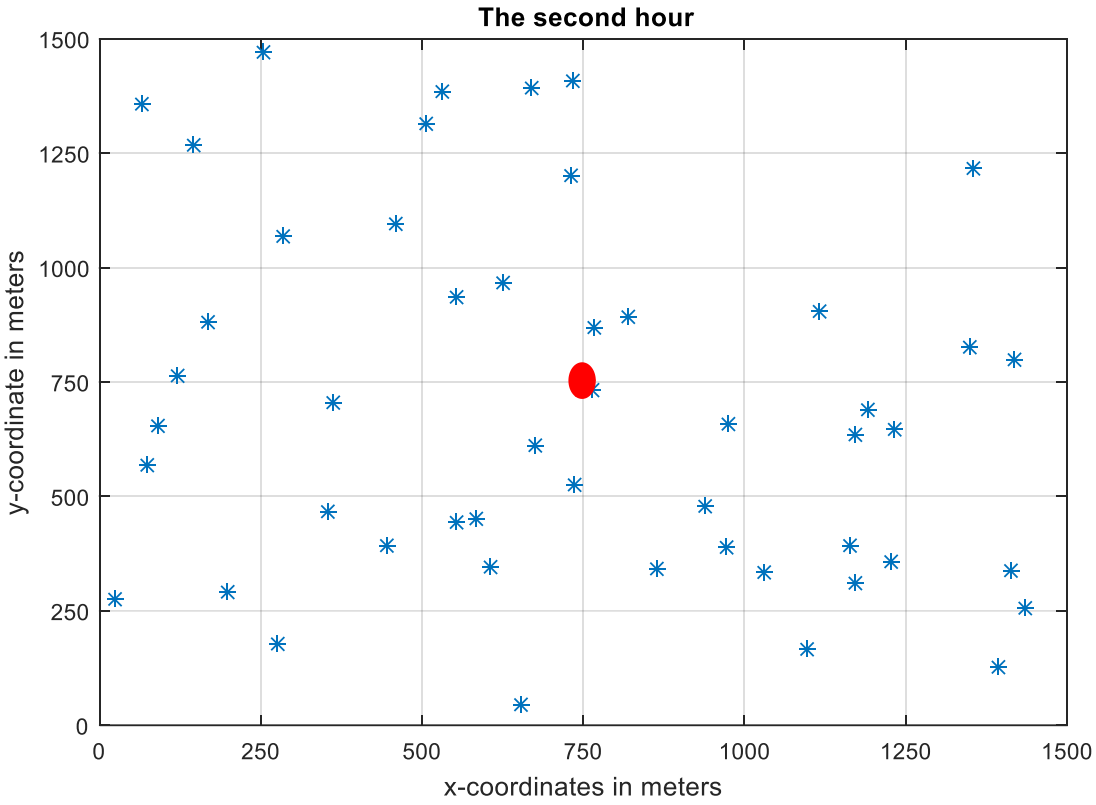

Figure 3: The x-y coordinate position of the mobile devices in the second hour

III. RESULTS AND DISCUSSION

The randomly generated device coordinate data and the hardware capacity of the devices were used along with SOM algorithm to simulate the selection of the cluster heads with MATLAB 2019a. In the simulation, the hardware capacity of the device greater than 4 is required for a device to be a cluster head. The results in Figure 4 and Figure 5 show that nine (9) cluster heads were selected by the SOM algorithm in the first hour and in the second hour. The positions of the cluster heads in the region for the 2 hours under consideration are shown in Figure 5 and Figure 5.

The cluster heads with number of cluster slaves to each of the cluster head in the first hour is shown in Figure 6. Similarly, the cluster heads with number of cluster slaves to each of the cluster head in the second hour is shown in Figure 7. The number of cluster slaves to cluster head for the first and the second hour is presented in Table 2 and Figure 8. The results in Table 5 and Figure 8 show that the first cluster head (which is device 2 with device capacity of 4.5290) had 5 cluster slaves in the first hour and 9 cluster slaves in the second hour. This implies that during the second hour the position of the second device was closer to the base station than it was in the second hour. On the other hand, the ninth cluster head (which is device 39 with device capacity of 4.7511) had 4 cluster slaves in the first hour and one (1) cluster slave in the second hour. This implies that during the second hour the position of the 39th device was father away from the base station than it was in the second hour.

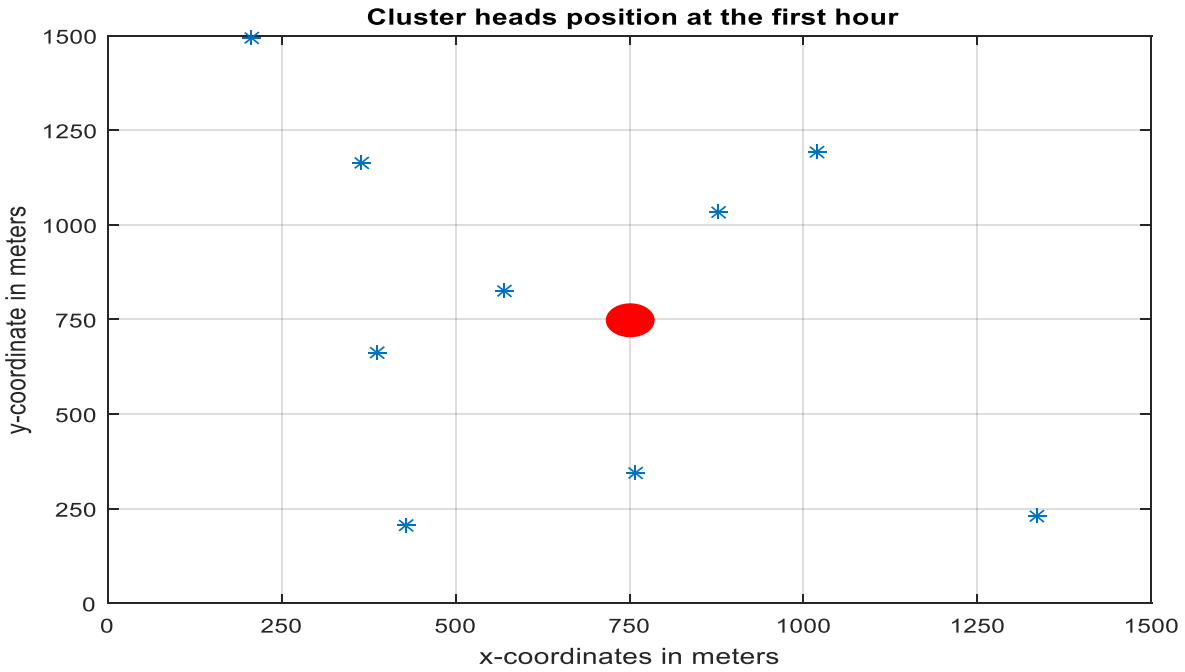

Figure 4; Cluster head position at the first hour

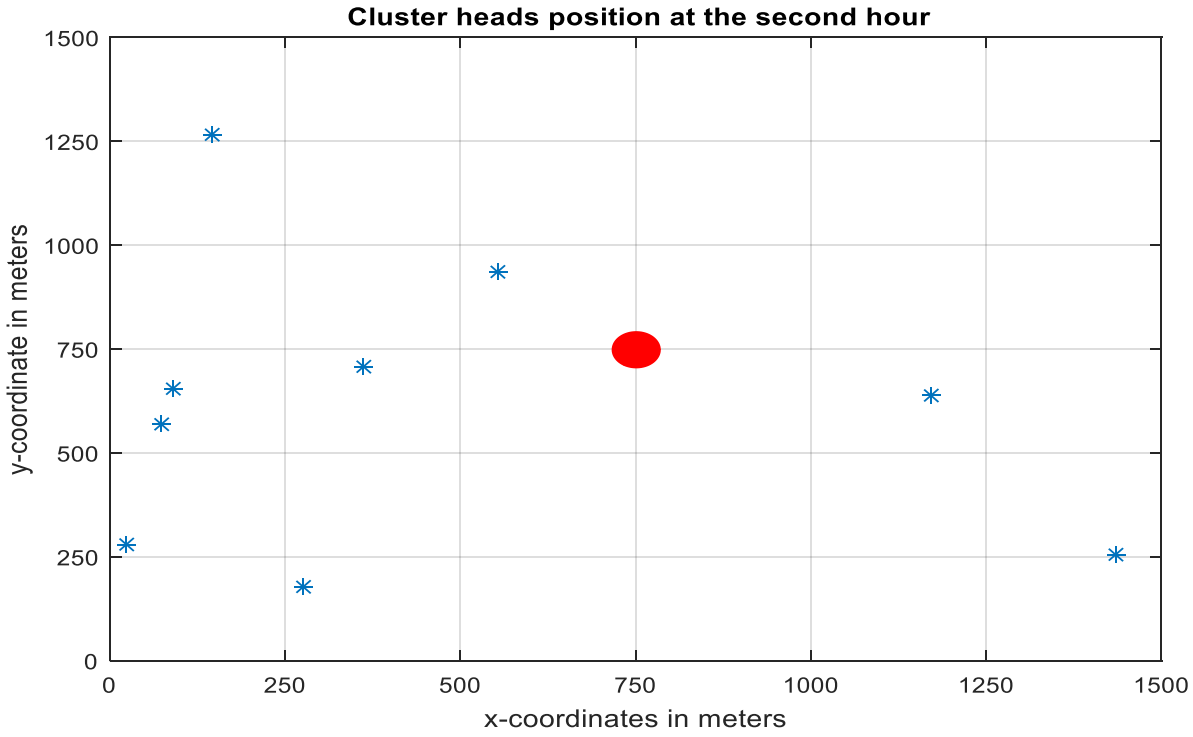

Figure 5; Cluster head position at the second hour

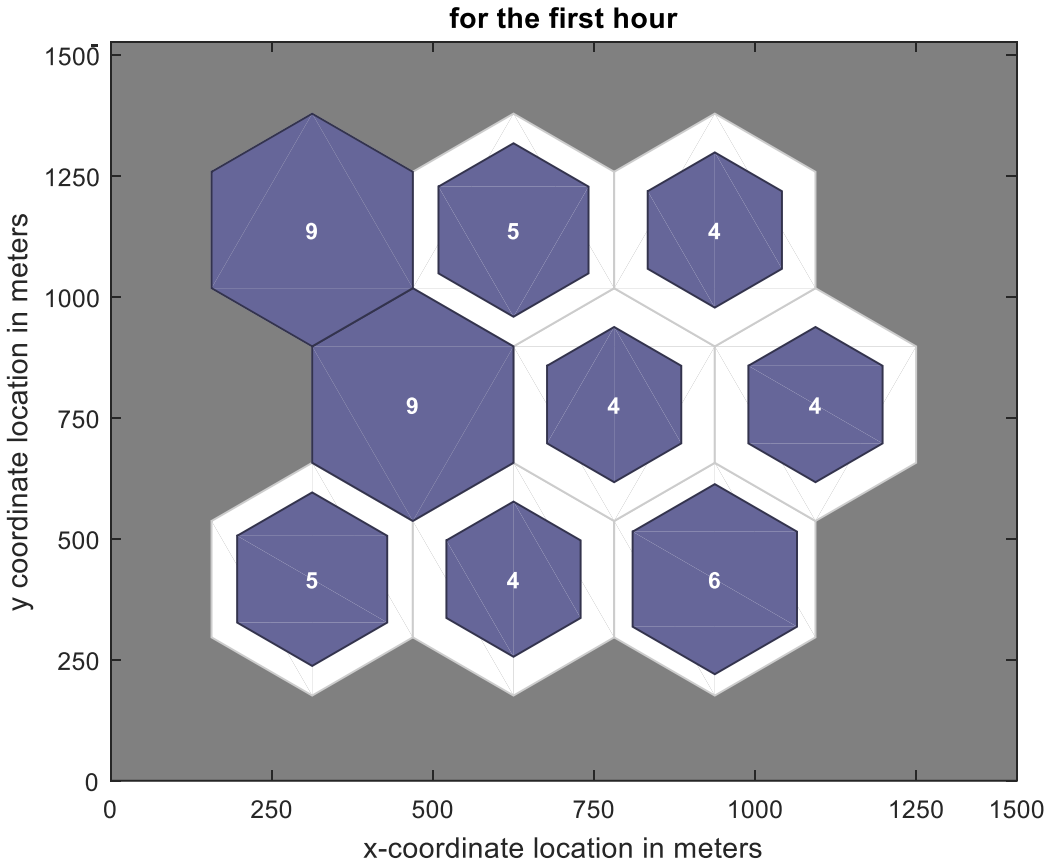

Figure 6; Cluster heads with number of cluster slaves in the first hour

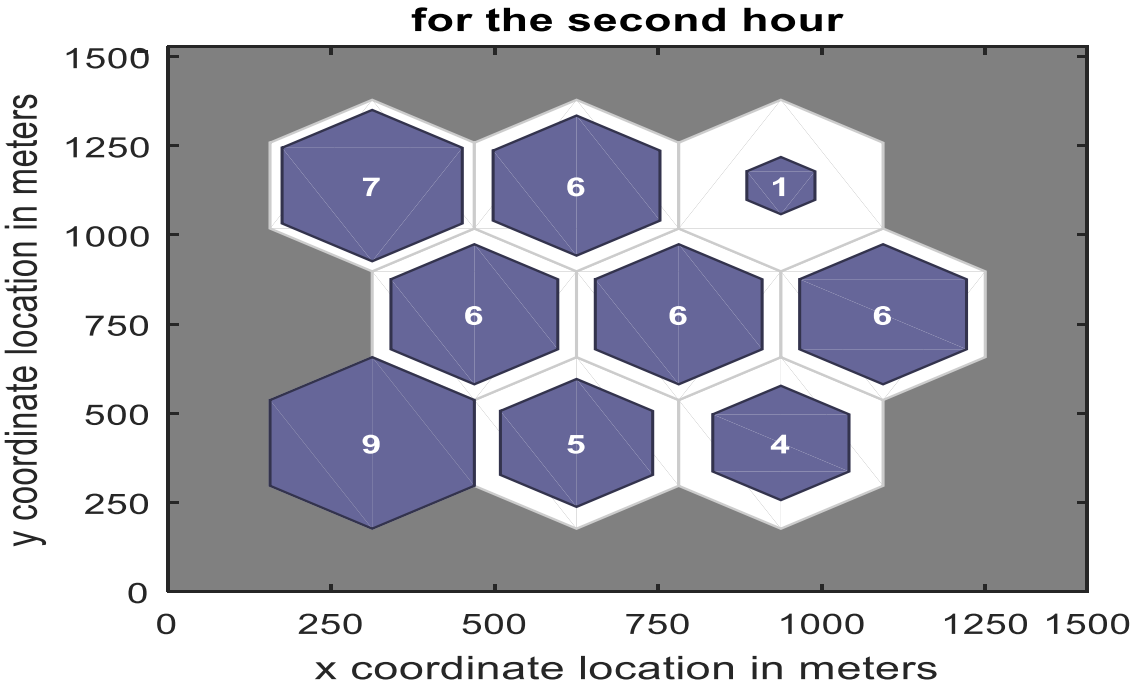

Figure 7; Cluster heads with number of cluster slaves in the second hour

Table 2 The number of cluster slaves to cluster for the first and the second hour

Cluster Head number (Device number)	Hardware capacity	Number of cluster slaves for First hour	Number of cluster slaves for Second hour
1 (2)	4.5290	5	9

2 (9)	4.7875	4	5
3 (13)	4.7858	6	4
4 (15)	4.0014	9	6
5 (18)	4.5787	4	6
6 (20)	4.7975	4	6
7 (24)	4.6700	9	7
8 (36)	4.1173	5	6
9 (39)	4.7511	4	1

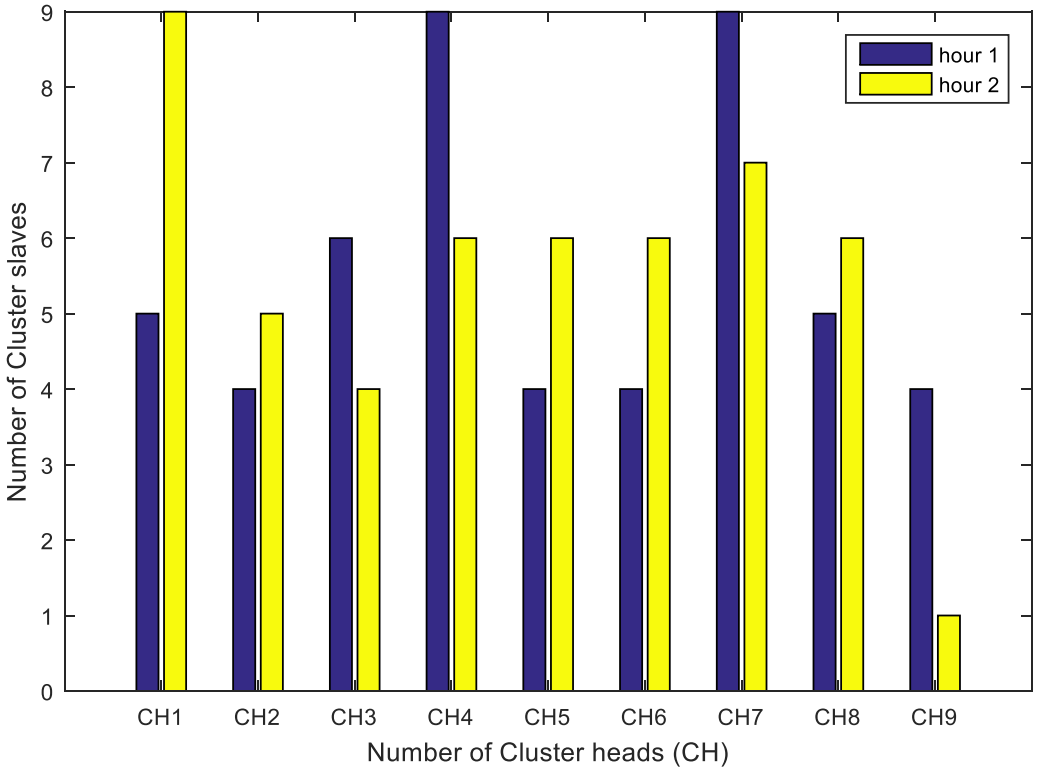

Figure 8; The bar chart of the number of cluster slaves to cluster for the first and the second hour

IV. CONCLUSION

A study on the effect of mobility on device-to-device (D2D) clustering was presented. The self organizing map (SOM) was used for the selection of cluster heads from a set number of mobile devices distributed randomly around a base station. In the study, it was assumed that at any instance, each of the mobile devices is expected to move and change its position relative to the base station. Hence, the clustering of the devices was conducted in two instances at an interval of one (1) hour. The variation in the number of cluster slaves to a given cluster head at any instance the clustering was conducted is a clear indication of the effect of mobility of the devices on the D2D clustering.

REFERENCES

1. Van de Kaa, G., Fens, T., Rezaei, J., Kaynak, D., Hatun, Z., & Tsilimeni-Archangelidi, A. (2019). Realizing smart meter connectivity: Analyzing the competing technologies Power line communication, mobile telephony, and radio frequency using the best worst method. *Renewable and Sustainable Energy Reviews*, *103*, 320-327.
2. Holfeld, B., Wieruch, D., Wirth, T., Thiele, L., Ashraf, S. A., Huschke, J., ... & Ansari, J. (2016). Wireless communication for factory automation: An opportunity for LTE and 5G systems. *IEEE Communications Magazine*, *54*(6), 36-43.
3. Wu, Q., Mei, W., & Zhang, R. (2019). Safeguarding wireless network with UAVs: A physical layer security perspective. *IEEE Wireless Communications*, *26*(5), 12-18.
4. Rehmani, M. H., Reisslein, M., Rachedi, A., Erol-Kantarci, M., & Radenkovic, M. (2018). Integrating renewable energy resources into the smart grid: Recent developments in information and communication technologies. *IEEE*

Transactions on Industrial Informatics, *14*(7), 2814-2825.

5. Gangakhedkar, S., Cao, H., Ali, A. R., Ganesan, K., Gharba, M., & Eichinger, J. (2018, May). Use cases, requirements and challenges of 5G communication for industrial automation. In *2018 IEEE International Conference on Communications Workshops (ICC Workshops)* (pp. 1-6). IEEE.
6. Akpan, U., Kalu, C., Ozuomba, Simeon, & Obot, A. (2013). Development of Improved Scheme for Minimising Handoff Failure due to Poor Signal Quality. *International Journal of Engineering Research and Technology*, *2*(10), 2764-2771.
7. Donaldson, A. E., Kalu, C., & Dialoke, I. C. (2016). Cluster-based call acceptance principle for optimum reduction of call failures in a gsm network system. *Mathematical and Software Engineering*, *2*(2), 48-56.
8. Itoro J. Akpan, Ozuomba Simeon and Kalu Constance. "DEVELOPMENT OF A GUARD CHANNEL-BASED PRIORITIZED HANDOFF SCHEME WITH CHANNEL BORROWING MECHANISM FOR CELLULAR NETWORKS". Journal of Multidisciplinary Engineering Science and Technology (JMEST)
9. Omini Samuel , Kalu Constance and Ozuomba Simeon , "DEVELOPMENT OF FUZZY INFERENCE SYSTEM-BASED ANALYSIS OF NON-PRIORITIZED HANDOFF SCHEME WITH STATISTICALLY MODELLED IDLECHANNEL BORROWINGMECHANISM FOR CELLULAR NETWORKS" International Multilingual Journal of Science and Technology (IMJST)
10. Ozuomba, S., Enyenihi, J., & Rosemary, N. C. (2018). Characterisation of Propagation Loss for a 3G Cellular Network in a Crowded Market Area Using CCIR Model. *Review of Computer Engineering Research*, *5*(2), 49-56.
11. Johnson, E. H., Ozuomba, S., & Asuquo, I. O. (2019). Determination of Wireless Communication Links Optimal Transmission Range Using Improved Bisection Algorithm.
12. Ozuomba, S., Johnson, E. H., & Udoiwod, E. N. (2018). Application of Weissberger Model for Characterizing the Propagation Loss in a Gliricidia sepium Arboretum.
13. Njoku Chukwudi Aloziem, Ozuomba Simeon, Afolayan J. Jimoh (2017) Tuning and Cross Validation of Blomquist-Ladell Model for Pathloss Prediction in the GSM 900 Mhz Frequency Band , *International Journal of Theoretical and Applied Mathematics, Journal*: Environmental and Energy Economics
14. Akaninyene B. Obot , Ozuomba Simeon and Afolanya J. Jimoh (2011); "*Comparative Analysis Of Pathloss Prediction Models For Urban Macrocellular" Nigerian Journal of Technology (NIJOTECH)* Vol. 30, No. 3 , October 2011 , PP 50 – 59
15. Akaninyene B. Obot , Ozuomba Simeon and Kingsley M. Udofia (2011); *"Determination Of Mobile Radio Link Parameters Using The Path Loss Models"* NSE Technical Transactions , A Technical Journal of The Nigerian Society Of Engineers, Vol. 46, No. 2 , April - June 2011 , PP 56 – 66.
16. Nwaogu Onyeyirichi E., Ozuomba Simeon and Kalu Constance , "Development of Self-Organizing Map Clustering Algorithm for Relay Selection in High Density Long Term Evolution Networks", Science and Technology Publishing (SCI & TECH)
17. Florence Kingsley Atakpo , Ozuomba Simeon and Stephen Bliss Utibe-Abasi, "A COMPARATIVE ANALYSIS OF SELF-ORGANIZING MAP AND K-MEANS MODELS FOR SELECTION OF CLUSTER HEADS IN OUT-OF-BAND DEVICE-TO-DEVICE COMMUNICATION "Journal of Multidisciplinary Engineering Science Studies (JMESS)
18. Ozuomba Simeon "APPLICATION OF K-MEANS CLUSTERING ALGORITHM FOR SELECTION OF RELAY NODES IN WIRELESS SENSOR NETWORK" Journal of Multidisciplinary Engineering Science and Technology (JMEST)
19. Asadi, A. (2016). Opportunistic device-to-device communication in cellular networks: from theory to practice. *arXiv preprint arXiv:1610.08293*.
20. Shah, S. T., Hasan, S. F., Seet, B. C., Chong, P. H. J., & Chung, M. Y. (2018). Device-to-device communications: A contemporary survey. *Wireless Personal Communications*, *98*(1), 1247-1284.
21. Gandotra, P., & Jha, R. K. (2016). Device-to-device communication in cellular networks: A survey. *Journal of Network and Computer Applications*, *71*, 99-117.
22. Kar, U. N., & Sanyal, D. K. (2018). An overview of device-to-device communication in cellular networks. *ICT express*, *4*(4), 203-208.
23. Ahmad, M., Azam, M., Naeem, M., Iqbal, M., Anpalagan, A., & Haneef, M. (2017). Resource management in D2D communication: An optimization perspective. *Journal of Network and Computer Applications*, *93*, 51-75.
24. Jameel, F., Hamid, Z., Jabeen, F., Zeadally, S., & Javed, M. A. (2018). A survey of device-to-device communications: Research issues and challenges. *IEEE Communications Surveys & Tutorials*, *20*(3), 2133-2168.
25. Ooi, J. (2015). IMSI catchers and mobile security. *School of Engineering and Applied Science University of Pennsylvania*.

26. Vesanto, J., & Alhoniemi, E. (2000). Clustering of the self-organizing map. *IEEE Transactions on neural networks*, *11*(3), 586-600.
27. Kalteh, A. M., Hjorth, P., & Berndtsson, R. (2008). Review of the self-organizing map (SOM) approach in water resources: Analysis, modelling and application. *Environmental Modelling & Software*, *23*(7), 835-845.
28. Wu, S., & Chow, T. W. (2004). Clustering of the self-organizing map using a clustering validity index based on inter-cluster and intra-cluster density. *Pattern Recognition*, *37*(2), 175-188.
29. Kiang, M. Y. (2001). Extending the Kohonen self-organizing map networks for clustering analysis. *Computational Statistics & Data Analysis*, *38*(2), 161-180.