TABLE 2 Ten times the duration of time up to the first node dies in the network

Times	LEACH	EECRA
1	800	1300
2	812	1350
3	780	1301
4	795	1290
5	805	1289
6	823	1310
7	779	1333
8	803	1290
9	810	1293
10	778	1320

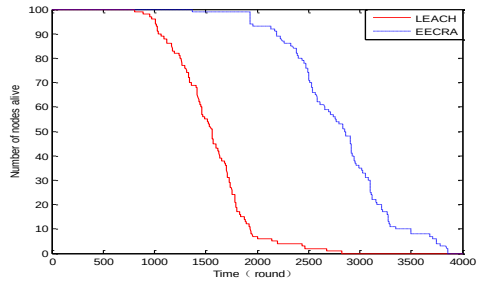

Fig.3 Number of nodes alive over the time with different cluster based protocols

In Fig.4, we see the average energy dissipation in the network per round. It shows that the energy dissipation of EECRA is less than that of LEACH. Moreover, the lifetime of EECRA is longer than that of LEACH. Now EECRA takes full advantages of heterogeneity, and the stable region increases ssignificantly in comparison with that of LEACH. This is because under EECRA, the node with higher residual energy and closer to the cluster center will be the cluster head.

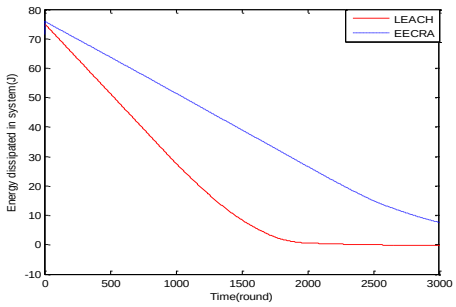

Fig.4 Comparison of average energy dissipation

V. Conclusion

In this paper, we present a energy-efficient clustering routing algorithm for heterogeneous wireless sensor networks, EECRA. This protocol uses FCM algorithm to create cluster structure in order to minimize the spatial distance among the sensor nodes and thus a better cluster formation is obtained. The node with the highest residual energy and nearest to the cluster center to be the cluster head. Our simulation results show that by the EECRA algorithm the power consumption is reduced and the life time of the network is extended significantly when compared with LEACH.

VI . Acknowledgment

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