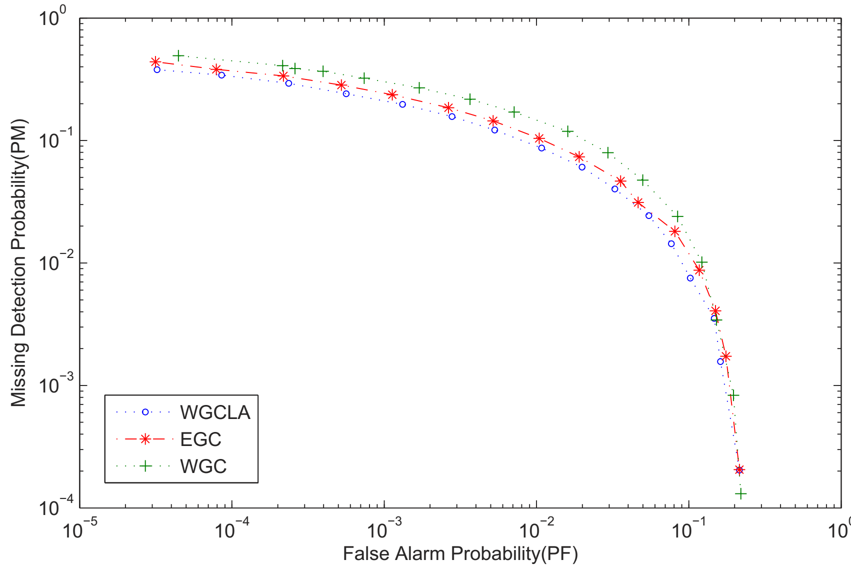

Fig. 5. Missing detection probability P_m versus false alarm probability P_f. (Each secondary user has different average SNRs varying from 3 to 8 dB.)

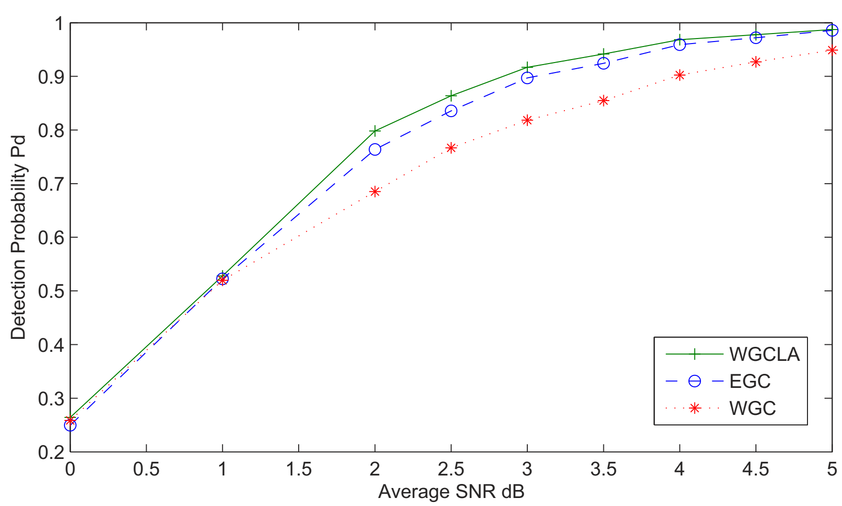

Fig. 6. Detection probability (P_d) versus average SNR ($P_f = 10^{-2}$, $TW = 5$)

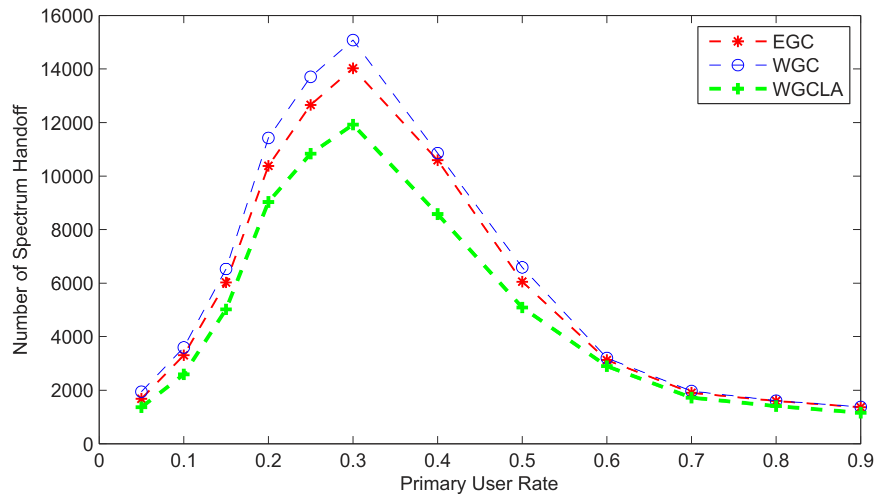

Fig. 7. The number of spectrum handoff versus PUs arrival rate in channel. ($P_m = 5 \times 10^{-2}$)

To evaluate the SUs quality of service in proposed method, we set up four channels with four PUs and 10 SUs scenario. After 10 SUs perform consensus sensing, one of them try to use idle channels. In this simulation, we use number of spectrum handoff and maximum delay as metric in SUs quality of service. In fig. 7, PUs have different arrival rate varying from 0.05 to 0.9 (pkt/sec). Fig. 7 shows the number of spectrum handoff in proposed algorithm, algorithm in [2] and [8] respectively. Compared with previous methods, the performance has been significantly improved by our propose algorithm.

Fig. 8 shows the number of spectrum handoff with respect to the SU arrivals rate varying from 0.05 to 0.9 (pkt/sec). We can see that when the SU arrivals rate is greater than 0.2 (pkt/sec), our proposed scheme achieves much better performance than the algorithm in [2] and [8].

Maximum delay is another SUs quality of service parameters. In other scenario, the maximum delay based on the number of time slot has been studied. In fig. 9, PUs have different arrival rate varying from 0.2 to 3 (pkt/sec) and in fig. 10 SU has different arrival rate varying from 0.2 to 3 (pkt/sec). As we see in fig. 9 and fig. 10, the maximum delay has been decreased by our propose algorithm.

5 Conclusion and Future Work

In this paper, we present a distributed cooperative spectrum sensing based on consensus algorithm and learning automata in cognitive radio networks. Simulation results show our approach has more accurate results than the existing

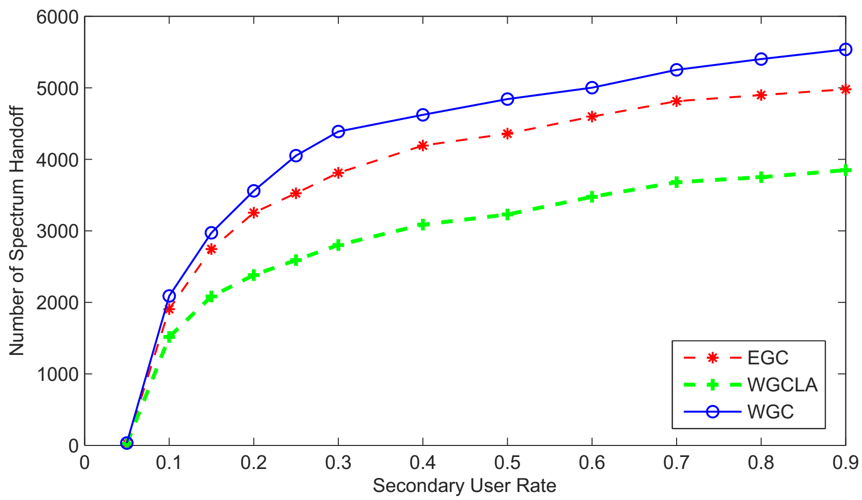

Fig. 8. The number of spectrum handoff versus SU arrival rate in channel. ($P_m = 5 \times 10^{-2}$)

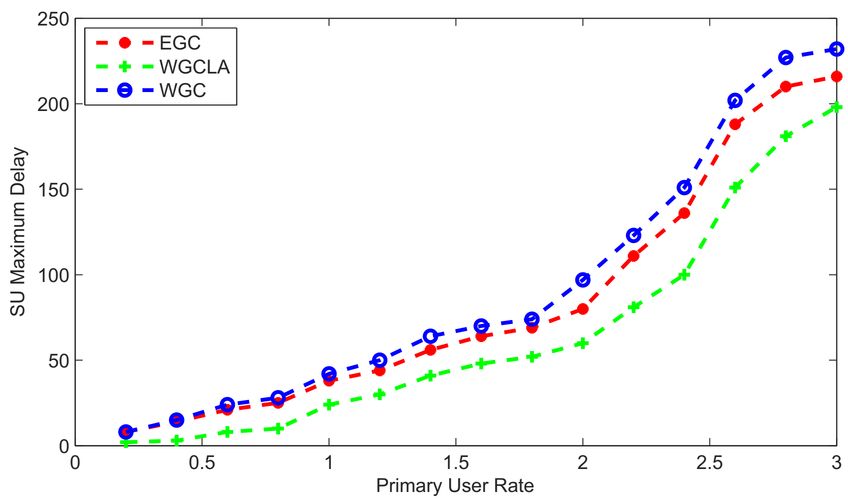

Fig. 9. The maximum delay versus PUs arrival rate in channel. ($P_m = 5 \times 10^{-2}$)

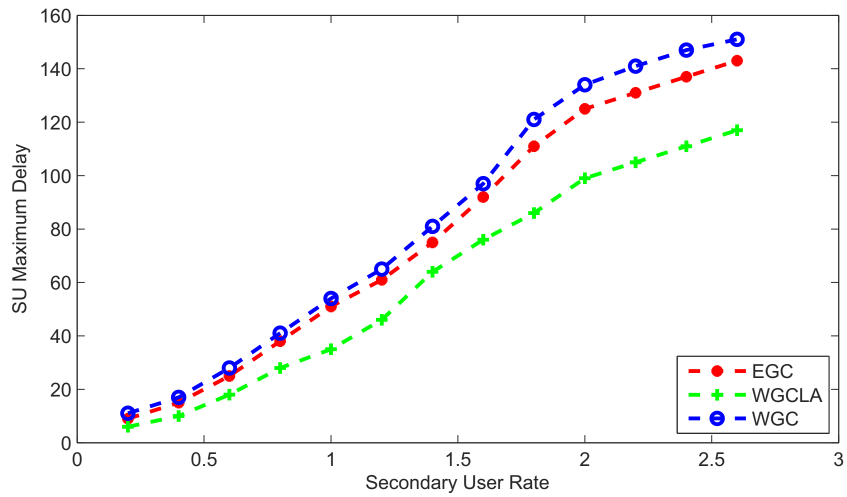

Fig. 10. The maximum delay versus SU arrival rate in channel. ($P_m = 5 \times 10^{-2}$)

scheme in practical conditions. Future work will pursue to use Multi Response Learning Automata (MRLA) to get more accurate weight for each SU.

References

1. J. Mitola, "Cognitive radio: An integrated agent architecture for software defined radio," Ph.D. dissertation, Roy. Inst. Technol. (KTH), Stockholm, Sweden, 2000.
2. Z. Li, F. R. Yu and M. Huang, "A Distributed Consensus-Based Cooperative Spectrum-Sensing Scheme in Cognitive Radios," IEEE Trans. Vehicular Technology., vol. 59, no. 1, pp. 383-393, Jan. 2010.
3. K. B. Letaief and W. Zhang, "Cooperative communications for cognitive radio networks," Proc. IEEE, vol. 97, no. 5, pp. 878893, May 2009.
4. A. Ghasemi and E. Sousa, "Collaborative spectrum sensing for opportunistic access in fading environments," in Proc. IEEE DySPAN, pp. 131136, 2005.
5. J. Unnikrishnan and V. V. Veeravalli, "Cooperative sensing for primary detection in cognitive radio," IEEE J. Sel. Topics Signal Process., vol. 2, no. 1, pp. 1827, Feb. 2008.
6. I. F. Akyildiz, B. F. Lo, and R. Balakrishnan, "Cooperative spectrum sensing in cognitive radio networks: A survey," Physical Communication, vol. 4, no. 1, pp. 40 62, 2011.

7. S. Mishra, A. Sahai, and R. Brodersen, "Cooperative sensing among cognitive radios," in Proc. IEEE ICC, pp. 16581663, 2006.
8. W. Zhang, Z. Wang, Y. Guo, H. Liu, Y. Chen and J. Mitola III, "Distributed Cooperative Spectrum Sensing based on Weighted Average Consensus," IEEE GLOBECOM, pp. 1-6, Dec 2011.
9. R. Olfati-Saber, J. Fax, and R. Murray, "Consensus and cooperation in networked multi-agent systems," Proc. IEEE, vol. 95, no. 1, pp. 215233, Jan. 2007.
10. K. S. Narendra, and M. A. L. Thathachar. "Learning Automata: An Introduction," Prentice Hall, 1989.
11. R. A. Horn and C. R. Johnson, Matrix Analysis. Cambridge, U.K.: Cambridge Univ. Press, 1987.