

Performance Evaluations for IEEE 802.15.4-based IoT Smart Home Solution

Nga Dinh, Sangsoo Lim*

Software R&D Center, Samsung Electronics, Seoul, Korea

Received 15 January 2016; received in revised form 21 April 2016; accepted 16 August 2016

Abstract

The Internet of Things (IoT) is going to be a market-changing force for a variety of real-time applications such as e-healthcare, home automation, environmental monitoring, and industrial automation. Low power wireless communication protocols offering long lifetime and high reliability such as the IEEE 802.15.4 standard have been a key enabling technology for IoT deployments and are deployed for home automation recently. The issues of the IEEE 802.15.4 networks have moved from theory to real world deployments. The work presented herein intends to demonstrate the use of the IEEE 802.15.4 standard in recent IoT commercial products for smart home applications: the Smart Home Starter Kit. The contributions of the paper are twofold. First, the paper presents how the IEEE 802.15.4 standard is employed in Smart Home Starter Kit. In particular, network topology, network operations, and data transfer mode are investigated. Second, network performance metrics such as end-to-end (E2E) delay and frame reception ratio (FRR) are evaluated by experiments. In addition, the paper discusses several directions for future improvements of home automation commercial products.

Keywords: IoT, home automation, 802.15.4, smart home, e-healthcare

References

- [1] L. D. Xu, "Enterprise systems: state-of-the-art and future trends," *IEEE Transactions on Industrial Informatics*, vol. 7, no. 4, pp. 630-640, 2011.
- [2] S. Li, L. D. Xu, and X. Wang, "Compressed sensing signal and data acquisition in wireless sensor networks and internet of things," *IEEE Transactions on Industrial Informatics*, vol. 9, no. 4, pp. 2177-2186, November 2013.
- [3] A. D. Rathnayaka, V. M. Potdar, and S. J. Kuruppu, "Evaluation of wireless home automation technologies," *Proc. IEEE International Conference Digital Ecosystems and Technologies Conference (DEST)*, IEEE Press, 2011, pp. 76-81.
- [4] M. Collotta, G. Scat`a, and G. Pau, "A priority-based csma/ca mechanism to support deadline-aware scheduling in home automation applications using ieee 802.15.4," *International Journal of Distributed Sensor Networks*, vol. 9, no. 5, May 2013.
- [5] E. Leite, L. Varela, V. F. Pires, F. D. Cardoso, A. Pires, and J. F. Martins, "A zigbee wireless domotic system with bluetooth interface," *IECON 2014 - 40th Annual Conf. IEEE Industrial Electronics Society*, IEEE Press, 2014, pp. 2506-2511.
- [6] C. A. M. Bolzani, C. Montagnoli, and M. L. Netto, "Domotics over ieee 802.15.4-a spread spectrum home automation application," *Proc. IEEE Symp. Spread Spectrum Techniques and Applications*, IEEE Press, 2006, pp. 396-400.
- [7] F. Dominguez, A. Touhafi, J. Tiete, and K. Steenhaut, "Coexistence with wifi for a home automation zigbee product," *Proc. IEEE Symp. Communications and Vehicular Technology in the Benelux (SCVT)*, IEEE Press, pp. 1-6, 2012.
- [8] G. Lu, B. Krishnamachari, and C. S. Raghavendra, "Performance evaluation of the ieee 802.15.4 mac for low-rate low-power wireless networks," *Conf. IEEE Performance, Computing, and Communications*, IEEE Press, pp. 701-706, 2004.

* Corresponding author E-mail address: lssgood80@gmail.com

- [9] B. Bougard, F. Catthoor, D. C. Daly, A. Chandrakasan, and W. Dehaene, "Energy efficiency of the IEEE 802.15.4 standard in dense wireless microsensor networks: Modeling and improvement perspectives," *Design, Automation, and Test in Europe*, pp. 221-234, 2008.
- [10] J. Misić, V. B. Misić, and S. Shafi, "Performance of IEEE 802.15.4 beacon enabled PAN with uplink transmissions in non-saturation mode access delay for finite buffers," *Proc. First International Conference Broadband Networks*, pp. 416-425, 2004.
- [11] J. S. Lee, "Performance evaluation of IEEE 802.15.4 for low-rate wireless personal area networks," *IEEE Transactions on Consumer Electronics*, vol. 52, no. 3, pp. 742-749, 2006.
- [12] S. Pollin, M. Ergen, S. Ergen, B. Bougard, L. Der Perre, I. Moerman, A. Bahai, P. Varaiya, and F. Catthoor, "Performance analysis of slotted carrier sense IEEE 802.15.4 medium access layer," *IEEE Transactions on Wireless Communications*, vol. 7, no. 9, pp. 3359-3371, 2008.
- [13] H. S. Kim, J. H. Song, and S. Lee, "Energy-efficient traffic scheduling in IEEE 802.15.4 for home automation networks," *IEEE Transactions on Consumer Electronics*, vol. 53, no. 2, pp. 369-374, 2007.
- [14] J. A. Nazabal, P. L. Iturri, L. Azpilicueta, F. Falcone, and C. Fernández-Valdivielso, "Performance analysis of IEEE 802.15.4 compliant wireless devices for heterogeneous indoor home automation environments," *International Journal of Antennas and Propagation*, vol. 2012, 2012.
- [15] M. A. B. Sarijari, R. A. Rashid, M. R. A. Rahim, and N. H. Mahalin, "Wireless home security and automation system utilizing ZigBee based multi-hop communication," *Conf. NCTT-MCP Telecommunication Technologies 2008 and 2008 2nd Malaysia Conference on Photonics*, pp. 242-245, 2008.
- [16] A. Kailas, V. Cecchi, and A. Mukherjee, "A survey of communications and networking technologies for energy management in buildings and home automation," *Journal of Computer Networks and Communications*, vol. 2012, 2012.
- [17] D. M. Han and J. H. Lim, "Smart home energy management system using IEEE 802.15.4 and ZigBee," *Consumer Electronics, IEEE Transactions on*, vol. 56, no. 3, pp. 1403-1410, 2010.
- [18] F. Xia, R. Hao, Y. Cao, and L. Xue, "A survey of adaptive and real-time protocols based on IEEE 802.15.4," *International Journal of Distributed Sensor Networks*, vol. 2011, 2011.
- [19] P. Yi, A. Iwayemi, and C. Zhou, "Building automation networks for smart grids," *International Journal of Digital Multimedia Broadcasting*, vol. 2011, 2011.
- [20] "Smartthings," <http://smartthings.com>, Accessed: 2015-05-30.
- [21] L. S. Committee et al., "Part 15.4: wireless medium access control (MAC) and physical layer (PHY) specifications for low-rate wireless personal area networks (LR-WPANs)," *IEEE Computer Society*, 2003.