ANALYSIS OF RECEIVED SIGNAL STRENGTH IN WIRELESS NETWORK OF FIREBIRD V ROBOT

Snehal Kokare[1], Rajveer Shastri[2], Shrikrishna Kolhar[3]

Department of Electronics and Telecommunication, VPKBIET Baramati, Pune, India

ABSTRACT

Now days wireless sensor network plays an important role for monitoring various parameter in the area of agriculture, coal mine, disaster management etc. Here ZigBee protocol is used for wireless communication. We successfully achieved wireless communication among multiple Firebird V robots and in between PC to Firebird V robots. In this paper we used centralized architecture i.e. star topology. We measure Received Signal Strength Indicators (RSSI) at various distance for indoor with Line of Sight (LOS) and for outdoor without LOS. We also measure transmission error and packet lost at various distance.

KEYWORDS

RSSI, XCTU, Wireless Communication, ZigBeeS2C

1. INTRODUCTION

In previous days, industrial monitoring system was based on wired network to send a monitored parameter to central computer [1]. Wired network has lots of complication at the time of installation, inflexible and its cost is also more. Several recent studies [2] have suggested that use of mobile robot in Wireless Sensor Network (WSN) brought various benefits such as mobility of sensor node and coverage area get increased. In hazardous area mobile robot is used to deploy the sensor node [3] instead of manual deployment of sensor nodes. For wireless network several protocols are available like blutooth, zigbee [4], Wi-Fi etc. Here we choose zigbee protocol because of its low cost and low power consumption, zigbee protocol is based on IEEE standard 802.15.4.

2. SYSTEM ARCHITECTURE

Fig.1 shows the star network of Firebird V robots [5]. We can control all three robots from laptop and also we get the data from all this robot to laptop; so there is a bidirectional communication in between laptop and robots. At the laptop side, we connect one zigbee module for wireless communication; on Firebird V there is on board zigbee module.

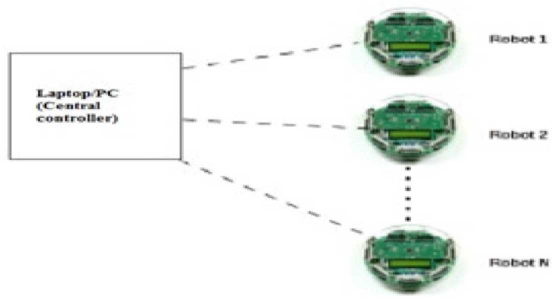

Fig.1 System Architecture of the Multi-robot Controller [5]

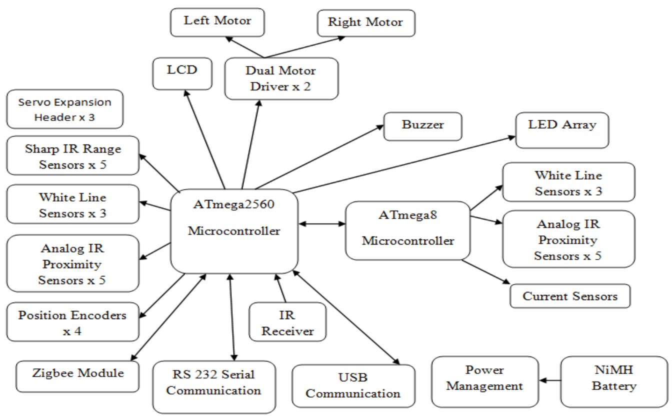

Fig.2 Fire Bird V ATMEGA2560 robot block diagram [6]

In the Firebird robot, there are different series of robots available. In this implementation we have used fifth series of Firebird. As shown in Fig.2, Firebird V robot [6][7] consist of atmega2560 as a master microcontroller and atmega8 as a slave microcontroller, three white line sensors, one sharp IR range sensors, eight IR proximity sensors, Buzzer, LCD, two DC (Direct Current) motors, Zigbee module, RS232 serial port and USB port.

2.1. ZIGBEE

Here we used ZigBee S2C module which is developed by Digi international company it operates in ISM (Industrial Scientific Medical) band i.e.2.4GHZ [9]. ZigBee protocol work in physical and data link layer of OSI (Open Source Interconnection) model. Fig.3 shows different network in ZigBee such as star, tree and mesh [10]. ZigBee network mainly consist of 3 devices coordinator, router, and end device. In the absence of direct communication path in between coordinator and end device, router is used for routing packet at the correct destination. The coordinator and router create network, handle all functions related to ZigBee communication so they are known as Full Function Devices (FFD) [11]. End device only receives data so it is termed as Reduced Function Device (RFD) [11]-[12].

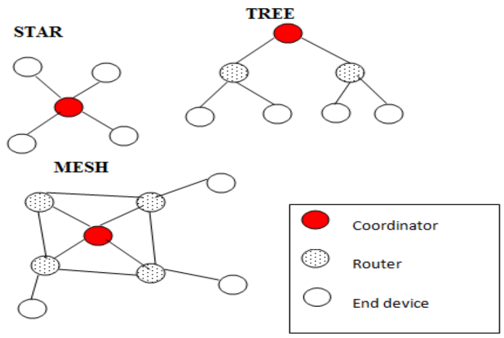

Fig.3 Different networks in ZigBee

2.1.1. ZigBee module operating mode

ZigBee module can be configured in two operating mode are as follows

1)Application Transparent (AT) operating mode
2)Application Programming Interface (API) operating mode [13]

AT mode

In this mode, data is transmitted in a queue and this mode is used for simple data transmission and reception. AT command is used for configuring the ZigBee module.

API mode

In API mode data is transmitted in frame structure [13]. In this mode we can configure ZigBee which is connected to PC, remote ZigBee in the network and we can also send data to various destination. Fig.4 shows the typical structure of API frame it consist of start delimiter, length, frame data, checksum [14]. Start delimiter indicates the beginning of frame its value is always 0x7E. Length indicates the length of data. Each frame has identity number in frame ID block. Checksum bit is used for test the data integrity.

Start Delimiter	Length	Frame ID	Destination address	RF data	Checksum

Fig.4 Frame structure

ZigBee configuration using XCTU software

Atmega2560 has four UART (Universal Asynchronous Receiver Transmitter), among this UART0 is used for wireless communication. We used XCTU software from Digi international company for configuring ZigBee module as an end device. Few configuration settings of ZigBee module are shown in Fig.5 such as PAN ID, Serial number, baud rate, Parity bit, MAC (Medium Access Control) mode, power level, API mode or AT mode and remote zigbee are in AT mode [15].

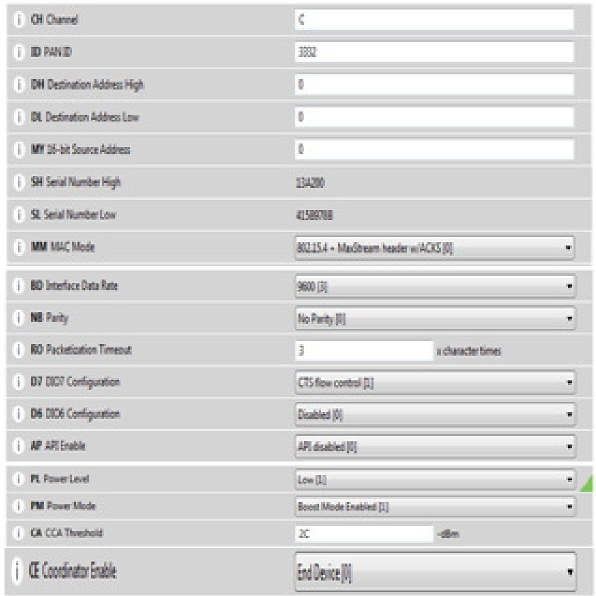

Fig.5 Zigbee configuration in XCTU software

3. PROPOSED FLOWCHART

After configuring the ZigBee module, we used console working mode in XCTU software for data transmission or reception. According to transmitted data robot perform actions, for example, if we press 8 from keypad of laptop then its ASCII(American Standard Code for Information Interchange) value get generates and transmit wirelessly towards robot via ZigBee and robot start to move forward. Table 1 shows the decimal number and its equivalent ASCII value and corresponding action of robot. Using these values robot can be moved in forward, backward, left or right directions and its buzzer can be turned on or off as represented by flowchart in Fig. 6.

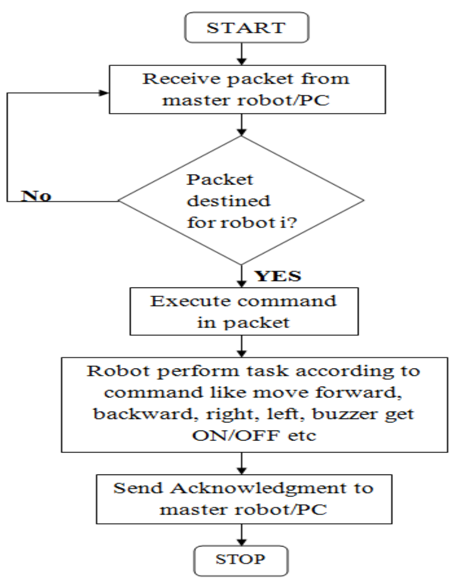

Fig.6. Slave robot flowchart

4. RESULTS AND DISCUSSION

Wireless communication is established in between laptop to robots and robot to robot. Fig.7 shows the experimental result of laptop to robots wireless communication. We have implemented star topology i.e. laptop is a master and robot are slaves. Fig.8 shows the XCTU software window from that we send a command to robots. In XCTU window there are two windows in first window decimal value is shown; in second window its equivalent ASCII value is shown. Values shown in blue colour indicates the transmitted value and values shown in red colour indicates ACK to laptop that robot has received transmitted command.

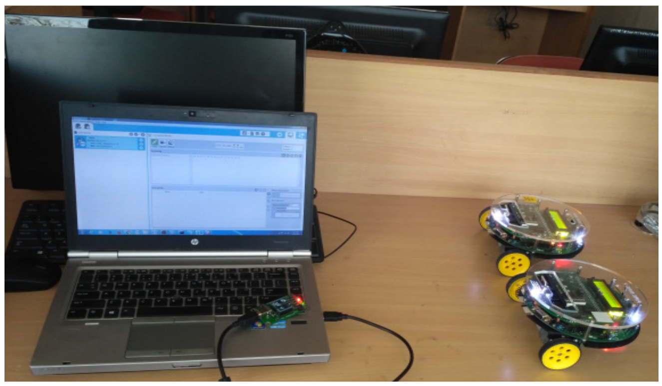

Fig.7 Robots motion controlled from laptop

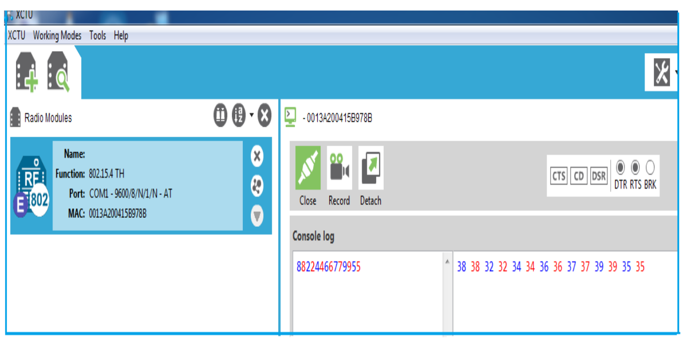

Fig.8 XCTU software window

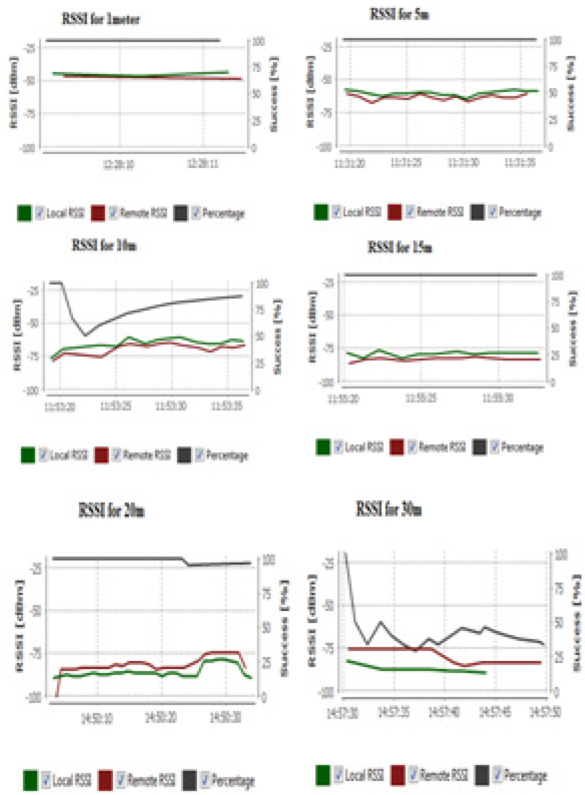

Fig. 9 RSSI plots at various distances

We have measured a Received Signal Strength Indicator (RSSI), at various distances using XCTU software is as shown in Fig 9. From Table 1 it is observed that as distance increases, RSSI values get reduces (refer Fig.10). We have measured RSSI and transmission error for indoor as well as outdoor. For outdoor situation with 30m distance, due to outdoor obstacles more transmission error is observed as shown in Table 1. Fig. 11 shows that transmission error get increases as distance increases in between local and remote ZigBee module.

Distance in meter	Local ZigBee RSSI (dBm)	Remote ZigBee RSSI (dBm)	Transmission Error	Packet Lost
1	-44	-49	0	0
3	-54	-57	0	0
5	-59	-61	0	0
7	-63	-67	0	0
10	-64	-67	2	0
12	-67	-70	0	0
14	-79	-84	0	0
20	-90	-84	1	0
30 (outdoor)	-90	-84	12	2

Table 1: RSSI values at different distance

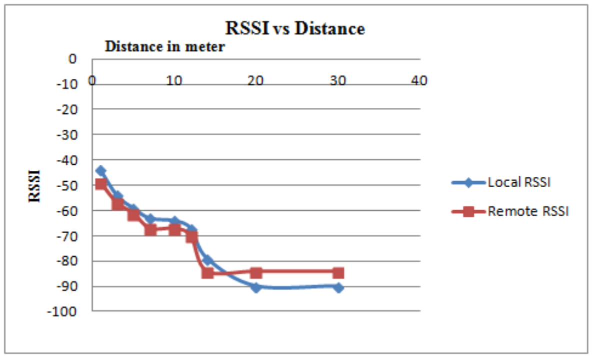

Fig. 10 Plot of RSSI vs. Distance

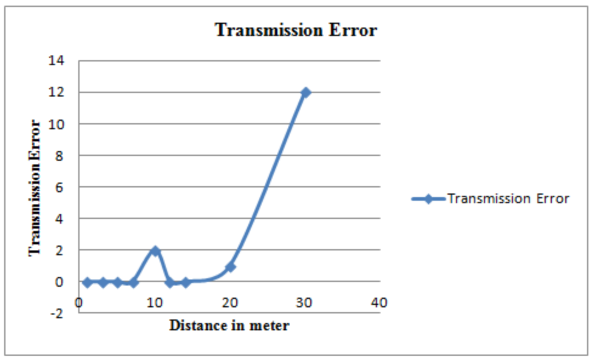

Fig. 11 Plot of transmission error VS distance

ACKNOWLEDGEMENTS

Author acknowledges to Embedded and Robotics Lab of Electronics and Telecommunication department at VPKBIET, Baramati for providing technical resources.

REFERENCES

[1] Diego Queiroz, Marcelo Alencar, “Survey and systematic mapping of industrial Wireless Sensor Networks,” Journal of Network and Computer Applications, vol. 97, pp. 96–125, Jul.2017

[2] R. Kazala et al. “Wireless Network for Mobile Robot Applications,” in conf. of International Federation of Automatic Control, Poland, 2015, pp.231-236.

[3] M. Rajesh, A. George, T.S.B. Sudarshan, “Energy Efficient Deployment of Wireless Sensor Network By Multiple Mobile Robots,” in Conf. of Computing and Network Communications, Trivandrum, India, Dec.2015, pp.72-78.

[4] Shuxiang Guo, Xin Li, Jian Guo, “Study on a Multi-Robot Cooperative Wireless Communication Control System for the Spherical Amphibious Robot,” in IEEE Conference on Mechatronics and Automation, china, Aug. 2016 pp.1143-1148.

[5] Gaurav Vijayvargia, Vaibhav Dave et al. “Multi-Bot Controller,” Dept. of Computer science IIT Bombay, Maharashtra, 684, Nov.2013

[6] Kuang-Yow Lian , Sung-Jung Hsiao, Wen-Tsai Sung, “Intelligent multi-sensor control system based on innovative technology integration via ZigBee and Wi-Fi networks,” Journal of Network and Computer Applications, vol.36, pp.756767, Jan.2013.

[7] S. Malewar, A. Malewar, “Fire Bird V ATMEGA2560 Research Platform Software Manual,” NEX Robotics Pvt. Ltd., Mumbai, Maharashtra, Version 2, Aug. 2012.

[8] S. Malewar, A. Malewar, “Fire Bird V ATMEGA2560 Research Platform Hardware Manual,” NEX Robotics Pvt. Ltd., Mumbai, Maharashtra, Version 7, Aug. 2012.

[9] Zulkhairi Mohd. Yusof .et al. “Wireless Mobile Robot Navigation using Zigbee protocol,” IEEE conference, Malaysia, March 2015

[10] Chia-Hsin Cheng, Chung-Ching Ho, “Implementation of multi-channel technology in ZigBee wireless sensor networks,” Journal of Computers and Electrical Engineering, vol.56, PP.498508, Nov. 2016.

[11] P. Medagliani, M. Martalo, G. Ferrari, “Clustered Zigbee networks with data fusion: Characterization and performance analysis,” Journal of Ad Hoc Networks, Vol. 9, PP.1083–1103, Jan 2011.

[12] Junli Wan, Yanqiu Wang, Qin Li, “Multi-Robots Communication System Based on ZigBee Network,” International Conference on Electronic Measurement & Instruments ICEMI, China, pp.3-14, 2009

[13] Digi International, “XCTU Configuration and Test Utility Software,” Nov. 2017.

[14] Okhamila Yusuf, “Determination of Optimal Power for ZigBee based Wireless Sensor Networks,” Ph.D. dissertation, Department of Electrical. Engineering, Windsor university, Ontario, Canada, 2014.

[15] Martin Hebel and George Bricker, “Getting Started with XBee RF Modules,” Parallax Inc., version 1, Nov. 2010

AUTHORS

Snehal Kokare received her BE (E & TC) degree in 2014 from Savitribai Phule Pune University. Presently she is M.E. (Digital System) student in department of E & TC at VPKBIET, Baramati.

Dr. Rajveer Shastri received his BE degree in 2000 from college of Engineering Ambejogai. In 2002, he completed M.E. in Electronics and PHD in the area of underwater signal processing in 2014, from Shri Guru Govind Singh Engineering and Technology, Nanded. He has served at the various academic levels and currently, he is professor in E & TC department at VPKBIET, Baramati.

Prof. Shrikrishna Kolhar received his BE degree in 2010 from SVPM COE Malegaon. In 2013, he completed M.E. in Digital System from Pune University. He is working as an assistant professor from 2012 till date in VPKBIET, Baramati.