2021 International Symposium of Asian Control Association on
Intelligent Robotics and Industrial Automation (IRIA)
Indian Institute of Technology, Goa, India. 20-22 September 2021

2021 International Symposium of Asian Control Association on Intelligent Robotics and Industrial Automation (IRIA) | 978-1-6654-3323-5/21/$31.00 ©2021 IEEE | DOI: 10.1109/IRIA53009.2021.9588718

An overview of a low energy UWB localization in IoT based system

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***Abstract* – Now days, Internet of Things (IOTs) plays an important role due to sophisticated state-of-the-art low power, low-cost wireless technologies. There are different areas that have witnessed an ever-increasing application of IOTs like smart home, smart city, smart industry, and smart factory etc. In each of these applications, an important aspect is to localize the person/ object/ device with an acceptable precision and accuracy. All the devices are interconnected to each other via internet in IOT. Localization can be categorized as measurements based on distance, angle, area etc. There are a slew of wirelesses technologies like WiFi, bluetooth low energy (BLE), radio frequency identification (RFID), ultra-wideband (UWB) etc used for achieving reliable localization in IOT based system. UWB has been found to play an important role in localization in IOTs due to a high frequency range (3.1GHz-10.6GHz), low duty cycle (maximum on time 5ms and off time 38ms),high accuracy of ranging(cm),usage of very small pulses(ns to localize), ability to penetrate through the obstacles, capability to avoid multipath fading etc. In a wireless sensor network (WSN), it gives robust performance and has been investigated to be a potential candidate for indoor localization. This paper represents the low energy UWB pulse for localization in an IOT based system and the use of channel impulse response (CIR) of a UWB channel model 4(CM 4) in carrying out localization.**

Keywords: IOT, UWB, Localization, WSN, CIR

I. INTRODUCTION

The Internet of things (IoT) refers to a system of interrelated along with interconnections of different devices, which are able to collect and transfer the data over the wireless network without user intervention [1]. Objects are attached with sensors in IoTs, which collect the information from the environment and send to a central server for e processing using a number of communication technologies. The determination of location of a given object is an important requirement of wireless sensor network (WSN) in IOT [2].There are varieties of wirelesses technologies like WiFi, bluetooth low energy (BLE), radio frequency identification (RFID), ultra-wideband (UWB) etc which are used for achieving reliable localization in an IOT based system. Ultra wideband (UWB) is a digital pulse based technique for transmission of digital data with a bandwidth of 7.5GHz. It requires a low power (approximately 0.5mw) for short or small distance (approximately up to 15m) of operation. The limited power spectral density (PSD) of-41.3dbm/MHz, allows it to be easily and safely deployed with existing wireless communication system without causing any interference. The high data rate communication with low energy consumption and multipath resistant property of UWB allows it for wireless ranging application in IOT applications with a high accuracy [3-4].The position of the target can be determined by different methods like triangulation and trill ateration. Generally the previously known data sensors called anchor nodes or reference nodes and the position of the target node can be determined by wireless network with deployment of anchor nodes having a known coordinate system. Localization through GPS is very cost effective. However, determination of the position in indoor areas through GPS service seems to be not properly functional, since it requires an unobstructed line of sight for its operation in location estimation [5]. By augmenting the localization with IOT, the service area can be enhanced to a large extent that the IOT can provide. IOT includes mainly three parts for its operation [6-7].

- Data sensing and collection
- Data communication
- Data Processing.

II. LITERATURE SURVEY

In an IOT system, one of the important tasks is to find the proper location of an object or a user through the use of radio signals. This is for providing the required services to users like navigation in indoor areas (shopping mall, airport, station), tracking of objects or people inside a smart building, positioning of objects in smart warehouses etc. [8-9]. In all these cases GPS can't provide service, since it can't properly work inside the indoor area. Hence different techniques are there to address the issue of choosing the localization methods. UWB has been chosen here for localization in an IOT environment which can provide the

Table 1: A brief summary of Different Localization Techniques used in IoT

Technology	Energy per bit (nJ/bit)	Maximum bit rate (Mb/sec)	Maximum range(m)	Advantages	Disadvantages
RF-ID[13]	50	10	200	Long recognition range (active RFID), energy efficiency high, not required LOS between TX and RX.	Low accuracy, requires more tags/antenna, consumes more power.
Zigbee[14]	296	0.250	75	Its sensors requires very low energy and low cost.	Operates in Unlicensed IS band and cause interference in same spectrum.
Bluetooth[15]	34	1	15	Low energy, low cost, built in smart phone.	High packet drop rate.
Wi-Fi[16]	130	54	100	Low cost	Based on signal strength position.
UWB[17]	5	100	10	High accuracy, not interfere with existing RF signal, easily pass through obstacles.	Range of positioning is short, High cost infrastructure.

requisite services [10-12].

III. LOCALIZATION SYSTEM IN FIELD OF IOTs

The main objective of localization in IOT system is to determine the environment conditions by sensors which are done by processing the instructed data. For accessing the smart environment system it contains different parts like sensors, processors, software part, actuator, and database [18]. For localization through UWB, the system uses different trillateration techniques [19]. In this, several receiver nodes are placed at known positions and the position of the target or the transmitter node is to find from the knowledge of the positions of the known nodes, which emits an omnidirectional signal at given intervals of time. This emitted signal reaches different receiver nodes at different times for the unequal distances from transmitter to receiver. Amount of energy consumption in localization is one of the important factors in IOT system. Many sensor nodes are attached with UWB for monitoring the environment, for measuring the physical condition inside the area which can locate the persons presence, monitoring the humidity, energy consumption etc. All the collected sensed data are sent to the data centre for analysis and processing. We can also find that the UWB pulse can lower the energy per bit (5nJ/bit) in comparison to other wireless sensor node. For a continuous signal, pulse width of the signal (T_{PULSE}) is equal to pulse period of the signal (T_{PRF}).but for a pulsed signal, $T_{PULSE} < T_{PRF}$.

Hence energy per bit (EPB) $= P_{TOT} * T_{PULSE} / T_{PRF},$

Where P_{TOT} is overall power consumption of the sensor. Pulsed UWB is very important for smart home low energy consumption system in field of IOT, and also helpful for localization in indoor environment.

In Fig.1, both the transmitter and receiver are present in sensor node along with a control system. Information that is collected through sensor (temperature) is converted to digital symbol and it is modulated by UWB pulse generator after which it is transmitted by UWB antenna. In the receiving end, the energy detection receiver can demodulate the information. The characterization and modelling of channel is very essential for accurate estimation of ranging error during the process of Localization [20]. The channel impulse response of the UWB channel (IEEE 802.15.3a) is formulated as [21-22]:

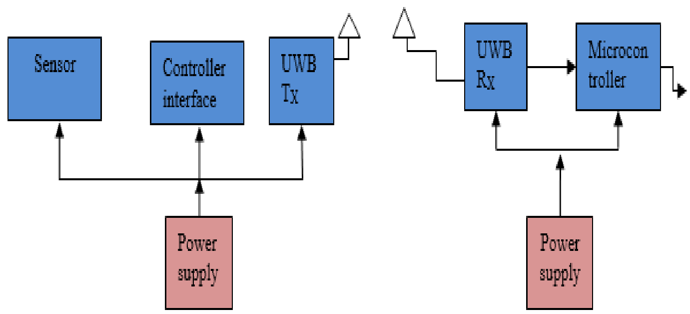

Fig.1 A Typical UWB System Architecture

$$h(t) = X_i \sum_{l=0}^{L-1} \sum_{k=0}^{K-1} \alpha_{k,l}\, \delta(t - T_l - \tau_{k,l}) \qquad (1)$$

Where $\alpha_{k,l}$ is the multipath gain coefficient of kth ray related to Ith cluster.

T_l is the delay or arrival time of first path of Ith cluster.

$\tau_{k,l}$ is the delay of kth ray path within the Ithcluster relative to T_l.

X_i is the log normal shadowing term and i refers to ith realization.

Generally UWB Channels have their focus on Indoor area with both Line-of-sight (LOS) and Non-line-of-sight (NLOS). The different significant parameters that affect the UWB channels are path loss model, Delay spread, power delay profile, Channel, Degrees of freedom etc. [23]. There is basically four different channel models (CM1,CM2,CM3,CM4) are defined depending on various channel characteristics (LOS, NLOS, Distance) [24].Here we have simulated the channel impulse response of CM4 due to its strong delay dispersion effect in the field of localization.

IV. SIMULATION RESULT

A typical CM4 profile has been simulated in MATLAB and shown in Fig.2. The CIR is observed to have duration of about 0.25µS.

A small duration pulse is used for the transmission of information in UWB systems. The short duration pulses provide immunity to multipath effect with much lower fading margin by which it provides multipath resolution. The UWB pulses are categorized into three types which are named as Gaussian pulse, Gaussian monocycle that is Gaussian Pulse of first derivative and Gaussian doublet that is Gaussian Pulse of second derivative.

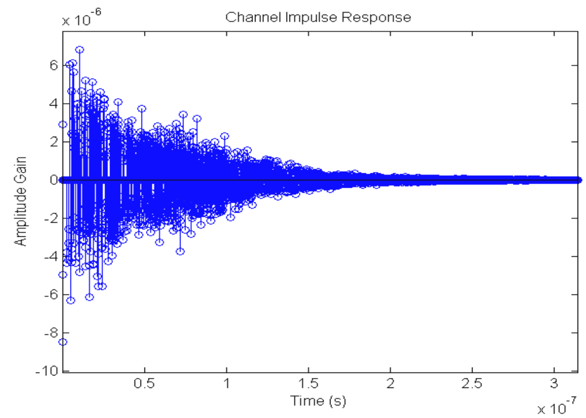

Fig.2 Channel Impulse response of CM4

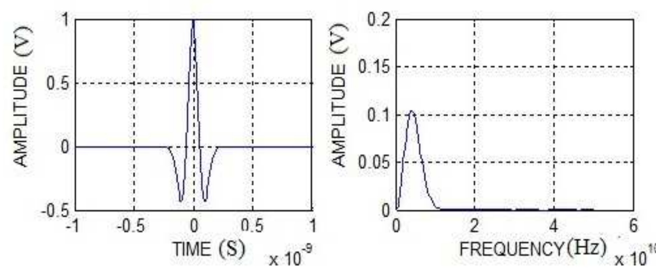

Fig.3 Simulated UWB Pulse in Time domain and Frequency domain

Now considering the Gaussian doublet as the second derivative of Gaussian pulse and is formulated as [25]:

$$\frac{d^2}{dt^2}p(t) = A\left[\frac{1}{\tau^2}\exp(-\frac{1}{2}((t-t_0)/\tau)^2) - \frac{t^2}{\tau^4}\exp(-\frac{1}{2}((t-t_0)/\tau)^2)\right] \qquad (2)$$

where t_0 is the time offset and τ is the time constant.

Fig.3 shows the simulated UWB pulses both in the time as well as the frequency domain. We observe the time domain pulse to have a width of 1 nS and the corresponding bandwidth is found to be 2.7 GHz.

V. CONCLUSION

UWB is an important part of IoT which provides the location of the object or person with high accuracy and without any interference with existing other radio frequency signals typically in indoor applications. A UWB channel model along with UWB pulse simulated here has a pulse width of 1 nS and a bandwidth of 2.7 GHz. Such a pulse is responsible for lower energy consumption during localization. The future work is to design and implement the 5th derivative of Gaussian pulse by digital pulse shaping method which can drastically reduce the power consumption during the process of localization in an IOT system.

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