CHAPTER 6

CONCLUSIONS

6.1 Introduction

This chapter presents the overall conclusion that this research work has established and successfully achieved. The chapter presents the achievement with its relevant conclusions. This chapter carries on to present limitations of the research as well as future works that would benefit future researchers, scholars and scientists to conduct this type of research and to improve UWB system to be able to serve a wide range of wireless applications and implementations.

The achievements section of this chapter will discuss the mechanism for the objective of this research has been met and in what way this research can be further researched, scrutinised and extended to create a fully optimised solution which parameter values can satisfy wireless scenario requirements. This research though presents a new design that sets the UWB parameters according to the proposed mathematical function.

6.2 Research Achievements

Studying the performance of a tunable impulse-based UWB communication system in specific or predefined wireless indoor applications via link budget analysis can lead to system optimisation at the PHY (Physical layer) level.

The first objective is to investigate a cross-layer architecture hence this research introduces the PHY-MAC aware architecture to support the different QoS of BER and data rates under different channel conditions and models. System optimisation can be achieved by selecting at the PHY level those physical parameters of the generated pulses (e.g. coding, modulations and shaping) that exhibit good performance in terms of BER across various distance conditions.

The methodology to achieve that can be considered as the introducing of IR-UWB cross-layer architecture design where the physical parameters of the generated signals are tuned based on sensing the changes of the conditions in the MAC layer, these changes are the applications certain requirements as distances, data rates and quality of the received signal as well as the channel models and types. The results obtained from objective one is that a PHY-MAC aware impulse-based UWB architecture design is presented. with the reconfiguration, capabilities to generate pulses as required to satisfy the changes sensed in the MAC layer. In brief, The physical parameters of the signal in this transceiver can be adjusted along with the changes in the channel conditions for specific BER requirements.

The second objective is to examine the link budget models. A link budget is designed to show the trade-off flexibility of the system as a function of BER across different scenarios with various data rates and distances. The proposed methodology of IR-UWB link budget template is implemented in several stages. The results are obtained throughout three stages. The first stage performs a MATLAB simulation to understand the effects of each IR-UWB signal parameter on AWGN, multipath fading channel models and the receiver. The second stage implementation is a real-time signal simulation model by using Simulink. This model simulates the signal generation, propagation, synchronisation and detection by controlling the signal parameters for different transmission rates. The third stage simulates the IEEE802.15.4a standard by using OMNET++ and MIXIM.

The third objective is to evaluate the performance of the received signal at different verification levels. The parameters are maintained according to the QoS level, thereby leading to efficient signal processing. The best signal quality is achieved by adjusting the parameters according to the environmental conditions. The methodology applied is that impact of capacity (e.g. bit rate) on system vulnerability (e.g. signal detection under different ranges and environmental conditions) is also quantified. A cross-layer correspondence design is proposed to evaluate the QoS in remote multi-media sensor systems with less time jumping drive radio UWB interchanges. The results that were realized is that qualitative analysis is conducted based on system performance improvements with regard to BER for certain Signal to Noise Ratio (SNR) range in coding for the proposed template design of impulse-based UWB. The template design is then simulated, and performance evaluation in term of BER improvements are shown to reach 10% to 50% when a suitable rake receiver structure is employed. The impulse-based UWB signal physical parameters are also tuned with the best matching values for certain applications to improve the BER by up to 65%.Therefore, the fourth objective is achieved in a simulated scenario where the data rates range from 20 Mbps to 200 Mbps, the maximum distance is 30 m and the BER requirement does not exceed 10^{-2}, the best BER performance is achieved by tuning the pulse modulation to 2-PAM. The real-time simulation results after analysing the data collected from the receiver side statistically show the suitability of impulse-based UWB for different wireless applications in short to medium ranges.

6.3 Research Findings Remarks

In this research work, the specific objective defined the techniques which improved the UWB link, and a flexible UWB simulator is designed to accommodate several features and functions. Different link configurations and signals at the physical layer, including signal pulse shaping, coding, spectrum spreading techniques with different modulations, PRRs and signal detection and demodulation, are also evaluated. The system shows a promising performance, thereby highlighting the potential of UWB as a global platform that combines different wireless indoor protocols ranging from short-range with HDRs (e.g. IEEE 802.15.3a) to medium range with LDRs (e.g. IEEE 802.15.4a). Impulse-based UWB systems emit trains of short pulses and code them for data transmission, spectrum shaping and spreading to satisfy certain requirements. The physical characters of an impulse-based UWB signal make the communication system almost digital-based. Signal coding can be achieved by coding the pulses in certain positions or amplitudes without the need to code a continuous carrier signal that carries the transmitted information unlike in narrowband communication systems. The performance of the system is then analysed across different scenarios or by using different channel models to highlight the advantages of a flexible UWB platform design.

The purpose of the real-time simulation is to study system behaviour for specific link settings and predefined BER requirements. The results are validated by checking the agreement between the theoretical and simulation results. The simulation of the IEEE802.15.4a standard is conducted by using the MIXIM-UWB framework, whereas that of the IEEE 802.15.3a standard is conducted by using MATLAB and Simulink. The statistical simulation of the captured and received packets is visualised by using OMNET++. The achieved throughput indicates that the best performance of TH-UWB in an indoor scenario with distances of 12 m to 100 m can be achieved with data rates of 110 Kbps to 6.8 Mbps.

The importance of the impulse-based UWB physical signal parameters is discussed in detail. The effects of these parameters on data transmission are demonstrated via MATLAB and real-time Simulink modelling and implementation in actual indoor/outdoor environments. The impulse-based UWB exhibits good trade-off flexibility amongst BER, data rates, and distances, which can be analysed in the link budget for specific applications (e.g. predefined BER). The data are collected from the different values of physical signal parameters (as shown in the proposed template design of the impulse-based UWB link budget) in MATLAB and Simulink. These values, in turn, are derived from the values of the configuration parameters for the generated pulses in the real-time (OMNET++) simulation.

The contribution of this study lies in its attempt to combine different UWB pulses into a single solution that supports different requirements for short to medium wireless communication systems. Therefore, the objective of this thesis is to design tunable impulse-based UWB solutions for diverse requirements has been achieved.

6.4 Limitations of the research

This study has some limitations to be considered. For example, the scope and opportunity of this thesis are restricted to tuneable IR-UWB communication and its performance in specific link budget template where the whole communication systems are described as a set of tunable and fixed parameters.

The verifications of the results are done as different simulated results from MATLAB, SIMULINK to OMNET++ MIXIM, where maybe experimental verifications as real NLOS and LOS can be considered in future works for further investigations.

6.5 Future Works

This study has several opened he gate wide-open for future works as follows:

This work can be extended to include optimised IR-UWB communication according to specific application requirements by selecting optimal signal parameters through several optimisation algorithms, such as the genetic algorithm, and by properly choosing a cost function that can be used to improve BER performance across various data rate and distance scenarios. Those signal parameters that affect data transmissions are pseudo-randomly selected to generate the first population of chromosomes that represent these parameters. Subsequently, the fitness (cost) function is determined by carefully choosing crossover and mutation points that can generate these chromosomes optimally or in near-optimal conditions.

The results of this work are verified in different levels and may be extended by verifying them with the findings obtained from real experimental wireless scenarios rather than simulation and modelling theoretical environments.