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PERFORMANCE ANALYSIS OF SRAKE RECEIVER AND NON-COHERENT RECEIVER IN UWB COMMUNICATION SYSTEM

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Abstract- Ultra-Wide Band (UWB) technology, which offers a solution for high bandwidth, high data rate, low cost, low power consumption, position location capability.The Rake receiver used for spread spectrum is considered a very promising candidate for UWB reception, due to its capability of collecting multipath components. Ultra Wide Band signals occupy such a large bandwidth; they operate as an overlay system with other existing narrowband (NB) radio systems overlapping with their bands. In order to ensure a robust communication link, the issue of coexistence and interference of UWB systems with current indoor wireless systems must be considered. Bit error rate (BER) performance study for UWB channel models are analyzed using proposed receiver models. Suppression of Narrowband interference in WLAN has been studied intensively to remove Inter Symbol Interference (ISI).For all simulated channels, TR receiver shows a performance degradation of 3 to 4 dB compared to ATR and DTR receiver due to the usage of noisy unmodulated reference template.

I. INTRODUCTION

Ultra-wideband (UWB) systems off late has attracted everybody's attention in the field of wireless communication for its role in commercial, security and military services [1]. Also it plays a pivotal role in spectrum management by sharing the already occupied radio spectrum rather than using any new bands, thereby obeying the overlay principle. UWB communication is a radio technology, used for short range and high bandwidth communication because its transmitted power is of low level [2]. Impulse Radio (IR) UWB systems convey information using ultrashort(short duration typically subnanosecond) [3] baseband pulses having low power density, high time resolution, rich multipath diversity. According to Federal Communications Commission (FCC), signals possessing a bandwidth exceeding 500 MHz or a fractional bandwidth fb more than 0.2 are said to be UWB [4], [5]. The fractional bandwidth fb is given by:

$$f_b = \frac{2(f_h - f_l)}{(f_h + f_l)} \qquad (1)$$

where, f_h and f_l correspond to higher and lower −10 dB frequencies. UWB devices are operational in the frequency bands 3.1 − 10.6 GHz and also above 10.6 GHz, thereby allowing 7500 MHz of spectrum for unlicensed use [6]. UWB technology is a hot topic of research because of the numerous advantages it presents in the form of wide unlicensed bands, high data rate, low power spectral density (PSD), high multipath resolution, multiple access, low cost, low power consumption, improved channel capacity, fine delay resolution and enormous bandwidth. Also higher bandwidth upto GHz range signifies that multipath is resolvable upto the order of nanosecond, thereby reducing fading. As a matter of fact interest in UWB communication has further motivated the researchers in their studies. Coherent IR-UWB RAKE receiver is found to be optimal over AWGN and non-ISI multipath channel in the sense that it minimizes the chances of error in detection. Inspite of its better performance criteria, IR-UWB RAKE receiver requires accurate channel estimation and precise synchronization to extract multipath energy, thereby leading to computational complexity [7], [8]. Also each path in the UWB channel distorts the UWB pulses in such a way that it requires the template signal available at each RAKE correlator to be adaptable, so as to achieve an optimal performance [9]. The problems faced by coherent IR-UWB RAKE receiver were circumvented with the onset of non-coherent IR-UWB autocorrelation (AR) receiver. Non-coherent IR-UWB receivers are preferred over coherent IR-UWB receivers because of less complexity, low data rate applications and robustness to synchronization errors [10]. AR receivers exploit multipath diversity by correlating the received signal with its delayed version. The non-coherent AR receivers discussed in this paper are Transmitted Reference (TR), Averaged Transmitted Reference (ATR) receiver and Differential Transmitted Reference (DTR) receiver. TR scheme, proposed by Hoctor and Tomilson [11], transmits two pulses per frame wherein the first pulse is an unmodulated reference pulse followed by a data modulated pulse. Wastage of energy due to the transmission of reference pulse is a major drawback of this scheme. The only difference between a TR scheme and ATR scheme is in the receiver structure. The receiver section in ATR scheme averages all the previous reference signals over Nf frames prior to demodulation. However, the transmitter sections for a TR and ATR scheme are similar in nature [12], [13]. A modified version of the TR scheme, DTR scheme, sends a single data pulse over the current frame by differentially modulating it with the data sent over the previous frame. As a result, bit rate of DTR scheme is doubled and performance improved as compared to TR scheme[14],[15]. The paper examines the BER performance of TR, ATR,DTR and rake receiver in IEEE802.15.3a in UWB channels.The signalling technique used for transmission and reception is Pulse Amplitude Transmission (PAM). The paper is divided into four sections. Section II throws light on system model,channel model.Section III discusses the Simulation Results, Section IV concludes the paper while Section V briefs us about the Future Work. It makes many important aspects not need manager to complete on the scene, which saves a lot of manpower and material resources and improves labor productivity.

II. SYSTEM MODEL

The paper discusses the system model for the various non-coherent IR-UWB schemes such as TR, ATR and DTR and coherent rake receiver. The system model comprises of signal model, channel model. The modulation scheme used is PAM signalling and the system considered is a single user system.

A. UWB Signal Model

1. TR Scheme

The difficulties faced by coherent IR-UWB RAKE transceiver were mitigated using a non-coherent IR-UWB transceiver. TR transceivers work by transmitting a train of pulses i.e. two pulses per frame [15], [9]. The first pulse transmitted over each frame is an unmodulated reference signal followed by a data modulated pulse [16]. A number of frames constitute a bit or a symbol. The conventional transmitted TR signal is expressed as:

$$s_{TR}(t) = \sum_{i=0}^{\infty} \sum_{j=0}^{N_f-1} [\sqrt{E}p(t-(iN_f+j)T_f) + b_i\sqrt{E}p(t-(iN_f+j)T_f-T_d)] \quad (2)$$

where $s_{TR}(t)$ represents the TR signal, bi ∈ (−1,1), represents the information symbol, N_f corresponds to the number of frames in one symbol, E denotes the energy per pulse, p(t) represents the transmitted gaussian pulse with pulse duration Tp, T_f signifies the frame duration and Td corresponds to the delay between the reference and data modulated pulse. Also, $T_s = N_f T_f$ represents the symbol duration.

2. ATR Scheme

The transmitted sequence for ATR scheme is same as that of the conventional TR signalling scheme. The conventional ATR scheme too transmits two pulses per frame where the first pulse denotes the unmodulated reference signal followed by the data modulated signal.

3. DTR Scheme

DTR system wastes no energy in transmitting a reference pulse, hence are preferred over TR system. As a result, DTR scheme requires less energy transmitting the same information as TR scheme. In this scheme, instead of transmitting a separate pulse, a single data pulse is sent over each of the frames by differentially modulating it with the data pulse in the previous frame, thereby saving energy [14], [17], [18]. Each pulse represents a frame and number of frames correspond to a bit or symbol. The transmitted DTR scheme is represented as:

$$s_{DTR}(t) = \sum_{j=0}^{\infty} \sum_{i=0}^{N_f-1} b_j\sqrt{E}p(t-(jN_f+i)T_f-D) \quad (3)$$

where N_f corresponds to the number of frames in one symbol, E denotes the energy per pulse, p(t) represents the transmitted gaussian pulse with pulse duration Tp, T_f signifies the frame duration and D corresponds to the delay between the frames. Also, the channel symbol bj is transmitted every Ts = NfTf seconds which represents the symbol duration in a UWB

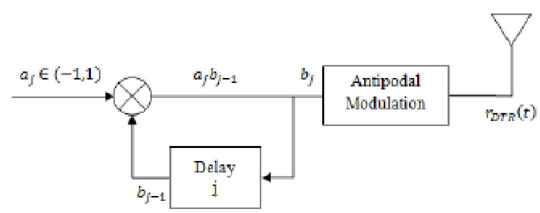

Fig. 1. DTR Transmitter

transmitter as seen in Fig 1. Also bj corresponds to the information bits aj ∈ (−1,1) by a differential encoding rule which states that bj = ajbj−1.

B. UWB CHANNEL MODEL

Channel is an environment which allows a signal to pass from a transmitter to the receiver so that the original information can be extracted. The frequency selective nature of reflective and refraction coefficients in the channel, forces delay dispersion in each multipath component of the UWB system. IEEE 802.15.4a channel is applicable for devices with data rates between 1 Kb/sec to several Mbit/sec [19] and is based on the modification of S-V model [20], since all the multipath components arrive in the form of clusters. The SV model is represented as:

$$h(t) = \sum_{l=0}^{L-1} \sum_{k=0}^{K-1} a_{k,l} \exp(j\phi_{k,l}) \delta(t - T_l - \tau_{k,l}) \qquad (4)$$

where $\alpha_{k,l}$ represents the tap weight of the k^{th} component in l^{th} cluster, T_l denotes the arrival time of the l^{th} cluster and φk,l represent the phase which is uniformly distributed between 0 to 2π. Cluster is a combination of n number of rays that are separated from each other in time and is formed due to the reflection and refraction of UWB signals from various surrounding objects. In IEEE 802.15.4a model, all the multicluster signals and the multipath signals in a cluster follow log normal fading [21]. The key features of this channel model, derived from a set of measurements and taken from the various locations of a building are, frequency dependency of path loss, Nakagami distribution of small scale fading, exponential nature of Power Delay Profile (PDP), delay dependence of cluster, cluster and ray arrival time denoted as independent Poisson process and their mixture considered also a Poisson process [19]. The IEEE 802.15.4a UWB channel h(t) can be modified as:

$$h(t) = \sum_{l=0}^{L-1} a_l \delta(t - \tau_l) \qquad (5)$$

where h(t) represent the channel model, l the number of multipaths, al denotes the magnitude of l^{th} tap, τl signifies the delay of lth tap and δ is the Delta function. To avoid Inter Pulse Interference (IPI) and Inter Frame Interference (IFI) in TR and ATR scheme, received reference and data pulses should have Tf > 2(τl − τ0 + Tp). Also the number of significant paths having more than 85% of energy been considered for simulation purposes [19].

III. SIMULATION RESULTS

The non-coherent IR-UWB receiver structures described in the previous section were simulated in IEEE 802.15.4a UWB indoor environment. In this paper, the UWB structures considered are applicable only for a single user.

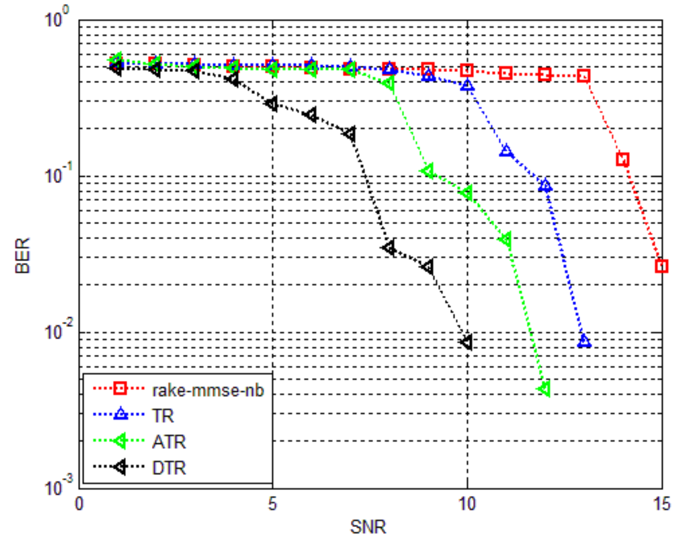

Fig2.BER performance of various non coherent UWB receivers in CM3

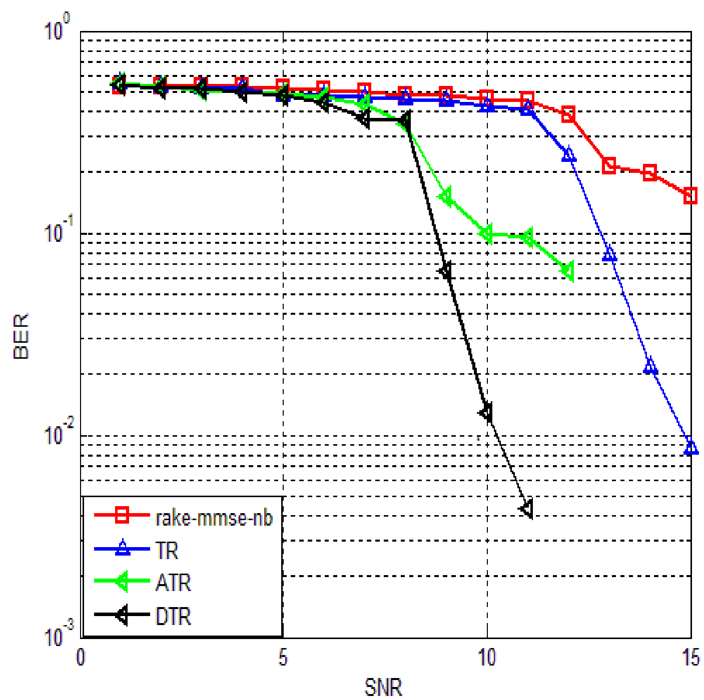

Fig3.BER performance of various non coherent UWB receivers in CM4

The Fig 2 clearly explains the BER performance of TR, ATR and DTR and rake receiver in IEEE 802.15.3a CM3 channel. CM3 environment is exclusively designed for NLOS indoor office environment covering a distance of 4-10 m. At a BER of $5*10^{-2}$, TR receiver shows a performance loss of 3 dB and 1dB with ATR. Another interesting fact noted is throughout the simulation analysis, ATR receiver shows a marginal gain of 2 dB over the DTR receiver.

The Fig 3 illustrates the BER performance of TR, ATR and DTR and rake receiver in IEEE 802.15.3a CM4 channel. Channel CM4 is designed for NLOS residential environment. As we move from channel CM3 to CM4, BER performance degrades. The DTR receiver performs better thanTR receiver by a margin of 5dB at a BER OF10^{-2}.It is also noted that the performance of ATR receiver degrades with increase in SNR.Over the range of SNR,DTR receiver performs better than the other non-coherent IR-UWB receiver such as TR and DTR.

For all simulated channels, TR receiver shows a performance degradation of 3 to 4 dB compared to ATR and DTR receiver due to the usage of noisy unmodulated reference template.

IV. CONCLUSION

IR-UWB is an emerging solution for the IEEE 802.15a (TG3a) standard, which provides low complexity, low cost, low power consumption and high data-rate in Wireless Personal Area Network (WPAN) system. For high data rate and short range, the receiver combats NBI interference by taking advantage of the Rake receiver and MMSE equalizer structure, but due to the complexity in receiver structure So non-coherent are preferred over coherent for suppression of narrowband interference in UWB communication system. The paper examines the performance of non-coherent IRUWB receiver in IEEE 802.15.3a channel for CM3 and CM4. The simulation results clearly show that BER performance of IEEE 802.15.3a UWB channel. For all simulated channels, TR receiver shows a performance degradation of 3 to 4dB compared to ATR and DTR receiver due to the us+age of noisy unmodulated reference template.

V. FUTURE WORK

Further, the combination of UWB communication with cooperative relay communication can be viable and a cost efficient method form proving the system performance quality of service and coverage area. Our future endeavour would be to club UWB communication with cooperative communication.

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