Original Research Article

Synchronization scheme for FD-IR-UWB receiver

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Abstract: Synchronization poses a major of challenge in UWB systems because low duty cycles in UWB. This research develops an better synchronization scheme for FD-IR- UWB receivers to improve the synchronization speed.The mechanism reduces the search durarion of the symbol boundaries to only a single frame duration. Moreover,delay element is needed in each branch, since a SLD is also proposed to lower complexity of the parallel search mechanism. performance analysis and simutaitons show that the proposed scheme achieves a lower MSE and a higher PD than other alternatives.

Keywords: Frame-differential,altra(FD; Sychromization timing acquisition; UWB(Ultra-Wide Band); FD(frame-diffeential); MSE(mean square error); TR(transmission-reference)

1. Introduction

UWB could utilize frequencies in the range 3.1- 10.6GHz[1].UWB could thus solve the bandwidth,cost, and onsumption requirements of next-generation CE devices, for example DVD players HDTVs, MP3 players and stereos.Diferent UWB systems have been proposed,including TH-IR UWB, MB-UWB, and DS-UWB.In TH-IR UWB systems[2],data is transmitt ed pulses on the order of sychronzation since the information bearing waveforms are pulse-like. Moreover, the channel through which these low-power pulses transmitted to be unknown to the receiver at the synchronization stage. So, peak-picking the output of a sliding correlator between there rceived signal and the transmitted template is not only suboptimal in the presence of a dense multipath, but also resuld to an unacceptably slow acquisition speed[4]. However,TR[5-7] systems eliminate this problem, since they do not require a channel estimation nanoseconds. Due to the pulse duration is narrow,TH- UWB systems achieve a fine resolution capability and low consumption, which makes TH-IR UWB systems viable candidates for short-range or indoor wireless communications[3].A major of challenge to TH-UWB systems is timing transmitted template is not only suboptimal in the presence of a dense multipath, but also resuld to an unacceptably slow acquisition speed[4]. estimation nanoseconds. Due to the pulse duration is narrow,TH- UWB systems achieve a fine resolution capability and low consumption, which makes TH-IR UWB systems viable candidates for short-range or indoor wireless communications[3].A major of challenge to TH-UWB systems is timing transmitted template is not only suboptimal in the presence of a dense multipath, but also resuld to an unacceptably slow acquisition speed[4]. Due to the pulse duration is narrow,TH- UWB systems achieve a fine resolution capability and low consumption, which Due to the pulse duration is narrow,TH- UWB systems achieve a fine resolution capability and low consumption, which makes TH-IR UWB systems viable candidates for short-range or Due to the pulse duration is narrow,TH- UWB systems achieve a fine resolution capability and low consumption, which makes TH-IR UWB systems viable candidates for short-range or indoor wireless communications[3].A major of challenge to TH-UWB systems is timing.indoor wireless communications[3]. A major of challenge to TH-UWB systems is timing. makes TH-IR UWB systems viable candidates for short-range or indoor wireless communications[3]. A major of challenge to TH-UWB systems is timing.

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2. Signal model

As discussed in[2],the transmitted symbol waveform from the user k is expressed as

$$s_k(t) = \sum_{i=-\infty}^{\infty} \sum_{j=0}^{N_f-1} d_{k,i} w(t - iT_s - jT_f - c_{k,j}T_c), \tag{1}$$

where k is the user index; is the symbol index; j is the frame index;dk,;∈{+1,-1}is the data sequence of the kth active user; w(t) is the transmitted pulse waveform;Ts is the symbol duration;Tf is the pulse repetition time $\{c_{k,j}\}_{j=0}^{N_f-1}$; the TH code,and Tc is the chip duration.

As discussed in[8],let Dk,p be the offset between the pth and the(p+1)th transmitted pulses from the user k, where Dk,p=Tf+(Ck,mod(p+1,N)-Ck,mod(p.N)×Te for p∈[0,Nf-1].The Sk(t)is given by

$$s_k(t) = \sum_{i=-\infty}^{\infty} \sum_{j=0}^{N_f-1} d_{k,i} w\left(t - iT_s - c_{k,0}T_c - \sum_{p=0}^{j-1} D_{k,p}\right), \tag{2}$$

where $\sum_{p=0}^{-1} D_{k,p} = 0$ is defined.

The multipath corresponding to user k is modeled as a tap delay line with Lk+1 taps.The amplitudes $\{ak_{,l}\}_{l=0}^{L_k}$ and delays $\{\tau_{k,l}\}_{l=0}^{L_k}$ of the taps are assumed to be invariant over one symbol duration.The channel impulse response is given by

$$h_k(t) = \sum_{l=0}^{L_k} \alpha_{k,l}\delta(t - \tau_k - \tau_{k,l}), \tag{3}$$

where Tk,0=0 is defined,Tk∈[0,Ts] represents the prop- agation delay of the first arrival signal,and Tk,L represents the maximum delay spread.

The collected waveform for all the active users has the form

$$
\begin{aligned}
r(t) &= \sum_{k=0}^{N_a-1} s_k(t) * h_k(t) + n(t) \\
&= \sum_{i=-\infty}^{\infty} \sum_{k=0}^{N_u-1} \sum_{j=0}^{N_f-1} \sum_{l=0}^{L_k} d_{k,i}\alpha_{k,l} w\Bigg(t - iT_s - c_{k,0}T_c \\
&\quad - \sum_{p=0}^{j-1} D_{k,p} - \tau_k - \tau_{k,l} \Bigg) + n(t),
\end{aligned} \tag{4}
$$

where Na is the total number of users,and n(t) denotes the additive Gaussian noise. Since $\{\alpha_{k,l}\}_{l=0}^{L_k}$ and $\{\tau_{k,l}\}_{l=0}^{L_k}$ are invariant over one symbol duration, let $v_{k,i,j}(t) = \sum_{l=0}^{L_k} \alpha_{k,l} w(t - iT_s - c_{k,0}T_c - \sum_{p=0}^{j-1} D_{k,p} - \tau_k - \tau_{k,l})$, and then $v_{k,i,j}(t) = v_{k,i,0}(t - \sum_{p=0}^{j-1} D_{k,p})$.Equation (3) could therefore be presenet as

$$
r(t) = \sum_{i=-\infty}^{\infty} \sum_{k=0}^{N_u-1} \sum_{j=0}^{N_f-1} d_{k,i} v_{k,i,0}\left(t - \sum_{p=0}^{j-1} D_{k,p} \right) + n(t). \tag{5}
$$

3. Simulations

The performance of the proposed PS-SLD sheme was evaluated through a series of simulations.The multipath were generated using the UWB channel model proposed by IEEE 802.15.3a[14] with parameters of (1/ A,1/A, T,y)=(42.9,0.4,7.1,4.3)nanoseconds(ns).Thc hannel pulse response was assumed to be unchange symbol duration. Furthermore, for each user k, an assumption was made that the propagation of the first arrival signal, Tk, was uniformly distributed over the interval [0,Ts Tx=Nf×T,.The frame duration was specified as] ns,where Tr=35ns,and each symbol comprised of N=32 frames. The desired user was assigned a TH code $\{c_{k,j}\}_{j=0}^{N_f-1}$ hat satisfied Dkp≠Dkg for every p≠q.

The remaining users were assigned random TH codes uniformly distributed over the interval (0,Ne×Tc)with Ne=35 and Tc= 1ns.The sequence for the DA TDT was composed of a repeated pattern(1,1,-1,-1)for all users,but the transmitted information dkj is randomly generated in the PS-SLD algorithm.The integration window,Tu,was

specified as 35ns in all of the PS-SLD simulations,except those presented in **Figure 5**.In all simulations,when comparing PS-SLD with TDT algorithms,

Figure 1 illustrates the PD for PS-SLD algorithms obtained using a simulation and a Monte Carlo .Simulation results of the PS-SLD algorithm are nearly the same as the Monte Carlo

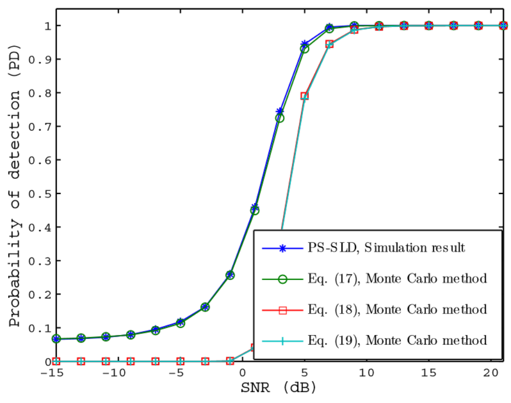

Figure 1. PD simulations and theory result, with T=Tf is single-user link.

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Ti in[12].Finally,SNR is given by. ,where N。

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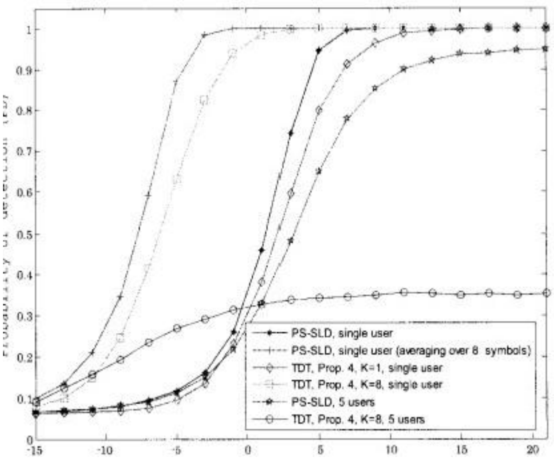
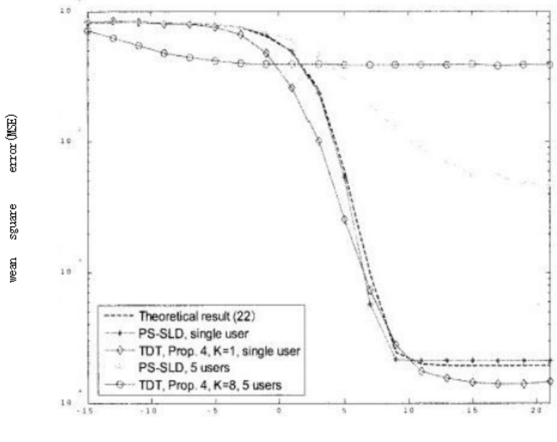


SNR(dB)

Figure 2. PD simulations of PS-SLD and TDT algorithms with TA=Ty.

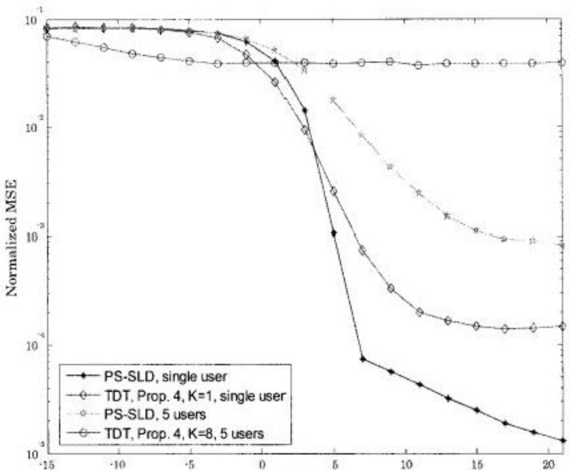


SNR(dB)

Figure 3. Normalized MSE with T △ =Ty.(MSE is normalzed with respect toT}).

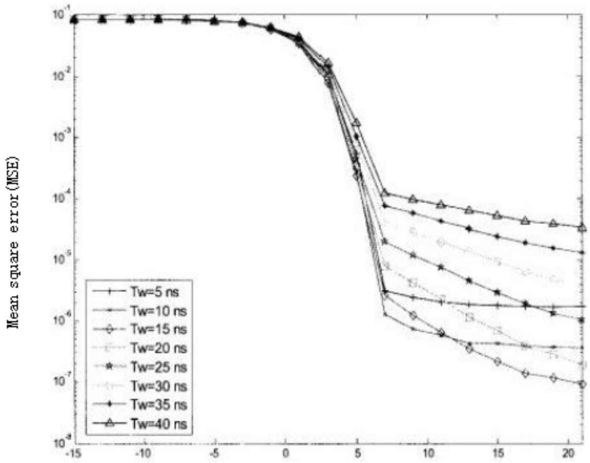
simulation results of Eq.(17),indicating that Eq.(17)forms sound performance analysis values of the PD. Moreover, the Monte Carlo results also show that Eq.(18)and Eq.(19) are same. Importantly, the PD does not start from 0 in poor SNR regions,because the "PD for coarse acquisition denotes the tolerable inaccuracy is between the interval of [-Ty,Tf]. In this research, the PD floor should be 0.0625(or 2/Ng).

Figure 2 shows the PD comparison between the PS- SLD and the TDT algorithms. For a comparison between the PS-SLD and the TDT algorithms when K=8,8 symbols were received on average for the PS-SLD algorithms. Simulation results show that the PS-SLD algorithms obtain a higher PD than TDT. This simulation result is acceptable because the SLD receiver utilizes the unique interval between successive pulses,i.e. Dk,p, as the delay when correlating the received signal with the TD signal.Hence,the



SNR(dB)

Figure 4. Normalized MSE with T △ =T.(MSE isnormalized with respect toT²).



SNR(dB)

Figure 5. Normalized MSE of PS-SLD for various T settings,with TA= T.in a single-user link(MSE is normalized with respect to T²).

SLD receiver is more robust to noise and ISI than the TDT.

Although the TDTs are blind,the PD of the TDT algorithms is around 1/N, because the receiver cannot determine the desired user's signals from other users' signals in a multi-user stuations.In this case, the performance of PS-SLD is obviously better than that of TDTs in a multi-user stuation.

Figures 3 and **4** compare the MSEs between PS-SLD and TDT for different TA,indicating that TDT algorithms with T △ =Tr perform the same as those with T △ =Tc. Although the performance of the MSE for PS-SLD and TDT algorithms are very close when T △ =Ty, PS-SLD has a better performance analysis to that of the TDT algorithms when T △ =Tc

Figure 5 summarizes the performance of the MSE for different tsettings. Usually, a larger of Timplies the potential for more signal power that can be acquired in the receiver. However more noise or IFI. Poewer is captured at high values of Tw, subsequently deteriorating the performance. Conversely, the captured signal when Tw is small may be inadequate,thus also degrading the performance[7].Therefore,the system parameter,Tw, should be small fine-tuned to optimize the MSE performance for various system stuiations.

6. Conclusions

This investigation proposes an NDA synchronization scheme named PS-SLD. As shown in Table 1,PS-SLD has a higher complexity than TDT. However,its uncertain region is bounded within one frame duration ,and is only 1/N, of that of the TDT algorithms.Simulation results indicate that the PS-SLD obtains a higher PD and a lower normalized MSE than the TDT algorithms in both multipath wand multi-user environments.

References

[1] K.Witrisal,G.Leus,M.Pausini,and C.Krall,”Equivalent system model and equalization of differential impulse radio UWB systems,” IEEE J.Sel.Areas Commun.,vol.23,no.9,pp.1851-1862,Sept. 2005.

[2] N.He and C.Tepedelenlioglu,”Adaptive synchronization for non- coherent UWB receivers,”ICASSP,vol.4,pp.517-520,Montreal, CA,May 2004.

[3] R.Djapic,G.Leus,and A.-J.van der Veen,”Blind synchronization in asynchronous multiuser UWB networks based on the transmit- reference scheme,”Asilomar Conference on Signals,Systems,and Compu ters,PacificGrove,CA,Nov.2004.

[4] C.Carbonelli,U.Mengali,S.Franz,and U.Mitra,”Semi-blind ML synchronization for UWB transmited reference systems,”Thirty-