Adaptive Resource Allocation for Visible Light Communication Using Probabilistic Interference Model

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Abstract

Visible light communication has emerged as an efficient mean of utilization of wavelength for long range communication. In Visible light communication the energy detector logic for wavelength estimation is the most eminent part for estimation of used wavelength over unused wavelength. The estimation error rate for such a system is dependent on the probability based hypothetical estimation approach. Wherein conventional energy detectors make the probability estimation based on derived threshold, the error rate is purely dependent on the accuracy of the threshold limits. In this paper a bi-probabilistic threshold modeling is proposed. The bi-probabilistic estimation approach presents an approach for non linearity factor consideration for secondary users in Visible Light communication. The obtained simulative observation illustrates the significance of bi-probabilistic estimator logic over conventional estimator logic.

Keyword: Visible light, wavelength estimation, energy detector, bi-probabilistic limits.

I. INTRODUCTION

In modern competitive world the long range networks are assigned by a fixed wavelength policy. Though a hefty portion of the wavelength is made available for the geographical variations. The assigned wavelength utilizes range from 15% to 85%

with a high variance in time for the periodically and geographical variations. Due to the limited availability of wavelength and inefficient usage of the wavelength led to a new communication to exploit the existing long range wavelength. This new communication model is referred to as Dynamic Wavelength Access   or Visible light (VLC) networks. A Visible light is defined as a transceiver which helps in detecting the availability of the channel in the wavelength and correspondingly changes its transmission or reception parameters in a given wavelength band. The theory of VLC is first introduced in [1], in which the secondary (unlicensed) users consume the licensed frequencies when the primary (licensed) user is absent or not fully utilizes the wavelength. In order to achieve this, the secondary users require sensing property in the wavelength environment in its surroundings in order to decide the absence and presence of the primary user. Many wavelength sensing methods are proposed [2], in which the energy detector has a simple structure and quick wavelength sensing property. For signals corrupted by Gaussian noise the energy detector is very useful and act as a non-coherent detector [3]. It measures the energy of the existence signal and compared with the preset threshold value. No channel state information is required for the measurement and the comparison. Because of its simple structure and sensing property the energy detector has been widely used in communication system.

Dealing with the anonymous undeterministic signals masked with Gaussian noise an energy detector [3] is proposed. For detecting the random signals corrupted by the Gaussian noise the extension the energy detector is used in [4] and [5]. Though the results obtained are based on the likelihood ratio test method and the likelihood ratio test method is maximized in [6]. In many communication applications, there is a possibility of the errors might occur, so the probability of erroneous detection or the probability of correct detection is of more interest. The energy detector has the ability to maximize the generalized likelihood function may not be the same in minimizing the probability of erroneous detection by maximizing the probability of correct detection. This gives motivation to explore the energy detectors much better than those proposed in [1], [4], [5]. In [7] based on the updation of square value to an arbitrary constant value 'p' for the signal amplitude, a new approach energy detector is proposed for improving the accuracy. In real time environment uncertainty in the channel exist, in this work uncertainty in the channel is not considered. So there is a need for modification in the proposed approach for uncertainty condition. For this reason, in this paper a bi-probabilistic threshold approach for energy detection is proposed. In [8], [9] for energy detection a 2 probabilistic thresholding approach is recently been used. This approach integrates the uncertainty condition in VLC communication. The rest of the paper is organized as follows, in Section2; the basic model is introduced. In Section3, under a single threshold, the new energy detector for random signals with Gaussian noise is discussed. Section 4 deals with the implementation of double threshold concept into the energy detection. Then in Section5 the simulation results are shown. The conclusions made for the proposed

work is presented in Section 6.

II. SYSTEM MODEL

In communication system modeling, considering the proposed communication under two assumptions. A binary hypothesis testing problem is considered as;

$$H_0: y_i = n_i$$

$$H_1: y_i = s_i + n_i \qquad (1)$$

where H_0 can be determined as the hypothesis that the signal is absent, H_1 can be determined as the hypothesis that the signal is present, $i= 1, 2, \cdots, n$ index the n signal samples, n_i is represented as an additive white Gaussian noise whose mean is zero and variance σ^2, and s_i is represented as the fading signal. In the proposed approach, the bit interval is divided into two parts. If the data bit values is 0, in the first part of the bit interval, the signal will be transmitted. If the data bit value is 1, here there is an additional time shift is defined, so that the signal will be transmitted in the second part of the bit interval. At the receiver end, in order to determine the presence of the signal, the energy of the first part is compared with that of the second part, and as a result, the data bit transmitted. In this case, y_i in H_0 represents the received signal for the part without signal in the bit interval, while y_i in H_1 represents the received signal for the part with signal in the bit interval. In a Visible light system, y_i represents he signal from the primary user. Let us assume that the random signal follows a Gaussian distribution with mean zero and variance α^2. Also, assume that the signal samples are independent. In this paper, real signals are considered. Because the results can be easily extended to complex signals. As well as, the noise samples, $n_i= 1, 2, \cdots,,$ are assumed independent.

Then the probability density function for the received signal under two hypotheses can be calculated as $P(Y|H_0)$ for hypothesis H0 and $P(Y|H_1, s)$ for H1, where Y=$[y_0, y_1, \dots \dots, y_n]$ and s=$[s_0, s_1, \dots \dots, s_n]$. By using the generalized likelihood ratio test approach along with the Gaussian distribution of s_i, the conventional energy detector can be derived as [4].

$$E = \frac{1}{n} \sum_{i=1}^{n} \left(\frac{y_i}{\sigma}\right)^2 > \delta \ (for \, hypothesis \, H_1) \qquad (2)$$

$$E = \frac{1}{n} \sum_{i=1}^{n} \left(\frac{y_i}{\sigma}\right)^2 < \delta \ (for \, hypothesis \, H_0 \qquad (3)$$

Where the signal sample y_i is normalized with respect to the noise standard deviation and then squared, and δ is the detection threshold to be determined. In order to estimate the threshold value, improved estimator logic is presented in [7].

III. ADAPTIVE RESOURCE ALLOCATION

In previous section the basic energy detecting model for a signal is presented under two assumptions H_0 and H_1 respectively. In this section trying to calculate the threshold in order to determine whether the received signal is under hypothesis0 or Hypothesis1. This can be done as follows Denote

$$P_F = \Pr\{E > \delta \mid H_0\} \quad (4)$$

as the probability of false alarm and

$$P_D = \Pr\{E > \delta \mid H_1\} \quad (5)$$

as the probability detection. The detection threshold can be determined by Using (4). According to the Neyman-Pearson rule as

$$T = F_{E \mid H_0}^{-1}(1 - P_F, \theta_0, k_0) \quad (6)$$

Where k and θ represent the shape and scaling parameters respectively. The energy detector has the ability to maximize the generalized likelihood function in (2 and 3) as seen in [9] and may not be the same in minimizing the probability of false alarm or erroneous detection by maximizing the probability of correct detection in (5). So as to improve the detection performance of the conventional energy detector, in this paper, a new energy detector is proposed as

$$E' = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{|y_i|}{\sigma}\right)^p > \delta' \quad (for\,hypothesis\,H_1) \qquad (7)$$

$$E' = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{|y_i|}{\sigma}\right)^p < \delta' \quad (for\,hypothesis\,H_0) \qquad (8)$$

Where $p>0$ is an arbitrary constant and δ' is the detection threshold to be determined. The difference between (2) and (7) is that the squaring operation in (2) is being replaced by an arbitrary positive power operation of p in (7) and accordingly the detection threshold is changed. When $p= 2$, the conventional energy detector is a special case of the new energy detector. In this case, the E′ doesn't follow a Gamma distribution in general. Though, E′ iswell approximated as a Gamma random variable by matching the mean and the variance is shown later. Such a kind of approximation help us to determine the detection threshold δ' for the new detector in (7), otherwise it would be difficult to obtain without the distribution of E′. Using [10], one has the mean and the variance of E′ as

$$M\{(E'|H_0)\} = \frac{2^{p/2}}{\sqrt{\pi}}\,\Gamma\left(\frac{p+1}{2}\right)$$

$$\mathrm{Var}\{(E'|H_0)\} = \frac{2^p\Gamma\left(\frac{2p+1}{2}\right)}{\sqrt[n]{\pi}} - \frac{2^p}{n\pi}\Gamma^2\left(\frac{p+1}{2}\right) \qquad (9)$$

Under H_0, and the mean and the variance of W as

$$M\{(E'|H_1)\} = \frac{2^{p/2}}{\sqrt{\pi}}\ \Gamma(\frac{p+1}{2})(\sqrt{1+\gamma})^p$$

$$Var\{(E'|H_1)\} = \frac{2^p(1+\gamma)^p\Gamma(\frac{2p+1}{2})}{\sqrt[n]{\pi}} - \frac{2^p(1+\gamma)^p}{n\pi}\Gamma^2(\frac{p+1}{2}) \quad (10)$$

Under H_1.

Finally, using (9) and (10), one has a closed-form expression for the detection threshold as,

$$\delta' = F_{E|H_0}^{-1}\left(1 - P_F, \theta_0', k_0'\right) \qquad (11)$$

Where θ_0', k_0' is defined as,

$$\theta_0' = \frac{Var\{(E'|H_0)\}}{M\{(E'|H_0)\}} \qquad (12)$$

$$k_0' = \frac{M^2\{(E'|H_0)\}}{Var\{(E'|H_0)\}} \qquad (13)$$

And the ROC curve for this new bi-probablistic detector as

$$P_D = 1 - F_{E|H_1}^{-1}\left(\delta', \theta_0', k_0'\right)(14)$$

In communication systems, the fading, hidden node problem, shadowing etc, results in worsening the wavelength sensing performance of secondary users. In Visible Light communication there are *N* secondary users, in which each secondary user experiences independent channel effects. In conventional energy detections, each secondary user has the ability to make local decisions by comparing the with a fixed threshold value. The threshold is derived from the squaring of the signal amplitude in [11 and 12]. In [7] an improvised version is outlined.   However in the proposed detection the threshold value is estimated by p factor without any concern or reference of the secondary user. The un-certainty of estimation hypothesis is observed, in presence of secondary user. In such a case single threshold approach is not optimal.

IV. RESULT OBSERVATION

By the simulation, the effectiveness of using bi probablistic threshold is evaluated over a UWB system. In the simulation process, the value of the pulse duration is set to 2 ns, whereas the additional time shift values are set to 100 ns. A second-order Gaussian monocycle is used. In order to avoid the intersymbol interference, the bit

interval is set to 200 ns. The data bits tested is 1000 and the number of channel realizations tested is 250. The BER performance over variable SNR is as shown in figure 3.
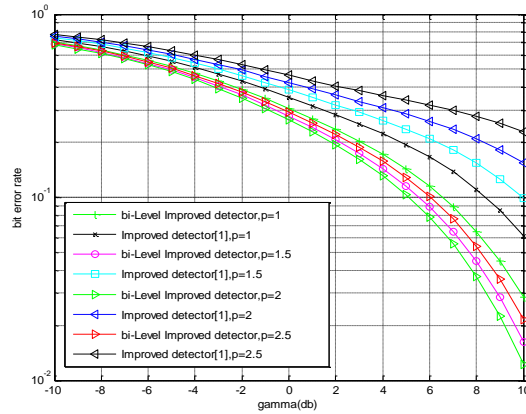

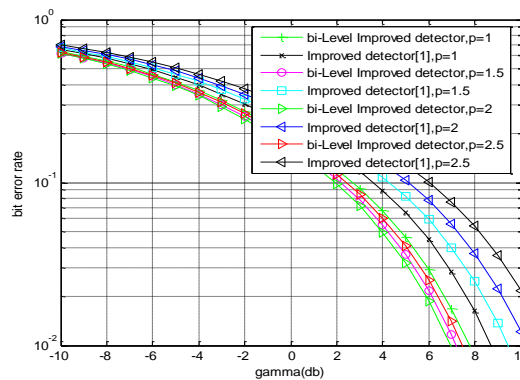Fig 3: Comparison of the bit error rates for the improved energy detector at n=10

Fig4: Comparison of the bit error rates for the improved energy detector at n=20

Using different fixed values of p, the proposed bi-probablistic energy detectorfor a BPPM UWB system in the IEEE CM1 channel.Fig. 3 and Fig 4   shows the comparison of the ROC curve of the conventional energy detector with that of the new energy detector with optimized $p$value at n=10 and n=20 respectively.

From the above mentioned two figures, one sees that, when $\gamma$is less than 0 dB, the performance difference is negligible. However, when $\gamma$is larger than 0 dB, the larger the value of $p$is, the better the new energy detector will perform. The conventional energy detector has a larger bit error rate than the new energy detector. Thus, the new energy detector outperforms the conventional energy detector even when a fixed $p$is used without any knowledge of the ASNR to determine the optimum p. The conventional energy detector is based on the maximization of the generalized

likelihood function, as can be seen from eq. (10), while the new energy detector is based on the minimization of bit error rate for various values of γ.
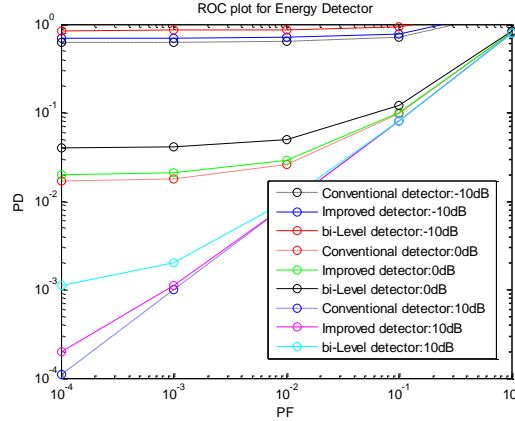

Fig 5: Comparison of the ROCs for the conventional energy detector and the new energy detector when $n = 10$ for different values of γ.

Fig. 5 compares the ROC curve of the conventional energy detector with that of the improved energy detector and with the bi-probablistic energy detector with optimized p from (11). The simulation results for bi-probablistic energy detectors are obtained by using eq.(14). From above figure one sees that the new energy detector with optimized p outperforms the conventional energy detector in all the cases considered. However, this is not obvious for $\gamma = 10$ *dB*, where the difference between the conventional energy detector and the new energy detector is graphically negligible. The probability of detection inVLCeases as the probability of false alarm deVLCeases, and it is significant when *PF* is less than or equal to 10^{-3}. This implies that one may choose *PF* to be smaller than or equal to 10^{-3} in order to achieve significant gain by using the optimized energy detector, or one may choose *PF* to be larger than 10^{-3} in order to avoid significant loss by using the conventional energy detector.
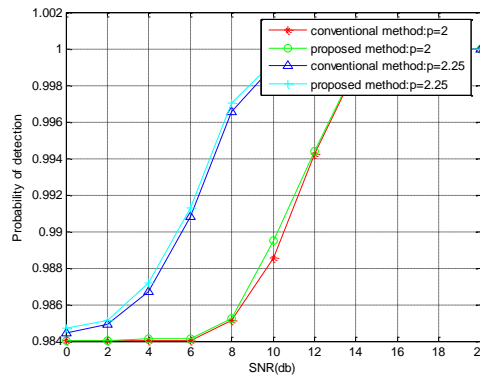

Fig 6: Probability of detection versus signal to noise ratio at p=2 , p=2.25

For p= *2, 2.25,* the probability of detection versus SNR curve is plotted in Fig. 6. It is shown in Fig. 6 that the probability of detection inVLCeases with inVLCease in the value of p.
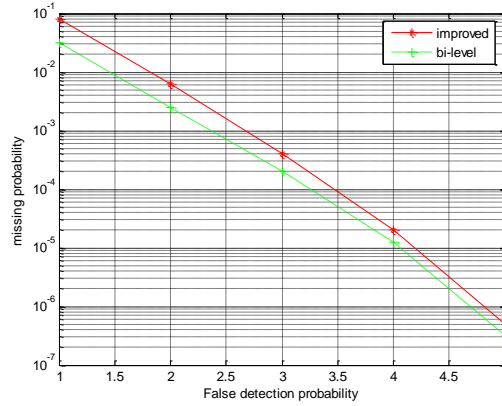

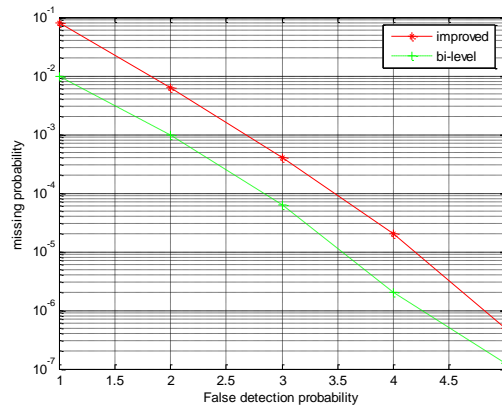Fig.7:Pm versus Pf in two kinds of wavelength sensing for $\rho = .01$

Fig.8:P_m versus Pf in two kinds of wavelength sensing for $\rho = .1$

From the above figures 7 and 8 we predict that an inVLCease in ρ When we inVLCease ρ , the detection performance have improved significantly. While $P_F$inVLCement, the proposed methodachieves extra detection probability, and it has nearly 1dB improvement upon the preceding method. However, the detection performance gain was achieved by the inVLCease of communication burdens introduced by the local energy values, so the practical implementation of our method should concern the tradeoffs between the wavelength sensing performance and the average communication burdens, which will be studied thoroughly in our future work.

V. CONCLUSIONS

A bi-probablistic thresholding approach for energy detection is proposed. The conventional approach of single thresholding approach is improved by the usage of two threshold limits under variant channel conditions. The estimation accuracy to such approach is observed to be improved due to the utilization of improved thresholding with bi-probablistic thresholding. The uncertainty of detection of PU under secondary user presence is developed and evaluated in this work. From the results observed it is proved that with the usage of bi-probablistic thresholding provides better estimation at any range of SNR as in comparison to conventional approaches.

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Dasari Subba Rao is a research Scholar from Rayalaseema University and working as Associate Professor Professor of ECE in Siddartha Institute of Engineering and Technology. He has done his Graduation in Engineering (ECE) in 2003 from JNTU, Hyderabad and Post Graduation in 2007 with specialization in Embedded Systems from SRM University, Chennai. He published 26 papers in International Journal, He is the life time member of ISTE. His area of interest is Wireless Communications.

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From 1991 to 1996 he was a lecturer to U.G courses in electronics, physics in faculty of science and various subjects of electronics and communications engineering for diploma holders (FDH) program of JNTU Engineering College at Hyderabad, and from 1996 to 2001 he was with R&T Unit for navigational electronics (NERTU). During his association with NERTU, he executed projects sponsored by RCA, VSSC, DLRL and DST. His research interests include electromagnetic modeling, atmospheric studies, optical fiber communication, low power VLSI, signal processing. Several international and national publications are under his credit.

He continued his teaching from 2001 and currently at Sreenidhi Institute of Science and Technology as a professor of ECE . As one of the earlier assignments now he was Principal of SV Insititute of Technology and Engineering (SVIET) and professor of electroncs and communications Engineering of SV group of institutions. He teaching interests for undergraduate courses includes Electromagnetic theory, antennas and propagation and microwave engineering, post graduate courses in communication systems and microwave radar engineering. Dr. N.S.Murthy Sarma is life member of Institute of Science and Technology education (ISTE) since 2002 and fellow of institute of electronics and telecommunication engineers (IETE) since 2003, fellow of Institution of Engineers IE(I) and Member of Institute of Electrical and Electronics Engineers (IEEE) since 2010. He usually reviewers papers for international journals viz. international journal of computer science and Engineering systems and international journal of International Journal of Emerging Technologies and Applications in Engineering Technology and Sciences , besides a regular conference reviewer of conferences(since 2010) of IEEE with immediate recent assignment of ADVCIT'2014. . He is one of the recognized Ph.D Supervisors of engineering faculty, Around Eight research scholars are working with him under Ph.D. programme of JNTUH/JNTUK/KLU in the area of Communications, Low power VLSI, GPS/GLONASS, since 2008.