Adaptive Channel Estimation Technique for SCFDMA System

[1]Gurubelli Yogeswararao, [2]Soma Umamaheshwar,[3]Patteti Krishna, [4]Tipparti Anil kumar,[5]Kunupalli Srinivas Rao and [6]Kalithkar Kishan Rao
[1]Department of ECE, SRIIT, Hyderabad, India,yogesh429@gmail.com
[2]Department of ECE, VREC, Warangal, India,umamaheshwarsoma@rediffmail.com
[3]Department of ECE, SVSIT, Warangal, India, kpatteti@gmail.com
[4]Department of ECE, SREC, Warangal, India,tvakumar2000@yahoo.co.in
[5]Department of ECE, TRRCE, Hyderabad, India,principaltrr@gmail.com
[6]Department of ECE, VCE, Warangal, India,kishanrao6@gmmail.com

Abstract—**This paper presents a robust technique for a single carrier frequency division multiple access channel estimation in flat- fading non- Gaussian channels. Further, the proposed detection technique is made robust by using a new *M*-estimator. Efficacy of the proposed detector over the least squares, Huber and Hampel based detectors in flat- fading non- Gaussian channels is demonstrated with the help of simulation results.**

Keywords— Channel estimation, Fading channels, M-estimator, single carrier-frequency division multiple access.

I.INTRODUCTION

Demand for high data rates in wireless communication systems is rapidly increasing in order to support broadband services. The Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) radio access standard provides peak data rates of 75 Mb/s on the uplink and 300 Mb/s on the downlink (orthogonal frequency-division multiple access (OFDMA) is used on the downlink). This supports different carrier bandwidths (1.25–20 MHz) in both frequency-division duplex (FDD) and time-division duplex (TDD) modes. In OFDMA each user is provided with a unique fraction of the system bandwidth. OFDMA combines scalability, multipath robustness, multiple-input multiple-output (MIMO) compatibility [1], thereby making it adaptive for wideband wireless accessibility.

OFDMA, being sensitive to frequency offset and phase noise, accurate frequency and phase synchronization is needed. In addition, OFDMA is characterized by a high transmit PAPR, and for a given peak power limited amplifier this results in a lower mean transmit level. For these reasons, OFDMA is not well suited to the uplink transmission. Hence, LTE proposed, Single carrier FDMA (SC-FDMA), also known as discrete Fourier transform (DFT) precoded OFDMA, for the uplink. PAPR reduction in SCFDMA is motivated by a desire to increase the mean transmit power, improve the power amplifier efficiency, reduce the bit error rate (BER), boost the data rate and energy consumption [2]. SC-FDMA ensures high data rate transmission, utilizing single carrier m frequency domain equalization. In algorithm is proposed for LTE uplink channel impulse response (CIR) knowledge of the channel.

II. CHANNEL MODEL

There are several possible modulation formats available at the transmitter side. Baseband modulator transforms the binary input to a multilevel sequences of complex numbers using one of the modulation techniques including binary PSK (BPSK), quaternary PSK (QPSK), 8 level PSK (8-PSK), 16-QAM, and 64-QAM. Then these modulated symbols are transformed into frequency domain representation by performing an N-point discrete Fourier transform (DFT). The DFT is followed by Inverse DFT in a distribution-FDMA (DFDMA) or localization-FDMA (LFDMA).Subcarrier mapping setup is carried out as an efficient implementation to an interpolation filter. Accordingly in distributed subcarrier mode[3,4], the outputs are allocated to an equally spaced subcarriers, with zeros occupying the unused subcarriers in between. While in localized subcarrier mode, the outputs are confined to a continuous spectrum of subcarriers. Apart the above two modes, interleaved subcarrier mapping mode of FDMA (IFDMA) is another special subcarrier mapping mode. The difference between DFDMA and IFDMA is that the outputs of IFDMA are allocated over the entire bandwidth, whereas the DFDMA's outputs are allocated for every several subcarriers.

The impulse response of the wide-sense stationary uncorrelated scattering (WSSUS) fading channel can be represented [5] as

$$w(\tau,k)=\sum_{j=0}^{l-1} w_j(k)\delta(\tau-\tau_j) \tag{1}$$

where fading channel coefficients $w_j(k)$ are the wide sense stationary i.e. $w_j(k) = w(m, j)$, uncorrelated complex Gaussian random paths gains at time instant k with their respective delays τ_j, where w(m, j) is the sample spaced channel response of the lth path during the time k, and $\delta(\bullet)$ is the Dirac delta function. The fading channel coefficients in different delay taps are statistically independent as per the above channel assumption. The autocorrelation function of above channel is given by

$$E\left[w(k,j)w^T(n,j)\right] = \sigma_w{}^2(j) j_0\left[2\pi f_d T_f(k-n)\right] \quad (2)$$

where $w(n;\ j)$ is a response of the l^{th} propagation path measured at time n, $\sigma_w^2(J)$ represents the power of the channel coefficients, f_d is the Doppler frequency in Hz, T_f is the symbol duration in seconds, and $J_0(\bullet)$ is the zero order Bessel function of the first kind.

.

III. PROPOSED ALGORITHM

The input signal $s(k)$ is transmitted over a time-varying channel w(k), and is corrupted by an noise $n(m)$ during the propagation before being detected in a receiver. The signal received at time index k is

$$\begin{aligned} r(k) &= s_1(k-1)w_1(m) + \ldots \quad \ldots + s_l(k-l)w_l(k) + n(k) \\ &= \sum_{j=1}^{l} s_j(k-j)w_j + n(k) \\ &= S^T(k)W(k) + n(k) \end{aligned} \quad (3)$$

where $s_j(k-j)$, $j = 1,2,\ldots,l$ represents the transmitted signal vectors at time m, l be the distinct paths from transmitter to the receiver, w(m) be the channel coefficients at time m, and n(k) represents the zero mean noise and σ^2 be the variance. After processing some intermediate steps such as synchronization, remove CP, DFT, and demapping the decision block reconstruct the detected signal approximated to the modulated signal. The output y(k) of the adaptive filter is expressed as

$$\begin{aligned} y(k) &= d_1(k-1)h_1(k) + \ldots \quad \ldots + d_l(k-l)h_l(m) \\ &= \sum_{j=1}^{l} d_j(k-j)h_j(k) \\ &= D^T(k)h(k) \end{aligned} \quad (4)$$

where $d_j(k-j),\quad j = 1,2,\ldots,l$ represents the detected signal vectors at time k.

$$D(k) = diag\left[d_1(k-1), d_2(k-2), \ldots, d_l(k-l)\right].$$

In ideal, adaptation procedure w$_j$(k) would be adjusted such that w$_j$(k)=h$_j$(k) as $k \longrightarrow \infty$. However in practice, w(k) are adjusted such that y(k) closely approximates the desired signal over a time. The instantaneous estimated error signal to update the weights of the adaptive filter is

$$\begin{aligned} j(k) &= p(k)e^T(k)e(k) \\ e(k) &= r(k) - y(k) \\ &= r(k) - D^T(k)h(k) \end{aligned} \quad (5)$$

The estimator error is minimized by updating the filter weights adaptively using initial error signal, e(k). $w(i) = [w_0(i),\ldots.w_{N-1}(i)]^T$ is the channel noise vector during the i^{th} symbol interval. $W(i)$ are assumed to be independent and identically distributed random variables with non- Gaussian distribution.

$$(1-\varepsilon)f(0,\sigma_1^2) + \varepsilon f(0,\sigma_2^2) \quad (6)$$

In this paper, M-estimator based robust clustering technique is proposed. It reduces the effect of outliers by replacing the squared residuals r_i^2 by less rapidly increasing function ρ of the residuals, yielding

$$\min_c \sum_{i=1}^{N} \rho(r_i) \quad (7)$$

where ρ is a symmetric, positive-definite function with a unique minimum at zero, and is chosen to be less increasing than squared function.

Let $C = [c_1, \ldots..c_k]$ be the parameter vector to be estimated. The M-estimator of c based on the function $\rho(r_i)$ is the vector $\boldsymbol{C}$ which is the solution of the following k equations:

$$\sum_i \psi(r_i)\frac{\partial r_i}{\partial c_j},\ for\ i = 1,\ldots,k \quad (8)$$

where the derivative $\psi(x) = \dfrac{d\rho(x)}{dx}$ is called the influence function. The influence function $\psi(x)$ measures the influence of a datum on the value of the parameter estimate. In this paper, a new M-estimator is proposed for robustifying the k-means clustering algorithm. The penalty function and the influence functions of the proposed M-estimator are given by [6,7] (also see Fig 1).

$$\rho_{PROPOSED}(x) = \begin{cases} \frac{x^2}{2}, \; for \quad |x| \le a \\ \frac{ab}{2} - a|x|, \; for \quad a < |x| \le b \\ -\frac{ab}{2}\exp\left(1 - \frac{x^2}{b^2}\right) + d, \; for \quad |x| > b \end{cases} \tag{9}$$

where d is any constant.

$$\psi_{PROPOSED}(x) = \begin{cases} x, \; for \quad |x| \le a \\ a\,\mathrm{sgn}(x), \; for \quad a < |x| \le b \\ \frac{a}{b} x \exp\left(1 - \frac{x^2}{b^2}\right), \; for \quad |x| > b \end{cases} \tag{10}$$

The choice of the constants $a\ \left(= kv^2\right)$ and $b\ \left(= 2kv^2\right)$ depends on the robustness measures derived from the influence function.

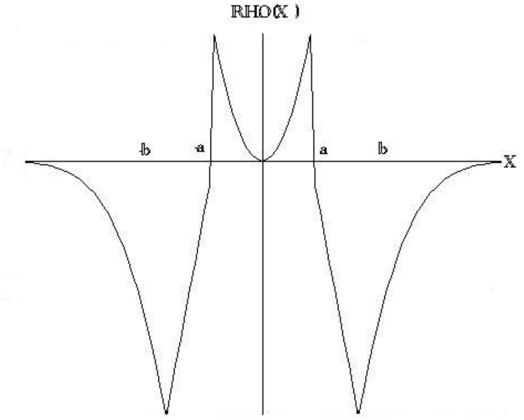

fig 1(a)

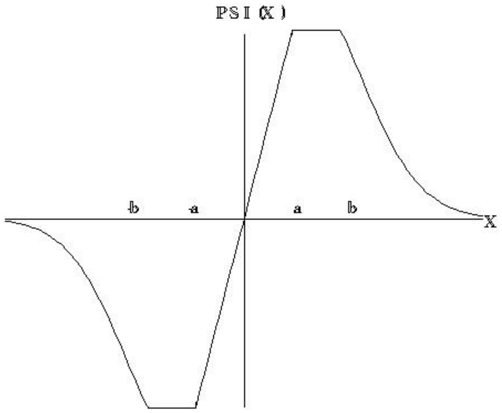

fig1(b)

Fig. 1 (a) Penalty function and (b) influence functions of the Proposed *M*-estimator.

IV. SIMULATION RESULTS

The performance of the proposed algorithm is compared with the Least Squares, Huber and Hampel based detectors in a Rayleigh fading environment and corrupted with non-Gaussian noise. The simulation parameters are listed in table1. The BER is a significant performance parameter for quality measurement recovered data in wireless communication effect of the proposed algorithm in terms of BER compared with existing estimators. It is evident from these results that the proposed algorithm outperforms the Least Squares, Huber and Hampel based detectors in non-Gaussian environment.

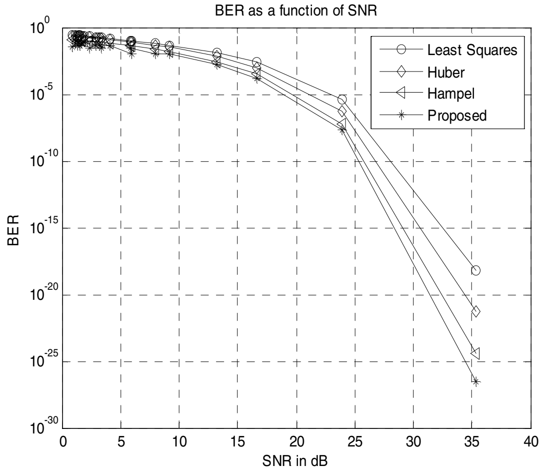

Fig. 2 Probability of error versus SNR for the considered detectors in Gaussian noise.

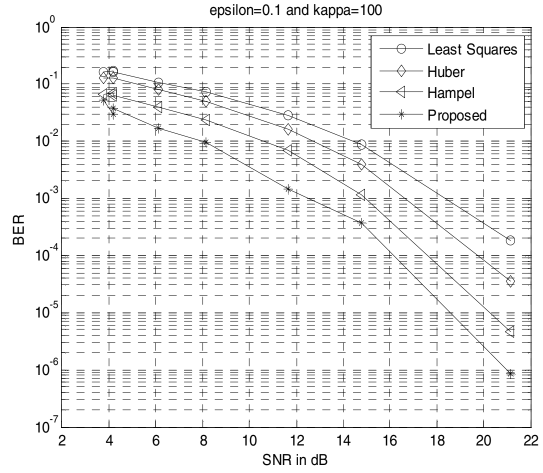

Fig. 4 Probability of error versus SNR for the considered detectors in non-Gaussian noise.

V. CONCLUSIONS

In this paper, a robust detection technique is proposed to estimate channel parameters when the signal is corrupted with non-Gaussian noise. A new M-estimator is proposed. Simulation results are also provided. These simulation results prove that the proposed detector outperforms Least Squares, Huber and Hampel based detectors in non-Gaussian flat- Fading channels.

REFERENCES

[1] R. Van Nee and R. Prasad, *OFDM for Wireless Multimedia Communications*, Artech House, 2000.

[2] Mohamed Noune; Andrew Nix; "Frequency-Domain Precoding for Single Carrier Frequency-Division Multiple Access", IEEE Commun. Mag.; June 2009

[3] Adachi. F, Tomeba. H, Takeda. K, Frequency-domain Equalization for Broadband Single-carrier Multiple Access,"*IEICE Trans. Commun.*, V.vol. E92-B, No. 5, pp. 1441 – 1456, 2009.

[4]Yameogo. S, Palicot. J, Cariou. L, "Blind Time Domain Equalization of SCFDMA signal," *Proc. Vehicular Technology Conference*, pp. 1 – 4, Sept. 2009.

[5] M D. Masud Rana, J. Kim, W. K. Cho, "LMS Based Adaptive Channel Estimation for LTE uplink," Radio Engineering, Vol.19, No.4, pp.678-688, 2010.

[6] P. J. Rousseeuw and A. M. Leroy, *Robust Regression and Outlier Detection.* New York: Wiley, 1987.

[7] Srinivasa Rao Vempati, Habibulla Khan, Anil Kumar Tipparti "Multiuser Detection in Shadowed Fading Channels with Impulsive Noise" *Proc. of International Conference on Emerging Trends in Engineering & Technology (ICETET 2014),* 29th-30th September, 2014, Telangana, India.