Improve Diversity with OFDM Technique in V-BLAST Architecture

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Abstract

There are several technologies to transmit any signal in wireless communication. Technologies are: Integration, Differentiation, TDM (Time Division Multiplexing), FDM (Frequency Division Multiplexing), OFDM (Orthogonal Frequency Division Multiplexing). In which OFDM is superior to any other technology. It is widely used in MIMO (Multiple Input Multiple Output) communication. Differentiation means large signal is divided into small signals. Differentiation means large signal is divided into small signals but wireless signals are always time variant. So, it is not applicable for wireless communication. Differentiation means large signal is divided into small number of signals with fixed length. To process of total differentiation length of that signal should be fixed. That is why; it is not applicable to find-out the solution of wireless scenario [1].

TDM technique is fulfilling the criteria of wireless signaling. In general TDM means band-width is allocated to multiple users with division of time. It means TDM provide full bandwidth for small number of time to multiple users. But wireless signals take full time to transmit and receive the digital information. So, TDM technique is not fulfilling all the requirements. FDM technique delivers small band-width for full time. But the problem is if numbers of users are more than the division of that small band-width is very small and if those small band-width signal transmissions changes its phase in air than error output will captured. Whenever signal change its phase vector also shift its position to its original co-ordinates. When vector shifts it produce disturbance on other user channel. It creates timing disturbances.

\[
\text{angle} = \tan^{-1} \frac{y}{x}
\]  

(1)

This is nothing but process of aliasing at side of receiver with digital multipath signals. Another drawback is those digital signals are finite in time (time limited) but infinite in band (band unlimited) so ideal receiver cannot give adequate output. Solution of above drawback is orthogonally (OFDM) signal transmission. Orthogonal FDM deliver better algorithm compare with all other previous technology [2,3].

Orthogonal signal means projection of output vector in two vectors with minimum angle. Spectral is also orthogonal where dot product of those two vector is zero. That means projection is zero and gives largest hemming distance (Figure 1).

**OFDM Mathematics**

**MSE in OFDM**

If any function \( f(t) \) filtered under \( a(t) \) filter where “a” is the weighted co-efficient of that filter for \( t_1 \) to \( t_2 \) time then, (Figure 2) Signal approximation \( f(t) \) by \( g(t) \); \( f(t) = a(t) \) over \( (t_1, t_2) \) and error is: \( e(t) = f(t) - a(t) \).

\[
\text{MSE} = \frac{1}{(t_2 - t_1)^2} \int_{t_1}^{t_2} e(t)^2 \, dt
\]

(2)

\[
\text{MSE} = \frac{1}{(t_2 - t_1)^2} \int_{t_1}^{t_2} f(t) - a(t)^2 \, dt
\]

(3)

MSE minimum at partial differenciation w.r.t. “a” when,

\[
\frac{\partial}{\partial a} \int_{t_1}^{t_2} f(t) - a(t)^2 \, dt = 0
\]

**Keywords:** OFDM; MSE; Throughput; Pre-coding; FFT; ZF; MMSE; ML

**Introduction**

When any signal passed through air it has list numbers of interferences where core interference is ISI (Inter Symbol Interference). Integration applied on multipath air signal means it combine small number of signal division with fixed length assumption. Integrations is applied on time invariant signals but multipath air signals always time variant. So, it is not applicable for wireless communication. Differentiation means large signal is divided into small band-width signal transmissions changes its phase in air than the division of that small band-width is very small and if those small band-width signal transmissions changes its phase in air than error output will captured. Whenever signal change its phase vector also shift its position to its original co-ordinates. When vector shifts than it produce disturbance on other user channel. It creates timing disturbances.

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**Figure 1:** Vector OFDM (small error and large hemming distance).

**Figure 2:** Pass frequency over \( t_1 \) to \( t_2 \).

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This is orthogonal condition for minimum MSE where two vectors A and B are orthogonal and gives minimum error e(t) because of magnitude of A and B is equal with appropriate phase angle $\theta$ [1].

### Throughput relation
As we seen before auto co-variance, integrator and differentiator is not used in transmitter.

Let $\mathbf{A} = a\mathbf{B}$ or $\mathbf{F} = \mathbf{B} + \mathbf{E}$ (Pythagoras)

But $\mathbf{F} \cdot \mathbf{E}$ or orthogonal then, $\mathbf{F} \cdot \mathbf{E} = 0$ then,

$\mathbf{A} = a\mathbf{B} + \mathbf{E} \Rightarrow \mathbf{A} \cdot \mathbf{B} = a\mathbf{B} \cdot \mathbf{B} + \mathbf{E} \cdot \mathbf{B}$.

"a" is optimally chosen then, $\mathbf{A} \cdot \mathbf{B} = a\mathbf{B}$.

In vector $||\mathbf{A} + \mathbf{B}||^2 = ||\mathbf{A}||^2 + ||\mathbf{B}||^2 + 2\mathbf{A} \cdot \mathbf{B}$,

$\int \left[ f(t) + g(t) \right]^2 dt$ In signals;

$\int f(t)^2 dt + \int g(t)^2 dt + 2 \int f(t)g(t) dt = \text{Total Energy} = \text{Individual Energy} + 2(\text{Cross Energy})$

For orthogonal cross energy is zero than throughput becomes high.

### Gain adjustment in OFDM
Let’s take more than one gain with its respective weighted co-efficient than, $ag(t) = a_1g_1(t) + a_2g_2(t)$; where $a_1$ and $a_2$ are weighted co-efficient with optimal value of gain $g_1(t)$ and $g_2(t)$.

$$a_1^2 + a_2^2 = 1,$$

$$a_1 = \frac{f(t)g_1(t)}{||g_1(t)||} dt, a_2 = \frac{f(t)g_2(t)}{||g_2(t)||} dt.$$

The system is orthogonal so $a_1$ and $a_2$ are adjusting value and individual each other.

### Motive of FFT in OFDM
If multiplication of total gain with its weighted code is taking more than one separate gain and weighted summation then,

ag(t) = a_1g_1(t) + a_2g_2(t);

$$a_1 = \frac{f(t)g_1(t)}{||g_1(t)||} dt, a_2 = \frac{f(t)g_2(t)}{||g_2(t)||} dt.$$

Orthogonal that is why $a_1$ and $a_2$ are adjustable values and individual each other.

### V-BLAST architecture
There are four BLAST technologies like D-BLAST, V-BLAST, H-BLAST and T-BLAST. D is known as Diagonal BLAST same as V for Virtual, H for Hybrid and T for Turbo. In these four technologies V-BLAST is very important technology. D-BLAST gives output but it is diagonally BLAST means Diagonal matrix have maximum energy (minimum error). V-VLAST has virtually division so it reduces time and increase accuracy over large bandwidth. H-BLAST and T-BLAST are faster than V-BLAST but suitable work for narrow bandwidth only [4-6].

### Result analysis:
Probability where random signal: If $< 0.5$ than Zero otherwise One.

Convert 0 and 1 to -1 and 1: Polar Signal Conversion

The combination of 2 × 2 antennas

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“U” identifies which vector has a lowest signal error:

\[
\text{nErr (n no. of Error where } n \text{ is user defined):}
\]

\[
\text{Ber3=}\frac{\text{nErr}}{N} \text{ (Ex: 72179/1000000=0.072179):-ML}
\]

Same as ber 1-MMSE:

And Ber2-ZF:

For any random input signal threshold (or cutoff) is identified. In this paper cutoff is 0.5. Means for any random input signal if the value is higher than 0.5 outputs is 1 otherwise 0. Polar form conversion is used because check signal parameters in three dimention and gives the values -1 and 1 (Table 1 and Figures 3 and 4).

**Conclusion**

A purpose of this paper is to analyze and compare to identify the behavior of different receiver techniques. Practical performance using Mat-Lab gives you the disturbance in signal due to the noise at receiver.

By performing above parameters disturbance in ML (Minimum Likelihood) is in 10^{-4.9} BER and 18 dB SNR. But for smaller SNR values ML gives sharper output (Less BER) compare with MMSE and ZF.

In MMSE (Minimum Mean Square Error) disturbance is in 10^{-4.3} BER and 32 dB SNR. When perform with high SNR with less fluctuation MMSE is used.

In ZF (Zero Force) disturbance is in 10^{-3.9} BER and 32 dB SNR. When perform with large range of SNR ZF is used.

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**References**

1. Mehana AH, Nosratinia A (2014) Diversity of MIMO Linear Precoding. Cornell University Library 60: 1019-1038.
2. Siriteanu C, Blostein SD, Takemura A, Shin H, Yusefi S, et al. (2014) Exact MIMO Zero-Forcing Detection Analysis for Transmit-Correlated Rician Fading. Information Theory Cornell University Library.
3. Neasmith EA, Beaulieu NC (1998) New Results on Selection Diversity. IEEE Transactions on Communications 46: 695-704.
4. Jariwala PP, Lapsiwala P (2013) Review: Performance Evolution of different Detection Techniques in V-BLAST. 4th ICCCNT, Tiruchengode, India.
5. Toboso AU, Loyka S, Gagnon F (2014) Optimal Detection Ordering for Coded V-BLAST. IEEE Transactions on Communications 62: 100-111.
6. Lathi BP, Ding Z (2010) Modern Digital and Analog Communication System (4th edn.). New-York.

7. Alnajjar KA, Smith PJ, Woodward GK (2015) Low complexity V-BLAST for massive MIMO with adaptive modulation and power control. Information and Communication Technology Research (ICTRC) Abu Dhabi: 1-4.

8. Huiqin W, Fen W, Minghua C (2015) A novel concatenated coding scheme combined LDPC and VBLAST for FSO links. Communication Software and Networks (ICCSN) Chengdu: 192-195.