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CONCLUSION AND FUTURE SCOPE OF THE WORK

14.1 CONCLUSION

14.1.1 ZF and MMSE for CDMA based MUD

Two linear multi-user detection techniques ZF (Zero forcing) and MMSE (Minimum Mean Square Error) have been implemented in Matlab 7.0 at the beginning of this research work in order to compare them with various algorithms like V-BLAST for OFDM and CDMA based system, GA for CDMA based system and PDA for CDMA based systems.

From the simulation results of BER vs Eb/No for varying users from 1 to 64 we have seen that the Performance of the MMSE algorithm is better than ZF algorithm because of desired symbols, MAI and noise terms are de-correlated by a wiener estimator.

14.1.2 V-BLAST for CDMA and OFDM based MUD

In this Research work, V-BLAST technique have been applied to CDMA and OFDM based Multi-user detection technique in wireless communication system with MIMO environments using MATLAB 7.0

From the simulation results for different users (2, 4, 8, and 16) for various modulation techniques like QPSK, 16-QAM, and 64-QAM in AWGN and MIMO Rayleigh fading channel, Here we could compare the performance of V-BLAST Algorithm with nulling techniques, Zero Forcing and MMSE, we found that result of MMSE nulling is comparatively better than ZF in some cases.

From the BER performance of the system model introduced for different parameters we conclude that

I. In CDMA based MIMO system 16-QAM with WALSH code Spreading gives better result , as mentioned

- Lowest at 17db for 2 users BER equals to 0.0157 , i.e. $10^{-1.90}$
- Lowest at 15dB for 4 users BER equals to 0.0125
- Lowest at 12 db for 8 users BER equals to 0.0267,
- Lowest at 16dB for 16 users BER equals to 0.4095

II. Comparing ZF and MMSE in OFDM based system for 16-QAM, only in the range of 15dB to 20dB MMSE result is better than ZF.

III. For the same number of users, modulation techniques, spreading codes and same MIMO Rayleigh Fading Channel 16-QAM result is considerably better then that of QPSK, and 64-QAM.

IV. As the number of user increases BER performance of the system model discussed clearly decreases.

V. Walsh code gives better performance then Gold code and PN code due to its orthogonal nature.

VI. Comparing CDMA and OFDM technique in terms of BER, OFDM BER is linearly decreases than CDMA but variation in BER is small compared to CDMA. In CDMA decreases in BER is very high in the 15dB to 20dB compared to OFDM and is around 30% decrease.

14.1.3 Genetic Algorithm for CDMA based MUD

Genetic Algorithm assisted Multi-user detection technique for CDMA based wireless communication system has been implemented in MATLAB 7.0.

From the simulation results of BER V/S Eb/No for different users(2,4,8,16,64) we have seen that the Performance of the Genetic Algorithm is considerably better than other currently available algorithms such as Zero Forcing, PDA etc. because of its powerful principle of estimating the best solution to given problem.

This thesis is a compilation of different approaches to linear multi-user detection in CDMA based wireless systems in presence of noise and multi path, fading environment. The matched filter bank just ignores the correlative structure of the MAI present in CDMA systems. Further, it was also shown that in the absence of the noise, the conventional algorithms used are slightly unreliable. This called for the need for better algorithms. The Genetic Algorithm(GA) was then introduced which takes the

conventional algorithms one step further by incorporating the correlative structure of the MAI in the detection.

From the BER performance of the system model introduced for different parameters we conclude that

I. For the same number of users, modulation techniques, spreading codes and type of channel the performance of 16-QAM is considerably better then that of QPSK, 64-QAM and GMSK.
II. As number of user increases BER performance of the system model discussed is clearly decreased.
III. Performance of the proposed system is better for 16 users with 16-QAM and AWGN channel is notably superior then other combinations.
IV. Performance of the system over Rayleigh fading channel is worst then that of AWGN channel.
V. Walsh code gives better performance then Gold code and PN code due to its orthogonal nature.

From the timing diagram performance of the system model introduced here for different parameters, we conclude that GA is better compared to other algorithms implemented in this research work. Because Genetic Algorithms converges easily and is less complex, it will defiantly be future application of multi-user detection in wireless communication especially in CDMA based applications.

14.1.4 PDA for CDMA based MUD

Probabilistic Data Association (PDA) Algorithm assisted Multi-user detection technique for CDMA based wireless communication system has also been implemented in MATLAB 7.0 and we also analyzed MATLAB simulation results with different number of users (2, 4, 8, 16 and 64) along with various modulation techniques like QPSK, 16-QAM, 64-QAM and GMSK under AWGN channel and Rayleigh faded environment. Here, we found that the Performance of the Probability Data Association Algorithm is considerably better than other algorithms like ZF and MMSE.

From the BER performance of the system model introduced for different parameters, we conclude that

- The Eb/No curve for the 2, 4 and 16 users with PDA algorithms between 8 to 18 db is good enough (e.g. near to 10^{-2}) in modulation technique 16-QAM. Therefore, 16-QAM is the best optimal solution to increase the system capacity requirements with PDA algorithm for good quality of services compared to QPSK, 64-QAM, and GMSK.
- As seen from BER v/s Eb/No results obtained for different algorithms we have observe that,
  - BER for ZF = 0.6 for 16-users at 0 dB Eb/Eo value.
  - BER for MMSE = 0.2 for 16-users at 0 dB Eb/Eo value
  - BER for PDA = 0.145 for 16-users at 0 dB Eb/Eo value using 16-QAM modulation technique and under influence of AWGN channel using Walsh code.
  - BER for PDA = 0.146 for 16-users at 0 dB Eb/Eo value using 16-QAM modulation technique and under influence of Rayleigh fading channel using Walsh code.
  - We also observe that BER performance of the PDA algorithm for 16-user is comparatively better at higher values of Eb/Eo then ZF and MMSE algorithms.
- The spreading code, which used in all the above modulation techniques, given a better response to BER curve is Walsh code compared to PN code and Gold Code.
- Performance of the proposed system is better for 16 users with 16-QAM and AWGN channel is notably superior then other combinations.
- Also, the performance of the system over Rayleigh Faded Environment is good as compared to AWGN channel.

From the timing diagram performance of the system model introduced for different parameters we can say that PDA is better compared to ZF and MMSE algorithms.

14.2 FUTURE SCOPE OF THE WORK

In this thesis, MIMO V-BLAST for OFDM and CDMA based MUD, GA and PDA for CDMA based MUD for wireless communication systems has been implemented in MATLAB 7.0

Since OFDM and CDMA both are current generation techniques, many research is possible on both of these techniques, but here OFDM is implemented with limited number of parameters such as FFT and IFFT size, type of prefix to symbol, modulation technique, etc and also CDMA is implemented with fix chip rate and up to 16 number of users.

A few possible extensions to the work presented in this thesis are described below.

- In OFDM we can analyze the performance of V-BLAST technique by varying FFT and IFFT size, using different type of prefix added to symbol, using modulation technique GMSK etc.
- In CDMA, we can analyze its performance using Asynchronous CDMA, using Different Length of Spreading Code.

OFDM and CDMA based MUD for wireless communication systems using V-BLAST,GA and PDA may also be implemented in DSP processor, to analyze their BER performance for different no. of users because the DSP is faster and is a real time application.

For the same purpose, these algorithms may also be implemented in VHDL or VERILOG which is CHIP level implementation.