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Reconfigurable architecture for the déteteur ML system MIMO

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Abstract: *MIMO systems based on the use of multiple antennas for transmission and reception is one of the most promising approaches to increase the rates in communication systems). The implementation of these techniques therefore necessary to develop specific hardware architectures guaranteeing high flows. The work of this paper focuses on finding flexible hardware architecture dedicated to the implementation of the functions used in MIMO decoders, and concludes with the integration of architecture used on a target FPGA.*

Mots Clés : *Systèmes de communication, algorithmes, implémentation, architecture reconfigurable, FPGA, décodeur MIMO, radio-logicielle, débit.*

I. Introduction

With The Integration Of The Internet And New Multimedia Applications In Wireless Communication Systems , The Demand In Terms Of Throughput Is Increasing . Mimo Technique Is Most Promising [1] . For Example, Standard Wireless Broadband , Such As Ieee 802.11n And Hiperlan2 Lans, The Mimo System Must Support Different Types Of Modulations And Propagation. These Are The Reasons Why A Reconfigurable Architecture Finds Its Interest In Mimo Systems. Mimo Algorithms Are Typically Implemented On Dsp , It Is Difficult To Achieve High -Speed Performance . The Traditional Asic Solution Is Used Programmable Fpga Circuits To Meet Our Reconfiguration Problem. The Rest Of The Paper Is Organized As Follows: Section 2 Briefly Presents The Mimo System. Section 3 Describes The Different Receiver Algorithms And Illustrates Our Choice Of Algorithm "Ml" In Terms Performance . The Following Section Details The Algorithm "Ml" , Which We Accepted. Section 5 Discusses The Functional Architecture Of The Algorithm. Section 6 Presents The Reconfigurable Architecture , We Analyze The Implementation Through Concrete Examples And Present The Results Of The Synthesis Of Different Architectures On Fpga. Finally , We Emphasize The Dynamic Aspect (Real Time) Reconfiguration .

II. Présentation Du Système Mimo :

Communications on the mobile radio channel have developed strongly in recent years, both in terms of number of users per user flow . This causes saturation radiofrequency resources in areas of high population. Therefore, there is a strong demand to increase the spectral efficiency of the communications. On the other hand , transmissions over the wireless radio channel are heavily penalized by the signal fading due to both multipath and intersymbol interference . a solution has been studied for some years . This is a transmission architecture based on the use of multiple antennas for transmission and reception. These architectures, called MIMO, were developed by Bell Laboratories in 1997. [2]

At the reception, each antenna receives the sum of symbols If issued simultaneously by each Ni transmitting antennas. The signal received by the y_j , j^{eme} antennas wrote:

$$y_j = \sum_{i=1}^{nr}\left(h_{ji}s_i + b_j\right) \qquad (1)$$

The received value y can be written in the following matrix form:

$$\mathrm{y} = \mathrm{Hs} + \mathrm{b} \qquad (2)$$

With $S = [S_1 \dots \dots \dots \dots \dots \dots S_{Nt}]$ the vector of transmitted symbols. H is the channel matrix of dimension Nr × Nt, is given by:

$$H = \begin{bmatrix} h_{11} & \cdots & h_{1Nt} \\ \vdots & \ddots & \vdots \\ h_{Nr1} & \cdots & h_{NrNt} \end{bmatrix} \qquad (3)$$

And $b = [b_1 \dots\dots\dots\dots\dots\dots b_{Nr}]$ the vector of additive Gaussian noise on reception.

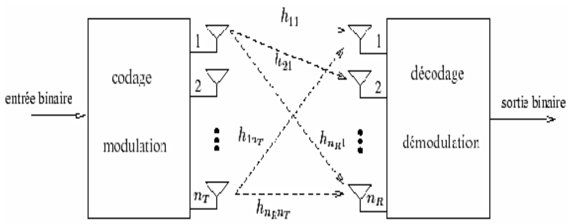

Fig (1) Principle of a MIMO system

there are two main types of techniques for transmission over MIMO systems the first is based on the space-time codes, the other on the spatial multiplexing [3].

2.1 Space-timecoding:

Improving The Quality Of Transmission Wing, Alamouti [4] And Tarokh [5] Have Designed Systems Based Primarily On The Diversity And Offering No Coding Un Spouses Of Label. This Space Coding-Temp (Sct) Also Allows Communications And Accurate, It Is Added To Redundancy Bit Data Issued To Increase Diversity And Space Avoid Specific Fading Mimo Channel. Pay More Details On Codes Spatiotemporal Refer [4] [5].

2.2 Multiplixage Space:

Spatial multiplexing, or V-BLAST (Vertical Bell Labs Layered Space-Time) [6], can be seen as a special class of space-time codes, its principle is to divide the data stream at the entrance in several sub-streams, the latter are transmitted on different antennas. This architecture is primarily intended to increase the system capacity.

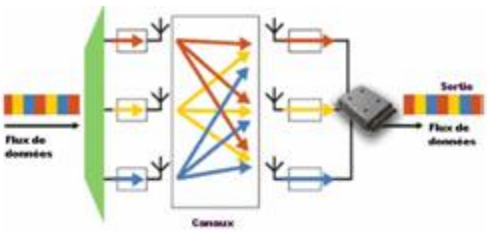

Fig (2) Principle of spatial multiplexing

III. Detection Algorithms With MIMO Systems:

There are many possible algorithms for recovering the reception symbols in a multi-antenna transmission.

3.1 Receiver of Forcing A Zero (ZF):

The simplest linear receiver is the receiver based on the criterion of zero-forcing (ZF zeroforcing) that simply reverses the channel matrix [7]. Assuming that H is invertible, the vector of estimated symbols size nT * 1 is then given by the relation

$$\hat{S} = H^{-1} r \qquad (4)$$

3.2 receivers which minimizes the mean squared error (MMSE)

The consideration for the complete separation of the signals is increased noise. The receiver which minimizes the mean squared error (MMSE) is an excellent alternative. [8] That other linear receiver minimizes the overall error due to noise and mutual interference of signals passing through the same channel. The mean square error is given by:

$$\epsilon = \varepsilon\{(s - \hat{s})^*(s - \hat{s})\} \qquad (5)$$

In this case, s is estimated from the relationship:

$$\hat{s} = \frac{\rho}{n_T} H^*(\sigma_v^2 I_{n_R} + \frac{\rho}{n_T} HH^*)^{-1} r \qquad (6)$$

3.3 Detector successive interference cancellation (ASI):

The detection algorithm uses the nonlinearity and thus exploits the inherent synchronization model. The principle, based on "the cancellation of symbols" is quite simple: the contribution of elements s already found is subtracted from the received vector r, which gives a received vector containing less interference. Using such a method, the order in which the elements of are detected becomes important to improve the system performance.

3.4 Receiver Maximum Likelihood (ML):

This receiver provides better performance in terms of error rate [9]. Assuming a Gaussian noise and channel state well known receiver side, the receiver gives the estimated MV s using the formula symbols

$$\hat{s} = argmin\|r - Hs\|^2 \qquad (7)$$

3.5 receiver decision feedback V-BLAST:

This receiver is the simplest and also the least efficient. It seeks to cancel the contributions of other issuers in each symbol. This is equivalent to the reverse transfer matrix of the channel [10]:

$$S = (H * H)^{-1} H * r \qquad (8)$$

3.6 Comparison of performance between the different receptors:

Figure (3) shows an evaluation of the BER for different receivers. These results are obtained in a 2x2 MIMO system provided with an antenna with BPSK modulation.

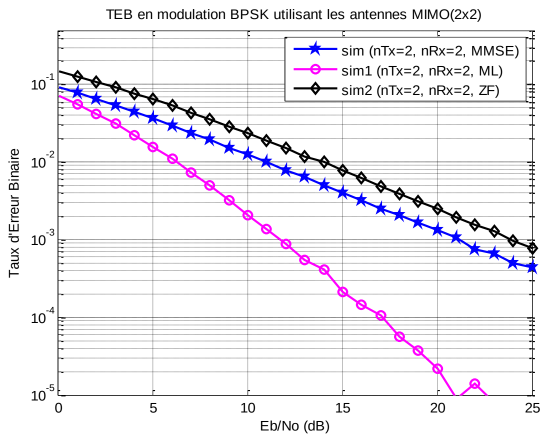

Fig (3) performance across 2x2 MIMO receivers

It is important to note that the algorithm of maximum likelihood (ML) has a better performance in terms of BER.

IV. The ML decoding algorithm:

The ML criterion is to minimize the distance between the received point and the point decoded. The Schnorr-Euchner algorithm used this criterion [11]. The equation which gives the network point representation of a MIMO system is: $\boldsymbol{y} = \boldsymbol{Mx} + \boldsymbol{z}$ (**9**)

The SE algorithm is performed to find this point, the steps to find this point are:

Case A: Whenever the algorithm finds a Uk component, it passes the layer k-1.

Case B: If the distance between the received and decoded item exceeds the current minimum distance, we move to the upper layer.

Case C: the algorithm afranchi every layer and you do get a point. This network point will be stored, and the distance will be updated.

V. The ML decoding algorithm using Simulink.

The decoding algorithm used in this paper applies the method of Schnorr-Euchner [12], Figure (4) shows schematically the algorithm using simulink.

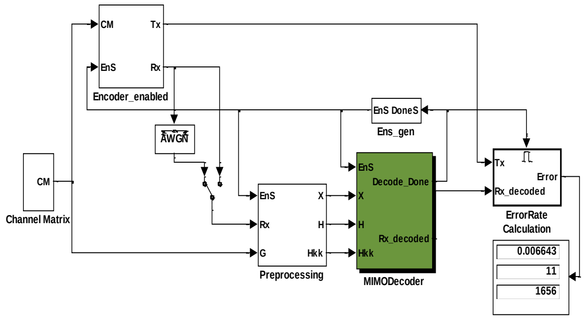

Fig (4) decoding algorithm using Simulink

This model is obtained in a 4x4 MIMO antenna system provided with a BPSK modulation.
Figure (5) shows the complete model of MIMO decoder based on the ML criterion was developed and adapted to MATLAB Simulink model contains seven modules: [13]

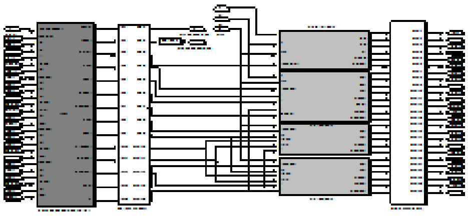

Fig (5) MIMO decoder block

VI. Result of the implementation:

Figure (6) shows the following bit error rate based on this model SNR

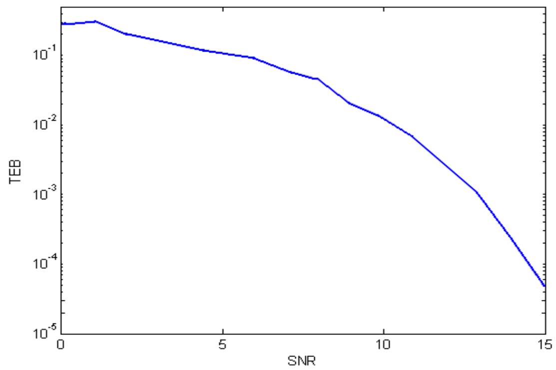

Fig (6) performance of the algorithm for MIMO decoding (SE)

The MIMO system has been presented in the previous model is modeled using VHDL and simulated in modele Sim. Each block is tested separately for its functionality.

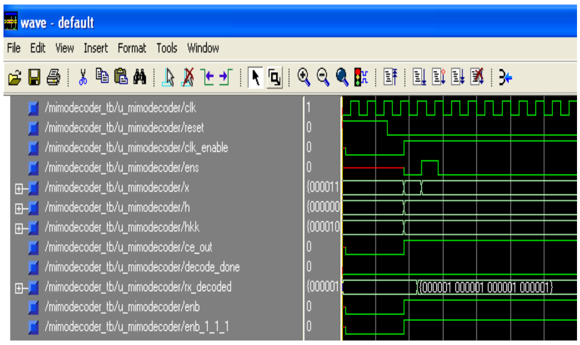

Fig (7) the timing associated with MIMO decoder

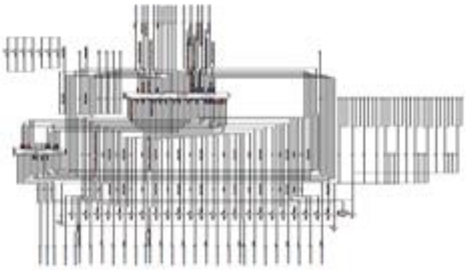

Fig (8) MIMO decoder architecture associated

the implementation of MIMO decoder was simulated a heterogeneous platform, the different functional modules of the decoder are described on FPGA [14].

VII. Implementation of a MIMO algorithm on FPGA :

A general view of MIMO decoder after placement / routing on Xilinx Virtex 4

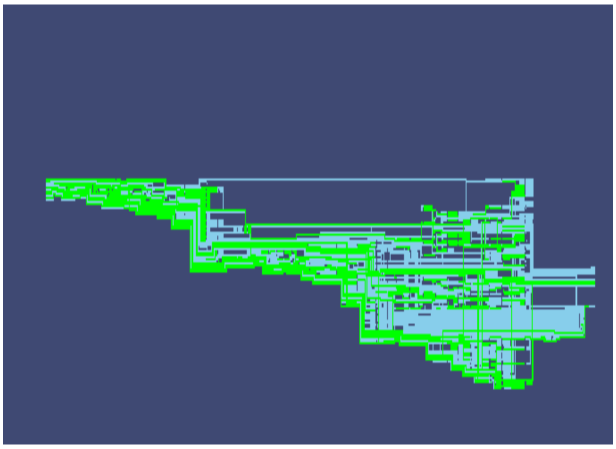

Fig (9) MIMO decoder after placement / routing on Xilinx Virtex 4

VIII. Conclusion:

The work presented in this paper focuses on the reconfigurable architecture for MIMO systems for the execution of signal processing applications, including software defined radio.

At first, we briefly compared the best known MIMO algorithms and we chose the algorithm ML Shnorr - Euchner (SE) as the best compromise in terms of performance.

Reconfigurable architectures offer new alternatives between the flexibility of DSP programmable processors and high-performance specific ASICs. After briefly analyzed and compared reconfigurable architectures, we rely on the FPGA technology to meet our need for reconfiguration.

To explore the use of reconfigurable architecture for MIMO decoding algorithm, we analyzed the MIMO detection algorithm with simulations in Matlab. We used a combination of MATLAB / Simulink and Xilinx System Generator for a simple hardware design and introduce a graphical interface for simulation tools.

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