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New Wavelet Transform Smart Processor for Massive MIMO System

Salah Talha Babiker
Department of Computer Engineering, College of Computers & IT, Taif University, Kingdom of Saudi Arabia

ABSTRACT: *Massive MIMO is an exciting area of 5G wireless research. For next-generation wireless data networks, it promises significant gains that offer the ability to accommodate more users at higher data rates with better reliability while consuming less power. Using the NI Massive MIMO Software Architecture, researchers can build Massive MIMO with Proactive code reader system, which consists of a digital signal processor (DSP) and smart processor (SP)as controller or embedded system that works according to the principle of Wavelet transformation (especially Haar transform) to rapidly prototype large-scale antenna systems which promises significant gains in wireless data rates and link reliability by using literally more antennas at the base transceiver station (BTS)than in current wireless technologies, The Flexible prototyping system uses SP as an integrated tool for managing system-level hardware and software details; visualizing system information .[1,2].Although many configurations are possible with this architecture, the Flexible prototyping system supports up to 40 MHz of instantaneous real-time bandwidth that scales from 2 to 512 base station (BTS) and can be used with multiple independent user elements (UE), especially method that we focus on signal transmission in this paper is Tine Division Duplex (TDD).*

Keywords: *massive MIMO, Haar Transform, TDD, DSP, Antenna, BTS*

I. INTRODUCTION

Every ten years or so, something big will happens in mobile. Now, 5G is emerging ahead of the turn of a new decade and the next big change to hit mobile. Massive MIMO (multi-input multi-output) is believed to be a disruptive technology for the upcoming 5G standard, which makes a clean break with current practice through the use of a very large number of service antennas that are operated fully coherently and adaptively. Extra antennas can help by focusing the transmission and reception of signal energy into ever-smaller regions of space. This brings huge improvements in throughput and energy efficiency, particularly when combined with simultaneous scheduling of a large number of user terminals.[2].It could further revolutionize the current well organized procedure.

There are number of different MIMO configurations or formats that can be used. These are termed SISO, SIMO, MISO and MIMO. These different MIMO formats offer different advantages and disadvantages - these can be balanced to provide the optimum solution for any given application.[2].

1-1 SISO

The simplest form of radio link can be defined in MIMO terms as SISO - Single Input Single Output. This is in fact a standard radio channel - this transmitter operates with one antenna as does the receiver. There is no diversity and no additional processing required.seefigure-1[3].

Fiqure-1 SISO - Single Input Single Output

The benefit of a SISO system is its simplicity. SISO requires no handing out in terms of the range of forms of diversity that may be used. However the SISO channel is limited in its performance. Interference and fading will impact the system more than a MIMO system using some form of diversity, and the channel bandwidth is limited by Shannon's law - the throughput being dependent upon the channel bandwidth and the signal to noise ratio. [1,2].

1-2 SIMO

The SIMO or Single Input Multiple Output version of MIMO occurs where the transmitter has a single antenna and the receiver has multiple antennas. This is also known as receiving diversity. It is often used to allow a receiver system that receives signals from a number of independent sources to combat the effects of fading. It has been used for many years with short wave listening / receiving stations to combat the effects of fading and interference. See figure-2

Figure 2 SIMO - Single Input Multiple Outputs

1-3 MISOS

MISO is also called transmit diversity. In this case, the same data is transmitted redundantly from the two transmitter antennas. The receiver is then able to receive the optimum signal which can then be used to receive extract the required data. See figure-3

Figure -3 MISO- Multiple Input Single Outputs

The advantage of using MISO is that the multiple antennas and the redundancy coding / processing is moved from the receiver to the transmitter. for instances such as cell phone UEs, this can be a significant advantage in terms of space for the antennas and reducing the level of processing required in the receiver for the redundancy coding. This has a positive impact on size, cost and battery life as the lower level of processing requires less battery consumption.[

1-4 MIMO

Where there are more than one antenna at either end of the radio link, this is called MIMO - Multiple Input Multiple Output. MIMO can be used to provide improvements in both channel robustness as well as channel throughput. See figure-4

Figure -4 MIMO - Multiple Input Multiple Output

In order to be able to benefit from MIMO thoroughly it is necessary to be competent enough to utilize coding on the channels to separate the data from the different paths. This requires processing, but provides additional channel robustness / data throughput capacity [5].

II. MASSIVE MIMO HARDWARE AND SOFTWARE ELEMENTS

Massive MIMO envisioned for cellular applications consists of the BTS and user equipment (UE) or mobile users. Massive MIMO, however, departs from the conventional topology by allocating a large number of BTS antennas to communicate with multiple UEs simultaneously. In this flexible NI prototyping system, the BTS uses a system design factor of approximately 10 base station antenna elements per UE, providing 12 users with simultaneous, full bandwidth access to the 128 antenna base station. A design factor of at least 10 base station antennas per UE has been shown to allow for most theoretical gains to be harvested and for optimal MRC decoder performance [1].

2.1 Designing a Massive MIMO system requires Fifth key attributes:

All flowing requirements should be considered in feature prototyping system combines the smart processor (controller), clock distribution modules and high-throughput proposed systems. Which provide a robust, deterministic prototyping platform for research. This section details the various hardware and software elements used in both Massive MIMO base station and UE terminals [3].

1. Flexible controller that can acquire and transmit RF signals
2. Accurate real time algorithm for deploying frequency synchronization among the BTS
3. A high-throughput and lossless bus for moving and aggregating large amounts of data
4. Reducing the RF chain number and the power consumption of the analog front-end for massive MIMO systems
5. High-performance processing for PHY and media access control (MAC) execution to meet the real-time performance requirements

2.2 new approaches for Massive MIMO

Our research focuses on hybrid RF/baseband beam forming for the massive MIMO systems. The DSP algorithms/processors are designed to build up the optimal RF beam-forming phase array vector and baseband MIMO preceding matrix. This approach can reduce the RF chain number and the power consumption of the analog front-end for massive MIMO systems see figure -5

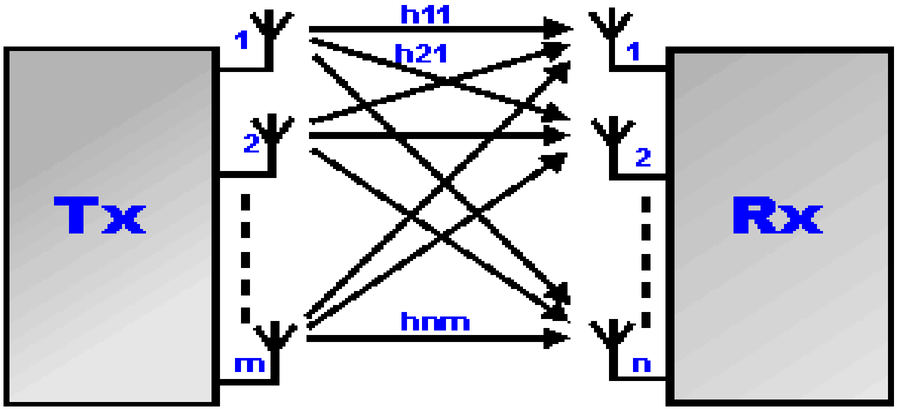

Figure -5 general approach designs for massive MIMO

III. NEW METHODOLOGY AND DESIGN PLAN

In the current LTE and Wi-Fi systems, orthogonal frequency division multiple-access (OFDMA) is the technology of choice [3]. OFDMA uses inverse fast Fourier transform (IFFT) at the transmitter and fast Fourier transform (FFT) at the receiver and allocates fixed resources to users for a given set of operating parameters. Despite its several advantages, if coupled with other components of the LTE A, the use of OFDMA increases the cost and utilization overhead of system resources. Moreover, it suffers from large implementation complexity, requiring a fixed allocation of resources to all the users, regardless of the present traffic as well as a high peak-to-average-power ratio (PAPR) [4].

Orthogonal wavelet division multiple accesses (OWDMA) have been proposed as a viable alternative to OFDMA in communication systems. Previous work concentrated on digital video broadcast, and results were only plotted for the BPSK modulation scheme [5, 6]. Raajan et al. [7] provided bit error rate (BER) performance graphs for all the wavelets and modulation schemes, but no hardware architecture was provided for the proposed system. Our proposed paper is being organized in sections, where a brief description is provided of previous work, the definition of wavelet transform, and reasons for choosing Haar wavelet [1,3].

3.1 HAAR Wavelet-Based BPSK OFDM System

The Haar Wavelet Transform based BPSK OFDM system have been adopted. The sequence of data symbols are decayed after mapping of binary to complex shows one part of the data symbols are zeros and the other part of the data symbols are either $\sqrt{2}$ or $-\sqrt{2}$. As compare to FFT-OFDM the PAPR reduced by 3dB in case of Haar wavelet based OFDM system. Then the strength of the system is checked with the traditional OFDM system which uses a decoding algorithm for the improvement and derived the bit error rate (BER) performance using unbalanced QPSK modulation. The BER performance shows a better result for the proposed work than the conventional OFDM over different channels. Wavelets are mathematical functions that were developed for sorting the data by frequencies. A Wavelet transformation converts data from the spatial into the frequency domain and then stores each component with a corresponding matching resolution scale.

OFDM system is one of the most useful technologies for the present and future wireless communications. The data bits are encoded to multiple sub-carriers using multicarrier modulation technologies when being sent simultaneously [3]. The each sub carrier in an OFDM system is modulated with amplitude and phase using the data bits.

3.2 Discrete Wavelet Transform

Here we try to employ some filters which are used to implement the DWT consisting of half band high pass g(b) and half band low pass h(b) filters in a multicarrier modulation system follow the relationship as in [2] if the impulse response of one filter is known the rest can easily be calculated [4]:

$$\psi(t) = \begin{cases} 1 & t \in [0, 1/2) \\ -1 & t \in [1/2, 1) \\ 0 & t \notin [0, 1) \end{cases}$$

here we see here the coefficients:

$$\psi_i^j(t) = \sqrt{2^j}\psi(2^j t - i), \ j = 0, 1, \dots \text{ and } i = 0, 1, \dots, 2^j - 1 \ .$$

Where, φ t represents the scaling function and ψ(t) is the wavelet function. These functions are discretized values at a (a = 1,2 … ,m) and at translation b (1,2 … . , t). The wavelet transform can be implemented by a two channel perfect reconstruction (PR) filter bank [6]. A filter bank is a set of filters, which are connected by sampling operators. Fig.1 shows an example of a two-channel filter bank applied by one dimensional signal. Our research focuses on hybrid RF/baseband beam forming for the massive MIMO systems.[4].

The DSP algorithms/processors are designed to build up the optimal RF beam-forming phase array vector and baseband MIMO preceding matrix. This approach can reduce the RF chain number and the power consumption of the analog front-end for massive MIMO systems [4,5].

IV. MASSIVE MIMO ARCHITECTURE SYSTEM

We have derived architecture, based on previous scheme wavelet filters. The computation of the method is described using filters, controller, and parallel-to-serial units. The scheduler is also implemented for easy interfacing of the sub-block with other blocks of the system. The architecture is validated on a centralized processor we suggest having 512.BTS , so it can compare our architecture with various other wavelets available in the literature as well with existing OFDMA implementations. We also compute the quality parameters BER, throughput, and PAPR for OWDMA and compare them with the existing OFDMA systems see figure-6

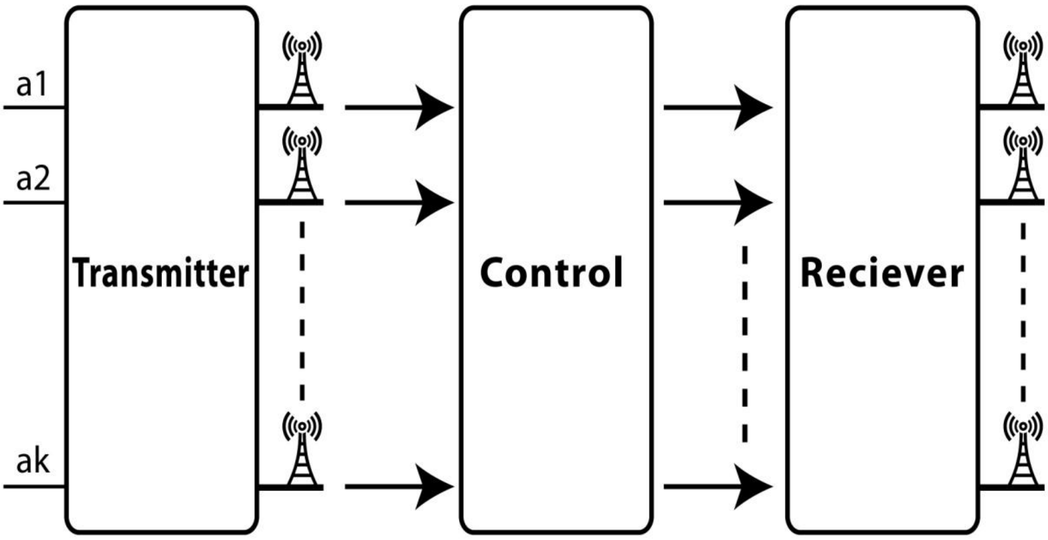

Figure -6 proposed Massive MIMO Architecture system

We proposed Signal-processing data path and control operations which can help system through controller count and compare the signals from transmitter to wireless base station (BTS). Most architectures implement the system control, configuration, and the signal-processing data path using a combination of microcontrollers, and programmable digital signal processors. While digital signal processor (DPS) handle the data-flow the controller Systems with take processing demands and control-oriented tasks under realization process in significant parallel processing benefits. The combination of digital signal processors and smart processor ensures complete system flexibility and offers reprogramming ability to fix bugs or even support entirely different standards. The partition between smart processor and digital signal processors depend on processing requirements; system bandwidth as well as system configuration; and the number of transmit and receive antennas. Figure 6 shows a typical digital signal processor/smart processor partitioning for baseband physical layer (PHY) functions in an OFDMA-based system such as WiMAX or LTE.

V. CONCLUSION

Massive MIMO is a key technology for 5G. It solves core problems in the PHY and MAC layers. The main research topics on Massive MIMO to determine the antenna configurations and frequency bands for Massive MIMO, system.It can be concluded from the results produced that wavelet transform is indeed a better scheme or the multicarrier modulated systems and also for any type of unreliable channels because of its effectiveness in multipath environments. It is also concluded that the guard band saving which typically depend on the system design and wastes bandwidth can be saved using wavelet transform. Furthermore the proposed use of the FEC in the DWT-MIMO systems showed remarkable performance improvement and gain of about 18dB as compared to a simple two transmit and one receive antenna systems, select appropriate methods for channel modeling to conduct the follow-up research, implement rational preceding design as well as rapid and effective channel detection and estimation, and improve control channel performance. Moreover, depending on the scenario and application, we should select appropriate matching algorithms and antenna segmentation or distributed antenna allocation methods for scheduling and allocating physical resources to enhance system performance.

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