

A HYBRID PRECODING SYSTEM BASED ON KALMAN ALGORITHM FOR MULTI-USER MILLIMETER WAVE MASSIVE MIMO SYSTEMS

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ABSTRACT

Millimetre wave (mm Wave) communication requires huge receiving wire clusters to increment the capability of cellular systems of the fifth era with great beam-forming picks up and a considerable lessening in way misfortunes for both transmitting and accepting terminals. Completely computerized procedures are infeasible with huge receiving wire clusters due to equipment imperatives at such frequencies, whereas absolutely analog arrangements endure extreme execution impediments. Crossover analog/digital beamforming is a promising arrangement, particularly, when amplified to a multi-user situation. This paper passes on two fundamental commitments: 1) a Kalman-based definition for half breed analog/digital precoding in multi-user environment is proposed; 2) an iterative arrangement is planned for the cross breed precoding plot with reasonable complexity. A Kalman-based crossover analog/digital precoding is utilized with a downlink rate of 4.64 Gbps/cell and an uplink rate of 1.84 Gbps/cell in multi-user environments

1. INTRODUCTION

Millimeter wave (mm Wave) communication is a key empowering innovation for understanding the range crunch in future 5G frameworks [1]–[7]. Due to restricted accessible range in the sub-6 GHz band, ordinary cellular and WiFi based arrangements cannot be scaled up to meet the ever-growing information requests of organize densification, and rising applications related with information centers and versatile gadgets. Whereas imaginative arrangements such as utilizing authorized range on an astute premise have been proposed [8], such approaches are still subjected to visit disturbance and are restricted by the channel transmission capacity accessible in the authorized groups, such as the TV groups. Millimeter wave (mm Wave) band communication in the as of late opened up touching piece of unlicensed range in the 57-71GHz extend is an opportunity for accomplishing gigabit-per-second information rates [9]. Undoubtedly, existing benchmarks like the IEEE 802.11ad working in these groups permit up to 2GHz wide channels for short-distance communications. mm Wave challenges: Due to the tall way misfortune that happens in the mm Wave groups, directional beamforming misusing expansive radio wire clusters at both base station (BS) and versatile stations (MSs) is required [10]–[13]. This empowers tall quality and long-distance communication joins, and increments the flag control concentrated at the recipient conclusion. The tall recurrence of operation too bolsters gigantic multi-antenna designs from a plan perspective, whereas decreasing the measurements of each receiving wire and permitting numerous of them to be stuffed in a little range. Whereas the equipment back from expansive radio wire clusters for beamforming capacities is accessible nowadays, the tall recurrence of operation, anticipated testing rates and channel transfer speeds make it difficult to send conventional completely advanced beamforming arrangements [10]

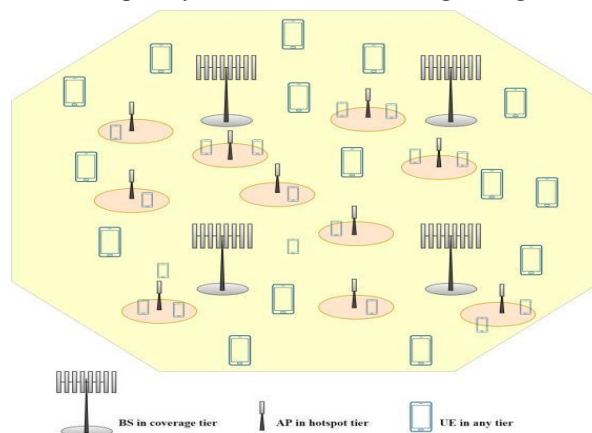


Fig.1 Heterogeneous Network

2. PROPOSED SYSTEM

We propose an iterative Kalman-based multi-user half breed arrangement that minimizes the blunder between the preface transmitted by the BS and the assessed gotten information at the MS. We scientifically define the blunder detailing as a work of as it were the precoding, combining and channel frameworks. In this way the calculation does not require any express information estimation. At that point, a two step method is carried out: first, the RF analog precoding/combining step is performed as in single-user frameworks based on vitality greatest rule; at that point an iterative Kalman-based approach is connected to appraise the advanced baseband precoder at the BS in arrange to diminish inter-user obstructions. Contributions. The primary commitments of this work are:1) we plan a Kalman-based half breed precoding/combining plot for the disclosure stage in multi-user mm Wave gigantic MIMO frameworks, where the precoding base-band network is considered as the state lattice in the Kalman formulation;2) we define the blunder between transmitted and assessed information as a work as it were of the precoding, combining and channel networks, so that information estimation is not needed;3) we appear comparative recreation comes about both in terms of ghastly efficiency and BER execution, which confirm that the proposed approach performs superior than other existing cross breed arrangements. The paper is organized as takes after: Sec. II portrays the sys-tem demonstrate, Sec. III points of interest the proposed Kalman detailing. Sec. IV presents the proposed Kalman cross breed analog/digital precoding calculation, and Sec. V gives the recreations comes about. At long last, a few concluding comments are given in Sec.

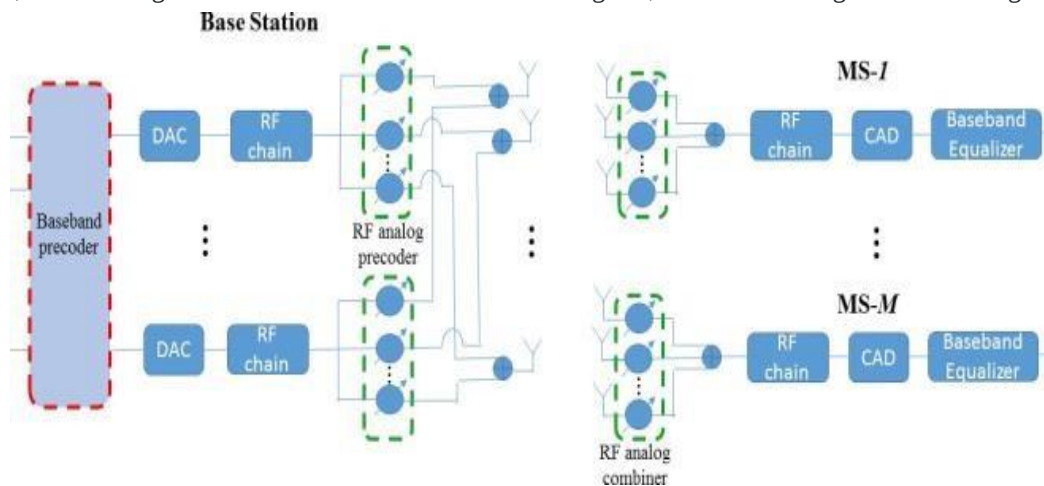


Fig. 2 mmWave multi-user system with hybrid analog/digital precoding and analog combining.

WORKING

determine first the RF beamforming/combining matrices for each BS-MS link independently, similarly to [12], and then continue with the baseband precoding to reduce the multi-user interference. In the first step, the BS and each MS-m calculate the RF beamforming and combining vectors, $\mathbf{f}_{RFm}$ and $\mathbf{w}_m$, by maximizing the signal power for the MS-m (line 3-6 in Algorithm 1). Existing single-user RF beamforming solution can be used on this purpose, such as [46], [47], in order to design the RF beamforming/combining vectors without explicit channel estimation and maintain a low training overhead. Once the combining vectors $\mathbf{w}_m$ are determined for all MSs, as well as the analog precoder FRF at the BS, the digital baseband precoder FBB is computed as follows. C. ITERATIVE KALMAN BASEBAND PRECODING At this step, the BS utilizes the effective channels $\mathbf{h}_{Hm} = \mathbf{w}_m^H \mathbf{H}_m \mathbf{F}_{RF}$ $\forall m$. Each effective channel vector $\mathbf{h}_{Hm}$ has dimension $M \times 1$, which is much lower than the original channel matrix $\mathbf{H}_m$ with size $N_{MS} \times N_{BS}$ [12]. Each MS-m uses a codebook $\mathbf{H}$ to quantize its effective channel response, and sends the index of the quantized channel vector to the BS (line 8-10 in Algorithm 1).

As the last step, the BS designs its Kalman-based digital precoder FBB based on the quantized channels (line 11-18 in Algorithm 1). The sparse mm Wave channels and the narrow beam forming ensure that the effective MIMO channel is well-conditioned [48]. This allows the Kalman-based digital beamforming approach to achieve near-optimal performance, as shown in Sec. V. In particular, we consider FRF with $\mathbf{w}_m$ calculated in Sec. IV-B. Thus, the Kalman algorithm can be incorporated in the following measurements update equations to compute FBB.

We calculate the conditional mean FBB ($\mathbf{n}|n$) and the variance $\mathbf{R}(\mathbf{n}|n) = E[\mathbf{FBB}(\mathbf{n})\mathbf{FBB}^H(\mathbf{n})]$ of the state matrix FBB ($\mathbf{n}$), the Kalman gains $\mathbf{K}(\mathbf{n})$, at time instant $\mathbf{n}$, according to (15), (16), and (17) respectively: $\mathbf{FBB}(\mathbf{n}|n) = \mathbf{FBB}(\mathbf{n}|n-1) + \mathbf{K}(\mathbf{n})[\mathbf{I} - \mathbf{H}\mathbf{D}\mathbf{FBB}(\mathbf{n}|n-1)]\mathbf{K}(\mathbf{n}) = \mathbf{R}(\mathbf{n}|n-1)\mathbf{H}\mathbf{D}\mathbf{H}^H[\mathbf{H}\mathbf{D}\mathbf{R}(\mathbf{n}|n-1)\mathbf{H}\mathbf{D}\mathbf{H}^H + \mathbf{Q}_n]^{-1}$ (16) $\mathbf{R}(\mathbf{n}|n) = [\mathbf{I} - \mathbf{K}(\mathbf{n})\mathbf{H}\mathbf{D}]\mathbf{R}(\mathbf{n}|n-1)$ (17) where $\mathbf{H}\mathbf{D}$ is set equal to the equivalent channel matrix estimate $\hat{\mathbf{H}}_e$, and $\mathbf{Q}_n$ is the covariance matrix of the noise $\mathbf{n}(n)$. We set $\mathbf{Q}_n = (1/\text{SNR})\mathbf{I}$, where SNR is the signal to noise ratio.

Although the proposed solution requires some iterations compared to the ZF [12] and MMSE [29] closed form equations, it gives better performance in adjusting the precoding matrix in a hybrid architecture. Moreover, as will be detailed in Sec. V, the number of needed iterations is limited to only few trials. Finally, we note that all the matrices involved in the Kalman formulation, i. e., H , K , Q , n , and R , have small size $M \times M$ where M is the number of users, and are independent from the large number of antennas N_B and N_M of the massive MIMO system. The pseudo-code of the proposed Kalman-based hybrid precoding is summarized in the following Algorithm 1.

V. PERFORMANCE EVALUATION

In this section, we evaluate the performance of the proposed Kalman hybrid analog/digital precoding algorithm.

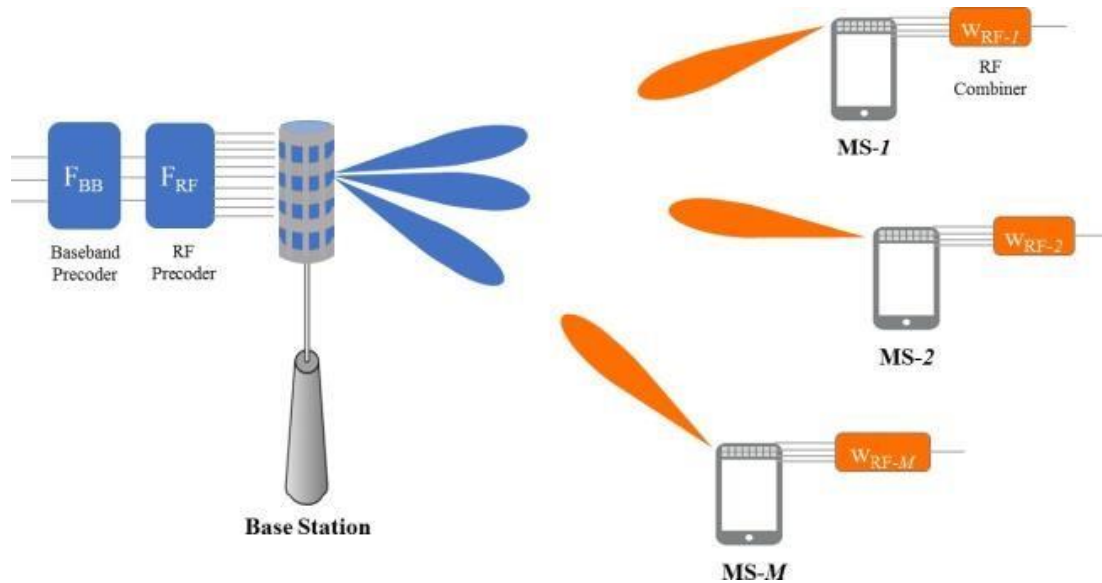


Fig.3 mmWave multi-user system model: BS hybrid analog/digital precoding and MS analog combining.

3. RESULT

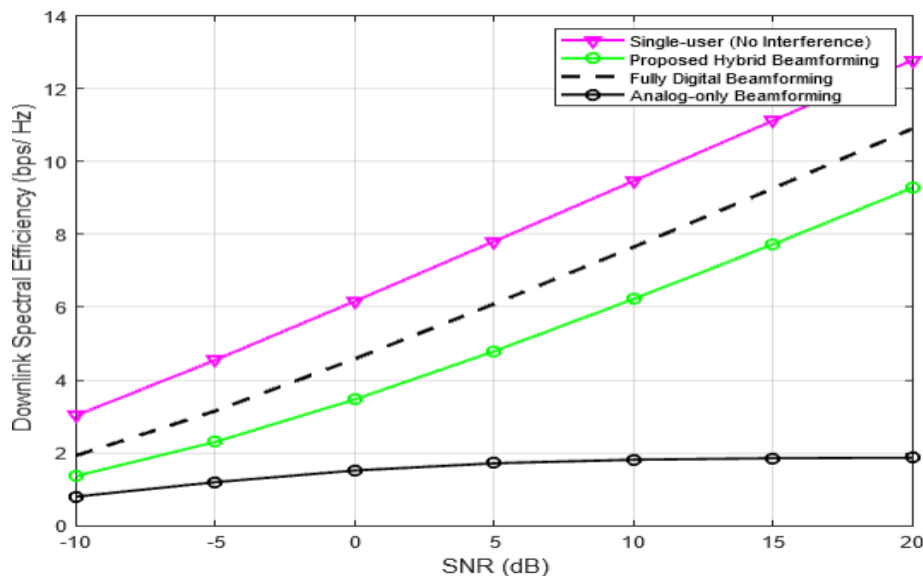


Fig.4 Downlink Spectral Efficiency varying SNR in multipath ($L=10$) range of $[-20, 20]$ dB

4. CONCLUSION

We proposed a multi-user beamforming solution for Wave massive MIMO systems, based on a Kalman formulation and a hybrid precoding designed by minimizing VOLUME 4, 2016 9The method uses a specially designed formulation of the error, and following this, a two step procedure is carried out to first calculate the RF precoding/combining matrix, and then design the digital baseband precoder at the BS. Simulation results show that the proposed algorithm outperforms existing solutions, in terms of both spectral efficiency and BER, due to its ability to better adjust the precoding matrix in hybrid architectures. In future work we will incorporate a channel estimation scheme into the Kalman hybrid precoding algorithm, and extend the proposed solution to mobile scenarios. Moreover, we will focus on extending the proposed solution to joint precoders/combiners iterative optimization [52] when user devices employ multiple streams.

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