International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-1, November 2019

Beamforming with Precoders Based Millimeter Wave Communication System

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Abstract*: *The 5G communications are used with baseband Precoders and Beamforming. The Technology is needed to update, all available characteristics in the present Wireless Communication System (WCS). The Hybrid Beamforming systems are across in the RF and Digital domain. In the mmWave MIMO system, the numbers of antennas has increased to improve the Spectral Efficiency of the system. The proposed algorithms observe that system performance for different SNR range.

Keywords: mmWave, MIMO, 5G

I. INTRODUCTION

In MIMO [1] systems a serious problem is introduced with the number of antenna and the number of different users. The 5G involve the main goals for the High data rates & Lower latency network access. The available bandwidth in the spectrum used with sub 6GHz not satisfies these requirements so that to meet the above requirements by using mm wave range. Due to this problem its use was avoided by using pre-coders in the system [2]. Here we proposed a full baseband pre-coder, which compares the simulation results. FOMP is the improved version of the OMP algorithm [3].

II. SYSTEM MODEL

The MIMO Base Station with M antenna uplink / downlink with K [4] uses channel coherence block S symbols. The overall Spectral Efficiency roughly limits to min$\left(M, K, \frac{S}{2}\right)$. In Future, MIMO with improved wide-area coverage would & handle super complex scenarios. Distributed for linear, Rectangular [7] & Cylindrical collocated deployment 1D, 2D & 3D arrays. Zero forcing processing cancels interference spatially [6].

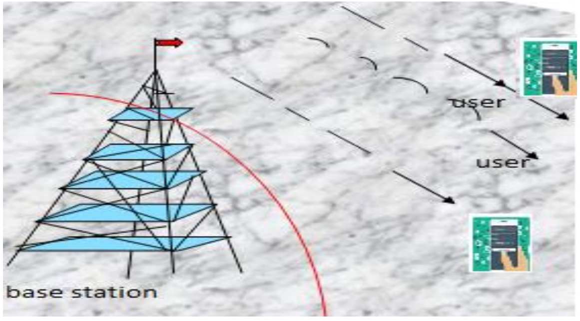

Fig 1. Base station overview

Revised Manuscript Received on November 30, 2019.

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Hybrid Beamforming (HB) technique is used with a partition of the beam between analog & digital domain. These HB technique design are for combining multiple array elements into a sub small array modules.

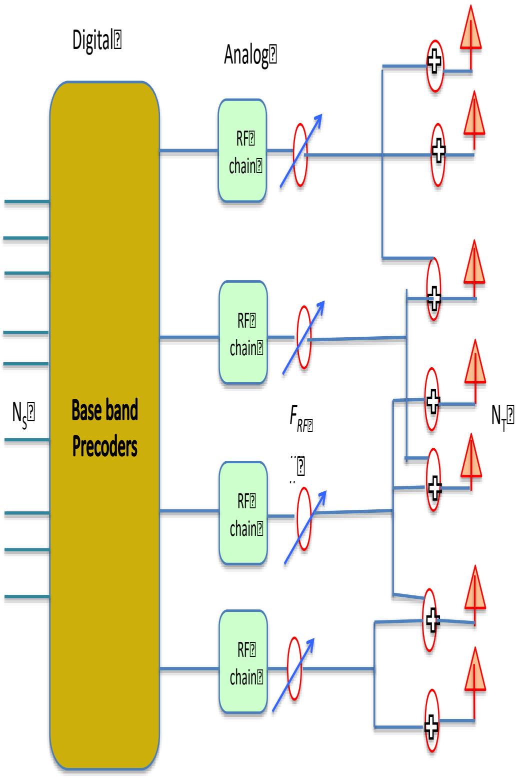

Fig2. System Model

Considering a single user Hybrid mmWave [7] MIMO every RF chain connected to antennas at the transmitter with unit magnitude phase shifters. Single user Hybrid mmWave MIMO the baseband side is displayed in Fig.1. The Fig2 illustrates that downlink of baseband combiner. The Down Link (DL) [9] on the Hybrid single-user Channel model illustrated in Fig 4 Here proposed the dynamic sub-band allocation to avoid DL interference [8]. The goals of the Resource allocation are to eliminate interference and optimizing the capacity in the n/w. The transmitted vector is given by

$$x = F_{BB} F_{RF} S$$
$$F = F_{BB} F_{RF}$$

Then $x = FS$

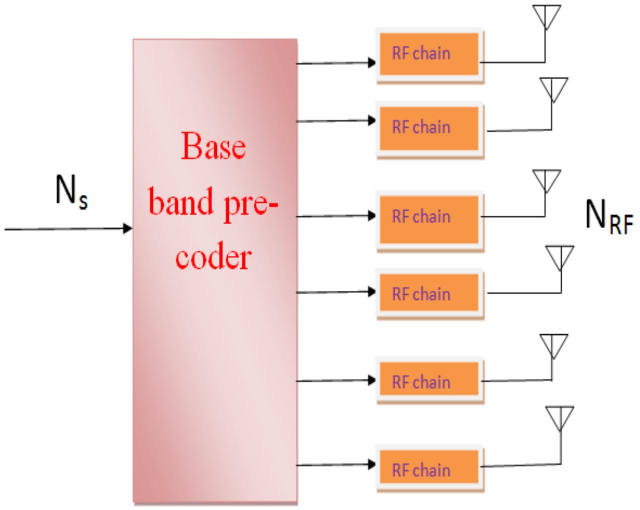

Fig3. Single user RF chain after pre-coding

Where S=symbol vector, $N_s \leq N_{RF} \leq N_T$ and $N_s \leq N_{RF} \leq N_R$ both the conditions are needed to satisfies for the single user [17].

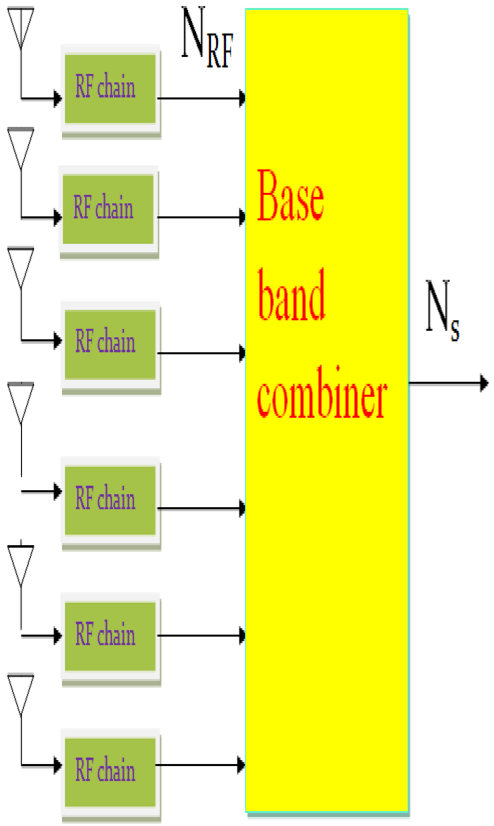

Fig4. DL baseband combiner

$$s = N_s x1$$
$$F_{BB} = N_{RF} x N_s$$
$$F^H = F_{BB}^H F_{RF}^H$$

The transmit symbol covariance as$E\{SS^H\} = \frac{1}{N_s} I$. Here one specifies that unity. I *is the identity matrix.* N_s *is the number of trannsmission equally distributed for all elements.*

$$\begin{aligned} E\{XX^H\} &= E\{(F_{BB}F_{RF}S)(F_{BB}F_{RF}S)^H\} \\ &= E\{SF_{BB}^H F_{RF}^H S^H F_{BB} F_{RF}\} \\ &= E\{SFF^H S^H\} \\ &= E\{Tr(SFF^H S^H\} \\ &= Tr[FF^H]E\{SS^H\} \\ &= \frac{1}{N_s} Tr[FF^H] \end{aligned}$$

$$y = \sqrt{p} W_{BB}^H W_{RF}^H H n F_{BB} F_{RF} + \breve{N}$$

Where assumed that the Transmit power equal to unity. i.e.

$$E\{XX^H\} = 1.$$

Then $\frac{1}{N_s} Tr[FF^H] = 1.$

$$Tr[FF^H] = N_s.$$

$$vec(y) = \sqrt{p}(F_{BB}F_{RF})^T \otimes W_{BB}^H W_{RF}^H . vec(H_n) + vec(\breve{N})$$

By use property$(A \times B)\ (C \times D) = AC \otimes BD$

$$vec(y) = \sqrt{p}\{(F_{BB}F_{RF})^T (A_T^H)^T \otimes W_{BB}^H W_{RF}^H A_R\} vec(H_n) + vec(\breve{N})$$

The transmitter array with receiver elements is not known.

$$Q_s = \left(F_{BB}{}^T F_{RF}{}^T A_T^* \otimes W_{BB}^H W_{RF}^H A_R\right).$$

$$vec(y) = \sqrt{p}\, Q_s vec(H_n) + vec(\breve{N})$$

So that some of the components value of the equal to non-zero and the large number of components of the values are equal to zero. The millimeter wave frequency range and these algorithms are more efficient to use the available spectrum. The spatial channels models are in the range of frequency >28 GHz.

The wavelength is small enables that MIMO signal implementation. To achieve better Beamforming control and flexibility by independent weight control for the entire array element.

Now mmWave system

$Y = HX + n$ Digital, RF and antenna subsystem includes wideband power amplifiers MIMO antenna [12] arrays and adaptive algorithms. 5G operate at mmWave.

By Friss's equation, the received power is

$$P_r = \frac{P_t G_t G_r \lambda^2}{L(4\pi d)^2}$$

where the average SNR is:

$$SNR = \frac{P_r}{P_n}$$

$$SNR = \frac{P_t\ G_t G_r \lambda^2}{L(4\pi d)^2} \cdot \frac{1}{N_o B}$$

$N_o$is unilateral PSD.

Milli meter Wave system model is

$$minE\left\{\left\| \bar{S} - W_{BB}{}^H W_{RF}{}^H \bar{Y} \right\|^2\right\}$$

$$\boldsymbol{=min} \left\| \boldsymbol{R}_{\boldsymbol{YY}}^{\boldsymbol{\frac{1}{2}}} (\boldsymbol{W}_{\boldsymbol{MMSE}} - W_{RF}\, \boldsymbol{W}_{\boldsymbol{BB}}) \right\|^{\boldsymbol{2}}$$

The Received signal matrix Y is given by

$$Y = \sqrt{P}\ \ W_{BB}{}^H\ \ W_{RF}{}^H H\, n\, F_{RF} F_{BB} + \tilde{N}$$

$\sqrt{P}$ is power constant.

$W_{BB}{}^H$ *and* $W_{RF}{}^H$ Combiner.

F_{RF} *and* F_{BB} are precoders and $\widetilde{N}$ is noise. Where RF chains= N_{RF} . $N_T^{Block} = \frac{N_T}{N_{RF}}$ & $N_R^{Block} = \frac{N_R}{N_{RF}}$. For example N_T**=64,** N_{RF}=4 then N_T^{Block}=16.

III. FORMATION OF PROPOSED ALGORITHMS

Beamforming is used for spatial signal Transmission filtering with reception [13].

3.1. Zero Forcing:

Considering a zero-forcing MIMO channel model $y = Hx + n$. Where y is output of the system, H is channel; x is the input and n is the noise [14]. The resulting receiver and cost function are important for the system.

The Cost Function is given by

$\widehat{x_{ZF}}$=arg{ min $[\|y - Hx\|^2]$}

$$\|y - Hx\|^2 = (y - Hx)^H(y - Hx)$$
$$= (y^H - x^H H^H)(y - Hx)$$
$$= y^H y - y^H Hx - x^H H^H y + x^H H^H Hx$$

We take Gradient on function, gradient rule $\nabla(.) = 0$. Then the function reduces to

$$\|y - Hx\|^2 = 0 - H^H y - H^H y + 2H^H Hx$$
$$= -2H^H y + 2H^H Hx$$

The ZF precoding that can impact on the unknown interference null signaling & background known noise signaling. The 5G which explicit MIMO can fully spatial degree of freedom by configuring hundreds of the antennas at the base stations to improve the spectral efficiency. For avoiding this antenna can used with less spacing wavelength. Less spacing which impact on the greater frequency then resulting on system performance. The Channel Estimation in the ZF and MMSE carried with a linear precoding. This results on the limited number of antennas. It shows an orthogonally between the subcarrier.

3.2. MMSE

Mean square error functions are basically two types i.e. Minimum Mean Square Error (MMSE) and LMMSE (Linear Minimum Mean Square Error)[18].

3.2.1.MMSE channel estimation

The received vector for the R^th^ BS antenna, Q^th^ MS antenna

$$y^{RQ}(n) = [{y_1}^{RQ}(n), {y_2}^{RQ}(n), \dots {y_N}^{RQ}(n)]^T$$

$$y^{RQ}(n) = S^Q(n)h^{RQ}(n) + w^R(n)$$

MMSE channel estimation as:

$$h_{\widehat{MMSE}} = R_{hy}R_{yy}^{-1}y^{RQ}(n)$$

3.2.1.LMMSE channel estimation:

Considering system model $y = Hx + n$. then

$$x_{\widehat{LMMSE}} = m_x + \left(k_{xy}k_{yy}\right)^{-1}y + m_y$$

m_x is $E[x]$ & m_y is $E\ [y]$.

$k_{xy}$is cross covariance and k_{yy} is auto covariance.

$$k_{yy} = E\{(y - m_x)\left(y - m_y\right)^H\}$$

$$k_{xy} = E\{(x - m_x)\left(y - m_y\right)^H\}$$

$$x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ . \\ . \\ x_{n-1} \\ x_n \end{bmatrix}$$

$$n = \begin{bmatrix} n_1 \\ n_2 \\ n_3 \\ . \\ . \\ n_{r-2} \\ n_{r-1}. \\ n_r \end{bmatrix}$$

$$E\ [y] = E[xH + n]$$
$$= HE[x] + E[n]$$

$$k_{xy} = E[xy^H] = E\{x(Hx + n)^H\}$$

$$= E[xH^H x^H + xn^H]$$

$$k_{yy} = E[yy^H] = E\{(Hx + n)(Hx + n)^H\}$$
$$= E[(Hx + n)(H^H x^H + n^H)]$$
$$= E[HH^H xx^H + nH^H x^H + Hxn^H + nn^H]$$

$$= PHH^H + 0 + 0 + \sigma^2 I_r$$
$$= PHH^H + \sigma^2 I_r$$

Then

$$\left(k_{xy}k_{yy}\right)^{-1}y = PH^H(PHH^H + \sigma^2 I_r)^{-1}y$$

Here the functions are always invertible. Condition of the invertible is based on zero forcing based on the rank min(r, t)[17].

3.2.3. Kalman filtering

Consider Kalman baseband precoding for MIMO, the system consisting of three single antenna terminals & one base station with M antennas. The BS assumed CSI perfect [15,16]. Three elements are to transmit the complex symbols x_1, x_2 & x_3 with transmit power P simultaneously in the same frequency band. Received signal strength at BS is $y = \sqrt{p}\ Hx + W$

$$y = \sqrt{p}.[h_1x_1 + h_2x_2 + h_3x_3]$$

h_1, h_2 & h_3 are independent $\mathbb{CN}\ (0, I_M)$.

III. SIMULATION RESULTS

The numbers of iterations are considered were around 2000 iterations. The no. of paths used was 12. The SNR ranged from -15 to 20 db. Hybrid precoding mmWave has the, low-cost data transmission. Each antenna is connected with RF precoding.The Fig5 illustrates, single user, hybrid precoding and MMSE precoding. Fig6 shows that Kalman and MSE precoding. The fig illustrates the response Spectral Efficiency w.r.t SNR (dB).

Retrieval Number: A5343119119/2019©BEIESP
DOI: 10.35940/ijitee.A5343.119119
Journal Website: www.ijitee.org

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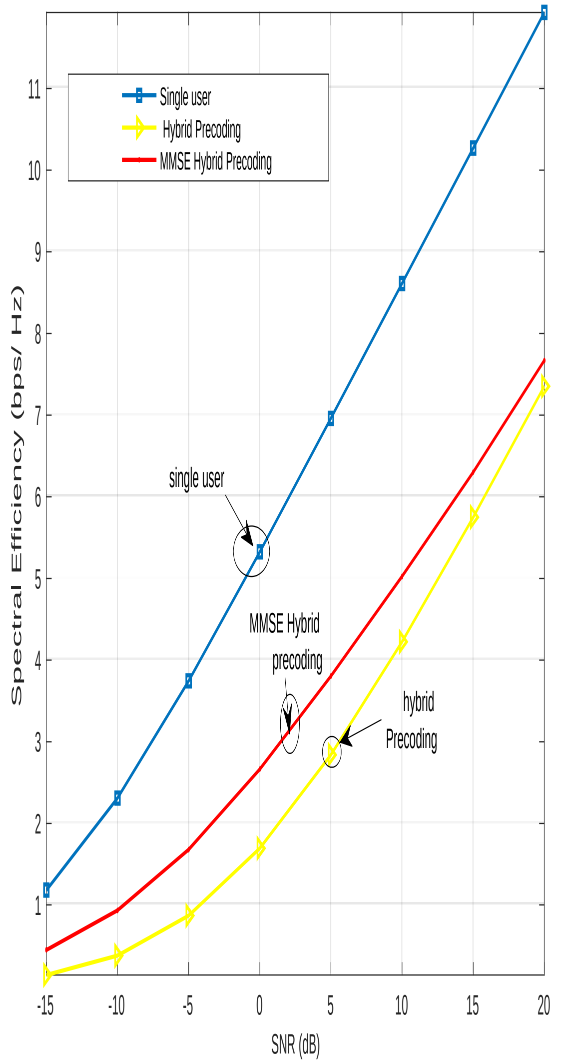

Fig5. MMSE and Hybrid Precoding

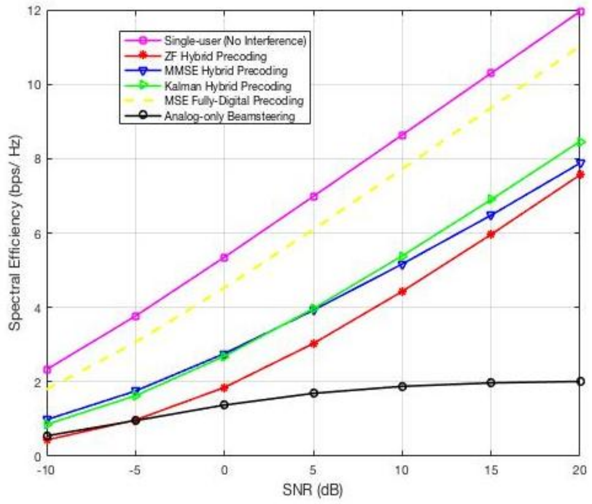

Fig 6.comparision of simulation results

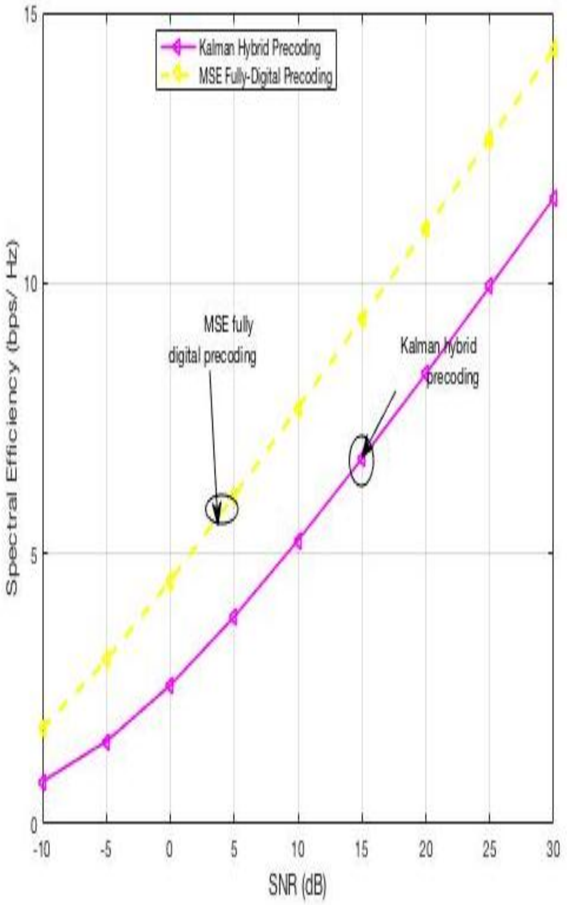

Fig7. Kalman and MSE precoding

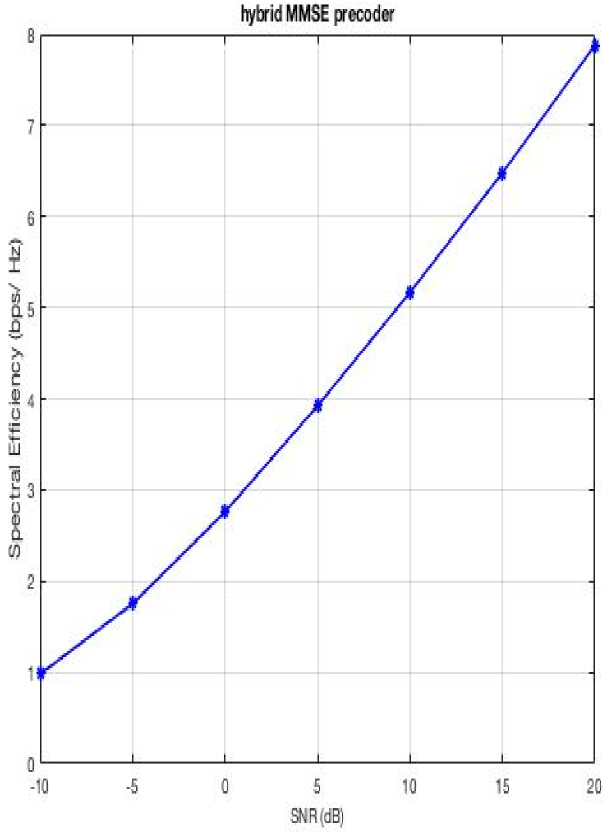

Fig 8. MMSE Precoders

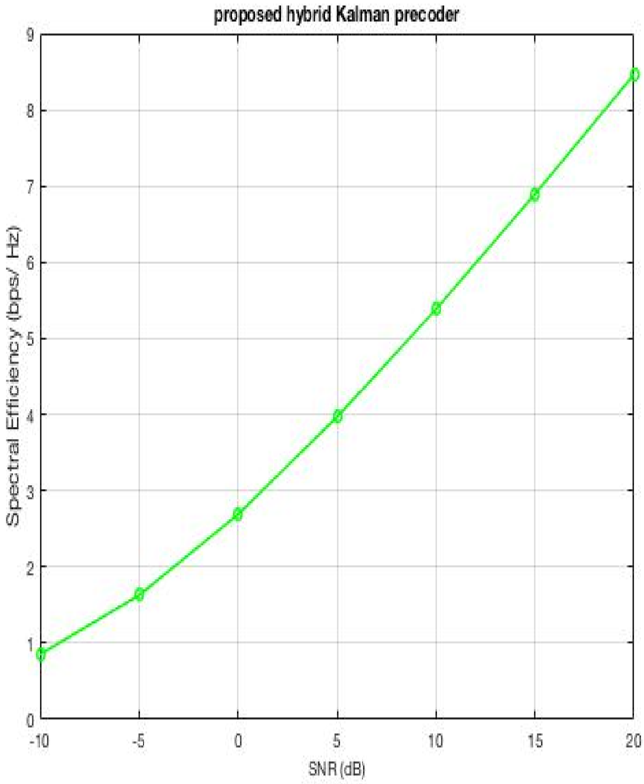

Fig9. Kalman precoders

V CONCLUSION

The communication on 5G with required baseband precoders improves the transmission and compared with different existing algorithms, the proposed algorithm also improved the spectral efficiency. The SNR calculation for the different ranges observes that the spectral efficiency of the system gets improved.

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