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Power Domain Multiplexing Approach in MIMO based Non Orthogonal Multiple Access

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Abstract: The NOMA to achieve with the more number of users in the power domain. NOMA is capable of significantly increasing the number of simultaneous connections. In NOMA the user with precoding data at the base station and reception receives from the radio base station a downlink signal that is non orthogonal multiplied by the same precoding. Here, conventional MIMO system compared with the mm-wave MIMO. The channel sparasity and uncertainty in bema space MIMO system. To reduce inter beam interference in proposed beam space MIMO NOMA system channel vector is determined for each beam to realize pre-coding based on Zero Forcing (ZF). The NOMA achieves higher SE & EE than OFDMA.
Keywords: mmWave, MIMO, NOMA

1. INTRODUCTION

The present invention is designed to enable uplink signal transmission power control that is suitable when NOMA is used on the uplink. Joint power optimization problem with to achieve higher spectrum and energy efficient [1]. The existing MIMO system did not concentrate on transmission characteristics. The Multipath environment is placed between the antenna array and user [2]. The conventional MIMO is compared with mmWave MIMO. The existing MIMO need to reduce inter beam interference realize precoding based on zero forcing [3]. Non-orthogonal resource allocation in NOMA indicates that the number of supportable users / devices is not strictly limited by the number of orthogonal resource available. Practical implementation issues in NOMA systems such as its hardware imperfections realizations of massive connectivity [4]. Requirement of channel feedback will be relaxed in power domain NOMA because the CSI feedback is only used for power allocation [5]. Hence there is no need for accurate outdated channel feed back associated with a certain maximum inaccuracy does not change rapidly. NOMA actively investigated in recent years. This may be realized by the sophisticated inter user interference cancellation at the cost of an increased receiver complexity [6]. NOMA has become important principle for the design of radio access technique for 5G wireless networks.

2. SYSTEM MODEL

Uplink NOMA

The uplink of NOMA received signal at BS is super imposed signal of x_1, x_2 *and* x_3 as follows:

$$y = h_1\sqrt{p_1}x_1 + h_2\sqrt{p_2}x_2 + h_3\sqrt{p_3}x_3 + W$$

The UE-User Equipment are 3 consider in this section.

We assume UE-1 is at cell center user, UE-2 cell corner user & UE-3 cell edge user then no error propagation can be calculated as

$$R_1 = \log_2(1 + \frac{p_1|h_1|^2}{p_2|h_2|^2+N_0})$$

$$R_2 = \log_2(1 + \frac{p_2|h_2|^2}{N_0})$$

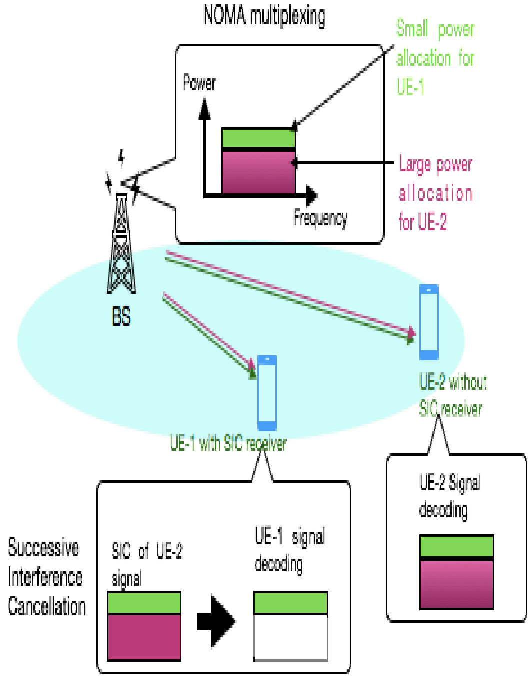

Fig 1. System model

Now, consider a single cell downlink mm-wave communication system base station with N antenna N_{RF} chain and k single user antenna simultaneously served by BS [7].

In beam space MIMO

$$Y = H^H WPD + V$$

$$D = [d_1, d_2, d_3, d_4, \ldots \ldots d_k]^T$$

$$D = \begin{bmatrix} d_1 \\ d_2 \\ d_3 \\ \vdots \\ . \\ d_k \end{bmatrix}$$

kx1 transmitted signal vector for k users.

Table 1. List of access with domain

Access type	Domain
OMA	Time, frequency and code access domain,
NOMA	Power domain
Transmitter	Supper position coding
Receiver	SIC

$$E[DD^H] = E[d_1 d_1^H, d_2 d_2^H, \ldots . d_k d_k^H]$$

$$= I_k$$

Where statistical independent data,

$$E[DD^H] = E[d_1 d_1^H] E[d_2 d_2^H] E[d_3 d_3^H]$$

$$E[d_4 d_4^H] \ldots . E[d_{k-1} d_{k-1}^H] E[d_k d_k^H]$$

$$P = diag\{p\}$$

Transmitted power all k users.

$$p = [\sqrt{p_1}, \sqrt{p_2}, \sqrt{p_3}, \ldots \ldots \sqrt{p_k}]$$

Satisfies

$$\sum_{i=1}^{k} \sqrt{p_i} = P$$

Massive MIMO& NOMA combination gives technical challenges resource allocation. In time and frequency domain improves quality of communication. Massive connectivity dense the network and meets effectively user's QoS requirements. Growth of mobile services are virtual & augmented reality. mmWave improvement in the spectral efficiency.

Random beam forming does not need to require base stations of the all the users channel vectors. In conventional beam forming random beam forming requires all the users to send the channel vectors.

Stochastic geometry is to apply the sum rate & outage probabilities. In fast time situations amplitude & phases of the users channel gain change frequently. The partial CSI on the performance of the mmWave-NOMA downlink network investigated.

The base station set threshold broadcast to the users. Where each user feeding one bit back to the base station it shows quality of channel. In single user case single beam produces with less interference. When compared multi users multiple beam more interference included such as intra interference and inter interference.

The basic principle of NOMA is to simultaneously serve multiple users over same spectrum resources (i.e. time, frequency, code and space) but with different power levels, at the expense of minimal inter-user interference [8].

3. NOMA DOWNLINK APPROACH

Now consider a downlink NOMA transmission at BS with single antennas & single antenna with *m* number of users with channel gains.

Difficult to realize millimeter wave massive MIMO in practice due to high transceiver complexity and energy consumption. Each antenna in MIMO system requires one radio frequency. The large number of antenna in mm-wave [9] a large number of RF chain. Performance of Beam space MIMO with beam selection is close to optimal. Non Orthogonal Multiple Access (NOMA) with beam space MIMO.

Orthogonal Multiple Access (OMA) relying on the time domain frequency domain and code domain. NOMA realizes in power domain. In this technique [10] the super position coding performed at transmitter and Successive Interference Cancellation (SIC) at the receiver.

New spectrum and energy efficient mm-wave transmission scheme, Beam space MIMO-NOMA. NOMA is a potential access technique for beam space MIMO in mm-wave communication system.

4. MmWAVE SYSTEM MODEL

The mmWave system model is given by

$$\min\{E[\|\bar{s} - W_{BB}^H W_{RF}^H \bar{y}\|^2 = \min \left\| R_{yy}^{\frac{1}{2}} (W_{MMSE} - W_{RF} W_{BB}) \right\|^2$$

Where the precoders design $\boldsymbol{F_{BB}F_{RF}}$

Optimum design $\left\| F_{opt} - F_{RF} F_{BB} \right\|^2$

The system model is given by $\bar{Y} = HX$

$$X = F_{BB} F_{RF} S$$
$$W_{BB}^H W_{RF}^H \bar{Y} = \bar{S}$$

Where $W_{RF} W_{BB}$ are the optimization variables.

$$\min\{E[\|\bar{s} - W_{BB}^H W_{RF}^H \bar{y}\|^2 = E\{Tr[(\bar{s} - W_{BB}^H W_{RF}^H \bar{y})(\bar{s} - W_{BB}^H W_{RF}^H \bar{y})^H]\}$$

$$= Tr\{E[(\bar{s} - W_{BB}^H W_{RF}^H \bar{y}) \left(\bar{s}^H - W_{BB} W_{RF} \overline{y^H}\right)\}$$

$$= Tr\{E[\bar{s}\bar{s}^H - W_{BB}^H W_{RF}^H \bar{y}\, \bar{s}^H - W_{BB}^H W_{RF}^H \bar{y} \bar{s}^H + W_{BB}^H W_{RF}^H \bar{y} W_{BB} W_{RF} \overline{y^H}$$

$$= Tr\{E[\bar{s}\bar{s}^H] - E[W_{BB}^H W_{RF}^H \bar{y}\, \bar{s}^H] - E[W_{BB}^H W_{RF}^H \bar{y} \bar{s}^H] + E\left[W_{BB}^H W_{RF}^H \bar{y} W_{BB} W_{RF} \overline{y^H}\right]\}$$

$$= Tr\left\{R_s - R_{sy} W_{RF} W_{BB} - W_{BB}^H W_{RF}^H R_{ys} + W_{BB}^H W_{RF}^H W_{BB} W_{RF} R_{yy}\right\}$$

$$= Tr\{-W_{MMSE}^H R_{yy} W_{RF} W_{BB} - W_{BB}^H W_{RF}^H\, R_{yy} W_{MMSE} + W_{BB}^H W_{RF}^H W_{BB} W_{RF} R_{yy}\}$$

$$= Tr\left\{R_s - R_{sy} R_{yy} R_{yy}^{-1} W_{RF} W_{BB} - W_{BB}^H W_{RF}^H\, R_{yy} R_{yy}^{-1} R_{ys} + W_{BB}^H W_{RF}^H W_{BB} W_{RF} R_{yy}\right\}$$

$$= Tr\{0 - W_{MMSE}^H R_{yy} W_{RF} W_{BB} - W_{BB}^H W_{RF}^H\, R_{yy} W_{MMSE} + W_{BB}^H W_{RF}^H W_{BB} W_{RF} R_{yy}$$

$$= Tr\{-W_{MMSE}^H R_{yy}^{1/2}\, R_{yy}^{1/2} W_{RF} W_{BB} - W_{BB}^H W_{RF}^H\, R_{yy}^{1/2} R_{yy}^{1/2} W_{MMSE} + W_{BB}^H W_{RF}^H R_{yy}^{1/2} R_{yy}^{1/2} W_{BB} W_{RF}\}$$

$$= Tr\{AB - B^H A + B^H B\}$$
$$= Tr\{(A - B)^H\, (A - B)\}$$

$$\|A - B\|^2 = \left\| R_{yy}^{\frac{1}{2}}\, W_{MMSE} - R_{yy}^{\frac{1}{2}} W_{BB} W_{RF} \right\|^2$$

$$= \left\| R_{yy}^{\frac{1}{2}}\, (W_{MMSE} - W_{BB} W_{RF} \right\|^2$$

$$W_{MMSE}^H R_{yy}^{1/2} = A$$

$$R_{yy}^{1/2} W_{RF} W_{BB} = B$$
$$W_{BB}^H W_{RF}^H\, R_{yy}^{1/2} = B^H$$

Where $E[\bar{s}\bar{s}^H] = R_s$

$$E[\bar{y}\, \bar{s}^H] = R_{ys}$$
$$E\left[\overline{y^H}\, \bar{s}\right] = R_{sy}$$
$$E\left[\overline{y^H} \bar{y}\right] = R_{yy}$$
$$W_{MMSE}^H = R_{sy} R_{yy}^{-1}$$

The transmitter and receiver UE beam

Table 2. List of operator

Operator	Description
$(.)^T$	Transpose
$(.)^H$	Conjugate transpose
$(.)^{-1}$	Matrix inversion
(.)	Moore pen rose matrix inversion
tr(.)	Trace of matrix
diag{p}	Diagonal matrix
E{.}	Expectation

pattern sectorial directive gain is given by

$$G(\emptyset) = \begin{cases} G_M, \emptyset \leq 0 \\ G_m, \emptyset > 0 \end{cases}$$

where G_M is main lobe gain& G_m is minor lobe gain. For Rth mmWave base station is given by $G_R = G_s(\emptyset_s) G_U(\emptyset_u)$. $\emptyset_s$ is the Angle of depature, $\emptyset_u$ is angle of arrival. NOMA base station all users are arriavl in terms of power domain only. The noise is assumed as AWGN [11].

The coverage of probability is used to charcterises the quality of network coverage. According to SIC the nth order coverage of probabilty is

$$P_n(T) = \mathbb{p}(SINR_{n,,1} > T, SINR_{n,,2} > T, SINR_{n,,3} > T, \ldots \ldots SINR_{n,,n}$$

QTM05G mmwave antenna module is the world's first announced fully Integrated RF for smart phone & other devices. To improve nnwave signal using 5G technology [12]. The module contain a 5GNR radio transciever, power maientenance, RF front end phased antenna array. Mmwave improves for wireless communication host challenges like Propagation, range, size.

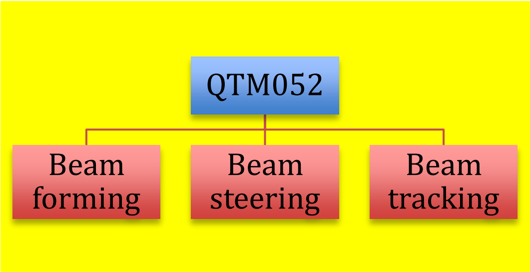

Fig 2: QTM052 Features

The beam forming, steering and tracking for bidirectional mobile mmwave communication sytem drastically improves the range & coverage of signals [13-16]. Design supports upto MIMO with dual layer polarization for both up & down link.

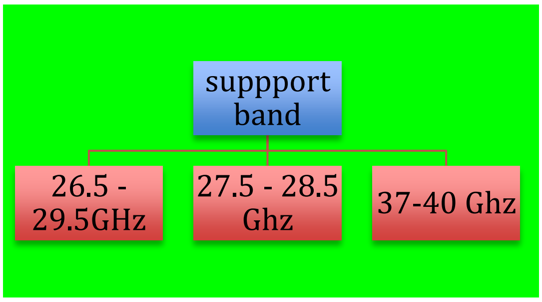

Fig3.Frequency band support

4.1. Precoding based Zero Forcing

Consider zero forcing MIMO channel model $y = Hx + n$. Where y is output system, H is channel; x is the input & n is the noise. The resulting receiver and cost function are important for the system. The cost function is given by $\widehat{x_{ZF}} = \arg\{\min[\|y - Hx\|^2]\}$.

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

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

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

5. SIMULATION RESULTS

In our analysis we assume static power consumption for the network due to power amp add to the power consumed for infoemation waveform. The total power consumption at the transmitter is given by

$$P_{total} = P_T + P_{static}$$

the Energy Efficient is the

$$EE = \frac{R_T}{P_{total}} = SE \frac{W}{P_{total}} (bits/joule)$$

$$SE = \frac{R_T}{W} bps/Hz$$

where SE=Spectrum Efficient

EE= Energy Efficient

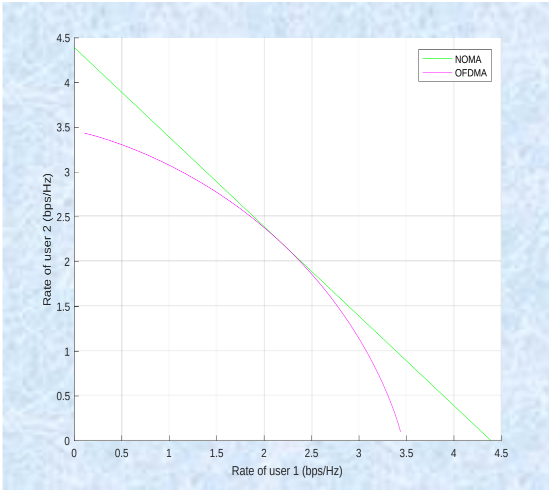

Fig 5.a.SNR1=20dB,SNR=20dB

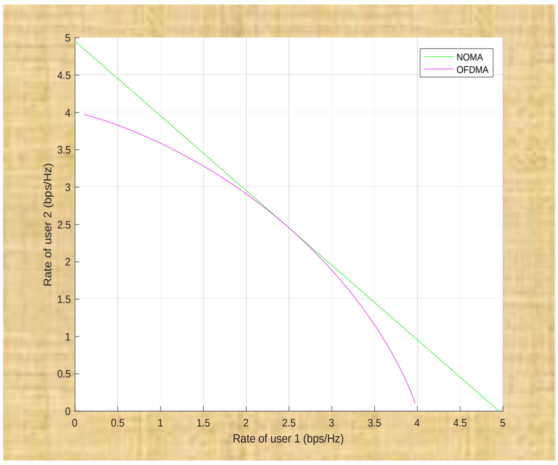

Fig 5.b. SNR1=30dB,SNR2=30dB

Fig 5 rate of user NOMA Vs OFDMA

In Fig 5 rate of user1 and user2 with NOMA and OFDMA. In Fig 5.a. shows that the SNR1 is 20 dB and SNR2 is 20 dB. In Fig 5.b. the SNR1 is 30 dB and SNR2 is 30 db.

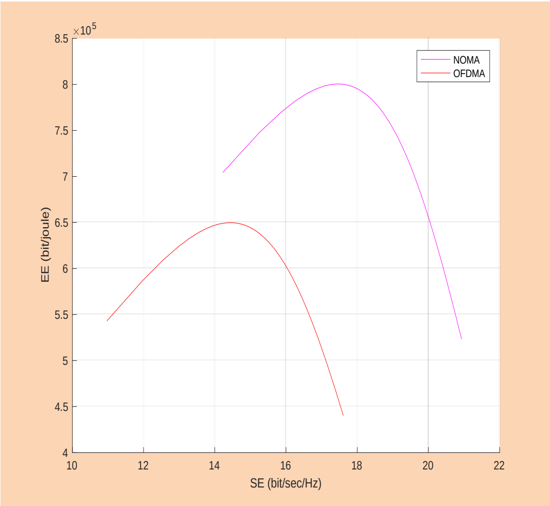

Fig 6.a.

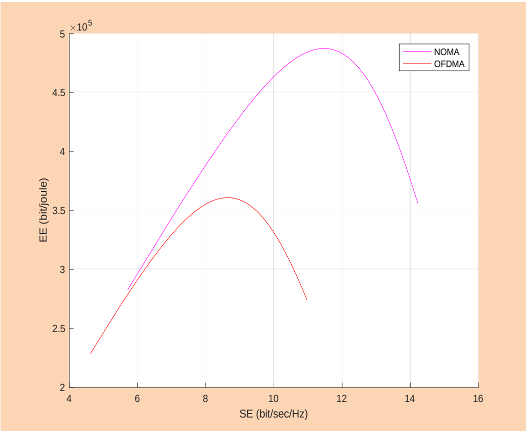

Fig 6.b.

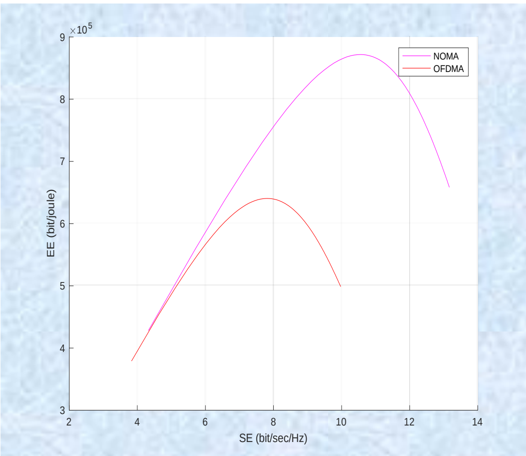

Fig 6.c

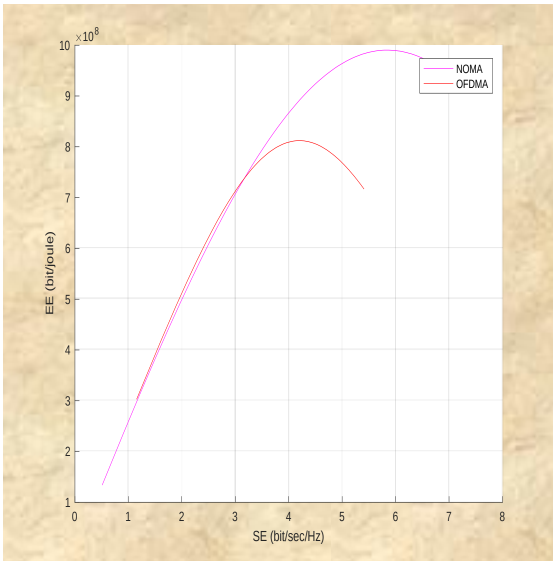

Fig 6.d

Fig6 Energy and Spectral Efficient of NOMA & OFDMA

The Fig 6 represents that the energy efficient and spectral efficient of the ssytem for NOMA and OFDMA. In Fig 6.a.Where the badwidth is assumed here 5MHz and user1 with SNR of -100 dB and user2 with SNR of -120 dB. In Fig 6.b. 5MHz with the user1 with SNR of -120 db and user2 with -140 dB. In Fig 6.c. 10MHz with user1-120 dB and user2 -140dB. In Fig 6.d.where 26.5 GHz with the user1-100 dB and user2 -120dB. The NOMA achieves higher SE & EE than OFDMA.

Bandwidth	Modulation index	NOMA
20MHz	0.5	235.70, 120.97, 114.70
10MHz	0.5	129.91 66.53, 63.3854
5MHz	0.5	70.35 35.96, 34.39
2MHz	0.5	30.86 15.74, 15.11
1MHz	0.5	16.44 8.37, 8.06
0.5MHz	0.5	8.72 4.44, 4.28
0.5MHz	0.2	7.4 3.77, 3.62
1MHz	0.2	13.8 7.05, 6.74
2MHz	0.2	25.58 13.09, 12.48

5MHz	0.2	57.22 29.33, 27.89
10MHz	0.2	103.8153.22 50.55
20MHz	0.2	84.06 94.14, 89.987

Table3. Based on frequency band

Bandwidth	Modulation index	NOMA
26.5GHz	0.5	0.4314, 0.0964, 0.3351
29.5GHz	0.5	0.3482, 0.0778, 0.2704
27.5 GHz	0.5	0.4006, 0.0895, 0.3111
28.5 GHz	0.5	0.373, 0.0833, 0.2897
37 GHz	0.5	0.2213, 0.0494, 0.1719
40 GHz	0.5	0.1894, 0.0423, 0.1471
26.5GHz	0.2	0.069, 0.0154, 0.0536
29.5GHz	0.2	0.0557, 0.0124, 0.0433
27.5 GHz	0.2	0.0641, 0.0143, 0.0498
28.5 GHz	0.2	0.0597, 0.0133, 0.0464
37 GHz	0.2	0.0354, 0.0079, 0.0275
40 GHz	0.2	0.0303, 0.0068, 0.0235

Table4: based on supported band

6. CONCLUSION

The average received power is under 10w. The results are calculated for radomly distributed data variables. The above results illustrates that the bandwidth for modulation with diffefrent ranges with different modulation index, offset and average transmitted power. The NOMA for user expressed interms of Mbits/sec. Therefore the NOMA achieves higher SE & EE than OFDMA.

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