ISSN 2278-3091
Volume 8, No.1.2, 2019
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse1681.22019.pdf
https://doi.org/10.30534/ijatcse/2019/1681.22019

Performance Evaluation of SFBC-OFDM System over Nakagami-m Flat Fading Channel

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ABSTRACT

This paper presents, the Bit error rate performance (BER) of space frequency block coded (SFBC) orthogonal frequency division multiplexing (OFDM) system with two Tx (transmit) / one Rx (receive) antenna and two Tx / two Rx antenna configuration tested over Nakagami-m flat fading channel with binary phase shift keying (BPSK) modulation is evaluated. For simulation, the Nakagami-m fading channel is generated using the sum of sinusoidals with Rayleigh and Ricean fading envelop (Tang et al. 2003). Simulation results demonstrate that the bit-error-rate performance and diversity gain MIMO-SFBC-OFDM system, the Nakagami-m fading model renders a decent match to exploratory information for the different fading environment. Furthermore, since the SF code symbol is transmitted in one OFDM block span, therefore it has a little handling delay than practically identical space time block codes (STBC).

Key words: MIMO, OFDM, SFBC, Nakagami-m channel.

1. INTRODUCTION

The time-varying fading almost experienced by any wireless channel is due to the multipath spread and the ruinous superposition of signals received from various paths, which make difficult for the receptor to dependably decide the transmitted signal except if some less constricted replica of the signal is reaching to the receiver. Transmitting the immitated version of the signal is known as diversity. A widely applied technique to lessen the impacts of multipath fading is antenna diversity [1]. In this paper, we consider various info numerous yield (MIMO) remote systems, where both spatial decent variety and recurrence assorted variety (due to multipath causing) are accessible. Symmetrical recurrence division multiplexing (OFDM) [2, 3] in a general sense lessens beneficiary multifaceted nature in the broadband remote frameworks. Space-recurrence coded MIMO-OFDM [4, 5, 6] is a transmission procedure, which applies coding over the transmit radio wire and OFDM tones, and besides recognizes both spatial and recurrence assorted variety gains without requiring channel information at the transmitter.Space-Time Codes (STC) was first presented by V. Tarokh et al. from AT&T research Labs in 1998 [7] as a novel method for obtaining the diversity at the transmitter for multpath fading channels. The scheme of transmission for an arbitrary number of transmit antennas was generalized by them, which can accomplish the full diversity guaranteed by the receive and transmit antenna [7, 8]. In 1998, S. Alamouti introduced the scheme for the implementation of a two branch receive and transmit diversity. “Alamouti code” was introduced by Alamouti as his name as shown in figure 1 given below [9]. The Alamouti code is used in space-frequency domain.

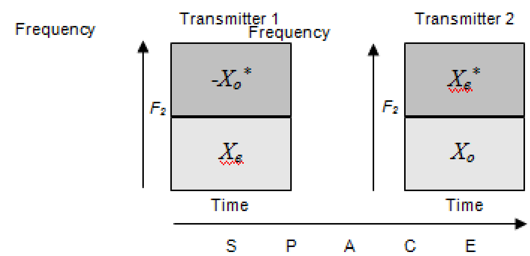

Figure 1. SFBC-OFDM scheme with 2 Tx- N_R Rx antennas

Transmit antenna diversity in the form of space-time block codes [7, 8] exploits time and space diversity, and furthermore accomplishes a greatest decent variety gain for two transmit reception apparatuses without rate misfortune. They should be executed under the suspicion that the channel coefficients remain unfaltering for two neighboring image lengths to guarantee requested assorted variety gain. This precondition can be indispensable in OFDM frameworks, where the OFDM image length Ts is N times the term of the data images T (N being the amount of subcarriers). To vanquish the need to use two nearby images for coding the copy which can be sent on different subcarriers in multicarrier structures. In this paper, an effective execution of a space recurrence square code (SFBC) is appeared, where the property of OFDM is abused that two neighboring narrowband subchannels are impacted by a comparable channel coefficients.Consequently, the SFBC requires just the gathering of one OFDM symbol for identification, and furthermore maintains a strategic distance from the issue with coherence time restrictions, which decreases the deferral in the identification procedure.

In 1960, Nakagami-m distribution proposed by Nakagami, Minoru [10], has been utilized as another valuable and essential model for portraying the amplitude of fading channels. It has more prominent adaptability and exactness in coordinating different exploratory information more broad than Rayleigh, log-normal or Ricean distribution. So the BER performance of MIMO-OFDM in the Nakagami-m fading channel turns into another logical research point.

Organization of the paper. An audit for the plan criteria for SFBC are quickly depicted in area 3.Then section 4 introduces the nakagami-m channel model and a quick survey for the generation of nakagami fading channel model using sum of sinusoids method [11]. Section 5, provides the error performance of SFBC-OFDM working over Nakagami fading, and finally in section 6 conclusion is reached.

2. PROBLEM STATEMENT

To avoid the issue of quick divert varieties in time, the pictures of a symmetrical arrangement can be transmitted on neighboring subcarriers of the equal OFDM picture rather than on the equal subcarrier of the subsequent OFDM pictures. This in like manner diminishes the transmission delay. In any case, the channel ought to be practically unfaltering over P neighboring subcarriers. This is substantial in channels with low recurrence selectivity or can be drilled by using endless number of subcarriers so as to make the subcarrier dispersing extremely restricted. Space-Frequency Block Codes avoid the issue of quick time varieties. It has a lesser taking care of deferral than practically identical ST codes. In any case, the execution will degenerate in thickly populated recurrence particular channels, where the doubt of reliable channel coefficients over a space-recurrence square code lattice isn't safeguarded. Particularly, this is an issue for a structure having more than two-transmit reception apparatuses [12][14].

3. SFBC-OFDM

Here, the design criteria for space-frequency block codes have been carried out. Let us assume SFBC-OFDM (figure 2) framework with two transmit antenna *(Tx = 2)*, using the G2 [8] codes. Like in OFDM, the sequence of information is changed over into parallel structure, producing block X (k),

$$X = \{x[1],\ x[2]\ ,.....,\ x[N-1]\} \quad (1)$$

where N represents the block size which is equal to the size of Fast Fourier Transform (FFT) in OFDM. Now the block X is divided into two vectors $\boldsymbol{x}_1(k)$ and $\boldsymbol{x}_2(k)$ as [13]:

$$X_1(k) = \{x_e \quad -x_o^*\} \quad (2)$$

and

$$X_2(k) = \{x_o \quad x_e^*\} \quad (3)$$

respectively. where,

$$x_e = (x_0,\ x_2,.....,x_{N_c}) \quad (4)$$

and

$$x_o = (x_1,\ x_3,.....,x_{N_c-1}) \quad (5)$$

The generation of an OFDM obstruct for two transmit anteena can be made as

$$G_2 = [(x_1[k])^T \quad (x_2[k])^T] \quad \text{for } k=0,.....,\frac{N}{2}\text{-1} \quad (6)$$

As per the method of generation of OFDM infromation symbol at the transmitter side by following SFBC scheme, we obtain two blocks X_1 and X_2, each one of length N. So as to use the SF diversity scheme, the information sequence as the input block are encoded as pursues:

$$X_1[k] = (x[0]\ \ -x^*[1]\ \ x[2]\ \ -x^*[3]\ \ x[4]\ \ -x[5].....x[N-2]\ \ -x^*[N-1])^T,$$
$$X_2[k] = (x[1]\ \ x^*[0]\ \ x[3]\ \ x^*[2]\ \ x[5]\ \ x^*[4].....x[N-1]\ \ x^*[N-2])^T, \quad 7)$$

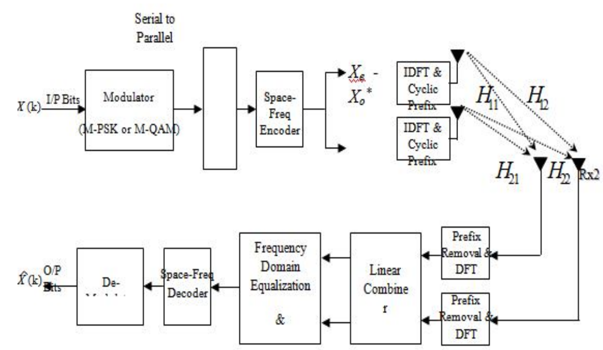

Figure 2: 2TX × 2RX SFBC-MIMO-OFDM transmitter and receiver block.

During the block instant k, X_1 (k) is transmitted from the respectable starting point station T_{x1}, while $X_2(k)$ is transmitted all the while from the a respectable second station T_{X2}. The channel is viewed as static among an OFDM obstruct, in the wake of emptying cyclic prefix at the getting side. A demodulated yield at the j^{th} receiving antenna would be estimated as:

$$r_j = H_{j,1}X_1 + H_{j,2}X_2 + W_j \quad (8)$$

where

$$r_j = (r_j[0],\ r_j[1],....,r_j[N-1])^T,$$

are received signal at j^{th}receiver,

$$H_{j,i} = diag(H_{j,i}[k])_{k=0}^{N-1}$$

is an $N \times N$matrix with component relating to the Discrete Fourier Transform repercussion generated through proposed method for generating Nakagami distribution function, and

$$W_j = (W_j[0],\ W_j[1],....,W_j[N-1])^T$$

denotes the AWGN. Under the assumptions that the perfect channel state data is known at the recipient side, maximum likelihood detection can be utilized for deciphering the signal at the receiver. Here zero forcing equalizer is used to estimate the transmitted signal. Now, the deciphering scheme can be composed as

$$\hat{X}_e = \sum_{j=1}^{N_r} (H^*_{j,1}[2k] r_j[2k] + H_{j,2}[2k] r^*_j[2k+1] \quad (9)$$

$$\hat{X}_o = \sum_{j=1}^{N_r} (H^*_{j,2}[2k+1] r_j[2k] - H_{j,1}[2k+1] r^*_j[2k+1] \quad (10)$$

Then, for the flat-frequency condition, the determination of quasi-static channel is fair, i.e., expecting that the channel gains between two contiguous subchannels are around equivalent, i.e.

$$H_{j,1}[2k] = H_{j,1}[2k+1] \quad and$$

$$H_{j,2}[2k+1] = H_{j,2}[2k]$$

the choice measurements can be composed as,

$$\begin{aligned}\hat{X}_e = &\sum_{j=1}^{N_r} \left(\left| H_{j,1}[2k] \right|^2 + \left| H_{j,2}[2k] \right|^2 \right) \mathrm{x}[2k] \\ &+ H^*_{j,1}[2k] W_j[2k] + H_{j,2}[2k] W^*_j[2k+1]\end{aligned} \quad (11)$$

$$\begin{aligned}\hat{X}_o = &\sum_{j=1}^{N_r} \left(\left| H_{j,1}[2k] \right|^2 + \left| H_{j,2}[2k] \right|^2 \right) \mathrm{x}[2k+1] \\ &+ H^*_{j,2}[2k] W_j[2k] - H_{j,1}[2k] W^*_j[2k+1]\end{aligned} \quad (12)$$

4. NAKAGAMI-M CHANNEL MODEL

The Rayleigh distribution has appeared to be a suitable model for expressing the momentary fading statistics of a high-frequency ionospheric channel. In any case, it is conceivable that fadin turns out to be more extreme than Rayleigh fading as a high variability of the high frequency channel. The case of fading, more critical than Rayleigh was seen by Nakagami, Minoru [10] in a progression of channel estimation for a long distance high recurrence correspondence links. His estimation results demonstrate that the circulation ranges from $0.5 \leq m \leq 1$ with fading parameter 'm' is valuable for modelling the fading characteristics of a high frequency channel, when fading is more extreme than Rayleigh. When m = 1%, it becomes the special case of Rayleigh distribution.

Let us consider *H (k)* isachannel matrix consiting of a complex channel frequency responses at k^{th} subcarrier. Where N_T and N_R being the number of transmit and receive antenna respectively. The channel impulse responses in time-domain can be decomposed as

$$h_{i,j}(t) = \sum_{t=0}^{L-1} h_{i,j}(l) \delta(\tau - \tau_l) \quad (13)$$

Where δ (•) is a kronecker delta function and the taps $h_{i,j}(l) = \alpha_{i,j}(l)\, e^{j\theta}$ uncorrelated with phaseθ_l uniformly distributed over [0,2π] for all receiver-transmitter antenna pairs (*i*, *j*). The Nakagami-m PDF is

$$p(\alpha) = \frac{2m^{\alpha} \alpha^{2m-1}}{\Gamma(m)\Omega^m} \exp\left(-\frac{m}{\Omega}\alpha^2\right), \quad \alpha \geq 0.$$

$$\Omega = E\left[\alpha^2\right], \quad m = \frac{E\left[\alpha^2\right]}{E\left[(\alpha^2 - E(\alpha^2))^2\right]}. \quad (14)$$

Where Γ (•) is the Gamma function, Ω is the normal intensity of the multipath dissipating field and *m* is the shape factor of the Nakagamidispersion, which portray the fading level of engendering field brought about by obstruction of the dissipating and multipath phenomenon. For the fading parameter *m* =½, the Nakagami appropriation decreases to one-sided Gaussian dissemination. For *m* = 1, the Nakagami conveyance is decreased to Rayleigh dissemination, and for *m*>1, the Nakagami dispersion is diminished to Rice appropriation. The connection between the Rice factor *k* and Nakagami fading factor *m* is given by

$$k = \frac{\sqrt{m^2 - m}}{m - \sqrt{m^2 - m}}, \qquad \mathrm{m} > 1 \quad (15)$$

In an OFDM system, the channel recurrence reaction between several anteena (I, j) can be imparted as

$$H_{i,j}(k) = \frac{1}{\sqrt{N}} \sum_{l=0}^{L-1} h_{i,j}(l) \exp(-j2\pi kl/N) \quad (16)$$

Where $H_{i,j}(k)$ is the frequency response of the channel for the k^{th} subcarrier, which is actually the $(i, j)^{th}$ component of the channel matrix *H (k).*

For simulation purpose we have created the Nakagami fading by utilizing the sum of sinusoidals utilizing Rayleigh and Ricean fading as given in equation (17). The received signal for Nakagami fading can be comumnicated as [11]

$$R_{Nakagami} = R_{Rayleigh}\, \mathrm{e}^{(1-m)} + R_{Ricean}(1 - \mathrm{e}^{(1-m)}) \quad (17)$$

Where $R_{Rayleigh}$ and R_{Ricean} are envelops of Rayleigh and Ricean channels respectively.

5. SIMULATION RESULTS AND DISCUSSION

In this segment, we present a ensemble average of simulation results to represent the impacts of employing 1Rx/2Tx and 2Rx/2Tx antenna on the error performance of SF block codes in various Nakagami-m fading channels. Give X a chance to be a M-PSK input flag and r be the gotten flag in the wake of ousting the cyclic prefix and performing FFT of the remaining sign. The yield signal is observed by $r = HX + W$. Our simulation example explores the impact of different Nakagami-m fading values on reduction of the bit error rate. The size for calculating FFT is 256 and the quantity of subcarriers utilized to be 320. The data was simulated for 1000 frames and using Space Frequency scheme with Alamouti code *G2*. The absolute symbol energy for every transmit antenna is standardized as *Es* =1. The figure 3 and figure 4 show the bit error rate for BPSK based

SF data for various *m* values over $N_T = 2$, $N_R = 1$ and $N_T = 2$, $N_R = 2$ respectively. In every one of the figurings, it has been expected that the fading channels are standardized. The simulation are carried out using Matlab over time-varying fading parameter m = 0.5, 1 and 2.

We infer from Tables 1 and 2 that the simulated results for different fading figure '*m*', the value of error reduces for $m \geq 0.5$. Table 1 and 2 show the error rate for 2 Tx- 1 Rx and 2 Tx- 2 Rx respectively.

Table 1: BER of STBC for fading 2 Tx-1 Rx

Fading 'm' **SNR (dB)**	**m=0.5**	**m=1**	**m=2**
BER (SNR=15)	0.3349	0.2857	0.2709
BER (SNR=20)	0.2679	0.1780	0.1485
BER (SNR=25)	0.2213	0.0914	0.0506
BER (SNR=30)	0.2010	0.0508	0.0121

Table 2: BER of STBC for fading 2 Tx-2 Rx

Fading 'm' **SNR (dB)**	**m=0.5**	**m=1**	**m=2**
BER (SNR=15)	0.2768	0.2197	0.1962
BER (SNR=20)	0.1913	0.1032	0.0726
BER (SNR=25)	0.1390	0.0332	0.0109
BER (SNR=30)	0.1180	0.0129	0.0009

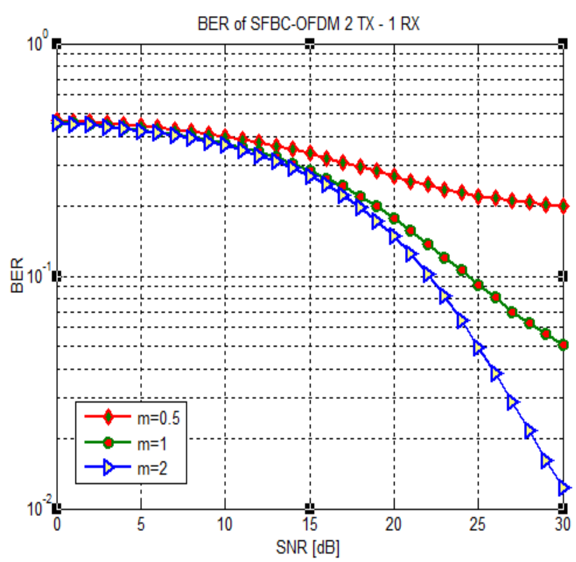

Figure 3: BER performance of SFBC-OFDM in Nakagami-m fading channel.

Simulations are done in two stages; in first stage, the outcomes are plotted considering 2 transmit and 1 receiving antenna; and in second stage 2 transmit and 2 accepting recieving antenna are considered.

Figure 3 shows three curves; all the curves are plotted for different values of '*m*' using Zero Forcing equalizer. The Bit error rate gets reduced to 0.3349, 0.2213, and 0.2010 at SNR of about 15, 25, and 30dB respectively. In first curve (m=0.5), which is an uncommon instance Nakagami fading, where the fading is more extreme than Rayleigh (one sided Gaussian distribution) and in second curve the Bit error rate reduced from 0.2857, 0.0914, 0.0508 on increasing the SNR value from 15, 25, 30dB respectively for (m=1), which is a case of Rayleigh fading. As we increase the value of *m*, the fading intensity decreases and consequently the error also reduces as shown in third curve shown in Figure 3.

Similarly in Figure 4 an improvement is seen in the curve as compared to Figure 3. On exploiting the receiver diversity, the error reduces up to 10^{-1} when SNR is about 30dB, which could not be achieved with 1 Rx (for m=0.5). The framework gives least S/N proportion improvement of about 5dB. On increasing the SNR about 30dB, the error reduces up to the $10^{-2,}$ which is not possible with 1 Rx.

As expected, the average BER performance improves on increasing the diversity order at the receiver. It can also be seen from the Table 1, and 2 that more the number of receiver (exploiting receive diversity), more improvement in the BER performance is seen.

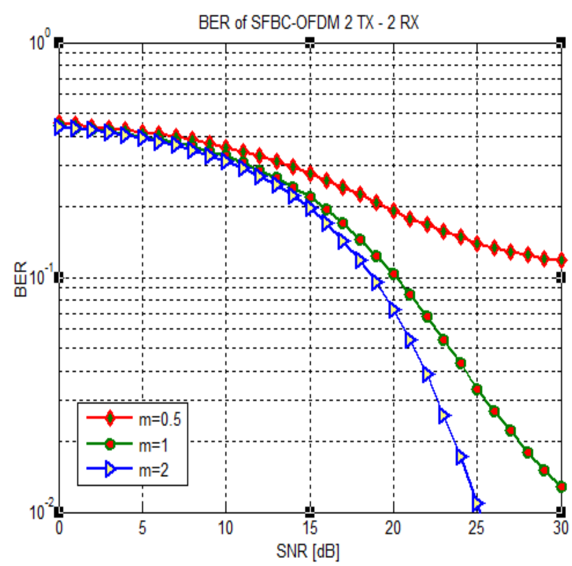

Figure 4: BER performance of SFBC-OFDM in Nakagami-m fading channel.

6. CONCLUSION AND FUTURE SCOPE

This article has presented the normal BER execution evaluation of SFBC, with BPSK modulation, for multiple input multiple output time-varying Nakagami-m flat fading channels. Systematic articulations have been appeared self-assertive fading parameters along the antenna branches. Simulated results indicate that both capacity and BER performances can be improved by expanding the quantity of antennas. The increasing value of fading factor '*m*' will definitely improvise the execution of the framework partly, however not clearly. Although the SFBC-OFDM is progressively touchy to channel gain varieties over frequency band yet it has a littler handling delay than practically identical STBC. In future, the results of this paper will be useful for predicting the performance of efficient data transmission over correlated or uncorrelated Nakagami fading environment.

REFERENCES

1. A.S. Bahai, B. R. Saltzberg. **Multi-Carrier Digital Communications Theory and Applications of OFDM**, Norwell, MA: *Kluwer Academic Publishers*, 1999.
2. L. J. Cimini. **Analysis and simulation of a digital mobile channel using orthogonal frequency division multiplexing,** *IEEE Trans. Commun*., vol. COMM-33, no. 7, pp. 665–675, July 1985. https://doi.org/10.1109/TCOM.1985.1096357
3. B. LeFloch, M. Alard , C. Berrou. **Coded orthogonal frequency division multiplex**, *Proc. of IEEE*, vol. 83, no. 6, pp. 982–996, 1995. https://doi.org/10.1109/5.387096
4. H. Bolcskei, A.J. Paulraj. **Space-frequency coded broadband OFDM systems**, in *Proc. IEEE* WCNC, Chicago, IL, pp. 1–6, Sept. 2000.
5. B. Lu, X. Wang. **Space-time code design in OFDM systems**, in *Proc. IEEE GLOBECOM*, vol. 2, San Francisco, CA, pp. 1000–1004, Dec. 2000.
6. S. Zhou, G.B. Giannakis. **Space-time coding with maximum diversity gains over frequency-selective fading channels**, *IEEE Signal Processing Letters*, vol. 8, no. 10, pp. 269–272, 2001. https://doi.org/10.1109/97.957268
7. V. Tarokh, N. Seshadri, A.R. Calderbank. **Space–Time Codes for High Data Rate Wireless Communication: Performance Criterion and Code Construction**, *IEEE Transactions on Information Theory*, vol. 44, no. 2, pp. 744-765, March 1998. https://doi.org/10.1109/18.661517
8. V. Tarokh, H. Jafarkhani, A.R. Calderbank. **Space–Time Block Coding for Wireless Communications: Performance Results**, *IEEE Journal on Selected Areas in Communications*, Vol. 17, no. 3, March 1999. https://doi.org/10.1109/49.753730
9. S. Alamouti. **A Simple Transmit Diversity Technique for Wireless Communications**, *IEEE Journal On Select Areas in Communications*, vol. 16, no. 8, pp. 1451-1458, Oct. 1998. https://doi.org/10.1109/49.730453
10. M. Nakagami. **The m-distribution, a general formula of intensity distribution of rapid fading**, in *Statistical Methods in Radio Wave Propagation*, pp.3-36 W. G. Hoffman, Ed, Oxford, England: Pergamum, 1960. https://doi.org/10.1016/B978-0-08-009306-2.50005-4
11. L. Tang, Z. Hongbo. **Analysis and Simulation of nakagami fading channel with Matlab**, *Asia-Pacific conference on environmental electromagnetic CEEM*', China, pp. 490-494, Nov. 2003. https://doi.org/10.1109/CEEM.2003.238296
12. H. Jafarkhani. **Space-Time Coding: Theory and Practice**. *Cambridge Academic Press*, 2005. https://doi.org/10.1017/CBO9780511536779
13. K.F. Lee, D.B. Williams. **A Space-Frequency Transmitter Diversity Technique for OFDM Systems**, *IEEE GLOBECOM*'00, pp. 1473-1477 (2000).
14. G. Bauch. **Space-Time Block Codes versus Space-Frequency Block Codes**, in *Proc. IEEE VTC-Spring*, Apr. 2003, vol. 1, pp. 567-571.
15. V.Porkodi, V.Manikandan. **Cooperative data dissemination via roadside WLANS using caching and transmission**, *International Journal of Innovative Research in Engineering Science and Technology*, Vol. 1, Issue 2, 52-57, 2013.
16. Saravanan S., Hailu M., Gouse G.M., Lavanya M., Vijaysai R. (2019) **Design and Analysis of Low-Transition Address Generator.** In: Zimale F., EnkuNigussie T., Fanta S. (eds) Advances of Science and Technology. ICAST 2018. *Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*, vol 274. Springer, Cham https://doi.org/10.1007/978-3-030-15357-1_19
17. R. Vadivu R. Reena, B. SaravanaBalaji. **A Framework design for Conceptual Similarity based Web Service Recommendation System**, *International Journal of Applied Engineering Research*, Vol. 10, Issue 21, 2015.
18. Priyanka Thakur and Dr. Rajiv Shrivastava. **A Review on Text Based Emotion Recognition System**, *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 7. Issue 5, 2018 https://doi.org/10.30534/ijatcse/2018/01752018