International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-5, January 2020

Performance Measurement and Optimization of Relays Used for 5G Ultra Reliable Low Latency Communication Network

Saraju Prasad Padhy, Madhusmita Panda, Srinivas Seth, Aruna Tripathy

Abstract: The objective of this paper is to analyse and optimize the performance parameters of Relay nodes used in the finite block length (FBL) regime. A relaying system with a single Decode and Forward (DF) Relay is used for this purpose. Here using FBL, the performance parameters like coding rate, decoding error probability etc are obtained for different scenarios like without relay, with relay and using cooperative relaying. Effects of SNR and code Block length on performance parameters are analyzed. To enhance the performance of the Relay in URLLC scenario, power distribution between source and Relay node is optimized using evolutionary algorithms such as Multi-Objective Particle Swarm Optimization (MOPSO) and Infeasibility Driven Evolutionary Algorithm (IDEA). Low error probability and high throughput at the desired block length and power were the optimization goals. After using both the algorithms, the optimized Relay has shown improvement in performances like throughput (coding rate) and decoding error probability. It is also observed that IDEA optimization approach is found to be more efficient than MOPSO to provide optimum design parameters.

Keywords: Relays, URLLC, MOPSO, IDEA.

I. INTRODUCTION

With the wireless technologies growing very fast and a huge competition in Telecommunication sector, utilization of spectral resources need to be maximized in order to meet the extremely high data rate targets of the next generation wireless communication networks. Relaying [1]-[2] has proved to be one of the efficient ways to enhance the performance of wireless transmission in the present wireless communication systems by mitigating wireless fading, minimizing path loss and exploiting spatial diversity apart from significantly improving the quality of service (QoS) and capacity. Among different relaying protocols decode- and-forward (DF) protocols are popularly used for improving quality of service and capacity [3]-[4].

For the design of next generation networks especially for 5G, two major concerns which need to be addressed are Low latency and high reliability. Thus Ultra Reliable Low Latency Communication (URLLC) has become a buzz word in 5th Generation wireless communication systems these days [5]. As a result researchers and designers are showing more and more interest in developing ultra reliable wireless links which will carry latency critical traffic. The coding characteristics of these URLLC networks need to be short due to low latency constraint.

Previous studies conducted on relays mainly used for 2nd to 4th Generation wireless communications systems were under the ideal assumption that the coding blocklength is unbound and communication is arbitrarily reliable at Shannon's channel capacity. In such scenario the transmission error was determined from the instantaneous channel capacity and applied coding rate. However these results hold good in the infinite block length (IBL) regime, that is, codes with unbound block lengths or at most for cases with finite but relatively large block lengths. However for URLLC applications, when the block lengths are short because of low late ncy, they do not seem to solve the purpose.

In case of communication with finite block length (FBL), particularly when the block length is short, data transmission becomes unreliable and significantly higher decoding error probability results even if the selected rate is less than Shannon limit . Considering this, a coding rate for an additive white Gaussian noise (AWGN) channel which is achievable under the FBL was derived [6]-[7]. Subsequently, for quasi-static fading channels the same work was carried out in [8].

To address this issue, Polyanskiy [6] defined an approximation of achievable coding rate for a system involving single-hop by taking error probability into consideration which seems to be accurate. The relationship between coding rate (r) , length of code block (m) , probability of error (Ɛ) and signal to noise ratio(SNR) (γ) as per the results in [7] are given by

$$r = R(\gamma, \varepsilon, m) = \log(1+\gamma) - \log_e \sqrt{(\gamma(\gamma+2)/(\gamma+2)^2 m)}\, Q^{-1}(\varepsilon) + \frac{\log m}{m} + \frac{0(1)}{m} \quad (1)$$

where $Q^{-1}(\varepsilon)$ is the inverse Q function. The Q function can be given by Q(x) = $\int_x^{\infty} (1/\sqrt{2\pi}) e^{-t^2/2} dt$

Manuscript published on January 30, 2020.
* Correspondence Author
Mr. Saraju Prasad Padhy*, Eastern Telecom Project, Bharat Sanchar Nigam Limited (BSNL), Gangtok, India. Email: sppadhy71@gmail.com
Mrs. Madhusmita Panda, Department of ECE -ITER, SOA University, Bhubaneswar, India. Email: madhusmita99@rediffmail.com
Dr. Srinivas Sethi, Department of Computer Science Engineering & Applications, Indira Gandhi Institute of Technology (IGIT), Sarang, India . Email: srinivas_sethi@igitsarang.ac.in
Dr. Aruna Tripathy, Department of Instrumentation and Electronics College of Engineering and Technology (CET), Bhubaneswar, India. Email: atripathy@cet.edu.in

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

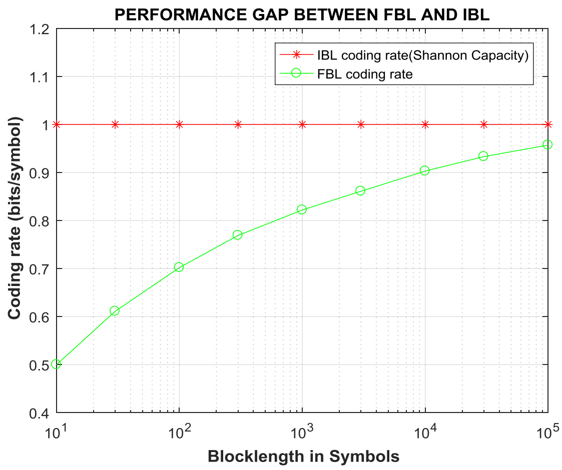

Fig. 1. Performance Gap between FBL and IBL regime for single hop system

The error probability obtained from equation (1) can be expressed as

$$\varepsilon = P(\gamma, r, m) = Q\{\log(1+\gamma) + (\log m / m) + (o(1)/m) - r) / (\log_e \sqrt{\gamma(\gamma+2)/(\gamma+1)^2 m}\ )\} \quad (2)$$

The FBL coding rate calculated as per equation (1) by considering error probability as 10^{-4} is shown in Fig-1. As indicated, a significant deviation is observed between the two performance models which is a clear indication that the Shannon capacity is not accurate for URLLC systems.

Based on the above results, it can also be illustrated that in case of FBL, the achievable coding rate is directly proportional to block length and can increase with increase in code block length. However the performance degrades and the gap becomes more significant for short block lengths. The most important issue which needs attention here is the gap in performance between the IBL achievable rate and FBL achievable rate. This result has opened several questions regarding the performance and utility of relays in the 5G URLLC network with FBL which motivated us to analyse the performance of these Relays with a objective to measure their contribution for the design of 5G URLLC network.

Therefore the objective of this paper is to find out whether relaying is still a promising approach for 5G URLLC scenario or not. Here we tried to find out the performance parameters like throughput, error etc for different scenarios like without relay, with relay and with cooperative relaying in the FBL regime. Effect of coding rate, Block length and power on the performance is also analyzed. We also tried to optimize the power of single hop DF relay using optimization algorithms like MOPSO and IDEA to conclude the performance enhancement in comparison with the un-optimized results.

II. SYSTEM MODEL

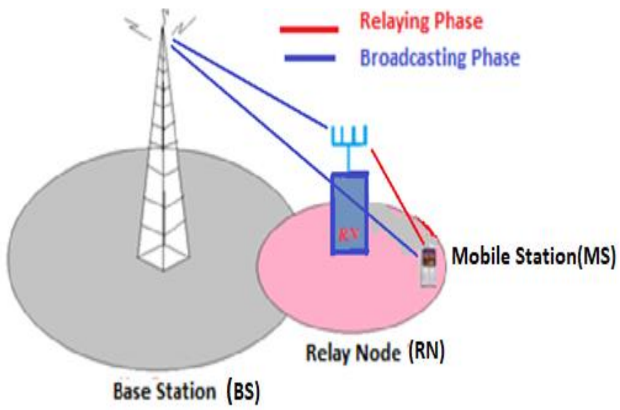

Fig. 2. Deployment of Relay node.

A simple relaying scenario is considered with a Base Station (BS), a Mobile Station (MS), and a Relay node (RN) as shown in Fig. 2. The relay is assumed to be a Decode and forward (DF) relay. The link between BS to MS is referred to as the direct link, the link between BS and RN is called the backhaul link and the link between RN to MS is termed as relaying link. For the operation of the system, each frame is assumed to be of length m (symbols) which means for each frame the code block length is equal to the frame length m.

For transmission of data from BS to MS, there can be three different scenarios. First, BS transmits data to the MS using direct link. In second case BS transmits data to the RN using Backhaul link and if the data is decoded by the RN correctly, it is then forwarded to the destination using relaying link during subsequent relaying frame. In the third case for data transmission from BS to MS, a broadcasting phase followed by a relaying phase is employed. During the broadcasting phase, data is transmited to the MS by BS using direct link and simultaneously to the RN using Backhaul link. If RN decodes the data correctly, it is then forwarded to the MS during the next relaying phase.

A Gaussian channel is considered here with static channel gains h_1, h_2, and h_3 representing the channels (scalars) of the direct link, backhaul link and relaying link respectively with the corresponding noise vectors denoted by n_1, n_2, and n_3. These noise vectors are identically distributed, independent Gaussian vectors: $n \sim N(0, \sigma^2 I_m)$, $n \in \{n_1, n_2, n_3\}$, where I_m denotes identity matrix of size $m \times m$. Further P_t represent the transmit power of the BS and RN. Thus when no relay is involved, the received signal at the destination can be denoted as $y_1 = h_1 x + n_1$ and the received SNR at the MS is given by $\gamma_1 = h_1^{2} \cdot P_t / \sigma^2$.

For the second case the received signals at the relay after first frame is given by $y_2 = h_2 x + n_2$. Next, if the relay forwards the data after decoding it correctly, the signal which is received by MS during the subsequent relaying frame is given by $y_3 = h_3 x + n_3$. As for as the third case is concerned, data received by both RN and MS simultaneously during broadcasting frame are given by $y_2 = h_2 x + n_2$ and $y_1 = h_1 x + n_1$ respectively.

Further, the data received at MS in the relaying frame subject to forwarding it by the RN after decoding it correctly is given by $y_3 = h_3x + n_3$.

As we have applied maximum ratio combining at the MS for this case, the channel gain for this case is given by $h_1^2 + h_3^2$. Thus at the destination the received SNR for this case can be $\gamma_{M=}$ $(h_1^2 + h_3^2)$ Pt/ σ^2. For all the above cases the transmitted and received signals are real m-dimensional vectors. Also a perfect CSI is considered both at the source and at the receiver.

It is assumed that both the RN and the MS detect the errors reliably as and when it occurs because in FBL regime, there is every possibility of occurrence of decoding errors. Basing considering the protocol that the RN never forwards the block to the MS when there is an error and transmits the information effectively when there is no error, the transmitted information becomes zero ($s=0$) for the first case and is equal to $s = m\cdot r$ for the second case . Hence the BL-capacity (CBL) of two-phase relaying, which is nothing but the average of effectively transmitted information per channel can be calculated as $E[S]/2m$ which is equal to $0.5(1- \varepsilon_T)$ r . Here $E[S]$ is the mean of effective information which is transmitted for both frames.

III. PERFORMANCE ANALYSIS OF FB RELAYING

For real additive white gaussian noise channel with channel gain h^2, rate of coding r, length of code Block m, decoding error probability ε the results in equation (1) and (2) can be formulated as [9]

$$r = R(h^2, \varepsilon, m) = C(h^2)\text{-}\sqrt{\frac{\left(1-2^{-4C(h^2)}\right)}{2m}}\,Q^{-1}(\epsilon)\log_2 e \quad (3)$$

where $C(h^2)= (1/2) \log_2 (1+ h^2 P_t/ \sigma^2)$ is Shannon capacity of a channel with gain h^2

Error probability at receiver is expressed as

$$\varepsilon = P^e(h^2, r, m) = Q[(C(h^2) - r)/(\log_2 e\sqrt{\frac{\left(1-2^{-4C(h^2)}\right)}{2m}}]$$

(4)

Equations (3) and (4) are now modified for the three different scenarios as mentioned above. For all the cases coding rate for different links are considered to be same.

A. Direct link between BS and MS

For the case where no relay is involved and $y_1 = h_1x + n_1$ with channel gain is h_1, the coding rate r and error probability ε the equation in *(3)* and *(4)* can be formulated as

$$r = R({h_1}^2, \varepsilon, m) = C({h_1}^2)\text{-}\sqrt{\frac{\left(1-2^{-4C({h_1}^2)}\right)}{2m}}\,Q^{-1}(\epsilon)\log_2 e \quad (5)$$

$$\mathcal{E} = P^e({h_1}^2, r, m) =$$

$$Q[(C({h_1}^2) - r)/(log_2 e\sqrt{\left(1-2^{-4C({h_1}^2)}\right)\frac{1}{2m}}] \quad (6)$$

B. Simple Relaying between BS and MS with single Relay node RN

As mentioned above the received signal at the relay after first frame is given by $y_2 = h_2x + n_2$. The data is then forwarded by the relay in the substituent relaying frame after decoding it correctly .Thus the received signal at the destination is given by $y_3 = h_3x + n_3$. Let us consider the decoding probabilities of error for direct link, backhaul link and relay link as $\varepsilon_1, \varepsilon_2, \varepsilon_3$ respectively. On the basis of CSI, the coding rate of both the links and particularly the bottleneck link of the system is determined by the source, which is assumed to be either the relay link or the backhaul link.

The overall error probability $\mathcal{E}_T$ of the two-hop relaying is equal to the probability obtained after considering the following two events "an error occurs at the relay" and "an error occurs at the destination". This leads to the proposition that ε_T of two hop relaying is the sum of probabilities when errors occur in the backhaul link and in the relay link. Hence the overall error probability from source to destination will

$$\mathcal{E}_T = \varepsilon_2 + (1 - \varepsilon_2)\varepsilon_3 \quad (7)$$

By replacing ε_2 and ε_3, Eq-7 can also be written as below

$$\mathcal{E}_T = P^e(h_2^2, r, m) + [1- P^e(h_2^2, r, m)]\, P^e(h_3^2, r, m) \quad (8)$$

The bottleneck link can be either the relaying link or the backhaul link. Thus the probability of error for the bottleneck link (ε_x) is equal to the maximum value among ε_2, ε_3 which means $\varepsilon_x = max\{\varepsilon_2, \varepsilon_3\}$.

Thus for the given error probability the coding rate found out by the source based on Equation (3) given by

$$r = R(\min\{h_2^2, h_3^2\}, \mathcal{E}_x, m) \quad (9)$$

C. Relaying between BS and MS with single RN using cooperative diversity

Considering the coding rate of different links to be r, the decoding probability of error at the RN is given by $\mathcal{E}_2 = P_e(h_2^2, r, m)$, where as at the MS, considering maximum ratio combining it is given by $\mathcal{E}_m = P_e(h_1^2 + h_3^2, r, m)$.

Considering CSI, the rate of coding of either the backhaul link or the combined link can be determined by the source. Thus the overall error probability ε_T of two hop relaying is the sum of probabilities when errors occur in the backhaul link and in the combined link as explained in the previous case with the condition that an error occurs at the RN and also it occurs at the MS after MRC. Therefore, the overall error probability ε_T for this case is equal to

$$\varepsilon_T = \varepsilon_2 + (1 - \varepsilon_2)\varepsilon_m \quad (10)$$

So the error probability (overall) depends upon error probability of all 3 links especially error probability of back haul link and combined link. However as the error probability of individual links depend upon the coding rate; the overall error probability depends upon the rate of coding as well. But as the rate of coding is obtained by the channel condition, it varies depending upon whether the channel gain of back haul link is higher or overall links are higher after MRC. Using the above stated conditions the coding rate of two hop relaying using cooperative diversity can be stated as below.

$$r = R(\min\{h_2^2, h_2^2 + h_3^2\}, \max\{\mathcal{E}_2, \mathcal{E}_m\}, m) \quad (11)$$

IV. NUMARICAL RESULTS AND DISCUSSION

Numerical results obtained by simulation are presented here. The relaying performance (coding rate) with finite block length is obtained for the above said cases by varying the error probability for different block lengths.

In the simulation an outdoor urban scenario with static channels in addition to the well known COST231 [10] model is considered. The parameters considered for simulation are shown in the table below.

Table -1: Simulation Parameters

Parameter	Value
Path loss model used	COST 231
Noise power (dBm)	-95
Trans power, P_t (dBm)	22
Backhaul link (mtr)	200
Direct link (mtr)	350
Relay link (mtr)	200
Centre frequency for Pathloss calculation(GHz)	2

Comparison between coding rate against overall error capability for three different scenarios that is for direct transmission, using simple relaying and using cooperative relaying is shown in Fig.3. First of all it is observed that relay improves performance in comparison to direct transmission irrespective of Block length which clearly indicates that it can still be a promising technology for design of next generation wireless standards. It can be observed that the coding rates Vs overall error probability plots are quasi concave although the channels are static. It is quite different from Shannon capacity where the coding rate is constant against overall error probability for static channels. It can also be seen that cooperative relaying offers better throughput in comparison to direct transmission or simple relaying under URLLC regime. This is another important observation which may be beneficial for 5th Generation wireless communication networks where attenuation is very high and path loss is more. Further we may observe from the graph that the variation of coding rate against overall error probability is large for short coding lengths in comparison to relatively larger coding lengths. Thus it becomes more essential to optimize shorter block length systems. Also the coding rate becomes maximum at different error probabilities for different block lengths which clearly indicate that optimization of coding rate can be influenced by code block length.

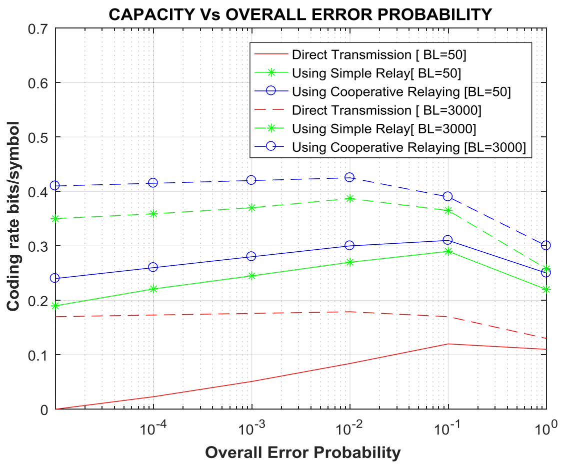

Fig. 3 Relationship between coding rate and over all error capability

V. PERFORMANCE OPTIMIZATION OF RELAY NODE

In the previous cases, we have assumed equal power distribution between Base station and Relay node. We now try to analyze the impact of power distribution between BS and RN on the performance. To achieve this objective performance parameters are found out by varying the power distribution between BS and RN. Evolutionary algorithms like MOPSO and IDEA are used for the purpose.

To optimize the design of Relay node by minimizing the error probability and code block length while maximizing the coding rate is indeed a difficult task.Thus evolutionary algorithms like IDEA and MOPSO are used for this purpose [11]-[12]. These algorithms are used for optimization of power distribution between BS and RN for finding out the optimum value of design parameters [13].

A. Design using multi-objective evolutionary algorithms

Let us consider relay with cooperative diversity. Let the transmit power levels at source and relay are denoted by P_1 and P_2 respectively, so that $P_t=P_1+P_2$. Thus, the received SNR at the destination for this case is given by $\gamma_{M}= (h_1^2 P_1+ h_3^2 P_2)/ \sigma^2$.

The multi-objective optimization issue can be stated as

$$\left.\begin{array}{l} \text{Minimize error probability } (\varepsilon) \text{ and} \\ \text{Maximize coding rate (r)} \\ \text{Subject to} \quad m= m_{specification} \\ \quad (P_2/P_t)_{min} < P_2/P_t < (P_2/P_t)_{max} \end{array}\right\} \quad (12)$$

where the expressions for r and ε are taken from equation (10) and (11) respectively ($(P_2/P_t)_{min}$ and $(P_2/P_t)_{max}$ are the ratio of power allocated to RN in comparison to total power and are limited by lower and upper boundary respectively.

Constraints:Performance Constraints (PC) : For this design, the Code Block length is kept at 50, i.e. the constraint is $m_{specified}$ =50.

Geometric Constraints (GC):
The power distribution between nodes are shared such that,
$0 < P_2/P_t < 1$.

$(P_2/P_t)_{min} = 0$ when BS is allocated with the entire power P_t
$(P_2/P_t)_{max} = 1$ when RN gets half of the total power P_t

B. Algorithm for Multi-Objective Particle Swarm Optimization (MOPSO)

For implementing MOPSO, [11, 13] N particles are considered as denoted by $\mathbf{x}i$, for i =1, 2, . . . , N .Each particle in the search space is indicated by its position.
The position of each particle $\mathbf{x}i = (x^1_i, x^2_i. . . x^n_i)$ indicated in search space depends on its previous global best position (G_{best}) and local best position (P_{best}) .

For each particle velocity can be calculated using the following equation

$$V_i=k_wV_i+ R_1(P_{besti}-P_i)+ R_2(G_{best}-P_i). \quad (13)$$

where P_i is the current position and V_i is the current velocity of the i_{th} particle. k_w is an inertia weight which is taken to be 0.4, R_1 and R_2 are chosen to be two random numbers whose values vary between 0 and 1, P_{besti} and G_{best} are the personal best of i_{th} particle and global best among the best solutions respectively.
The velocity obtained from the equation (13) is then used to calculate the new position of the i_{th} particle as below

$$P_i=P_i+V_i. \quad (14)$$

Algorithm 1: optimization of performance for Relay using MOPSO
Input: Objective functions $f(x)$ = [error probability ε , coding rate r] , design variable and constraint function is set to be $x = P_2/P_t$
Specify limits for boundary P_2/P_t [$0 < P_2/P_t < 1$].
Output: design solution x_{opt} optimization
1: **Initialize** each particle's velocities, the population (N) and total number of Loops(M).
2: In population for every particle
Evaluate *objective functions(OF)* = [*error probability* ε , *coding rate r*]
3: Update P_{best} of each particle.
4: In the repository REP, position of the non-dominated particles are saved.
5: **for** i= 1 to M **do**
6: **for** every particle j **do**
7: Using equation (13) and (14) update the particle position and velocity.
8: Within the search space maintain the particle's new position.
9: **end for**
10: For each particles in the population
Evaluate *f(x)*
11: Update P_{best} of every particle
12: Save in REP, after selection the non-dominated particle's position.
13: From the non-dominated particles select G_{best} randomly
14: **end for**

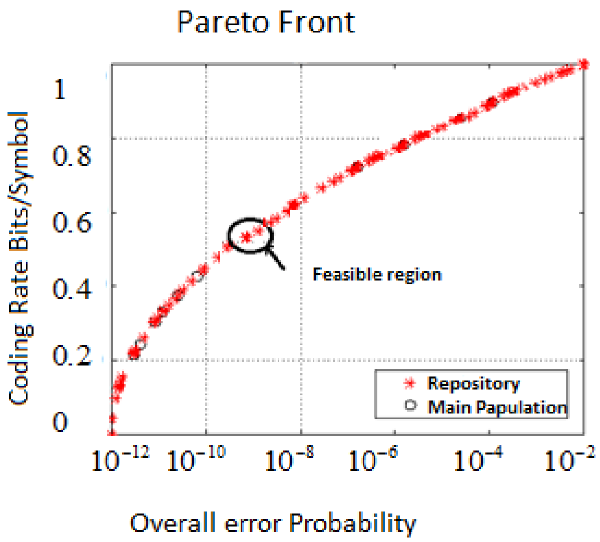

Fig. 4 Resultant Pareto frontiers using MOPSO

The Pareto front obtained for the Relay network generated with the use of MOPSO algorithm is indicated in Fig.4. It can be seen from the figure that the error probability varies inversely with coding rate. For the Relay design the region of feasibility is indicated on the figure where error probability and code block length are optimized. From graph it is observed that for error probability ranging from 10^{-10} to 10^{-8} code rates varies in the range of 0.5 to 0.58 bits/symbol. It is found that in the feasible region $P_2/P_t = 0.78$. Thus when 78% of the total transmitted power is allocated to RN and 22% is allocated to BS optimum results are obtained.

C. Infeasibility Driven Evolutionary Algorithm (IDEA)

For confirmation of the results obtained using MOPSO, another optimization technique, IDEA is implemented. IDEA is an evolutionary optimization algorithm involving multiple objectives [12]-[13] where in the solutions are found out using the problem definition as stated below and the solutions that are infeasible are indentified in the population. The solutions in the child and parent population are separated into an infeasible set (S_{inf}) and feasible set (S_f) after child population is generated from parent. With the help of non-dominated sorting and crowding distance, the solutions of both sets are ranked individually. In this algorithm a parameter α, defined by the user is used for determining the number of feasible (N_f) and infeasible (N_{inf}).solutions.

The problem definition can be formulated as

$$\left.\begin{array}{l} \text{Maximize coding rate (r) and} \\ \text{Minimize error probability (} \varepsilon \text{)} \\ \text{Subject to } m= m_{specification} \text{ and} \\ (P_2/P_t)_{min} < P_2/P_t < (P_2/P_t)_{max} \end{array}\right\} \quad (13)$$

where the expressions are shown in the equation (10) and (11) respectively. ($P_2/P_t)_{min}$ and $(P_2/P_t)_{max}$ are the ratio of power allocated to RN in comparison to total power limited to by lower and upper boundary respectively.

Algorithm 2: IDEA to optimize the performance of Relay Node

Input: Objective functions $f(x)$ = [coding rate r, error probability ε], constraint functions and design variable is set to be $x = P_2/P_t$.

Specify limits of the boundaries [$0 < P_2/P_t < 1$] and code block length $m_{specification}$ =50

Output: Optimized solution x_{opt} for design parameters

Set: Size of the population: N and Number of Generations: $N_G > 1$

Set: Part of infeasible solutions α between 0 and 1such that $0 < \alpha < 1$

1: Number of infeasible solutions, $N_{inf}=\alpha * N$

2: Number of feasible solutions, $N_f = N - N_{inf}$

3:***While*** *PC* = [(P_2/P_t)$_{min}$ < P_2/P_t < $(P_2/P_t)_{max}$, $\varepsilon_{min} < \varepsilon < \varepsilon_{max}$] ***do***

4: pop_1= Initialize ( ) depending upon *PC.*

5: Compute

OF = [coding rate r (pop1), error probability (pop1)]

6: **For** $i = 2$ to N_G **do**

7: $childpop_{i-1}$ = Develop (pop_{i-1})

8: Compute [$r\ (childpop_{i-1})$, $m\ (childpop_{i-1})$]

9: Evaluate $Diff = |m - m_{specification}|$

10: If $Diff \leq €$ then S_f

else S_{inf}

end if;

11: (S_f, S_{inf}) = Split (pop_{i-1} + $childpop_{i-1}$)

12: Rank (S_f)

13: Rank (S_{inf})

14: $pop_i = S_{inf}(1 : N_{inf}) + S_f(1 : N_f)$

15: **end for**

16: **end while.**

Table -2 Different Control parameters considered for IDEA

Parameter	Value
Generations (iterations)	500
Population size	200
Probability of Crossover Probability of Mutation	0.8 0.2
Index of Crossover	10
Index of Mutation	17

After implementation of IDEA algorithm, the convergence to a near value is achieved much ahead of the generations = 500 as indicated in Fig.5. It further shows that the algorithm converges at 0.59 bits/symbol. It is clear from the evolution process that the mean fitness level reduces exponentially before being converged to an optimum value.

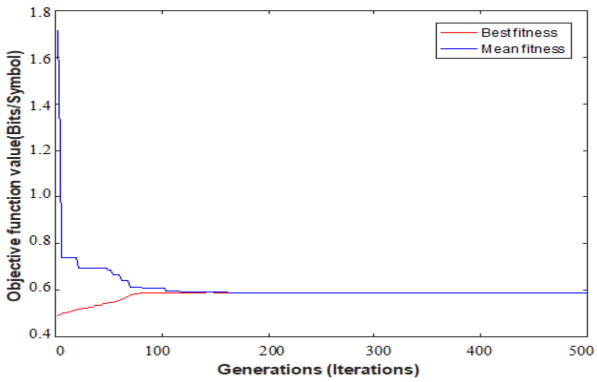

Fig. 5 Convergence plot of IDEA for Relay optimization

This result has also shown improvement in comparison to the analytical result obtained in [12] regarding optimum allocation of power for maximizing the performance parameters.

VI. CONCLUSION

In this article, we have analysed the performance of relays used for 5th Generation mobile networks under the finite bock length regime. Despite division of the block length, a significant improvement in the performance of Relays operating with short block length codes are noticed. The coding rate and overall error probability of the Relays are derived for different scenarios. In comparison to direct transmission and simple relaying, cooperative relaying has shown performance improvement, which can be utilized very well in future generation wireless networks. Then for relay-enabled URLLC networks, optimization techniques were presented. Optimization of the coding rate and the error probability of the system by efficient allocation of power between BS and RN using evolutionary algorithms like MOPSO and IDEA were analysed. It was observed that by choosing proper allocation of power between BS and RN optimum performance can be achieved. Hence it can be concluded that Relaying has performance advantage in FBL regime as well and thus can be a potential candidate for the design of 5th Generation wireless networks .

In this paper performance of relaying was analyzed using a simple system model. However this can be further extended to URLLC networks in presence of real and practical constraints where relaying transmission involves more than two hops. Design of URLLC nodes with EH (energy harvesting) to optimize simultaneous transmission of data and power can also be an added research direction in this regard.

REFERENCES

1. Sami Baroudi, Yousef, R Shayan "Performance enhancement of muitihop wireless systems by optimizing the number and location of relays ", ISBN:978-1-4799-5344-8/15, IEEE 2015, Pages 465-468.
2. S. Karmakar and M. Varanasi, " The Diversity-Multiplexing Trade-Off of the Dynamic Decode- and- Forward Protocol on a MIMO Half-Duplex Relay Channel," *IEEE Trans. Info. Theory*, vol. 57, no. 10, Oct. 2011, pp. 6569–90.

3. Y. Hu, J. Gross, and A. Schmeink, " QoS-Constrained energy efficiency of cooperative ARQ in multiple DF relay systems," *IEEE Trans. Veh. Technology*., vol. 65, no. 2, pp. 848–859, Feb. 2016.
4. M. Bhatnagar, "On the capacity of decode-and-forward relaying over Rician fading channels," *IEEE Commun. Letters*, vol. 17, no. 6, pp. 1100–1103, Jun. 2013.
5. M. Simsek *et al.*, "5G-Enabled Tactile Internet," *IEEE JSAC*, vol. 34, no.3, Mar. 2016, pp. 460–73
6. Y. Polyanskiy, H. Poor, and S. Verdu, "Channel Coding Rate in the Finite Blocklength Regime," *IEEE Trans. Info. Theory*, vol. 56, no. 5, May 2010, pp. 2307–59.
7. V. Y. F. Tan and M. Tomamichel, "The Third-Order Term in the Normal Approximation for the AWGN Channel," *IEEE Trans. Info. Theory*, vol. 61, no. 5, May 2015, pp. 2430–38.
8. G. Ozcan and M. C. Gursoy, "Throughput of Cognitive Radio Systems with Finite Block length Codes," *IEEE JSAC*, vol. 31, no. 11, Nov. 2013, pp. 2541–54.
9. Yulin Hu , "On the capacity of Relaying with Finite Block length ," IEEE *Trans. Veh. Technol.*, vol. 65, no. 3, pp. 1790-1794, Mar. 2016.
10. K.Deb. 'Multi-objective optimization using evolutionary algorithms' New York: Wiley. 2001.
11. H. K. Singh, A. Isaacs, T. T. Nguyen, T. Ray, and X. Yao. "Performance of infeasibility driven evolutionary algorithm (IDEA) on constrained dynamic single objective optimization problems" in IEEE Congress on Evolutionary Computation. IEEE 2009: 3127-3134
12. Yulin Hu, M C Gursoy and A Schimeink ,"Optimal power allocation for Amplify and Forward Relaying with Finite Blocklength codes and QoS Constraints," IEEE,2018, 978-1-5386-6355-4/18.
13. Panda M, Patnaik S K, Mal A K, " Performance enhancement of a VCO using symbolic modelling and optimization ", IET Circuits, Devices & Systems, 2018, 12, (2), pp. 196 –202.

AUTHORS PROFILE

Saraju Prasad padhy obtained his Master in Engineering degree from BIT, Mesra, India with a specialization in Microwave Systems. He has more than 22 years of Industrial experience in the field Telecommunication and IT both in India and abroad. He worked in different wireless communication technologies starting from CDMA, GSM to Wi-MAX and LTE Advanced. He also worked in different digital switching systems starting from TDM switchs to Soft switches. His subject interests include communications, signal processing and wireless communication networks. He is presently perusing Ph.D. in the field of wireless communication. He has already published a paper on traffic analysis and optimization of Mobile Network in a reputed journal.

Madhusmita Panda obtained her MTech from BPUT, Rourkela, India in electronics and communication engineering with a specialization in Microelectronics and VLSI design. She has published more than 10 papers in different national and international journals and conferences. She has academic experience of about 15 years during which she taught several subjects to both UG and PG students. Her subject interests include Semiconductor devices and circuits. Presently, she is serving as an Assistant Professor in the department of Electronics and Communication Engineering at ITER (Institute of Technical Education and Research) under SOA University, Bhubaneswar in addition to perusing her Ph.D. in the field of Microelectronics and VLSI Design at NIT, Durgapur.

Srinivas Sethi obtained his Ph.D. from Berhampur University, Berhampur, India in the field of Computer Science. He has published about 60 papers in different national and international conferences and journals. He also authored three text books apart from successfully supervising 5 Ph.D. scholars and 15 masters degree students. He was involved with more than 35 International/ National Level Conferences/Seminars /Workshops in the capacity of Special session Chair /Coordinator/Technical Committee Member/ Advisor Committee Member. He also organized 5 State Level Conferences / Seminars /Workshops and delivered more than 50 Invited Lectures at International/National/University level Conferences/Seminars.Presently he is working as a Professor in the Department of Computer Science Engineering & Applications, Gandhi Institute of Technology, Sarang, Odisha, India.

Aruna Tripathy obtained her Ph.D. from IIT, Kharagpur, India with a specialization in Wireless communications. She has published about 40 papers in different national and international conferences and journals. She has both industrial and academic experience of about 25 years. She taught several subjects to both UG and PG students She also authored a text book "Optoelectronics and Systems" published by Studium Press (Int). About 33 master's theses have been supervised by her. Her subject interests include communications, signal processing and photonics. Presently, she is serving as the head of the department of Instrumentation and Electronics Engineering at college of Engineering and Technology (CET), Bhubaneswar.