Optimized Relay Node Deployment and Resource Allocation in LTE-Advanced Relay Networks

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Abstract

In LTE-Advanced (LTE-A) networks, Relay nodes (RN) are used to improve the system coverage. However, it also brings new kind of interference to users which reduces the system performance. In this paper, we use an optimization relay node deployment to reduce the interference as much as possible and resource allocation to improve the user throughput. Our simulation results show our method is able to improve the user SINR and throughput.

1. Introduction

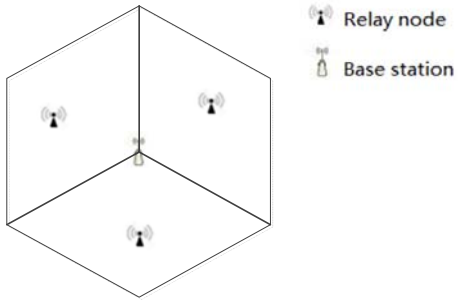
In LTE-A relay networks, the interferences from inter-cell and intra-cell limited the system performance. Because the interference is depending on the amount of the interference sites and distances between the interference sites and user. However, the interference sites are relay node in LTE-A relay networks, when we have less interference sites, the interferences will be reduced, but also the system performance, so if we can use less relay nodes and use other method to offset the system performance the bottleneck will be solved.

In a three sectors cell, two relays in each sector are enough to improve the cell throughput and make a good system performance for user communication [1]. In [2][3], the different kinds of relay nodes are assumed to be deployed around the base station to improve the system performance and reduce interference: sharing relay node, different kinds of antenna relay node and so on. In LTE-Advanced relay networks, the interference problem has been a hot study, and many researcher have tried to solve this problem [4]-[6]. However, all of these methods have different kinds of resource wasting and some of them bring new kinds of interferences users, so it is very hard to find a method have both effective resource allocation and high users SINR.

In this paper, we proposed a optimized relay nodes deployment to reduce the interferences as far as possible and a resource allocation method to offset the system performance.

2.Optimizations RN deployment and resource allocation

A.Optimization of relay nodes deployment



Figre 1. System structure

We divide each cell into 3 sectors, and put several relay nodes in each sector. We will do a test to decide the number of relay nodes which deploy in the system. There are three links in the relay system: direct link, relay link and access link. When the UE communicate by the relay node, the SINR of UE cannot show the system performance completely, so we use the spectral efficiency as a judgment that can include the performance from relay link. The spectral efficiency(η) of each link can calculate by Shannon's formula [1],

$$\eta = b_{ef} \log_2(1+\frac{SINR}{SINR_{ef}}), \quad (1)$$

Where b_{ef} and $SINR_{ef}$ are t\he bandwidth efficiency and SINR efficiency. After we find the best position of relay nodes, we will calculate the SINR to decide the number of relay nodes in each sector, because the resource allocation in the next step is related to the SINR.

B.Resource allocation

After deciding the best position and number of RN nodes in each sector, we use a resource allocation base on the SINR of users. The base method of this method is to recover the inefficiency resource and reassignment them to the users which can improve the performance by using there resource. The flow chart of resource allocation method is showed in Figure 2.

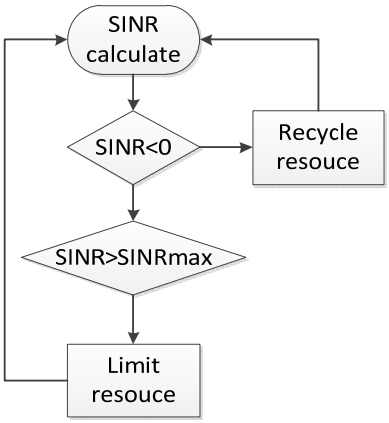


Figure 2. Resource allocation method

The algorithm of resource allocation scheme is showed below,

$$r = \frac{u}{U} R, \quad (2)$$

Where r is the number of resources which assigned to a relay node, R is the total number of resources, u is the numbers of relay users attached to this relay node, U is the total numbers of users.

3. Performance evaluation and analysis

A. Optimized relay nodes deployment

We use (1) to calculate the best relay node position, in order to show the result we draw one of the three sectors as Fig.3, where a is the the angle between RN and sector boundary, r is the distance between RN to eNB, and d is the distance between eNB to sector boundary. We use the angle and distance to show the position.

First, we put just one relay node in each sector and calculate the SINR of users to verify the effect of this deployment algorithm, the position come out from (1) is a=35, r=0.82d, the CDF of users SINR is showed in Fig.4.

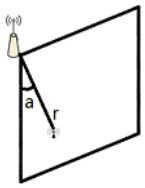


Figure 3. Relay node position

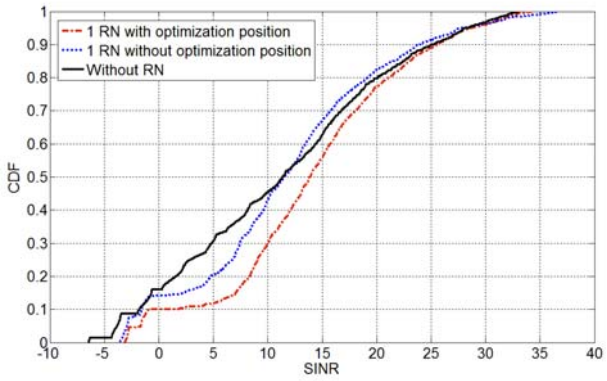


Figure 4. CDF of the SINR considering optimization relay node position

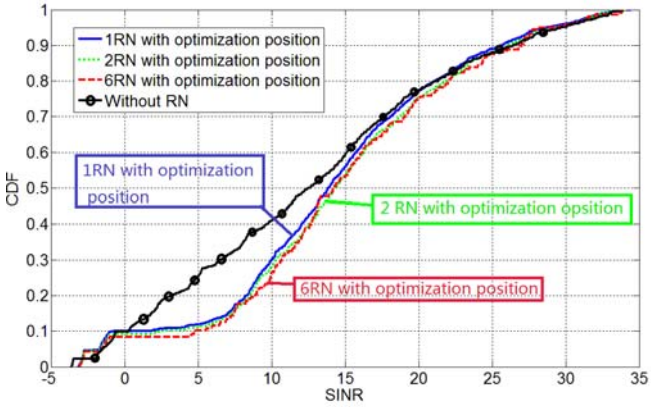


Figure 5. CDF of the SINR considering optimization relay node numbers

Fig. 4 shows the SINR for users with a optimization position in a ISD 500 m scenario. The horizontal axis shows

the users SINR, and the vertical axis shows the CDF of SINR. Results show that the optimization position algorithm has a significantly improvement.

Then we do a test to chose the number of relay nodes we put in each sector, from Fig.5 we can find that when we use the optimization relay node position, the system performance improvement is rarely by increasing the relay nodes in each sector, so we can get this conclusion one relay node in each sector is enough by using optimization relay node deployment.

B. Resource allocation

Next, we add the resource allocation algorithm, Fig.6 shows the UE throughput considering resource allocation. We can find that when we use the resource allocation, the system performance when just put one relay node is even better than two relay nodes deployment without resource allocation. And when we add the relay nodes the system performance only improved a little, so it is not necessary to put too much relay nodes in this method, one relay node is enough.

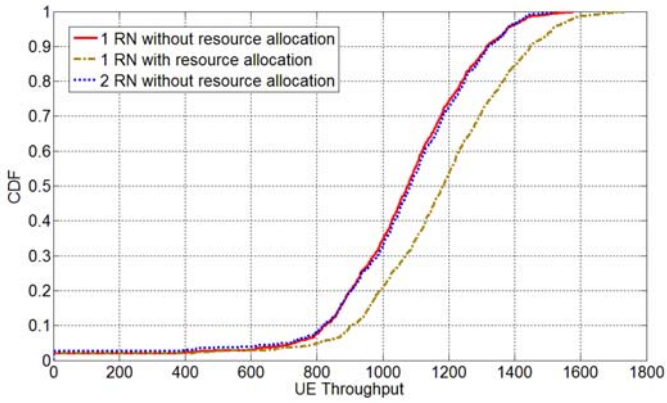


Figure 6. CDF of the UE throughput considering resource allocation

4. Conclusion

We proposed an optimization deployment of the relay node with resource allocation. This method reduce the requirement development cost, and it makes the system more efficient. The purpose of the simulation is to demonstrate the effect of resource allocation and the optimization deployment of the relay nodes. The UE SINR and UE throughput were significantly increased in this method. Because we configure only 1 relay nodes in each sector as 3 in each cell, this method has concentrated on the small and medium scale networks.

References

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