MACHINE LEARNING ASSISTED CELL ASSOCIATION FOR ULTRA-DENSE COMMUNICATION NETWORKS

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Introduction

- Ultra-dense communication networks form the 5G infrastructure. Our aim is finding the best solution for cell association with the help of SNR values. Our first solution is traditional brute force solution and second solution is Machine Learning solution.

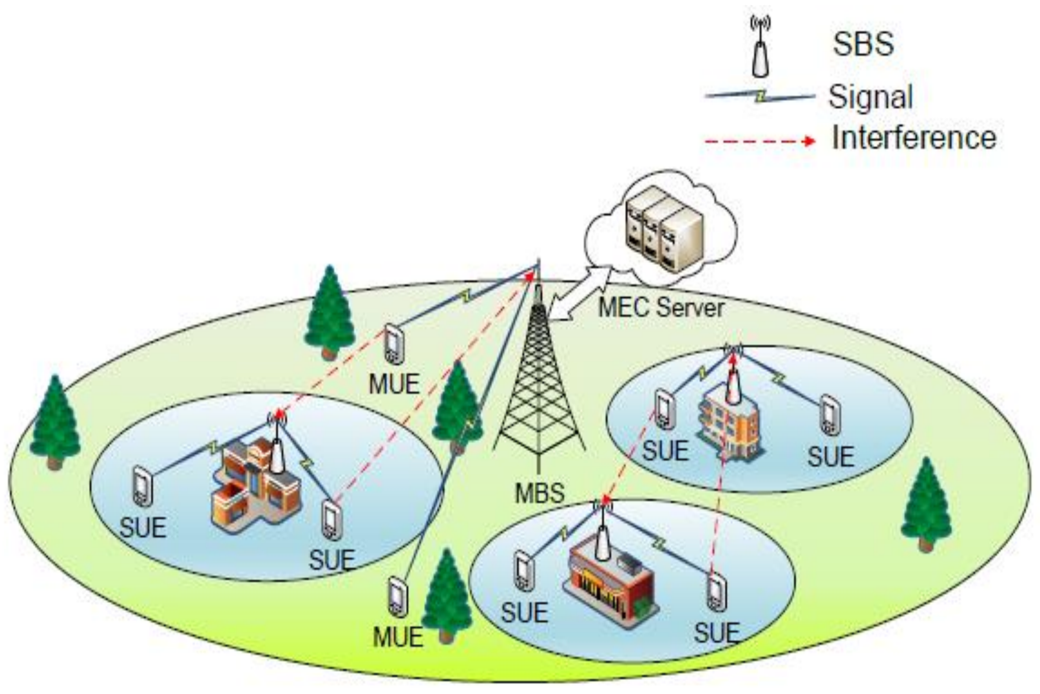

Figure 1. Ultra-Dense Heteregeneous Network Scenario

Specifications and Design Requirements

- Problem:

$$SNR_{i,1}=\frac{|h_{i,1}|^2 P_{B1}}{BN_0},\; SNR_{i,2}=\frac{|h_{i,2}|^2 P_{B2}}{BN_0},$$

$$\sum_{i=1}^{N}\left(x_{i,1}SNR_{i,1}+x_{i,2}SNR_{i,2}\right),$$

$$x_{i,k}\in\{0,1\}, \qquad \forall i,k,$$

$$\sum_{k=1}^{2} x_{i,k}\le 1, \qquad \forall i,$$

$$\sum_{i=1}^{N}\sum_{k=1}^{2} x_{i,k}\le N.$$

$$\sum_{i=1}^{N} x_{i,2}\left|h_{i,1}\right|^2 P_{UE}\le Q_1,$$

$$\sum_{i=1}^{N} x_{i,1}\left|h_{i,2}\right|^2 P_{UE}\le Q_2,$$

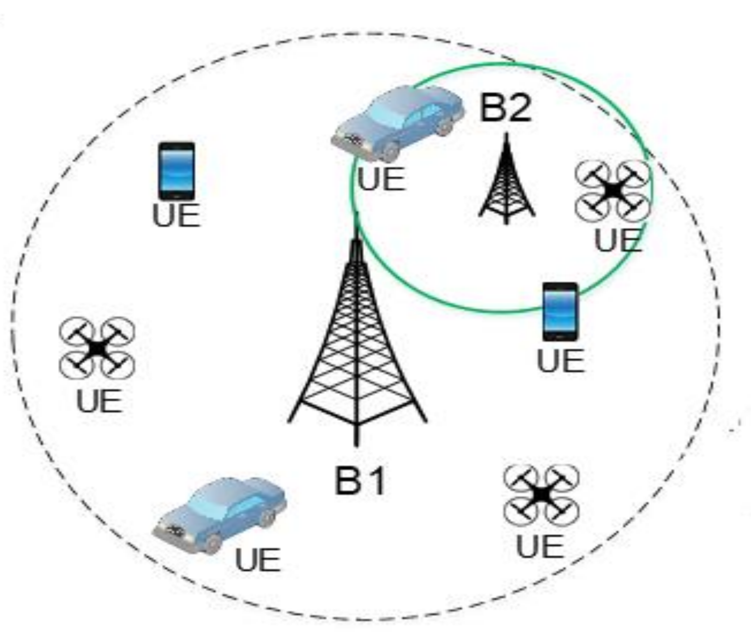

Figure 2. HetNet with 2 Base Stations and Multiple Users

Solution Methodology

❖ Our first approach is solving the optimization problem with brute force and finding the optimum connections with our heteregeneous network.

❖ Because of the slow performance of brute force, our second approach is creating a neural network and trying the solve the problem with machine learning.

Application Areas

❖ This project can be used for the help of power allocation in ultra-dense networks.

Results and Discussion

❖ The results in the figures obtained for 5 users. The exact solution for optimization problem with brute force is shown in Figure 3.(1’s represent connected, 0‘s represent not connected). The machine learning solution is shown in Figure 4 and the logical XNOR of these two matrices is shown in Figure 5.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	1	1	1	1	0	1	1	1	1	0
1	0	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1
3	1	0	1	1	1	0	1	1	1	1	1	0	1	0	1	0	1	0	1	1	1	1	0	1	0
4	1	0	0	1	1	0	0	0	1	1	1	0	1	1	0	1	0	1	1	1	1	1	0	1	1
5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0
9	0	1	1	0	0	1	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	0	0

Figure 3. Brute Force Solution

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1
1	0	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	0	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	0	0	0
4	1	1	1	1	1	0	1	0	1	1	0	1	1	0	0	1	1	1	1	1	1	1	0	1	1
5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Figure 4. Machine Learning Solution

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	True	True	True	True	True	True	True	True	True	False	True	True	True	True	True	True	True	True	True	False	True	True	True	True	False
1	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True
2	True	True	True	True	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True
3	True	False	True	True	True	False	True	True	True	True	True	False	True	True	True	True	True	False	True	True	True	True	True	False	True
4	True	False	False	True	True	True	False	True	True	True	False	False	True	False	True	True	False	True	True	True	True	True	True	True	True
5	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False	True	True	True	True	False	True	True	True	True	True
6	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False	True	True	True	True	True	True	True	True	True	True
7	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False	True	True	True
8	True	True	True	True	True	True	True	True	True	True	True	True	True	True	True	False	True	False	True	True	True	True	True	True	True
9	True	False	False	True	True	True	True	False	True	True	True	False	True	True	True	True	False	True	True	True	True	True	False	True	True

Figure 5. Comparing Matrix of 2 Solutions

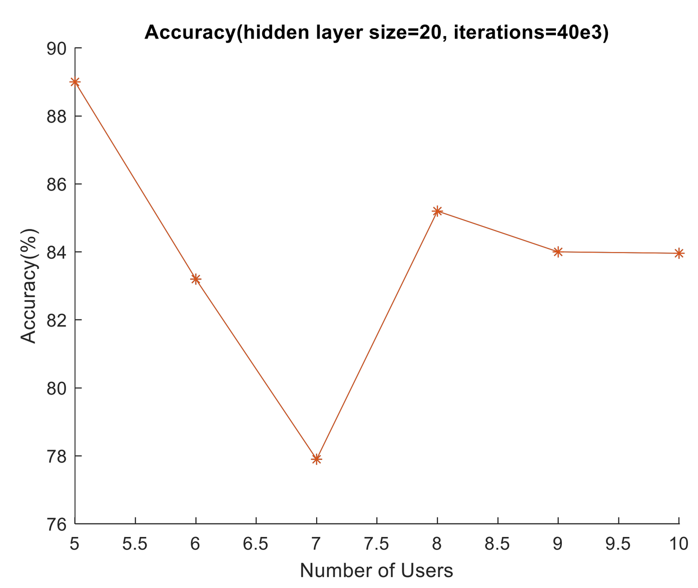

Figure 6. Accuracy with Different User Numbers

❖ As a result, we obtained the solution with two ways. Machine learning solution has accuracy about 85%-90% but it is much faster than brute force algorithm. If number of users are greater than 15, machine learning is the better solution and the difference of speeds is more with the increasing number of users. With brute force, only 1 output takes for 100 seconds for 10 users and with the machine learning it takes 5 seconds for 25 data examples.

❖ We achieved best results with one hidden layer for 5 to 10 users but different results can be obtained with different hidden layer numbers for more users.

References

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