

# Co-Primary Multi-Operator for Optimal Resources and Spectrum Sharing for Small Cell Networks

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**ABSTRACT:** To deal with the challenge of providing higher data rates within limited spectral resources, the case of multiple operators sharing a common pool of radio resources is considered. Three algorithms are proposed to address co-primary multi-operator radio resource sharing under heterogeneous traffic in both centralized and distributed scenarios. The performance of these algorithms is assessed through extensive system-level simulations for two indoor small cell layouts. It is assumed that the spectral allocations of the small cells are orthogonal to the macro network layer and thus only the small cell traffic is modeled. The main performance metrics are user throughput and the relative amount of shared spectral resources. The numerical results demonstrate the importance of coordination among co-primary operators for an optimal resource sharing. Also maximizing the spectrum sharing percentage generally improves the achievable throughput gains over non-sharing.

**KEYWORDS:** PRB-Physical Resource Block CQI-Channel Quality Informative CS-Capacity Source

## I. INTRODUCTION

Wireless cellular systems are experiencing a growth data rate demands from users and it is expected that this trend will continue to speed up in the near future. Even though the fourth generation (4G) is still in its infancy, yet growing rapidly, the interest has already moved toward fifth generation (5G) networks. The continuing growth in demand for better coverage and capacity enhancements is pushing the industry to look ahead at how networks can meet future extreme capacity and performance demands.

5G mobile communication systems are expected to revolutionize everything seen so far in wireless systems. The requirements for 5G vary by application but will include data rates ranging from very low sensor data to very high video content delivery, stringent low latency requirements, low energy consumption, and high reliability. All of these technological requirements are expected to be achieved while keeping similar or lower cost than today's technologies. 5G is likely to integrate enhancements in legacy radio access technologies with new developments in the areas of multiple access, waveform design, interference management, access protocols, network architecture and virtualization, massive MIMO, full-duplex radio technology.

## II. CQI MODELING

For each user the CQI is estimated from the received signal with SINR calculated for every PRB. when the SBS supports CoPSS users have to calculate CQI over the other operators bandwidth. Here user equipment is required to receive/request reference signals from the other operators SBS. In this case a user can only receive wide band reference signals from other OPs SBSs, because spectrum sharing is up to the user they may share are not the bandwidth. This means that a user can only estimate if there are other OPs' SBS is near by but they may not estimate the SINR accurately for each PRB when spectrum is shared. With accurate channel quality information (CQI) estimations, we propose three centralized algorithm for CoPSS. The proposed algorithms use

moderate amount of shared information among OPs/SBSs and they do not require long iterative information exchange processes. Backhaul links between SBs or connections to the central controller .

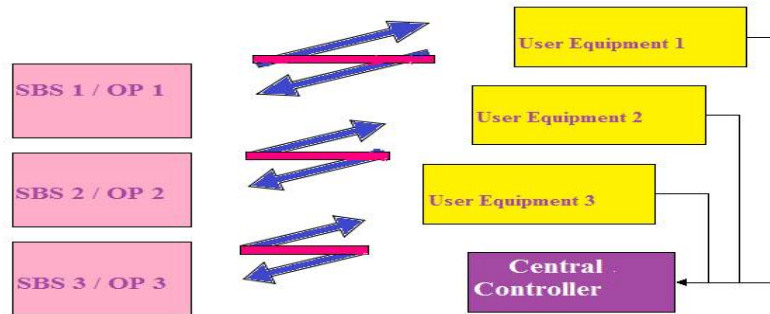


Fig. 1 CQI Modeling of with and without sharing of Ops

The central controller has the responsibility to control the entire network. In a randomly deployed network, there can be large number of users collecting information from sensor nodes. As a different scenario, here we use small cell base station network. The main objective of our paper is the usage of minimum bandwidth also to increase the capacity of small cell networks.

All the data's sensed are recorded and controlled by the base station. The users communicate with the corresponding small base stations with different levels of packet rate to ensure the use of bandwidth efficiency. The packet rate differs with 25%, 50%, 75% of data transmission to determine the bandwidth efficiency.

### III. COPSS ALGORITHM

- To minimize signaling overhead, in this work it is assumed that each SBS/OP starts allocating PRBs from the beginning or from the end of its bandwidth.
- Arbitrary allocations could require detailed resource allocation information exchange, significantly increasing the signaling overhead.
- The three types of algorithm for spectrum sharing are
  - i) random sharing
  - ii) equal sharing
  - iii) connection based sharing.

### IV. MATHEMATIC EXTRACTATION FOR CQI AND COPSS

It is assumed that the SBSs communicate with each other if the distance is less than or equal to 50 meters. Let  $G_l = (V_l, E_l)$  denote the graph, where  $l = [0, \dots, L]$  is the number of graph, the number of vertices in the graph (in this case SBSs) is  $V_l = \{V_0, \dots, V_n\}$  and the edges in the graph ( $v_i$  is connected to SBS  $v_j$ )  $E_l = \{(v_i, v_j)\}$ . Let  $K = \{1, \dots, K\}$  denotes the set of OPs. we define function of operators ( $\cdot$ ) which maps SBS  $v_i$  to respective operator, i.e.  $\forall v_i, \text{op}(v_i) \in K$ .

$$A_{ij} = \begin{cases} 1 & \text{if } \text{SBS}_i \leftrightarrow \text{SBS}_j \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Given that  $v_j$  is the selected SBS, the available free shared PRBs from OP  $k$  to any SBS  $v_j$  are given by:

$$w_{jk} = \begin{cases} \lfloor \min(W_k, S) \rfloor \times Q, & \text{if } v_j = v_{j'} \\ 0 & \text{otherwise,} \end{cases} \quad (2)$$

Therefore we define new set  $v_+ = \{v_i | BWU(v_i) = 1\}$  which includes all the overloaded SBSs. Here, free shared PRBs from OP  $k$  to SBS  $v_j$  are and the total amount of free PRBs for SBS  $v_j$  is  $\sum_{k \in K} w_{jk}$ .

$$w_{jk} = \begin{cases} \left\lfloor \frac{1}{|v_+|} \min(W_k, S) \right\rfloor \times Q, & \text{if } v_j = v_{j'} \\ 0 & \text{otherwise,} \end{cases} \quad (3)$$

We let  $N(v_i)$  denotes the set of neighbor vertices of  $v_i$  and from (4) we define two different sets,  $N_{ol}(v_i)$  for overloaded neighbors, and  $N_{nol}(v_i)$  for not overloaded neighbors,

$$\mathcal{N}(v_i) = \{v | v \in V_l, (v, v_i) \in E_l\}, \quad (4)$$

$$\mathcal{N}_{ol}(v_i) = \{v | v \in \mathcal{N}(v_i), BWU(v) = 1\}, \quad (5)$$

And

$$\mathcal{N}_{nol}(v_i) = \{v | v \in \mathcal{N}(v_i), BWU(v) < 1\}. \quad (6)$$

From (5), we define a set of OPs which are overloaded neighbors and rest of the OPs are not overloaded

$$\hat{\mathcal{K}}_i = \{OP(v) | OP(v) \in \mathcal{K}, v \in \mathcal{N}_{ol}\}, \quad (7)$$

$$\tilde{\mathcal{K}}_i = \mathcal{K} \setminus (\hat{\mathcal{K}}_i \cup \{OP(v_i)\}), \quad (8)$$

respectively. Now we can define free shared PRBs  $w_j$  from neighbors  $\sim Ki$  to SBS  $v_j$ ,

$$w_j = \sum_{\forall k \in \tilde{\mathcal{K}}_i} \left\lfloor \frac{\min \left( 1 - \max_{\substack{v \in \mathcal{N}_{nol}(v_i) \\ OP(v)=k}} (BWU(v)), S \right) \times Q}{|\hat{\mathcal{K}}_i \cup \{OP(v_i)\}|} \right\rfloor. \quad (9)$$

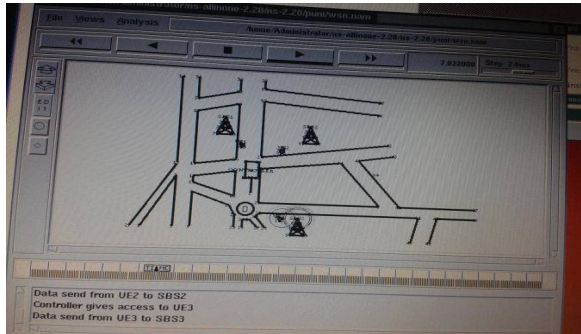
Now we can define free shared PRBs  $w_j$  from neighbors to SBS  $v_j$  as

$$w_j = \sum_{\forall k \in \tilde{\mathcal{K}}_i} \left\lfloor \frac{\min \left( 1 - \max_{\substack{v \in \mathcal{N}_{nol}(v_i) \\ OP(v)=k}} (BWU(v)), S \right) \times Q}{|\mathcal{N}_{ol}(v_i)| + 1} \right\rfloor. \quad (10)$$

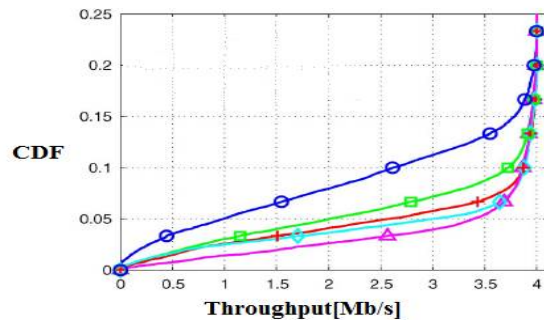
The round trip-delay in the coordination methods is 5 ms and it is assumed that each OP uses the same maximum allowed sharing percentage. 2 Backhaul links between SBSs or connections to the central controller are assumed to be ideal.

## V. EXPERIMENTAL RESULTS

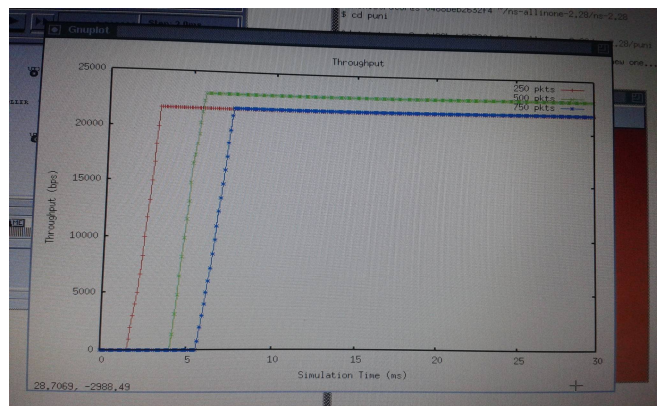
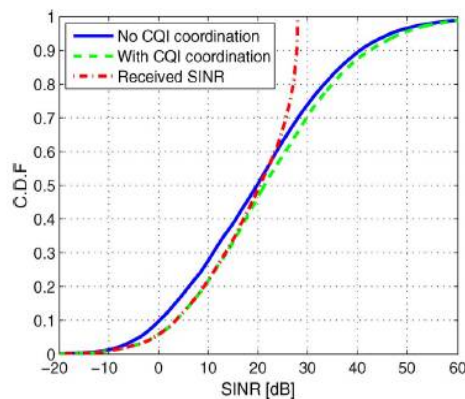
It shows the mean throughput of full buffer users for each CoPSS algorithm with sharing percentage from 0% to 100%. When the results are compared with the fixed layout results it can be clearly seen that the achieved rates are higher because users are now closer to SBS. When 0% of the bandwidth is shared mean throughput is 7.0 Mb/s.



**Fig.2** Central controller optimization of small base cell station **Fig.3** CDF of Multimedia Stream user throughput for Different COPSS algorithm in the random network layout



CQI Coordination for CoPSS cumulative distribution functions (CDFs) of SINR as estimated for the CQI with and without coordination, and as experienced at the receiver, when 50% bandwidth is shared. The SINR in the CQI and in the receiver is the mean SINR over the allocated PRBs. It is assumed that UE can report the PRB based CQI information and SBS then averages out the SINR with allocated PRBs and then selects one MCS level that is used for the transmission. The CDF shows that when the users are able to receive information about the bandwidth utilization of other SBSs/OPs in the vicinity SINR increases 3 dB (between 0 dB and 15 dB).



**Fig.4** UEs SINR with and without CQI coordination **Fig.5** Throughput and simulation time for packets and data sharing node and in the receiver when the fixed layout is used.

## VI. CONCLUSION

In this paper the results reveal the utmost importance of channel quality signaling among OPs to take full advantage of shared resources. It also shows that, the connection based centralized and distributed scenarios outperform simpler random and equal sharing schemes.

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