# A Novel Idea of Spectrum Management (SM) using Spectrum Load Balancing (SLB) Algorithm


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*Abstract*— **Next Generation Network (NGN) is troubled by the difficulty of growing demand for the spectrum, to resolve the problem, it is possible to find a more efficient way in using the existing spectrum bands and technologies. The radio spectrum can be expressed in three dimensions: frequency, space and time. If any one of these differs between transmitters, interference should not occur. At present, the spectrum sharing (SS) technology is gaining concentration and dissimilar strategies are being studied to allow different operators to share the spectrum in opportunistic way and at the same time gain higher spectrum efficiency. The intention of this paper is to equalize the total distribution of the allocated radio spectrum resources among more interfering devices that work in the same space. Mitigation of the destructive, mutual interference in the wireless network can be achieved with the application of the spectrum load balancing (SLB) algorithm. This enables an equally-smoothed allocation of the spectrum by redistributing, with respect to their individual QoS requisites, and optimized use of the obtainable spectrum. In fact, it permits the detection of the unused spectrum, which was initially licensed, and to release it if it is needed again.**



***Keywords— Load Level (LL); Maximum Load Level (MLL;) Spectrum Management; Spectrum load balancing(SLB)***


## I. Introduction

The main intention of radio spectrum management is to reduce interference between different users, mitigate blocking probability and access time for any radio devices. For this purpose, we use Spectrum Load Balancing (SLB) technique that is derived from the idea of water filling. To manage spectrum, various techniques are used such as DSA (dynamic spectrum allocation), SS (spectrum sharing); but SLB is more beneficial than the other techniques because it can improve through reservation and it can also work based on observation of the past frame (without reservation). In the Spectrum Load Balancing (SLB) technique a fixed frame structure and a fixed single frequency is considered and the SLB is done by one device per frame. The frame is constituted by four slots, which have the same length and represent an interval in which the multiple accesses are done. All devices sharing a set of channels can apply in SLB [1]. The transmission of current, legacy or non-SLB using devices is seen as constant allocations and the SLB devices allocate, if achievable, their distribution around them.

## II. SLB Algorithm

The purpose of spectrum load balancing (SLB) is conflict-free set coloring formulation of iterative algorithm is to reallocate the allotment and achieve a stable overall consumption of the slots. In the following figures such as Fig. 1 and Fig. 2 the iterative resolve of the smoothed load level is exposed.

In this following scenario the further devices are considered as interferer (i.e. device 2); thus the spectrum load balancing (SLB) amount is calculated as the sum of the transmission times per slot that are obtainable. Therefore as the sum of the differences among the Maximum Load Level (MLL) and the occupancy of each slot $C_i$:

$$\text{SLB\_A}= \sum_{i=1}^{4}(MLL - C_i) \tag{1}$$

Where the MLL is the threshold of the highest slot practice and it is capable of identical to slot length when this is totally used.

In the first step, the slot less consumed is considered and the preliminary load level of the device 1 goes up of the step size:

$$w = \frac{SLB\_Amount}{Number\_of\_Slots} \tag{2}$$

Therefore the value of SLB Amount is updated and we get the value:

$$SLB\_A = SLB\_A - w \tag{3}$$

If the latest Load Level (LL) is over the occupancy of the supplementary slots, so the parts, that remain blank, are filled with the allotment of device 1.

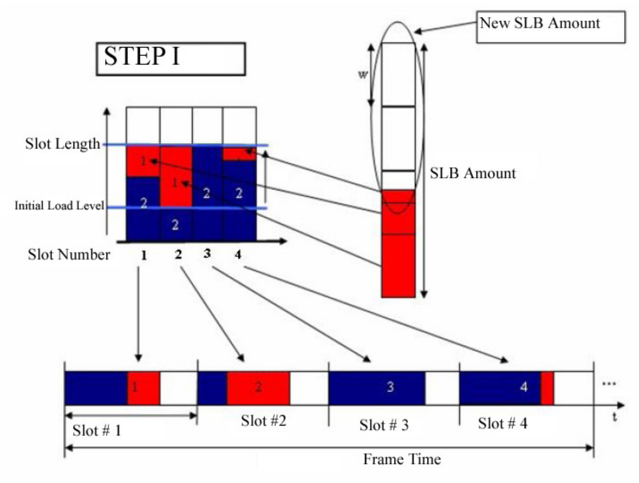


Fig. 1. First step of iterative SLB algorithm

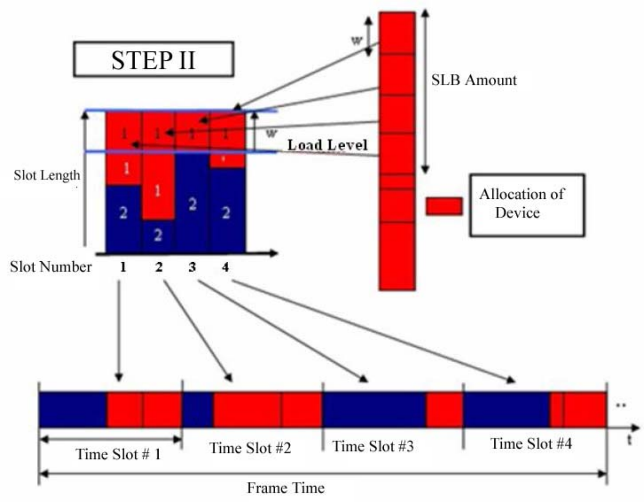


Fig. 2. Second step of iterative SLB Algorithm

For this reason, these allocations are deducted from the quantity, which is still to be distributed. The innovative value of SLB amount in this case will be:

$$SLB\_A = SLB\_A_{old} - \sum_{i=1}^{4}(LL - C_i^{New}) \qquad (4)$$

Where, $SLB\_A_{old}$ is the non-updated value of SLB_A;

$C_i^{New}$ is the new tenancy vector after the allocation of the step size.

Thus as result of successive iteration, SLB amount and step size reduce until the MLL is achieved. Thus the MLL is used as the value that provides the condition for closing stages of this iterative algorithm [2, 5].

## III. Structure Of SLB Frames

The frames of the SLB algorithm that primarily were considered compiled of 4 slots, are transformed and each frame considered is constructed by 4 frames, that will be signified similar to sub-frames. In this way the duration of one frame is equal to 20 ms. The frequency frame can be drawn as follow which is shown in figure 3:

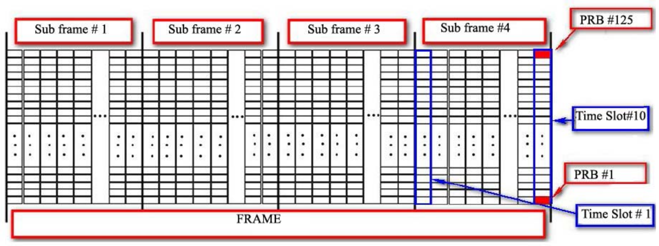


Fig. 3. Frequency Frame

In this way the allocations of many users in every time slot are predetermined; consequently the frame structure can be made straightforward as shown in figure 4:

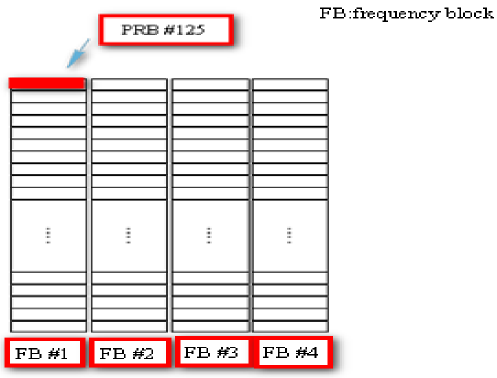


Fig. 4. Simplified Frequency Frame

In each frequency frame there will be a reasonable distribution of PRBs and an increase of the total throughput for the coexisting operators that show the way to a far above the ground probability of a booming access to the mutual spectrum [3].

## IV. Calculation Of SLB In A Reallife Scenario

To deploy an application of this algorithm it is considered in an office circumstances, in which the corridor is not essentially the border of the cell, the walls of the office are considered as light walls and the Home eNode B (HeNB) has a restricted coverage area. In exacting only two HeNB are considered therefore the cells will have 10x2 rooms and every cell may have from 5 to 10 users (UEs). As shown in fig. 5, five (5) users for cell are considered.

The blueprint that characterizes the situation is flexible to ensure the quantity and the position of walls, HeNBs and UEs can be altered. Once the fundamental layout is created, HeNBs and UEs will be positioned and the path loss will be calculated. The UEs will be arbitrarily placed within the cell coverage and will change their location after the number of frames that was selected, while the HeNBs can be produced at any pre-defined positions or any random locations [4].

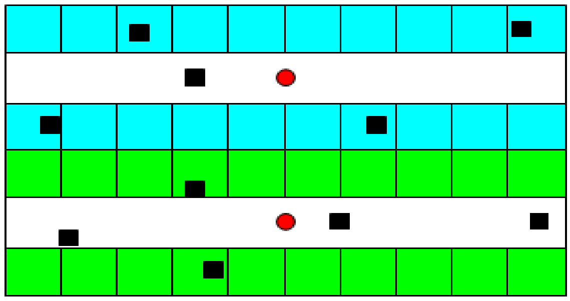

Fig. 5. Office situation topography in the company of two operators

To calculate the performance of SLB in this situation we considered the HeNBs having the following characteristic:

- Transmission power: from 27 dBm to 30 dBm;
- Antenna: omni- directional, 3 dBi gain;

While the UEs characteristics are:

- Transmission power: Min:-30 dBm Max:24 dBm;
- Antenna: Omni-directional, 0 dBi gain

Moreover the path loss and the shadow fading correlation are calculated in the following way:

*Path-Loss:* in the Matlab simulator, mutually LOS (corridor-to-corridor) and N-LOS (corridor-to-room) are measured. In the N-LOS case, a fundamental path-loss calculus for the users in the rooms contiguous to the corridor, in which the HeNB is located, is done; while for the users, that are placed in the supplementary rooms also the wall penetration losses are considered:

*LOS:* $$PL = 18.7\log_{10}(d[m]) + 46.8 + 20\log_{10}\left(\frac{f_c[GHz]}{5}\right) \quad (5)$$

*NLOS:*

$$PL = 36.8\log_{10}(d[m]) + 43.8 + 20\log_{10}\left(\frac{f_c[GHz]}{5}\right) \quad (6)$$

*NLOS with path penetration factor:*

$$PL = 20\log_{10}(d[m]) + 46.4 + 20\log_{10}\left(\frac{f_c[GHz]}{5}\right) + n_w \times L_w \quad (7)$$

*Shadow Fading Relationship* is concerned a log-normal model with standard deviation of 3 for LOS case, 4 or 6 for N-LOS case depending on the quantity of walls among users and HeNB.

So, for this work the following parameters are considerd:

- Scenario: indoor office;
- Number of operators: 2;
- Rooms per cell: 10x2;
- Cell coverage: 100mx25m;
- Number of users per cell: the lowest amount number is 5, the highest number is 10, in this work the number of the users per cell considered is equivalent to 5 for both HeNBs ;
- Frequency re-use factor: 1, all cells utilize the similar frequency band;
- Synchronization: perfect;
- Traffic load: fractional;
- Signal Bandwidth: 100 MHz;
- Frequency: 3.5 GHz;
- Layout: 40 based on SINR and Interference Threshold 20 for Spectrum Load Balancing Algorithm;
- Selects: It is signified by this parameter how many times the number and the location of Users (UEs) alters; its duration is equivalent the number of frames. Threshold 20 for Spectrum Load Balancing (SLB) Algorithm;
- Frames: Threshold 40 for Spectrum Load Balancing Algorithm.

## V. RESULTS AND DISCUSSION

Prior to place the SLB algorithm in the Matlab simulator, its accuracy was verified; and from the results is confirmed that both SLB Amount (Fig.6) and Step Size (Fig.7) reduce until they get in touch with 0 so as to means that all resources are allocated as shown in figure 8.

In the Matlab code, a single frame that contains four slots and two devices, of which one is an interferer, are considered.

At the foundation, the following parameters are used:

- Slot Duration Ts=5 ms;
- Slots Number Ns=4;
- A maximum load level, that is the maximum available time for transmission (i.e. MLL=5 ms);
- Duration Frame Tf=Ns*Ts=20 ms;
- A vector that holds the initial occupancy of each slot (i.e. C= [2.5 4 0.25 1.5]);
- A variable SLB_Amount that contains the amount of allocation to be distributed.

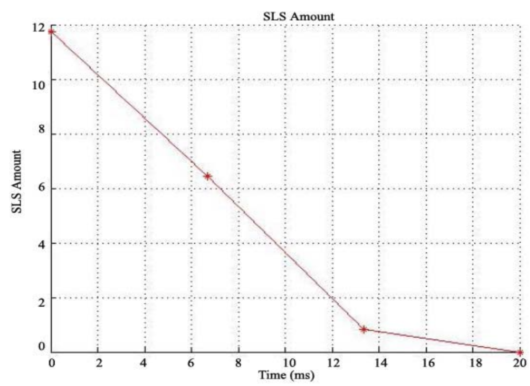


Fig. 6. SLB Amount a behavior

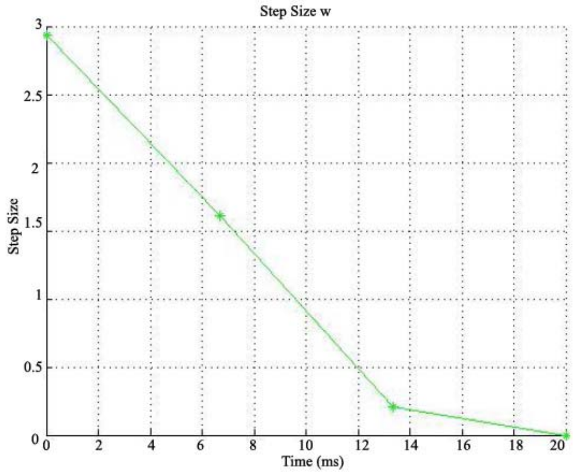


Fig. 7. SLB Step Size behavior

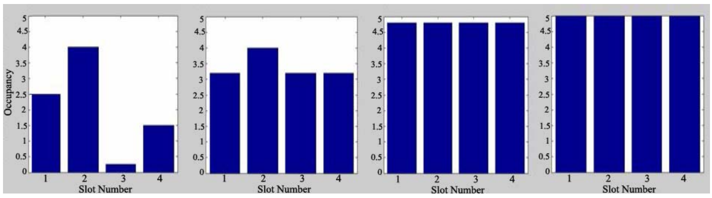


Fig. 8. Iterative SLB Algorithm

## VI. CONCLUSION

In this paper the SLB algorithm applied in the two operators collaborate among them, consequently every operator identify the number of PRBs previously occupied by the other HeNB (Home eNode B) in this advance the orthogonality is conserved and the probable clash as well as the reduced spectrum utilization are kept away from. From the evaluation of the results for the SLB algorithm with the reference case, in which all spectrum are allocated, a development for the outage throughput is obtained. From the comparisons with the other algorithms based on SINR, it is seen that the beginning of a latest threshold the SLB algorithm based on SINR and interference allow assigning more spectrum with respect to the SLB algorithm based on SINR, but it leads to a fair allocation [6]. In this paper for the SLB algorithm based on SINR and interference between the two operators are judged to the equal, indeed the similar threshold are measured, but as an growth it would be striking to study what occurs by establishing different thresholds for the dissimilar operators, thus moving from an horizontal to a vertical spectrum sharing paradigm.

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