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Load countervail access for spectrum management in wireless sensor networks following Industry 4.0

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ABSTRACT

Attention to the utmost spectrum administration is to ease interference between different operators and to eliminate potential blockings possibility and occupy time slots for the spectrum users of wireless sensor networks. To stop the difficulties, the load countervail access (LCA) algorithm is a given idea that can simply resolve the reciprocal intervention. The effective and efficient practice of the attained frequency spectrum to be smooth and equal dispensation in a reallocation manner, given their specific QoS basics, is agile by the application (LCA). It lets us find the initially licensed spectrum which is unused and released as soon as required. The authors' aim following the paper, is the total allocation of the estimated resources of the curse wireless spectrum among more intrusive operators that function in a similar comfortable zone of environment coverage to create equality with the given application (LCA) from the water-filling model.

Keywords: NLL; FLL; DSA; Spectrum management; LCA

Introduction

The obscurity of a sharp rising need for the next-generation new spectrum network in view of Industry 4.0 is a matter of concern following the difficulties in accessing technologies and radio spectrum bands on hand sought for solving in a practical manner and contemporary way. There are three dimensions considered in the radio spectrum as frequency, space, and time where interference ought not to occur if the degrees of propagation shift between transmission sources (Fahimi and Ghasemi, 2015). Today, spectrum-sharing technologies and various approaches to developing attention are being practiced to share the spectrum in an optimistic method to provide license-exercising maximum users as well as to generate higher proficiency. Spectrum sharings- dynamic spectrum allocation, cognitive radio, spectrum load balancing, and easy access spectrum (EAS) algorithms which are various spectrum allocation techniques to manage but LCA application is a technique that is comparatively more suitable than the others because there are two (02) matters distinguished- one is the actual frame identified at the outset through reservation accessed the LCA by the devices and successfully they broadcast their reservation (Grosu and Chronopoulos, 2005; Liu *et al.* 2018), and the second is through without reservation following previous frame observation at the ending or beginning simultaneously load balancing access (Tran *et al.* 2014).

The network scenario

To setup a network topology considering an office environment, the corridor of indoor space is a cell of coverage area not enough edge where the walls are taken into account simply light-walls. The Office eNode B (OeNB) in that network has a coverage area that is restricted coverage area. Considering that, there are only two (02) OeNB available in the field where each room is 10×2 cells space may have 5 to 10 users maximum in the scenario (Figure 1).

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To measure the path loss and location of the OeNB and Us within the cell area, the randomly located user's location point will be shifted after the frequency frames that were designated, at the same time any previous or random location of the OeNB can be found. The power emission properties of the OeNB are considered between 27 dBm and 30 dBm with 3 dBi gain of the Omnidirectional antenna. Alongside, the power transmission characteristic of the users is measured between 24 dBm and 30 dBm where zero (0) dBi is Omnidirectional gain as well (Zeng and Fodor 2020).

Proposed load countervail access algorithm

Setting a color order formulation of the given periodic framework named load countervail access (LCA) algorithm is used to rethink collision-free spectrum allocation in wireless networks and get achieve overall balanced access of the Slots. Figures 2 and 3 expose easy load levels resolved in an iterative manner.

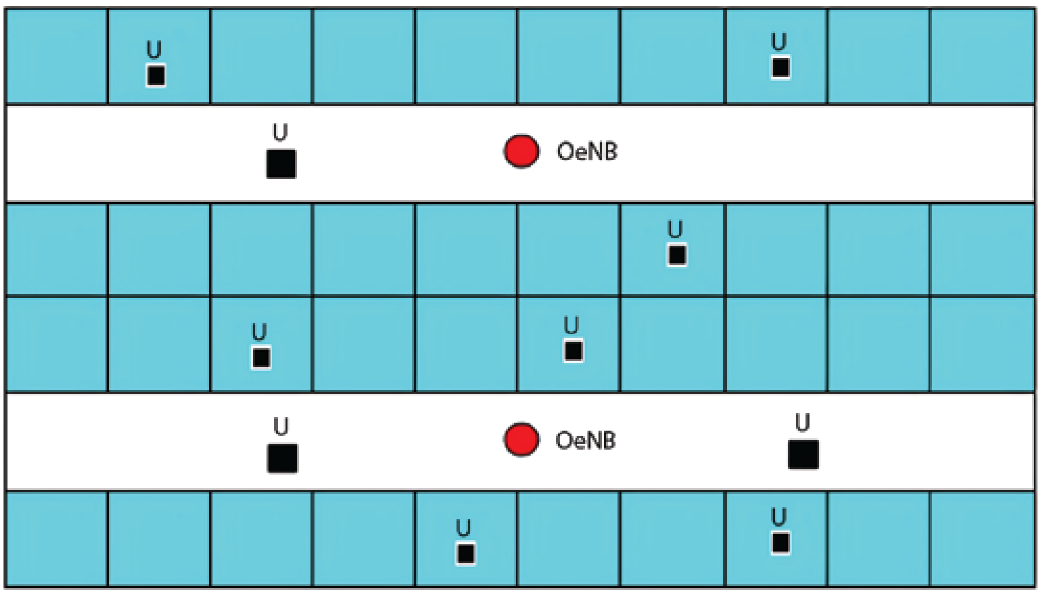

Fig. 1. Official topography of two operators

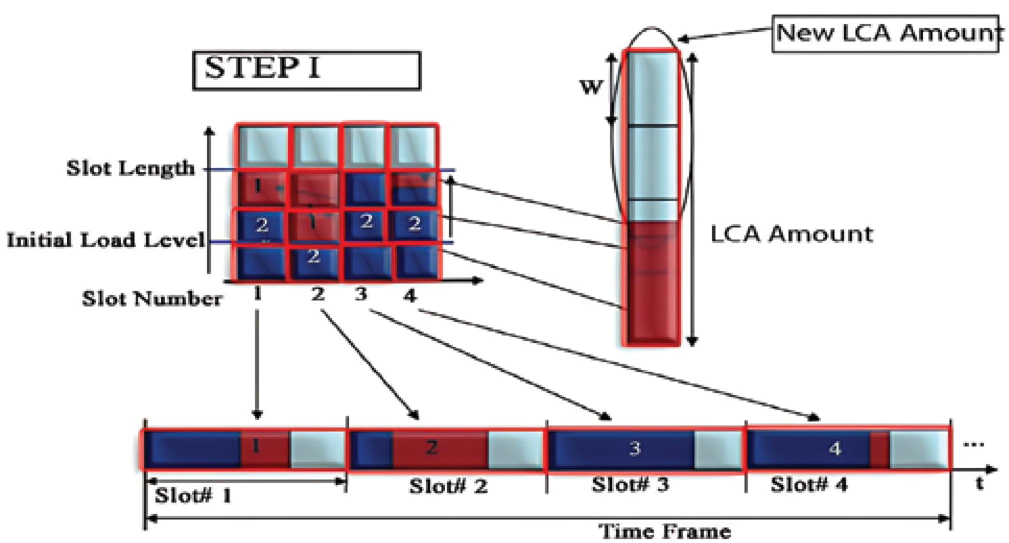

Fig. 2. First step of LCA

In the following scenario, a single frequency and a frame structure are fixed to be considered by one device per frame, and the algorithm (LCA) is executed. The same length and gap form a frame in four (04) time slots are allowed for are occupied. As a result, the quantity of these allotments is subtracted which is still to be distributed. In this case, the new LCA volume amount will be.

$$f(s)_{new} = f(s)_{old} - \sum_{i=1}^{4}(NLL - C_i^{New}).$$

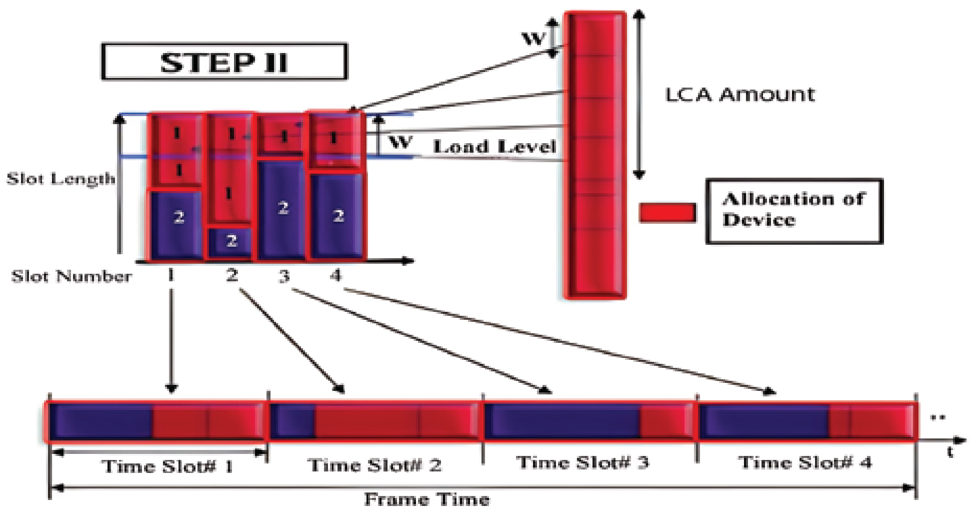

Fig. 03. Second step of LCA

multiple access. All devices in the cells are allowed to execute the algorithm (Kabir *et al.* 2015; Cao *et al.* 2023) to share a set of channels. Through the devices, a fixed allocation is allocated seeing the current, legacy, or non-LCA transmission and distribution around them, if achievable. Thanks to the circumstance, the interferer which is device 2 considered (i.e. other devices). The summation of per Slot transmission times, that are gainable is counted toward the LCA amount. The time problem of the LCA periodic algorithm is defined as f(s) is $O(\sum_{i=1}^{4}(FLL - C_i))$ which is the summation of differences among the selected Slot C_i each and First Load Level FLL, where i is the number of iterations placed by device i=1 ... , 4 for LCA to coverage for a single frame. The threshold of the utmost slot exercise is FLL is capable of identifying slot length when this is on the whole utilized. At the first step, the step size w is $\frac{LCA\_Amount}{Number\ of\ Slots}$ of the device 1 considered the less used of the time slots alongside load level of primary access goes up. Thus, the value of f(s)_Amount is updated as f(s)= f(s)-w. While the occupancy of the other slots is over by the New Load Level (NLL), hence remaining free parts of device 1's allocation

Therefore, the iteration is completed successfully until to achieving the FLL and the step size along with the volume of f(s) amount is reduced. In this way, the value of FLL is used to convey the condition of the LCA, periodic algorithm is on the closing stage (Kabir, 2015).

A sustainable circumstance of the LCA frame formations

The above-depicted algorithm's frames primarily complied with fixed 4-time slots to make a frame and modified into a subframe setting by 4 frames. One frame duration is 20 ms is considered, as follows in Figure 4.

Each operator cooperates among them (operators), knows the number of PRBs- physical resource blocks- has already been employed by the further OeNB in an orthogonal technique of sharing and, the potential clash and the use of reduced spectrum are shunned. For instance, if the operator 1 transmits first, thus, the first slot will be known as well as the number of allocated PRBs in the present slot that can be accessed from the operator, the direction of occupied of the present frame that holds the occupied PRBs from the operator in each frequency block, and the assigned of the used PRBs in each frequency block that is an effective PRBs used from the operator. Having received this information, operator 2 in the recent frequency frame can compute the amount of LCA and launch allocation of it without choosing the same PRBs of the operator 1. A fair allocation of PRBs in each frequency frame consists. The coexisting operators' grand throughput is an increase that leads to a higher possibility of fruitful access to the shared spectrum (Xie *et al.* 2007).

Path loss of node mobility and shadow fading Correlation

Considering that the nonline of sight (NLOS) is room to corridor as well as the line of sight (LOS) is corridor to corridor where OeNB is installed in a room space and attached corridor area while the users are considered to be located in the next to the room. The users' path loss is calculated taking into account the wall partition penetration losses (Zhao *et al.* 2010) as defined in PL

The users are concerned about the number of walls and OeNB for shadow fading correlation (Salo *et al.* 2005; Kabir, 2015)

$$\begin{cases} 18.7\log_{10}(d[m]) + 46.8 + 20\log_{10}(f_c[GHz]/5), Line-of-Sight-(LOS) \\ 36.8\log_{10}(d[m]) + 43.8 + 20\log_{10}(f_c[GHz]/5), Non-Line-of-Sight-(NLOS) \\ 20\log_{10}(d[m]) + 46.4 + 20\log_{10}(f_c[GHz]/5) + n_w \times L_w, NLOS-with-path-penetration-factor \end{cases}$$

is used in probability theory as a lognormal distribution model where its LOS case and NLOS case standard deviation is 3, and 4/6 consecutively. In these working parameters, the indoor office scenario is associated with the number of two operators with a function of 10×2 Rooms per cell users 5<10. The value of the cell coverage area specifics is 100m×25m. 1

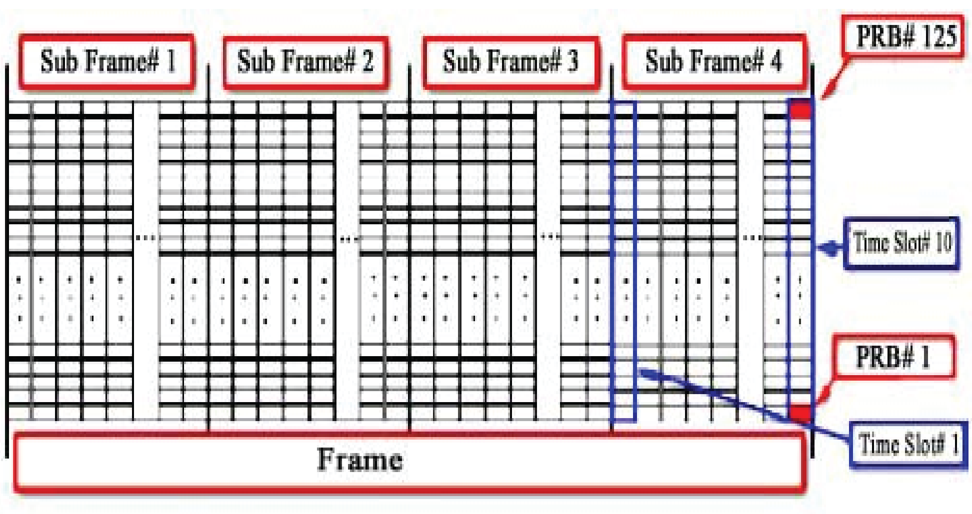

Fig. 4. Frequency frame

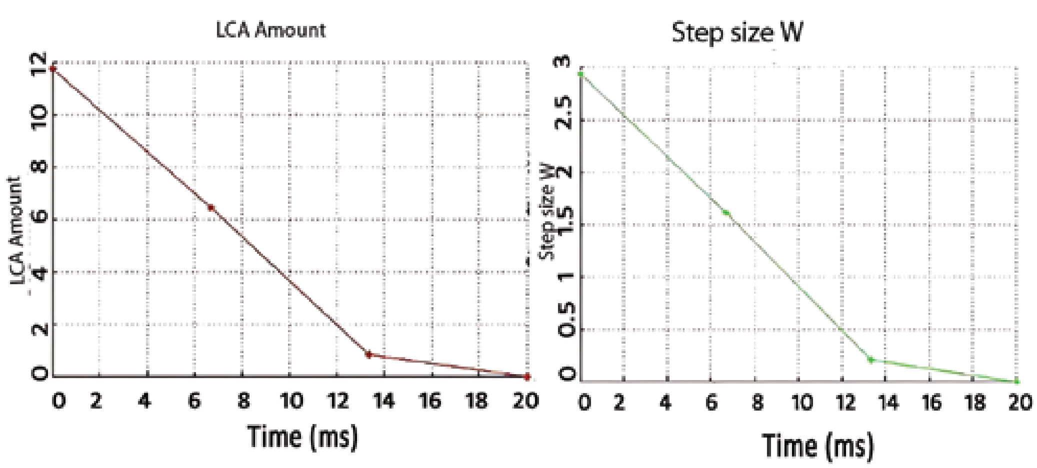

Fig. 5. The amount of LCA and the step size

is used as the frequency reuse factor of all cells with the same frequency band 21.97265 MHz of 3.5 GHz frequency using 20 frames. Signal bandwidth 21.97265 MHz ÷ 15KHz is equal to 1500 subcarriers where to achieve PRBs number is measured as the number of subcarriers (1500) ÷ PRBs size (12 symbols) is equal to 125 PRBs. The selection parameter shows the results and indicates the number and the position of Us of how many times is changing; its duration as well as the number of frames are equal, but in this situation, it is considered 40, and the threshold is the same.

Optimization results and discussion

The accuracy of the algorithm was signified and ensured that both the step size and the LCA amount (Figure 5) which are declined until reached zero (0). It indicates to have allocated all the resources shown in Figure 6. There are four slots (N_s=4) and two devices- one is considered as an interferer that consists of a single frame is considered in each device and requires the function of parameter Q= F (T_s, N_s, FLL, T_f, C>0). The duration of a slot $T_s \leq 5$ms, where the time period ms>0. The transmission time for the First Load Level is 5s, where T_f is defined as frame duration ($N_s \times T_s$) at 20ms. The frame time represents a time vector containing each slot's C= [2.5, 4, 0.25, 1.5] initial occupancy and the LCA_ Amount is a variable to hold the allocation amount that is to be distributed.

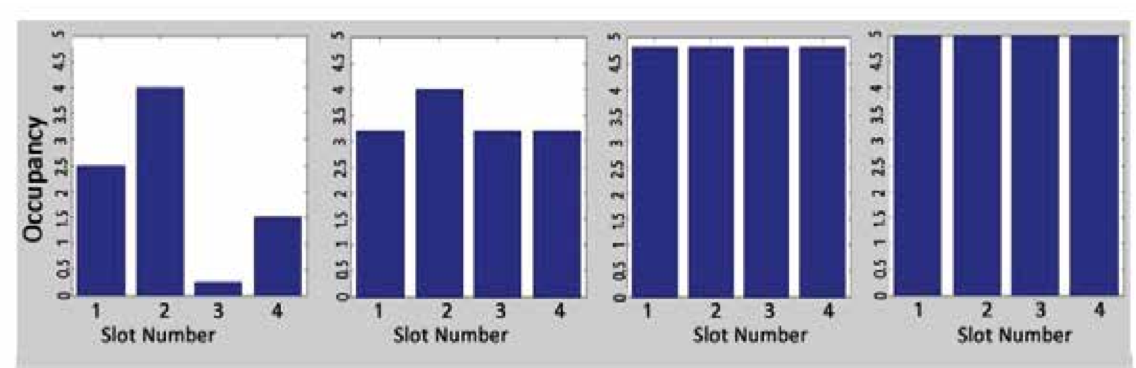

Fig. 6. Occupied LCA algorithm

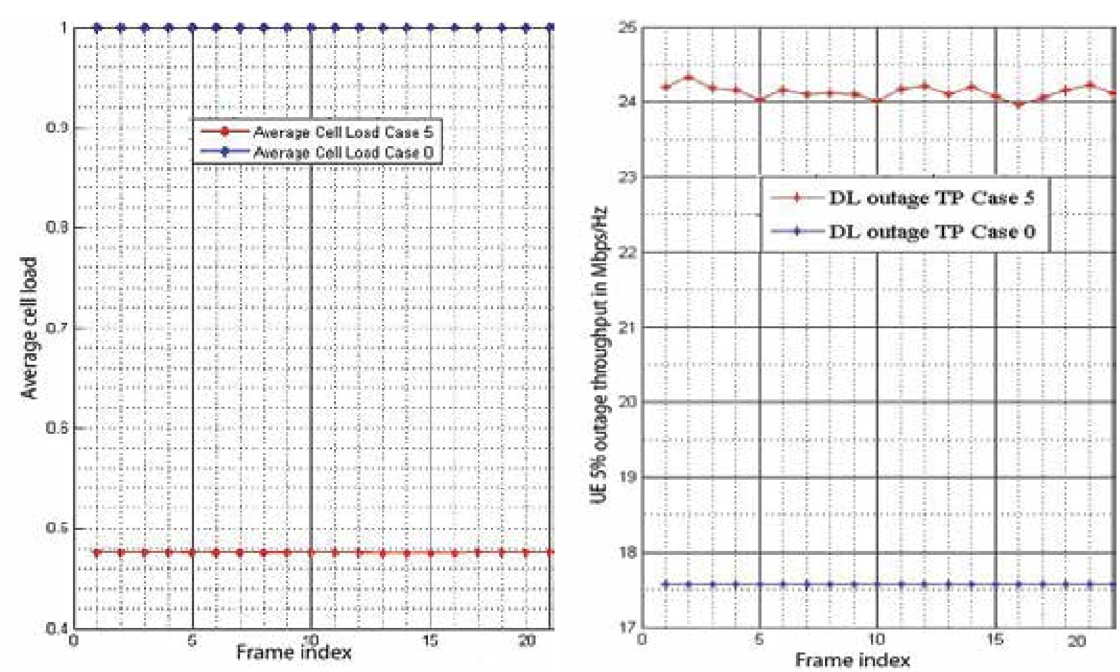

Fig. 7. (i) Avg cell load between case 0 (reference case) and case 5 (LCA algorithm). (ii) User outage throughput

It seems that with the introduction of the used LCA spectrum is less than the spectrum used in case 0 which is referred to as the reference case. A fair spectrum sharing is about 50% of the total spectrum reached (Fig. 7. i). With the application of the LCA algorithm, the minimum achieved throughput is 95% of the user with respect to the reference case 0. In this circumstance, in which the executed algorithm (case 5) is performed. The outage users' throughput in accordance with reference case 0 is increased (Fig. 7. ii).

Conclusion

This algorithm (LCA) consists of two operators cooperating between them, at that time each operator perceives the PRBs number already acquired by the other OeNB. The Orthogonal method is followed and ignores the possible collisions as well as reduced spectrum use. The outcomes are assessed for the LCA algorithm with respect to reference case 0. In this way, spectrums are distributed and it is seen that a successful outage throughput is attained. Between two operators that are the basis on SINR and interference are taken into account with the same thresholds received. The outstanding results of the study keep an eye for further work if the different thresholds and the users are taken to extension exercise using the spectrum allocation algorithm from horizontal to vertical shifting.

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