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GREEN CELLULAR DESIGN USING AN ADAPTIVE POWER MANAGEMENT REDISTRIBUTION FOR MOBILE COMMUNICATION

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ABSTRACT

With the advent of the 5G revolution, the demand for wireless access data rates is growing exponentially at a pace where supply cannot keep up with. Similarly, there is an enormous growth rate of telecommunications data. In addition, user behavior is changing towards using more features and apps on their User Terminal (UT). This leads telecom companies to build new infrastructure to meet the rapid increase of resources. Many previous works tackled this problem, but at the expense of many factors such as the Quality of service (QoS) provided to the user, power consumption and CO_2 footprint, and the behavior of user such as the user in the loop (UIL) which leads to annoy the user and to make theses solution inapplicable. This research paper proposed a novel solution based on optimizing distribution for the users in order to maximize the network capacity while keeping the same infrastructure and resources. This paper was performed using real network modeling using Matlab. The model used in this paper is according to (IEEE) 802.15.4 Machine Access Control (MAC). Based on the power equations, the received power was calculated, and the users were redistributed automatically according to the proposed methodology. Accordingly, it is found that the proposed solution (automatically redistribution) allows the cells to accommodate the largest possible number of users and thus reduces the possibility of blocking by 43% for 70 users compared with the current solution before applying our algorithm (random redistribution). Therefore, the system is more efficient while maintaining the same resources.

The performance evaluation of many system metrics according to the proposed solution was investigated. Power consumption, CO_2 footprint, number of assigned users to each cell in each scenario were investigated in addition to reliability and probability of blocking and failure to the system. The QoS provided to the user does not decrease by enabling the service providers to utilize the allocated channels as efficiently as possible to reduce call blocking probability. Also, CO_2 footprint and power consumption noticeably reduced by 27% for the same amount of users in comparison with other solutions.

Keywords:- *Green Cellular Network, Redistribution Dynamically, Dynamic Cell Allocation, Cell Maximum Capacity, Power Consumption, CO_2 Footprint*

1. INTRODUCTION

These days, energy consumption due to information and communications technology (ICT) items and services is developing at an astounding rate due to the radical advancement of technology. This issue has pulled in incredible consideration of analysts since of its effect on the environment and economy. Concurring to the report by Green touch, ICT contributes about 2-2.5% of the worldwide CO2 emanations, which incorporates emissions from ICT companies as well as the power required by ICT equipment. Especially, mobile communication as one of the ICT divisions contributes 9% of the overall [1]. Moreover, the relative share of ICT products and services within the worldwide power consumption expanded from around 4.0% in 2007 to 4.7% in 2012 [2]. This assures that the contribution of ICT to the worldwide power utilization will increment advance to support the new advancing ICT items and services such as smartphones, tablets, machine to machine communication, and social systems. As a result, a part of the research is required to be conducted to create energy-effective ICT items, especially on cellular mobile data communication.

With the rapid evolution of cellular networks in the world, one should take into account the issue of energy efficiency. The telecommunication industries are responsible for about 2 percent of the total CO2 emissions in the world and this number is predicted to double by 2021 with the exponential growth of mobile traffic [3]. The increase in energy consumption is caused by the growing number of users equipments (UEs) and the subscription to higher rates of mobile broadband data as well as the higher contribution of information technology in the world [4]. This increase has an environmental impact on the world, not to mention the economic. This fact has been gaining importance lately, especially with wireless networks [5]. In particular, solutions should be focused on the architecture and system design techniques of mobile cellular networks, particularly in the base stations (BS), which contribute 60 to 80 % (Fig.1) of the total energy consumed in the network [6]. This concept of reducing energy consumption is known as "Green Cellular Networks".

This has constrained mobile operators to quickly grow their network capacity to fulfill the client's need by conveying numerous BSs beyond what they already anticipate.

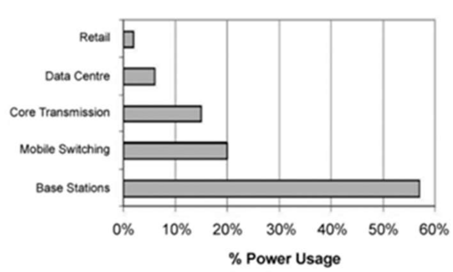

Fig 1: Cellular network power consumption

This in turn profoundly increments the energy consumption which is the major component of the operational consumption of the mobile network operators [7]. Several works tackled the problem of increasing the capacity of cells while maintaining the same number of resources and therefore reducing the carbon footprint for wireless mobile communication and increasing Quality of Service (QoS). Authors who studied this problem followed several techniques and methods, which are classified, into two categories, service side that includes antenna design, small cells, switching on/off modes, and sleep modes. and demand-side, which includes demand shaping, tariff mode, and user in the loop (UIL). Another approach is the dynamic channel allocation in which the allocation of the channel for each cell is dynamic. This means for each cell; the number of channels depends on the varying numbers of users inside that cell. If the number of user increases, the allocated channel will also increase without causing interference or system failure. In this approach if a cell needs more channels, then the system will borrow idle channels from cells that have unused channels.

In [8], the authors targeted to boost spectral efficiency and accommodate the continual rise in demand for wireless capacity. They improved a dynamic load-aware, and self-adapting frequency allocation scheme designed for dense cellular networks: the Dynamic Cost/Reward based Allocation (DyCRA). The scheme makes decisions based on cost-reward trade-offs: rewards arise in the form of capacity, and costs arise in the form of interference (under spatial reuse). To reach that they implemented cost and reward functions, Single Load Interval (SLI) algorithm. And finally, they concluded that the DyCRA scheme provides efficient resource allocations that adapt to changing traffic conditions and yield significant performance gains in scenarios with non-stationary traffic demands. In [9], the authors targeted to maintain the blocking/dropping calls that occurred when there is no free channel is assigned for the subscriber. They proposed a solution that shows how to change dynamically the number of reserved channels and optimizing it based on the incoming offered traffic type (new or handover calls). To reach that, they implemented the Guard Channel and Non-Prioritized schemes. And finally, they concluded that call blocking and dropping probabilities performs better while compared with the other existing scheme.

Moving to the demand side, which is based on a hybrid technique that used demand shaping, tariff mode, and UIL. The authors in [10] tackled the increase of the capacity with the increasing of demand. They suggested a solution by sharing the user in the process so that it is notified when transferred in addition to the motivation to encourage the user to change the current location. To obtain that, the user's location (for better coverage) should be changed besides the tariff model to encourage the user to change his position (financial or data rate). To prove their solution, they test the mobility of the user to a new location (for few meters). Their obtained results concluded that when moving only a few meters it is expected to increase efficiency by 25% to more than 100%. On the other hand, the authors investigated reducing the carbon footprint or green index in cellular communication at the same time satisfy user requirements and the agreed quality of service [11]. They proposed a solution that controls the demand shaping considering the QoS guarantees, by using the methods of user-in-the-loop and tariff control. To reach that, they implemented demand shaping as temporal and spatial punish and reward in addition to tariff control using a non-linear logarithmic pricing curve. To validate their solution, they followed long and short terms control mathematical analyses. While their obtained results showed for long-term control reduction in the traffic to 80%. On the other hand, for the short term, the traffic was reduced to 28%.

Tahat and others [12] studied reducing the carbon footprint in cellular communication. They discussed techniques to control the demand of enhancement capacity. To obtain that, they Deployed the particle swarm optimization (PSO) algorithm. They implemented an experiment on the Uncontrolled Communications System with and without applying PSO. They notice the number of rejected users increased in the busy hours in addition to payment of 1.024 JDs for every 1Mbit downloaded in the system without PSO. On the other hand, while applying PSO, the cost has changed, depending on the user if he accepts the offer or rejects it. Besides increasing the capacity of 66.2%. Moving to the service side, in [13], the authors studied reducing the cellular radiation from radiating antennas. They proposed a solution that submits a new structure for wireless networks to minimize the emission from a mobile station. For that end, the transceiver BSs has to be increased with receiving -only the algorithm devices. They implemented an experiment on the mobile station's (MSs) transmitter (TX) power with a green antenna and without a green antenna. Their results showed that MSs TX power with green antenna of 40% of the user is below the target power. On the other hand, for MSs TX power without a green antenna was 7% of users are below the target power.

In [14], Guo and O'Farrell discussed Reducing energy consumption while maintaining the quality of service (QoS). They proposed a solution by using a vertical sector antenna in addition to sleep mode operation. To achieve that, they performed Energy Reduction Gain (ERG). They implemented Active mode and sleep mode with and without vertical sectorization. Their obtained results showed that in sleep mode energy will reduce to 50-90% (in a small cell). On the other hand, the reduction will be approximately 10 - 40% (in medium to large cells). Also meeting the spectral density with the growing demand as well as RF pollution and energy conservation has been tackled, as explained by Katiyar, Jain, and Agrawal in [15]; they mentioned a solution that uses green cellular networks with the participation of multi-layer overlaid hierarchical structure. To achieve that, they implemented a multi-layer overlaid hierarchical structure. They tested their solution on the adaptive antenna, low-power Pico cell, and femtocell in existing 2G / 2.5G networks. The results were to meet the increasing demand and reduce RF pollution and power consumption. In [16], the authors discussed reducing the carbon footprint or green index from small cell base stations. They suggested saving the power by switching off the macrocells and offloading to a small cell without exposing the QoS. They implemented Uplink and downlink resource blocks to validate their method. They tested the utility function for each base station (macro-small cells BSs and macrocells BSs). Their results showed reducing the outage threshold below 5% when deploying small cells.

Also, Oh, Son, and Krishnamachari suggested in [17] reducing energy consumption in wireless cellular networks. They discussed dynamic base station (BS) by implementing a switching-on/off based energy saving (SWES) algorithm, where they experimented with Switching-on decision and Switching-off decision. The result was as follows; Energy reduction 55% and 80% during weekday and weekend, respectively. Additionally, Shakir and others in [18] studied reducing the carbon footprint or green index in cellular communication. They suggested an increase in the network capacity and reducing the co-channel interference and carbon by the deployment of the two-tier heterogeneous small-cell network (HetSNet). They implemented an experiment on cell-on-edge (COE) and macro-only network (MoNet) deployment. Their obtained result concluded that COE deployment reduced CO2 emissions up to 82% in comparison to MoNets without employing power control. In [19], the authors investigated reducing energy wastage from BSs. The proposed load balancing by identifying whether the BSs to become idle or stay active depending on-demand traffic. To obtain that, they performed Message passing with a Load balancing algorithm (MPLA) by exchanging messages between BSs to end up with final decision on whether it should stay active or idle to decrease energy wastage. This is done by experience the data rate for users after and before

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load balancing. Their results showed that the energy saving of 50% with guaranteed QoS is achieved.

As explained, by Yang, Zhang, and Wang in [20] who studied the saving energy consumption in the 5G cellular network. They suggested a two-stage BS sleeping scheme to reduce energy consumption in nonhomogeneous cellular networks. To achieve that, they implemented the Markov decision process (MDP). To validate their solution, they performed a Two-stage sleeping scheme (TS) and Light sleeping only scheme (LS). Their obtained results showed TS scheme could save as much as 150% of than LS scheme. In [21], the authors targeted to reduce the energy consumption from BSs in addition to improve the greenness of the future cellular systems. They improved the greenness of the future cellular systems cell configuration by using an active cell rotation (ACR) scheme to reduce the power consumption effect of the BS. This has been done without exposing the QoS whereas the cooperative active cell rotation (CACR) scheme proposed enhancing the channel utilization as well as higher energy efficiency for the edge BSs under neighbor cell cooperation. They implemented the birth-death Markov Process. They tested ACR and CACR schemes Compared to conventional schemes. Finally, they concluded that ACR achieves about 39% potential savings while the CACR scheme achieves nearly 49% savings on average.

In [22], the authors discussed the energy consumption from the most energy-consuming component of the power amplifier PA. They suggested a solution to improve energy efficiency by small cells and increasing the number of antennas. To reach that, The Degree of freedom (DoF) was exploited to increase energy efficiency and reduce OPEX (Operating Expenses) for the operator. To validate their solution, they tested a distributed antenna network in a C-RAN architecture and massive MIMO in 5G. Their obtained results showed that PAPR (peak to average power ratio) reduction and energy efficiency are improving by reducing the consumption up to 90% Besides Better performance for the RNN method when increasing the number of antennas, on the other hand, bad performance for least squares (LS).

In this paper, the proposed algorithm is suggested to solve the problems in the previous works such as reducing the carbon footprint without exposing the QoS and reducing energy consumption which are followed by several techniques and methods. Those methods are classified into two categories: the service side that includes antenna design, small cells, switching on/off modes, and sleep modes. And demand-side, which includes demand shaping, tariff mode, and user in the loop (UIL). Most of the solutions in the previous works were based on user behavior who is considered as the decision-maker. This leads to a decrease in the QoS, and not providing channels for new users on the network. Automatically redistributing users using a specific algorithm is a suitable solution that does not affect service quality and gives good results in terms of increasing cell capacity and increasing the QoS while maintaining the same performance of the network because of using the same resources in addition to reducing the CO2 footprint and power consumption.

2. SYSTEM DESCRIPTION

A. System Model

A cellular system consists of a group of seven cells (cluster) where the area of size (50× 100) km2 is considered. Different scenarios with a different number of users were investigated with uniform user distribution. BSs are uniformly placed on a hexagonal grid in the area according to the cell radius of each BS. The system performed using real network modeling using Matlab. The model used in this paper is according to (IEEE) 802.15.4 Machine Access Control (MAC).

The parameters of the simulated system are shown in the table below [23] [18]

Table 1: The Parameters used in the simulated system

Parameter	Value
K	1
α	2
β	2
p_o	0.8
p_{max}	1 W
Cell maximum capacity	10 users
H_{mu}	2m
h_{bs}	12.5m
λc	12.5 e-2 m
Cell radius	500 m
Max time	1000 sec

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The parameters in Table. 1. are explained as follow: K represents the path loss constant, α and β are the basic and additional path loss exponents, respectively, h_{BS} is the BS antenna height, h_{MU} is the mobile user antenna height and λc is the carrier wavelength, P_{max} denotes the maximum transmit power of the mobile users and Po is the cell-specific parameter to control the target signal to interference ratio (SINR) at a given sub-channel.

A. Algorithm Description

In this paper, a novel method is applied for efficient user distribution among cells for cellular systems. The proposed method is based on the automatic distribution for users between cells according to distance and power equations. The main goal of such a method is to increase cellular system capacity as efficiently as possible and reduce call blocking probability in a cellular system. On the other hand, the QoS provided to the user does not decrease and the CO2 footprint and power consumption noticeably reduced compared random distribution of users between cells (current solution). The proposed novel algorithm (automatic users distribution) is explained in the following procedures:

Firstly, the cell shape and parameters are defined. The cell shape is chosen Hexagons with 6-sided polygons. Regular hexagons have all the sides of the same length. all the hexagons are assumed to be regular. Hexagons have 6 sides and 6 corners. Each side is shared by 2 hexagons. Each corner is shared by 3 hexagons. A hexagonal cell layout in an unlimited plane is consists of BS at the center of the cell with the inner radius R. which serves the mobile users that are uniformly distributed over the cell area of individual BS, as shown in Fig.2 Each user is associated with the nearest BS; thus, the serving BS is selected as that with the highest average received power for the considered user

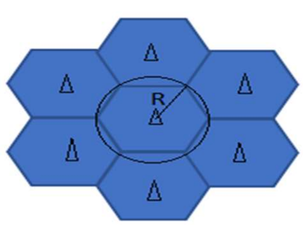

Fig 2: Hexagonal cell geometry

Secondly, the overlap region between adjacent cells are determined by drawing a circle around the cell edges. The general standard equation for the circle centered at (h,k) with radius R is shown as:

$$(x-h)^2 + (y-k)^2 = r^2 \quad (1)$$

In the third step, the cell capacity is checked by applying a loop for each cell and check the condition whether the number of users in that cell greater than or equal to the cell maximum capacity which is assumed to be 10 users for each cell in our model as in [23]. Then the capacity flag is determined according to the following criteria:

$$\begin{Bmatrix} if\ cells\ capacity\ >= 10 & capcity\ flag = 1 \\ else. & capacity\ flag = 0 \end{Bmatrix} \quad (2)$$

In the fourth step, the user location is checked whether it is on the overlapping region between adjacent cells as shown in Fig.3. In random distribution (current solution) users are uniformly distributed over all cells, which leads to the presence of users in the overlapping areas, these users receive a signal from both adjacent cells. According to proposed algorithms, the Euclidean distance is measured between user and the closet two BSs in the adjacent cells which are r_1 and r_2 as in (3) and (4), The distance between two points in the plane with coordinates (x, y) and (a, b) is given by:

$$r_1((x_1.y_1).(a.b)) = \sqrt{(x_1-a)^2 + (y_1-b)^2} \quad (3)$$

$$r_2((x_2.y_2).(a.b)) = \sqrt{(x_2-a)^2 + (y_2-b)^2} \quad (4)$$

Where $(x_1.y_1)$ and $(x_2.y_2)$ are the coordination of the first and the second BSs in two adjacent cells respectively, and $(a.b)$ is the user coordination. Based on this user can be determined whether are located in the overlapping areas between adjacent cells or not. The distance between each user and the BS's is calculated as in (3) and (4), and if both distances r_1 and r_2 are less than cell radius which is assumed to be 500 m, which means the user is in the overlapping region.:

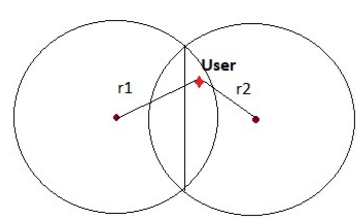

Fig 3: Overlapping region for the user.

Then in the fifth step, the power received power to each user from the BS is calculated equation as in [18]:

$$P^{r1x} = P^{tx}\frac{K}{r^{\alpha}\left(1+\frac{r1}{g}\right)^{\beta}} \qquad (5)$$

$$P^{r2x} = P^{tx}\frac{K}{r^{\alpha}\left(1+\frac{r2}{g}\right)^{\beta}} \qquad (6)$$

where P^{tx} [W] is calculated as in (7 and 8) and defines the adaptive transmit power of the mobile user from the desired BS which is located at a distance r from the considered mobile user, α and β are the basic and additional path loss exponents, respectively, $g = \frac{4h_{BS}h_{MU}}{\lambda c}$ is the breakpoint of a path-loss curve which depends on the BS antenna height h_{BS}[m], the mobile user antenna height h_{MU} [m] and carrier wavelength λc, K is the path loss constant. P_{max}[W]denotes the maximum transmit power of the mobile users and Po is the cell-specific

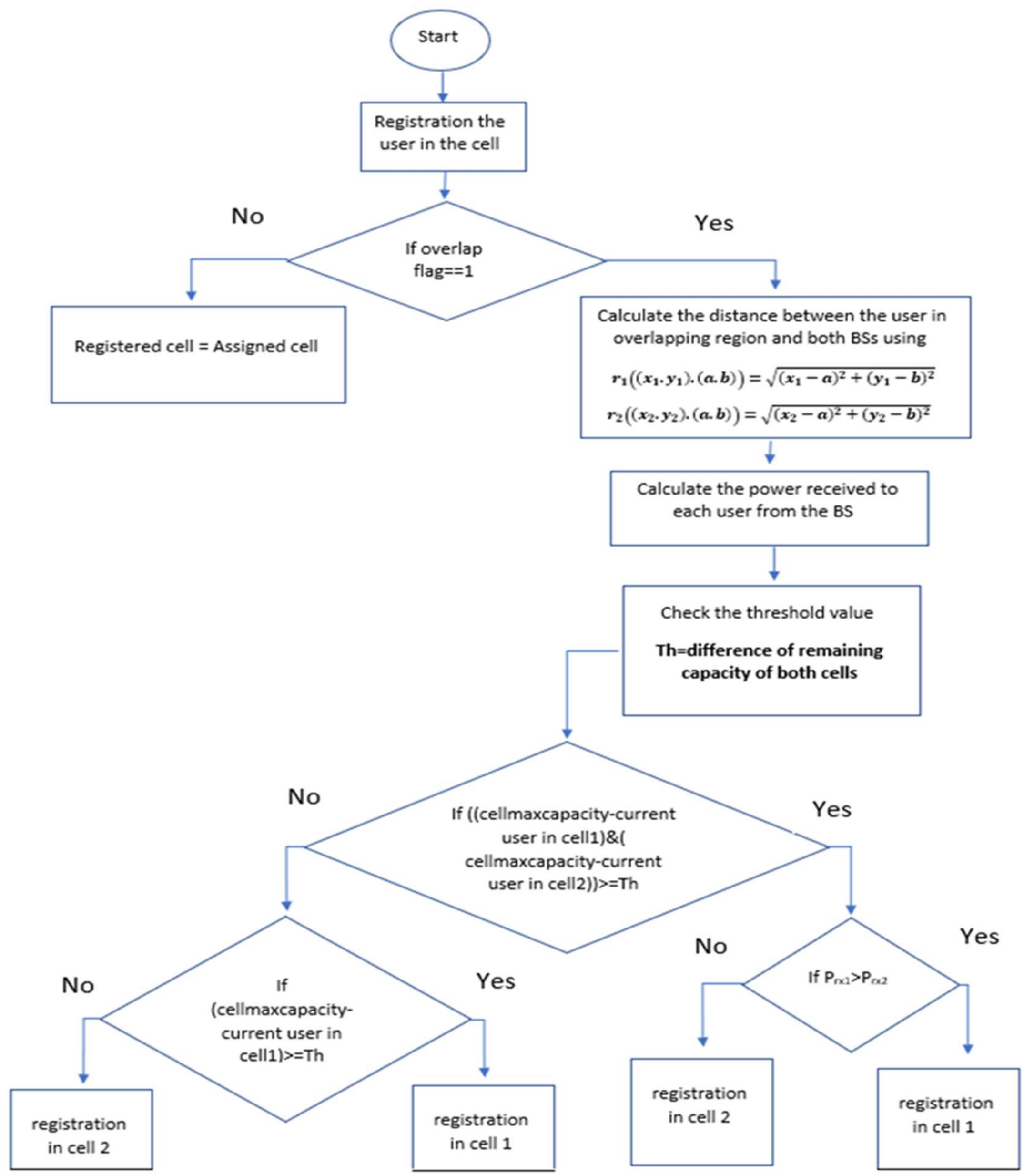

Fig 4: Algorithm flowchart

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parameter to control the target signal to interference ratio (SINR) at a given sub-channel.

$$P^{t1x} = min(\, _{max} . P_o \frac{r^{\alpha}\left(1+\frac{r1}{g}\right)^{\beta}}{K} \,) \qquad (7)$$

$$P^{t2x} = min(\, _{max} . P_o \frac{r^{\alpha}\left(1+\frac{r2}{g}\right)^{\beta}}{K} \,) \qquad (8)$$

Consequently, cells that have reached the maximum capacity are determined.in (2), the overlapping areas have been identified by the circles around the hexagonal cells, and users in the overlapping area are determined in (3) and (4), and the received power of each user is determined as in (5) and (7). According to previous calculations, automatic redistribution of users between cells is executed as in the algorithm flow chart in Fig.4.

The simulation parameters are shown in Table I. The coordinates of each user were specified in addition to determining if he was in an overlapping area according to (2) and to which cell it was assigned and registered. Also, the distance between each user and the BS of the cell was found in which the user is located according to (3and 4). The proposed solution is based on the redistribution of users in a way in which the largest possible number of users can be accepted and obtained a service. It is known that the presence of a user in an overlapping area leads to has a signal from both adjacent cells and thus has power from both cells. The following flowchart illustrates the methodology used in this paper Fig.4.

3. SIMULATION AND DISCUSSION

Two scenarios were investigated in this study mainly for a different number of users and a fixed number of base stations. According to standard IEEE 802.15.4, the first one is a random distribution of users (current solution), and the other one is the automatic distribution of users after applying distance and power calculations (proposed algorithm).

Table 2. Studied Scenario

Number of users	Current solution			Proposed solution		
	Assigned (Out of 70)	Rejected	First rejected	Assigned (Out of 70)	Rejected	First rejected
70	46	24	43	59	11	39
80	53	27	40	63	17	51
90	53	37	33	68	22	49
100	51	49	42	69	31	38
120	53	67	37	70	50	44

From fig.5, it can be noticed that 46 users out of 70 are assigned to the overlap region, and 24 are rejected. In addition to the fact that the system starts to reject early. Compared to the proposed solution, 59 users are assigned while 11 users are rejected, and the first rejection value starts from user 39 (fig.6). By increasing the number of users to 80, 53 users out of 70 are assigned and 27 users are rejected, where the first rejected starts from user 40 (fig.7). Compared to the proposed solution 63 users are assigned while 17 users are rejected, and the first rejection value starts from user 51 (Fig.8).

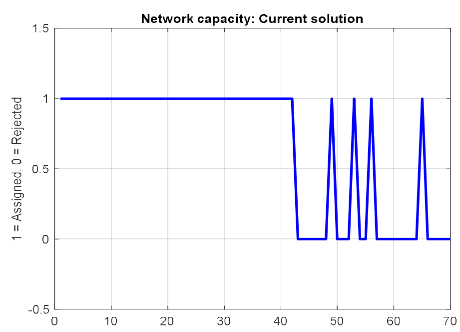

Fig 5: Distribution of 70 users in the current solution

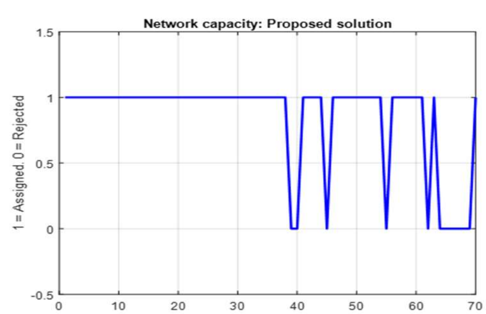

Fig6: Distribution of 70 users in the proposed solution

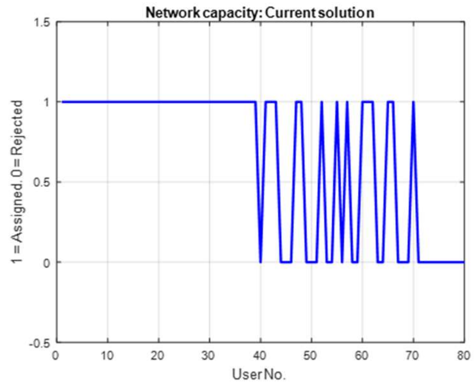

Fig 7: Distribution of 80 users in the current solution

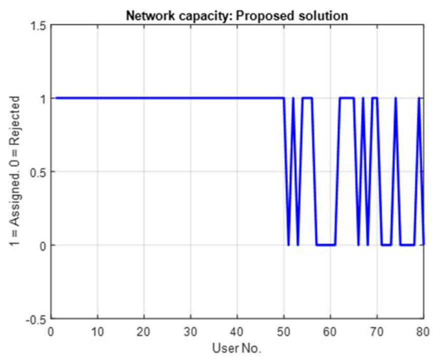

Fig 8: Distribution of 80 users in the proposed solution

Increasing the number of users to 100 users (Fig.s. 9 and 10), 51 users out of 70 are assigned and 49 are rejected, where the first rejected starts from user 42. Compared to the proposed solution 69 users are assigned and 31 are rejected while the first rejection value starts from user 38. It was observed that after increasing the number of users to 120 users, 53 users out of 70 are assigned and 67 are rejected (Fig.s.11 and 12), where the first rejected starts from user 37. Compared to the proposed solution 70 users are assigned and rejected 50 users, also the first rejection value starts from user 44.

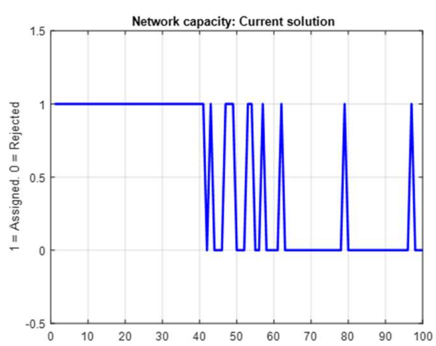

Fig 9: Distribution of 100 users in the current solution

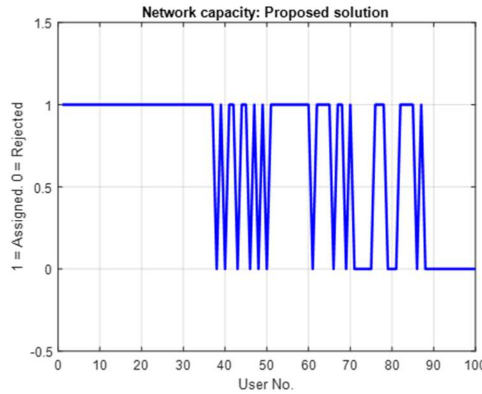

Fig 10: Distribution of 100 users in the proposed

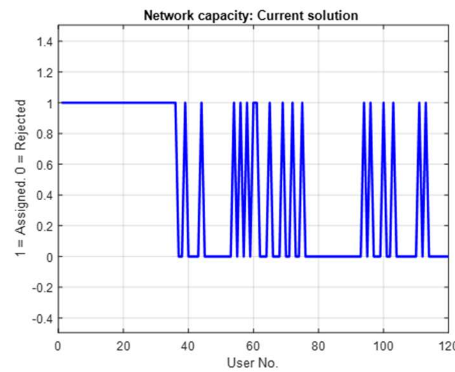

Fig 11: Distribution of 120 users in the current solution

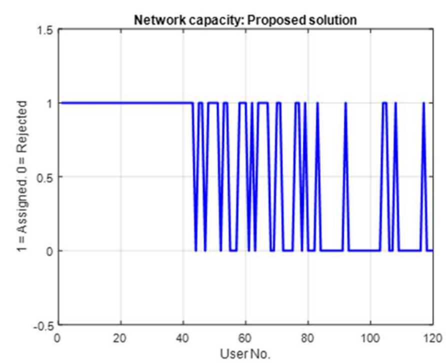

Fig 12: Distribution of 120 users in the proposed solution

A. Assigned And Rejected Users

Fig.s 13 and 14, compare the assigned and rejected users for both solutions. we can calculate the percentage of change (increasing or decreasing) by the equation:

$$\%chang = \frac{(\text{new value} - \text{original value})}{\text{original value}} * 100\% \quad (9)$$

In the proposed solution, the number of users assigned to the cells increases by 29% according to equation (9) as the number of users increases in addition to reject fewer users.

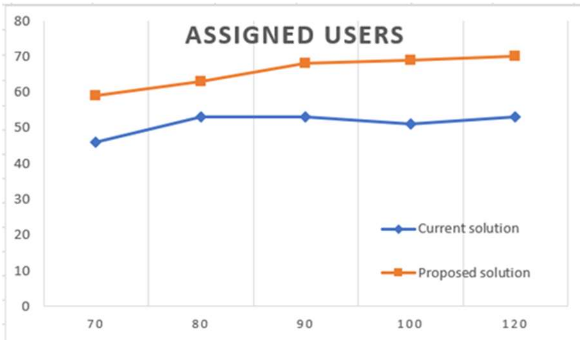

Fig 13: Assigned users in both scenarios.

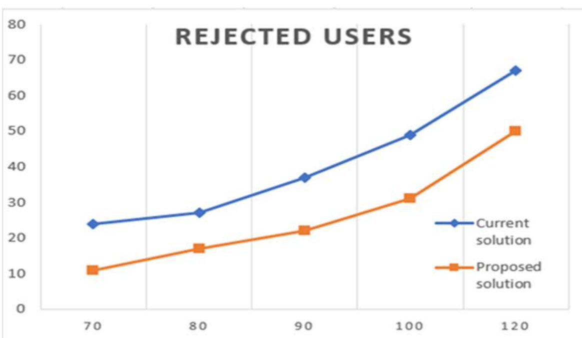

Fig 14: Rejected users in both scenarios.

B. *Probability Of Blocking*

As the number of users continues to increase within the cellular system, the channels are gradually used up. Using up the channel, in this case, it means that the available channels will no longer provide the users with communication links. When the number of channels is limited concerning the number of users accessing the network, So an enormous number of users will not have access to the network resources(channels). A common quality of service measure is the blocking probability, which is the probability that a new call will not be admitted to the network due to insufficient network resources. The performance measure of interest is called the blocking probability, and it is defined as the long-term probability that an incoming arrival is lost [24].number of users accessing the network, So an enormous number of users will not have access to the network resources(channels). A common quality of service measure is the blocking probability, which is the probability that a new call will not be admitted to the network due to insufficient network resources. The performance measure of interest is called the blocking probability, and it is defined as the long-term probability that an incoming arrival is lost [24].

$$P_b = \lim_{t\to\infty} \frac{\sum_{i=1}^{k} Y_i(t)}{A(t)} \quad (10)$$

where $Y_i(t)$ is the total number of calls lost in cell i up to time t and A(t) is the total number of arrivals up to time t.

After applying equation (10) to both scenarios, the results showed that the blocking probability in the proposed solution decreases because of the efficient distribution of users between cells and an increasing number of available channels. By comparing the results between the current and proposed solution, in Fig.7, it is clearly shown that the effect of automatic distribution comparing to a random distribution. It can be noticed that blocking probability is close to zero after the availability of 17 for user 17 only compared to the current solution which needs 40 available channels to reach zero blocking probability the values are nearly zero after user 40.

To calculate the percentage of reduction we can use ratio and proportion:

$$\frac{X}{100} = \frac{40}{70} \quad (11)$$

$$\frac{X}{100} = \frac{10}{70} \quad (12)$$

For the first scenario (70 users), in the current solution, the (Fig.s .15 to 20) show the probability of blocking for each scenario in both solutions.

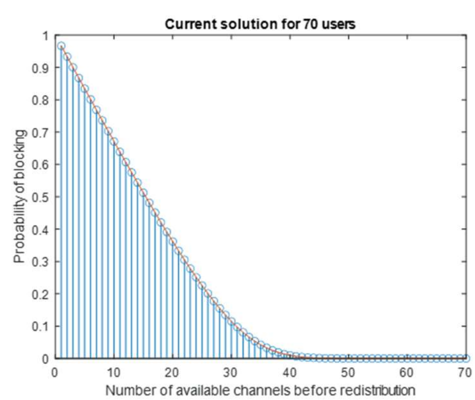

Fig 15: Blocking probability of 70 users in the current solution

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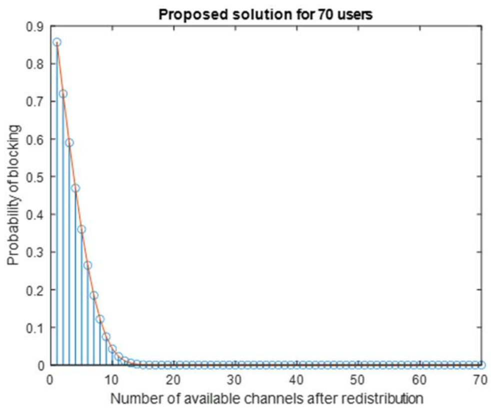

Fig 16: Blocking probability of 70 users in the proposed solution.

From fig.s 17 and 18, it can be deduced that as the number of channels increases, the probability that a user is denied access to the network in terms of call drop is drastically reduced. It can also be inferred from the fig.17 that at a certain instant of 62% of the maximum number of available channels in the cluster is required to reduce Pb to zero, while after the redistribution of users by the suggested algorithm only 33% of available channels of cluster blocking reduced to zero, so the curve started to get to zero at 40 users so, compared to the proposed solution, the curve started to get to zero at 10 users by the current solution, 57% of the maximum number of available channels in the cluster is required to reduce P_b to zero for 70 users, while after the redistribution of users by the suggested algorithm only 14% of available channels of cluster blocking reduced to zero, so the blocking reduced by 43%. blocking reduced by 29%. For 100 users 60% of the maximum number of available channels in the cluster is required to reduce Pb to zero, the blocking is reduced by 20% (fig.s 19 and 20).

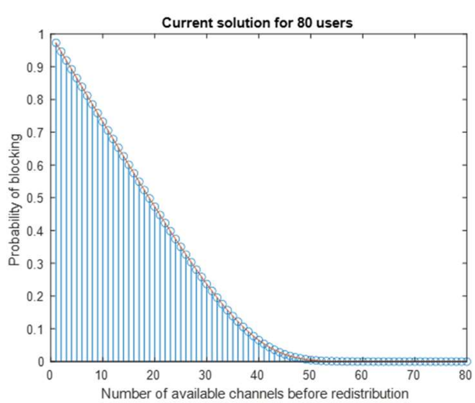

Fig 17: Blocking Probability Of 80 Users In The Current Olution

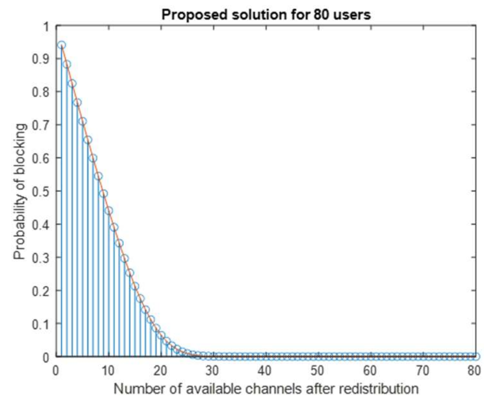

Fig 18: Blocking Probability Of 80 Users In The Proposed Solution

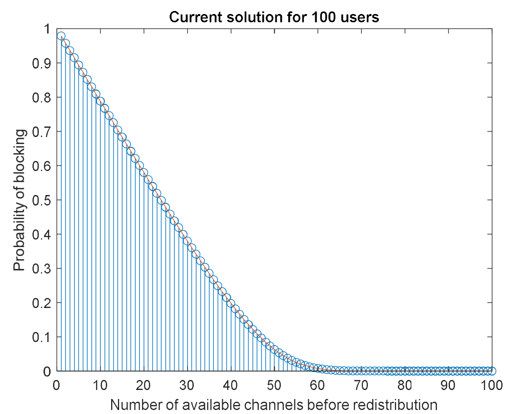

Fig 19: Blocking Probability Of 100 Users In The Current Solution

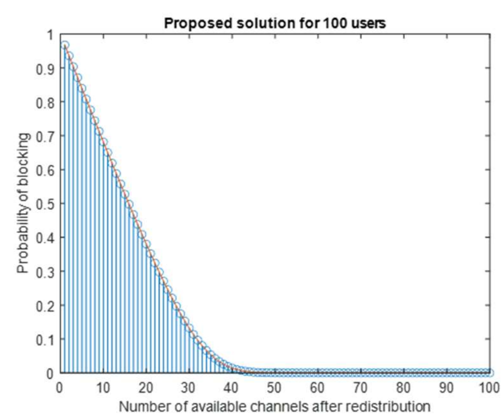

Fig 20: Blocking Probability Of 100 Users In The Proposed Solution

C. Power And CO_2 Footprint Consumption

In this paper, the efficiency of the proposed algorithm in improving system efficiency regarding increasing number of users with a significant reduction in power consumption and CO_2 footprint compared to current solutions (random distribution) are proved. The number of extra required cells by current solutions to provide the same amount of users by the proposed algorithm is figured out. Then the power consumption and CO_2 footprint for base stations in these extra cells are calculated and compared to consumption for several required cells by the proposed algorithm to provide the same system capacity in terms of users number.

From table 2, In each scenario, we increased the number of users to serve the largest possible number of users in a specified number of cells. For example, when K users were distributed to all 7 cells, M users were assigned to the current solution while N users were assigned to the proposed solution. So, how many cells are required to make the current support N users?

If we divided M users by 7 cells we will have A as an average of users number. Divided A by N we have B, which means we need B cells to support N users in the current solution. these new cells need new resources and extra power and consume more CO_2. By applying this process to each scenario, we find that the current solution each time needs more numbers of cells to reach the same number of accepted uses.

$$M/7 = A \tag{13}$$

M: Assigned number of users in the current solution

A: average of users number in each cell

$$A/N = B \tag{14}$$

N: Assigned number of users in the proposed solution

B: the cells needed to support N users

As mentioned in [30,31] we have consumption ranging(3000 kWh/month &10 000 kWh/month) during its operation (regardless of a transaction), in our paper, we find that the proposed solution saved more power compared to the current solution. Fig.s 21 and 22 show the saved power Vs the number of users, Note that the number of users increases significantly with the decrease of power values.

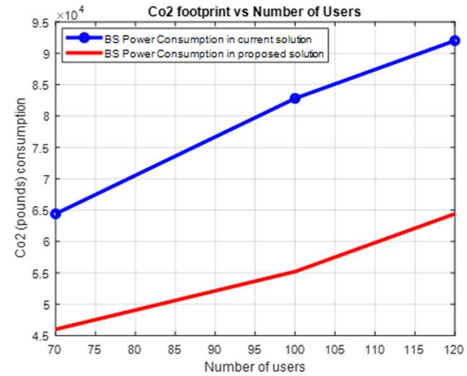

Fig 21: Power consumption (Range=10 000 kWh/month)

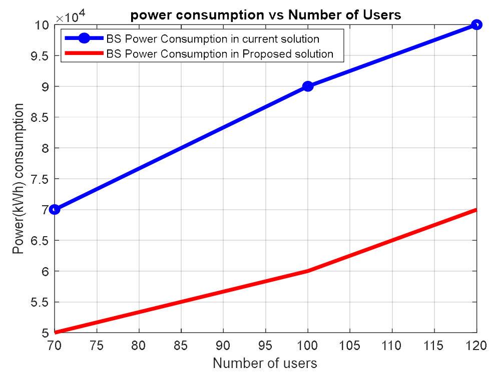

Fig 22: Power consumption (Range=3 000 kWh/month)

In 2019, total U.S. electricity generation by the electric power industry of 4.13 trillion kilowatt-hours (kWh) from all energy sources resulted in the emission of 1.72 billion metric tons 1.90 billion short tons of carbon dioxide (CO_2) [32]. This equaled about:

$$92 \text{ pounds of } CO_2 \text{ emissions per kWh.} \tag{15}$$

Based on that the CO_2 footprint produced by applying our solution we notice in fig.23 a reduction in CO_2 consumption with the increasing number of users:

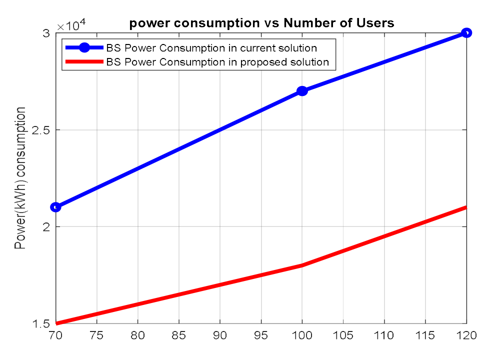

Fig 23: CO_2 consumption.

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By that, we can prove that our solution is **green.**

The performance evaluation for other metrics in the cellular network is investigated for the proposed solution and compared to the current solution before using a new solution. The results of the propagation model demonstrate that after implementing the algorithm, the network behavior remains the same. The behavior of the network will change if the infrastructure and resources are increased, but we notice through the two scenarios that the plans are identical, which means that the redistribution of users did not affect the propagation model and remained the same. The reliability of a network is based on the successful transmission of data packets from the source towards the destination. Results in Fig. 24 show that a network is more reliable with reduced load and less reliable with increased load. Longer Backoff Period length increases the reliability of successful transmission.

The failure probability p_f is defined as the probability for exceeding a limit state within a defined reference time period. Fig. 25 shows that with light offered loads, failure probability becomes low and it started to increase with increasing the offered load

4. CONCLUSION

Redistribution of users all over the cells was performed in order to achieve the desired increase of the capacity and decrease of CO_2 footprint because of limited supply due to limited resources. A group of seven cells (cluster) area of size (50× 100) km2 is considered, with uniform user distribution. BSs are uniformly placed on a hexagonal grid in the area according to the cell radius of each BS. Various scenarios are investigated, based on optimal user distribution. The model used in this paper is M-file model an Institute of Electrical and Electronics Engineers (IEEE) 802.15.4 Machine Access Control (MAC)

Results show that increasing the number of assigned users by 29% can be accomplished by applying the suggested approach also reducing the possibility of blocking by 43% for 70 users, and therefore the system is more efficient while maintaining the same resources. The performance evaluation for other metrics in the cellular network is investigated for the proposed solution and compared to the current solution before using the new solution. The results of the standard IEEE 802.15.4 model demonstrate that after implementing the algorithm, the network behavior remains the same. The behavior of the network will change if the infrastructure and resources are increased, but we notice through the two scenarios that the plans are identical, which means that the redistribution of users did not affect the propagation model and remained the same. and finally, We prove that our solution is green by decreasing the power and CO_2 consumption by 27%.

5. FUTURE WORK

The research paper studies the status of users who are at the overlapping region, more analysis could be done to discuss the user's situation at the edges of the cells

Combining other types of green cellular methods in the literature reviews and with this method and investigate the effect of the power and CO_2 reduction for better efficiency.

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