COVERAGE ENHANCEMENT IN CELLULAR RADIO NETWORKS BY APPLYING DIGITAL FIXED RELAY[+]

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Abstract:-

The modern cellular networks are always endeavoring continuously to present multi services, like internet service, multimedia, file transfer, download etc, in addition to providing high quality voice for customers. All these services need a high data rate coverage. Therefore, interest has focused on increasing the coverage area to enhance the performance of networks. In this paper, we present employment of the Digital Relay to increase the coverage ratio of cell, through covering the areas that are not covered by Base station (BS), these areas are known as coverage holes (dead spots), which are studied in accurate form. This paper includes how to determine the position and angle of the coverage holes, which depend on analysis of the results of propagation Model and Signal to interference ratios. Therefore, we propose to put relays in these areas (coverage holes) with distance equal to fifth of cell radius between this position and the edge of cell. Also in this paper, the optimum number of Digital Relay is determined for each cell and the optimum transmitted power from Base station and Digital Relay to avoid the interference problem. The simulation system in this paper focuses on the handoff process between Base Station and Digital Relay, the results show that the proposed position gives suitable period to execute the handoff process without blocking the calls. The results show when the cluster size of system consists of seven cells high enhancement in performance of cellular networks which apply the Digital Relay. Where the enhancement ratios when comparison the cellular networks that applying Digital Relay technique with conven-tional cellular networks 33.16% in the blocking probability and 18% in the number of users. When the cluster size of system consists of thirteen cells, the enhancement ratios is 34.18% in the blocking probability and 18% in the number of users.

المستخلص :

ان الشبكات الخلوية الحديثة تسعى دائماً وبشكل مستمر الى تقديم خدمات متعددة مثل خدمة الانترنت ، الصورة والصوت ، نقل الملفات ، التحميل ، ..... الخ ،أضافة الى جودة الصوت العالية للمستخدمين.ان ذلك يتطلب تغطية ذات معدل بيانات عالية لذا ركز البحث الحالي الاهتمام على زيادة مساحة التغطية للخلية لتحسين اداء النظام . يقدم البحث الحالي مقترح لاستخدام تقنية مقوي الاشارة الرقمي. لتحسين نسبة التغطية للخلية من خلال تغطية المساحات التي لا تغطى من قبل برج الارسال والاستقبال حيث تدعى تلك المساحات بـــ فجوات التغطية (المناطق الميتة) .كما يقدم البحث دراسة تفصيلية وذلك لتحديد موقع وزاوية فجوات التغطية وبالاعتماد على تحليل نتائج الانتشار الموجي ونسبة الاشارة الى التداخل لذا اقترحنا وضع مقوي الاشارة في تلك المناطق (المناطق الميتة)

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وبمسافة تساوي خمس نصف قطر الخلية ما بين مقوي الاشارة و حافة الخلية.كما تم في البحث الحالي تحديد العدد المثالي لمقوي الاشارة الرقمي لكل خلية كذلك تم تحديد قدرة الارسال المثالية من برج الارسال والاستقبال و مقوي الاشارة الرقمي لتجنب مشكلة التداخل .لقد تم التركيز في النظام المصمم على عملية الـــمناولة بين مقوي الاشارة الرقمي وبرج الارسال والاستقبال وقد أظهرت النتائج ان الموقع المقترح يعطي فترة أمان كافية لاجراء عملية المناولة بشكل دقيق دون حدوث انقطاع بالمكالمات.كما اظهرت النتائج لحجم العنقود ذو السبع خلايا تحسن عالي في اداء الشبكات الخلوية والتي تطبق تقنية مقوي الاشارة الرقمي حيث كانت نسب التحسين عند المقارنة ما بين الشبكات الخلوية التي تطبق تقنية مقوي الاشارة الرقمي مع الشبكات الخلوية التقليدية ٣٣،١٦% في إحتمالِ قطع المكالمات و١٨ % في عدد المستخدمين كما اظهرت النتائج لحجم العنقود ذو الثلاثة عشرة خلية. نسب التحسين كانت ٣٤،١٨ % في إحتمالِ انقطاع المكالمات، ١٨ % في عددِ المستعملين.

1.Introduction:

Traditional cellular systems have provided voice services since the first analog system was introduced about 15 years ago. In the last decade, with the unprecedented increase in demand for personal mobility and dependence on personal commun-ications, both the number of subscribers and the amount of wireless traffic have surged at an exploding speed. With the advent of the Internet, especially the wireless access to the Internet, wireless data traffic is expected to exacerbate the demand for bandwidth. The carriers and infrastructure providers now face a major challenge in meeting the increased bandwidth demand of mobile Internet users [1][2].

The network proposed in this paper is similar to the current cellular networks, the BS is located in the centre of the hexagonal cell, but with proposed network, three fixed relays are placed in each cell as new elements enhancing the cellular infrastru-cture. Each relay is located on distance, which is equal to fifth of cell radius between this position and the edge of cell. The major difference between BS and the proposed Relay is as follows. Once a BS is installed, its location is fixed since it often has a wired interface to an Mobile Switch Center (and a backbone network).On the other hand, the Relay is a wireless communication device deployed by a network operator. It has its own controller with a much lower complexity and less functionality than that needed for a BS [3]. This paper covers design and implementation of the simulation model for cellular network when the Relay is applied as new technique to work in this network. This technique (Relay) is proposed in this paper because it is increases the coverage ratio of cell in order to achieve as close to 100% coverage as possible. This enhancement has a role to increase the S/I ratio to good levels. That means decrease in the Blocking probability (P_B) to the acceptable level. Since the P_B is defined as the probability that the signal to interference ratio (S/I) is less than a specified threshold i.e., $P_B \triangleq P[S/I \leq \eta]$ [4]. Also in this paper the performance of the system is analyzed depending on the P_B which is determined by using Erlang B formula as follows [5][6][7] .

$$P_B = \frac{\frac{A^C}{C!}}{\sum_{K=0}^{C} \frac{A^K}{K!}} \qquad \text{.....(1)}$$

where A is the total offered traffic in Erlang, C is the number of channel per cell, K is the number of cells per cluster.

2. Radio Propagation Model

In an urban environment, the radio signal is attenuated severely as the distance between the transmitter and the receiver increases. The severity of this attenuation is inversely proportional to the distance between the transmitter and receiver raised to some exponent. This propagation exponent is commonly found to lie between 2 and 5.5 in an urban environment. Therefore, the average received power (Pr) for a certain mobile node can be represented by the following formula [7][8]:

$$Pr = Pt\left(\frac{G_t G_r}{PL}\right) \qquad \text{.....(2)}$$

where Pt is transmitted power, PL is the mean path-loss and is described by the following equation:

$$PL = \left(\frac{4\pi d_o}{\lambda}\right)^2 \left(\frac{d}{d_o}\right)^n \qquad \text{.....(3)}$$

where Gt & Gr are the antenna gain of the transmitter and receiver respectively; do is a reference distance at free space; d is the distance between the transmitter and the receiver, n is the propagation exponent, and λ is the wave length in meters. Furthermore, the actual received signal will deviate from the above average. This deviation is due to the shadowing effect caused by large obstructions such as tall buildings and trees. This effect, also known as the large-scale variations, is referred to as lognormal shadowing. The variation in the received signal power, when measured in a log scale (in dB), has a Normal distribution. The depth of this fade variation is measured by the standard deviation and is represented by σ. Thus, in order to account for the effect of shadow fading, equation (2.12) can be further written as[7] [8]:

$$Pr = Pt\,\frac{G}{PL}\,X_\sigma \qquad \text{.....(4)}$$

G is Combined antenna gain of the transmitter and the receiver, Xσ is Log-normally distributed random variable with0 (dB)mean, σ (dB)standard deviation.

3. Analysis of the System Model

In this paper, the simulation model for cellular network with Relay technique is proposed, according to group of sequential steps as follows.

3. 1 Appointing Weak Signaling Regions in Cell

Coverage has invariably been a major concern for cellular service providers. In a built up urban environment, the radio signal decays very rapidly as the distance between the transmitter and receiver increases [9]. In addition there are regions within the cell not covered by BS, commonly known as dead spots or coverage holes [10], this matter leads to decay the signal at very fast rate. Accordingly, the weak points within cell, which would be the calculated received power, is very low, the coverage holes that can be observed in the Figure (1), you shows the radiation pattern of the directional antenna. In this figure can observe the coverage holes which are between the two patterns after the point 0.8 at the angle 60˚ [10].

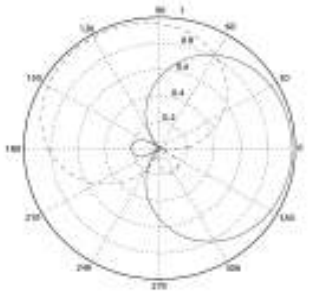

Figure (1) The coverage holes in cell

There is important parameter which affects the antenna gain and subsequently affects the power of transmitted signal that is Half-power-Beamwidth Φ_{HPB}. Φ_{HPB} is the angle where the antenna gain has dropped to half of its beam center value, i.e -3dB. Another pattern parameter is the front-to-back ratio and it is the gain ratio between the front lobe and the back lobe. The front to back ratio is set to -15 dB. The antenna gain is 0dB at the center. Depending on the equation (5), we can calculate the antenna Gain in the case of HPB [11].

$$G(\Phi)[dB] = \begin{cases} \frac{-3}{(\frac{\Phi_{HPB}}{2})^2}\Phi^2 & \text{If } |\Phi| \leq \sqrt{\frac{15\Phi_{HPB}}{2}} \\ -15 & \text{otherwise} \end{cases} \qquad \text{.....(5)}$$

3.2 Selection the Optimum Position of Relay

3.3

From the relevant literature exactly the last 5 years we found many suggestions for position and number of Relay per cell where Relays are placed on the segment between the center and one corner of that cell, with dependence on this equation:-

$$D = \frac{X}{m} \qquad \text{.....(6)}$$

where (D) is the distance between Relay and one of the cell corner, (X) is the radius of cell and (m) is proposed position factor of Relay in cell (1, 2, 2.5, 3, 4, 5)that is clear in Figure (2)

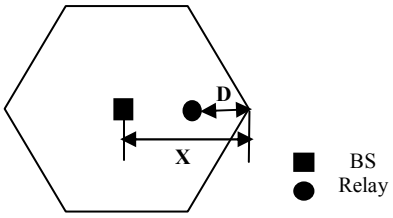

Figure (2) The distance between BS and Relay

For instance the study of [12][13] suggests six Relays placed close to the corner of cell at distance equal to X/3 as shown in Figure (3).

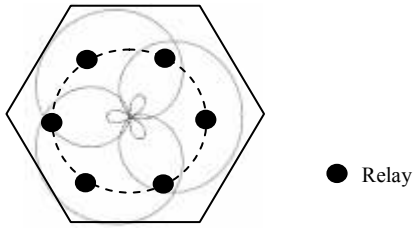

Figure (3) The position of Relays where D is equal to X/ 3

Another study [1][2][3][14][15][16] suggest six Relays placed on the six sides of cell respectively as shown in Figure (4).

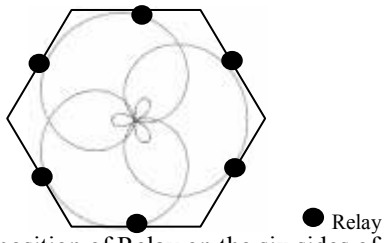

Figure (4) The position of Relay on the six sides of cell

In this section we have two proposals, the first proposal is selection of the optimum position of Relay depends on appointing weak signaling regions in cell and where the weak points is determined in cell (previous section 3.1) so the best position of Relay is at these points. The second proposal in this section is determining the number of Relays per cell. When the sector is 120˚, the number of the coverage holes regions is equal to three regions, so the number of Relay that is needed is three. That is important point for reducing the number of interference sources instead of six Relays as observed in other studies; as a result, we can say that the interference value is reduced to 50% from its value. Accordingly, six position cases of Relays (X, X/2, X/2.5, X/3, X/4, X/5) with three Relays to be used in cell. Both proposals are represented in Figure (5).

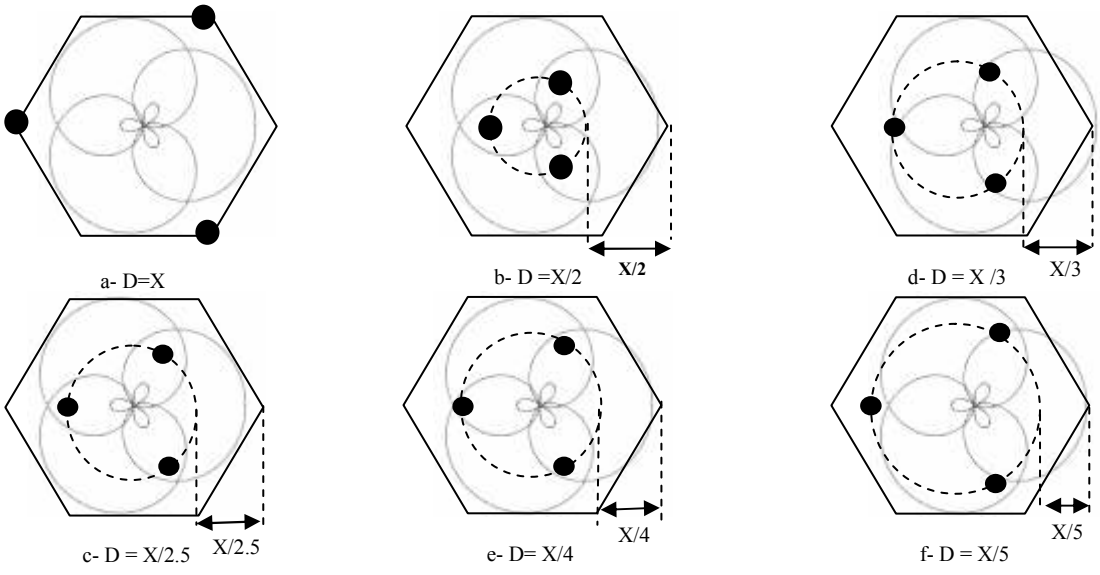

Figure (5) The six proposed position of Relay Where (a- D=X), (b- D=X/2), (c- D=X/2.5), (d- D=X/3), (e- D=X/4), (f- D=X/5)

For perfect selection of best position of Relay through comparing with all suggestions related to position of Relay we depend on the signal to interference ratio (S/I or SIR) for mobile receiver which monitors a forward channel it can be expressed as :-

$$\frac{S}{I} = \frac{S}{\sum_{K=1}^{Ko} I_K} \qquad \text{…....… (7)}$$

where: I_K : is the main interference power originating from the k-th cell.

K_o : the number co-channel interference cells.

S : the power signal [9].

Depending on proposed number of Relays, we can calculate the total interference power [12].

$$I_K = I_1 + I_2 + \text{……..} + I_{12} \qquad \text{…….(8)}$$

Figure (6) illustrates the interference sources (BS, Relays) when the cluster size is equal to 7 and the mobile at the cell boundary, it experiences worst case co-channel interference on the forward channel. By using mathematical equations that deal with distance we can calculate the distances between the mobile and any interference sources (BS, Relay), then calculate the S/I ratio depending on that distances. In addition, in Figure (7), the same case can be seen but with cluster size equal to 13.

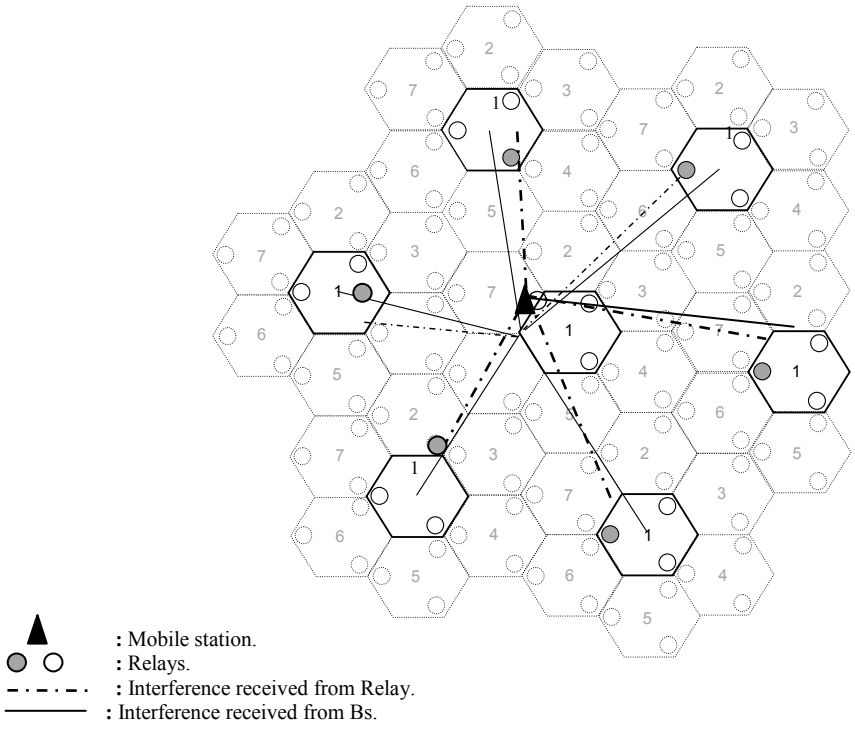

Figure (6) The interference sources (BS Relays) when the cluster size is equal to7

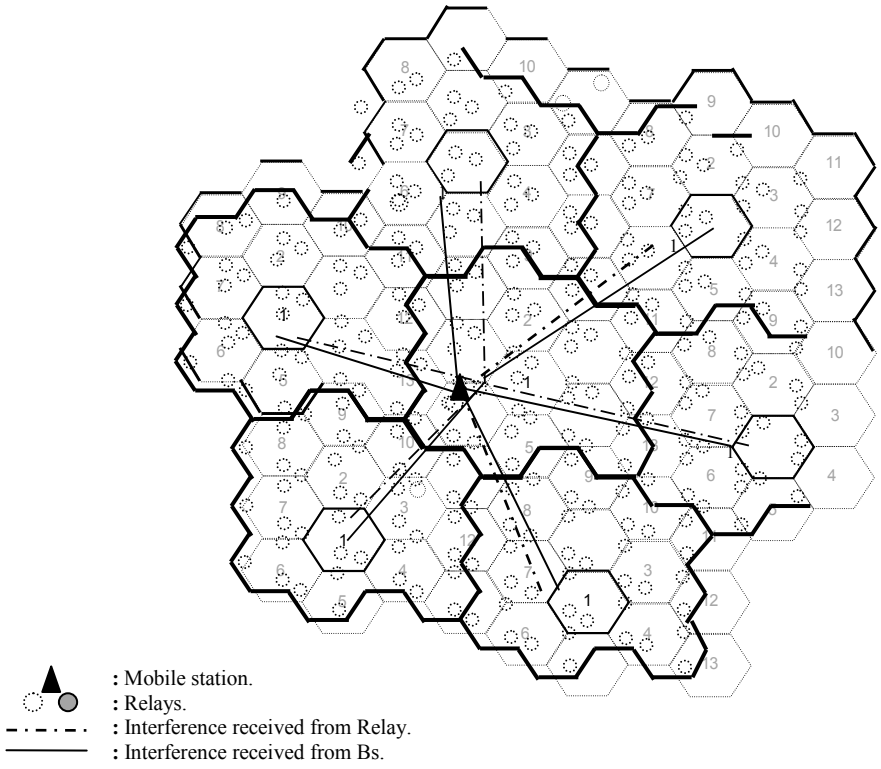

Figure (7) The interference sources (BS,Relays) when the cluster size is equal to 13

At last and from the equation of coverage ratio (9), you can determine the best coverage ratio for various positions of Relays (X, X/2, X/2.5, X/3, X/4, X/5) [3].

$$P = \frac{n_r a}{A_c} \text{ ..... (9)}$$

a : the coverage area of Relay.
A_c : the area of cell.
n_r : number of Relays per cell.

3.3 Calculate the Optimum Transmitted Power for BS and Relay

When the new equipment (Relays) is involved working in the cellular networks, this leads to increase the interference value. Therefore, you must re-calculate the Pt for BS and Relay to guarantee the best interference environment. Depending on equation (6) would determine the optimum power for BS and Relay the S/I ratio is calculated for various values of Pt (0.1w to 1w).

3.4 The Handover Between BS and Relay

Depending on equation (4) the received power is calculated for all frequencies in the frame that is used in the communication between BS, Relay and UE. Then Compare these values with threshold value (-71dB) which is used to determine the communication with BS or transition to the closer Relay to subscriber or inversion. If the value of Pr is greater than threshold value (-71) then it is stored in matrix (M1) but if the value of Pr is less than threshold value (-71) then it is stored in matrix (M2), then the number values between matrixes M1 and M2 are compared. Now there are two cases to handover, the first is when the subscriber is moved from BS to Relay, secondly when the subscriber is moved from Relay to

BS. In the first case (BS to Relay) if the number of values in matrix (M2) is larger than the number of values in matrix (M1), then the communication is transformed from BS-subscriber to Relay-subscriber with allocating suitable communication channel. However, when the number values in matrix (M2) is less than the number of values in matrix (M1), then the communication is continued between BS and subscriber. In second case (Relay to BS) if the number of values in matrix (M1) is larger than the number of values in matrix (M2), then the communication is transformed from Relay-subscriber to BS-subscriber with allocating suitable communication channel. However, when the number of values in matrix (M1) is less than the number of values in matrix (M2), then the communication is continued between Relay and subscriber. This process is continued until ending the communication process.

4. Simulation Results

This paper presents the simulation results for all suggestions in previous sections. The objectives of this simulation are to prove performance enhancement of cellular networks by using Relay technique. These are presented in accordance with the comparison between two proposed cases as follows:-

1-With Relay.

2-Without Relay.

To investigate reliability of results in our paper two types of cluster size 7 and 13 are used.

.4.1 Selection The Optimum Position of Relay

Figure (8) illustrates the results of Half- Power- Beamwidth for the case where the number of cell per cluster is equal to 7 and 13. The Pt of BS is equal to 1w and system without Relay. It shows the change in value of S/I ratio to user who moves 100m every step away from BS at the same time nearing the coverage holes (dead spots). Accordingly we can see acute downfall in the S/I ratio when the distance between user and BS is more than 800m. When cluster size (K) is 7 the S/I ratio is equal to 108.6 dB at 800m and decreases to 83.5 dB at 900m, same the decrease happens in K= 13, the S/I ratio is equal to 113.5 dB at 800m and 88.5 dB at 900m. These results are out of acceptable levels to operate. Figure (9) illustrates the same problem although Pt is increased to 50% (1w to 1.5w). In K= 7 the S/I ratio is equal to 110.5 dB at 800m and decreases to 85.5 dB at 900m. In K= 13 the S/I ratio is equal to 115 dB at 800m and decreases to 90.21 dB at 900m. Therefore the effect of increase in the transmitted power dose not solve the problem of downfall in S/I ratio. To solve this problem we suggest using Relay as new equipment in the environment of cellular network.

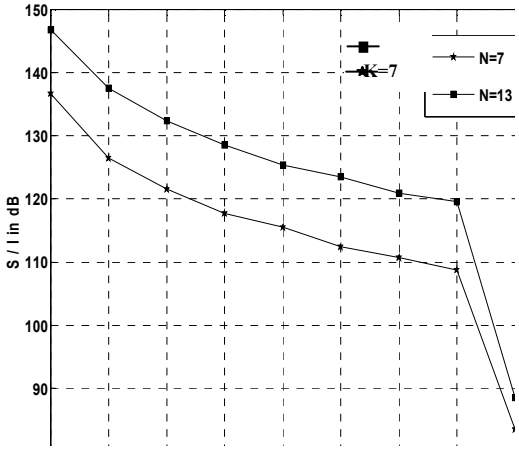

Figure (8) The relationship between S/I ratio and the distance between user and BS when Pt of BS=1w in k= 7and13. The cell without

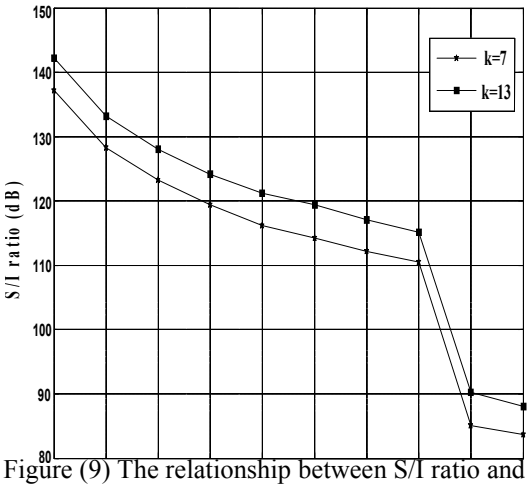

Figure (9) The relationship between S/I ratio and the distance between user and BS when Pt of BS=1.5w in k= 7and 13. The cell without Relay.

Figure (10) shows the relationship between S/I ratio with position of Relay. All values of S/I ratio are calculated when the user is stopped in the corner of cell (worst case), and the transmitted power for BS, Relay is equal to 1w, 0.5w respectively, the radius of cell is equal to 1000m, and the K= 7,13. It is clear our suggestion the position of Relay is equal to 200m (X/5) from the corner of cell and the number of Relay per cell is equal to 3 giving that high S/I ratio , it is equal to 118dB in K= 7 and 122.8 dB in K= 13. In Figure (11) you can see the same values approximately of S/I ratio at D equal to 200 (X/5) when the transmitted power for BS and Relay is increased to 1.5w and 0.75w respectively. The S/I ratio is equal to 119.8dB in K= 7 and 124.8dB in K=13. Also from results shown in Figure (11) you can see other values to S/I ratio of the position (X/4, X/3, X/2.5, X/2, X) are less than the value of S/I ratio at position (X/5) and decrease whenever Relays are moved away from the (X/5) position. From the Figures (12, 13, 14, 15, 16, 17) you can observe the reason for decrease or increase in the S/I ratio. We take one case at a time (X/5, X/4, X/3, X/2.5, X/2, X) and study the behavior of propagation model when we use Relays that are through the relationship between Pr from BS and Relay with the radius of cell. When the position of Relay is (X/5) it gives perfect performance because this distance represents the downfall point of Pr from BS as shown in Figure (13) in distance (800m-850m), where the Pr is very weak (-101dB at 850m). This case means that region is protected from the interference signal, which guarantees perfect operating environment for Relay leading to better performance system

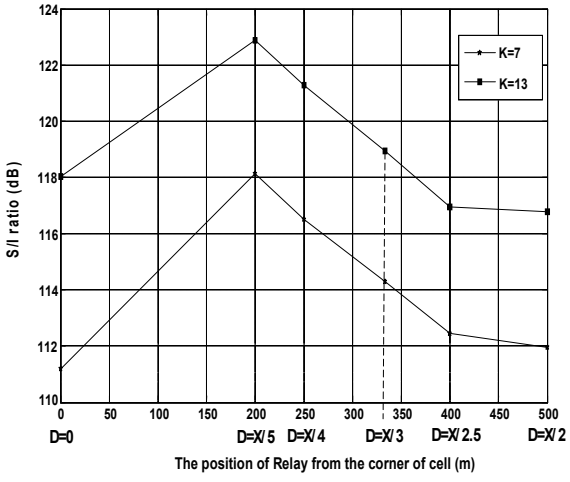

Figure (10) The S/I calculated for user stopped in the corner of cell. The user received power from Relay, Pt of BS=1w and Relay=0.5w

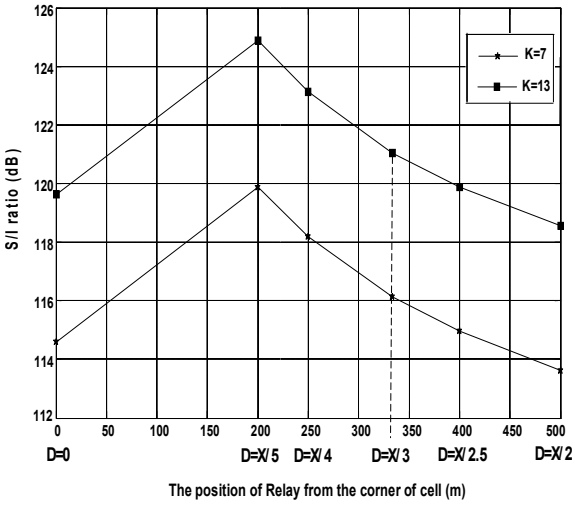

Figure (11) The S/I calculated for user stopped in the corner of cell, the user received power from Relay when power transmit BS=1.5w, Relay=0.75w

When the position of Relay is X just as in Figure (12) this case would produce the interference with the neighboring cells, additionally the matter requires increase in Pt of Relay to be able to cover coverage holes (dead spots) completely. In Figure (14) when the position of Relay is X/4, we can observe the Power effect of Relay on BS, where the Pr is equal to -65dB in 600m. This value leads to high interference environment and these value increases whenever Relay is nearing from BS, this is clear in Figures (15, 16, 17) which illustrate the interference in power between Relay and BS on the other hand and in the opposite side Pr of Relay decrease, so Relay cannot cover a coverage holes (dead spots) completely.

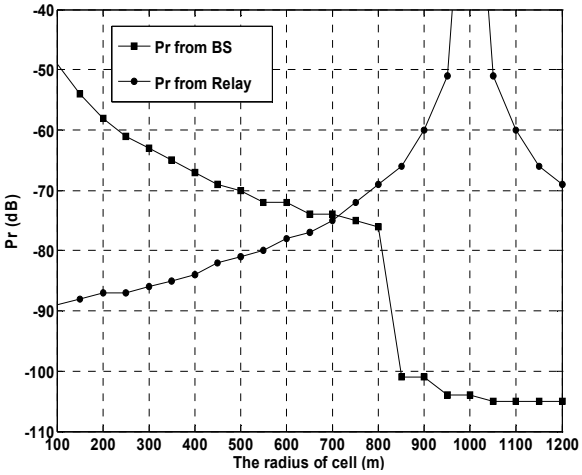

Figure (12) The Pr from BS and Relay when the position of Relay is X. The Pt of BS=1w and Relay=0.5w

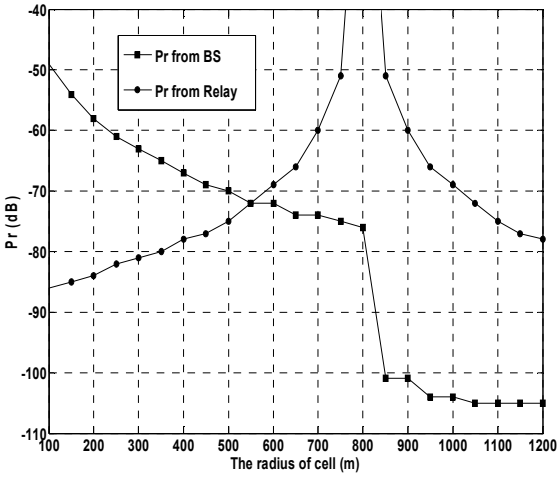

Figure (13) The Pr from BS and Relay when the position of Relay is X/5. The Pt of BS=1w and Relay=0.5w

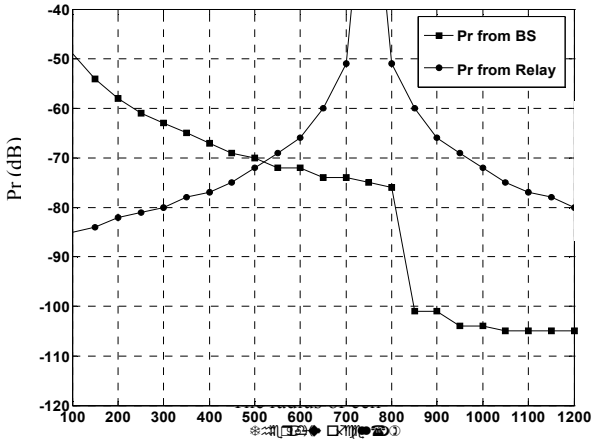

Figure (14) The Pr from Bs and Relay when the position of Relay is x/4 .The Pt of BS=1w and Relay=0.5w

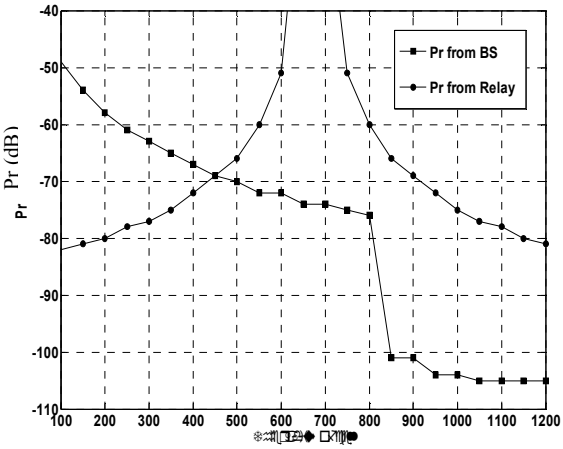

Figure (15) The Pr from Bs and Relay when the position of Relay is x/3. The Pt of BS=1w and Relay=0.5w

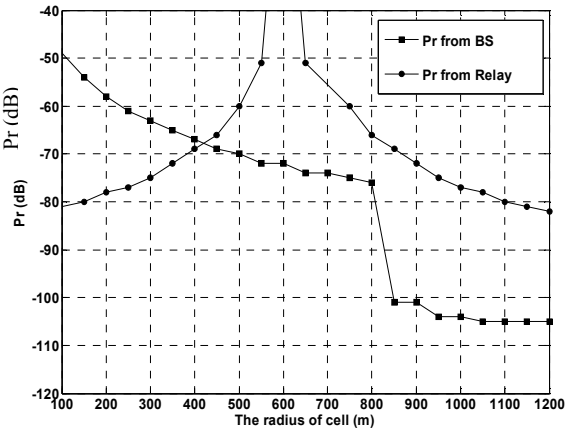

Figure (16) The Pr from Bs and Relay when the position of Relay is x/2.5. The Pt of BS=1w and Relay=0.5w

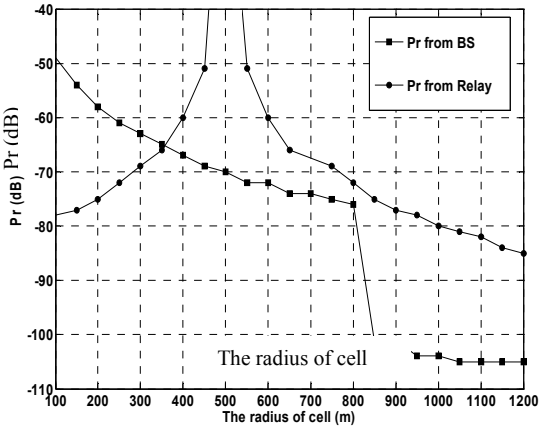

Figure (17) The Pr from Bs and Relay when the position of Relay is x/2. The Pt of BS=1w and Relay=0.5w

Also from the results shown in Figures (12) , (13) , (14) , (15) , (16) , (17) we can calculate the coverage ratios of Relays for all cases (X , X/5 , X/4 , X/3 , X/2.5,X/2) according to the equation (6), where the results are as follow:-

Table (1) Coverage ratio of Relays

The position of Relay	The coverage ratio
D = 0 (X)	7%
D = 200 (X/5)	14.5%
D = 250 (X/4)	22.6%
D =333.33 (X/3)	40.3%
D = 400 (X/2.5)	58%
D = 500 (X/2)	90.6%

Depending on the coverage ratio of BS in cellular networks, which are not, less than 70% and not more than 90% we can determine the best ratio. The first ratio for the case (X) represents the fewest ratios, which is not enough to solve the problem of coverage holes (dead spots). The second ratio for the case (X/5) is more acceptable and the total coverage ratio (For BS and Relays) is close to 100%, the remainder ratios are very high, that means expending in power of the system and producing the interference. The result shown in these Figures the importance of using Relay for enhancement the performance of cellular network but the position of Relay is equal to X/5. The Figures (18 and 19) illustrate the method of solving the downfall problem in S/I ratio when the Relays are located in the optimum position. We can see how the S/I ratio is decreasing gradually whenever distance between user and BS increases but this ratio is increasing when the distance is 600m, the increase continues whenever the user is nearing Relay and then goes back to decrease when the user moves away from Relay. When the Pt of BS and Relay equal to 1w, 0.5w respectively .at the cluster size equal to 7cells, the S/I ratio equals 117dB in 500m, 118.12dB in 600m and 178.5dB in 800m. Cluster size equals 13cell, the S/I ratio 122dB in 500m, 123dB in 600m and 183dB in 800m. Approximately the same value but with slightly change when Pt increases 50% for BS and Relay. This matter guarantees high reliability of proposed method and has the ability to work at any cluster size.

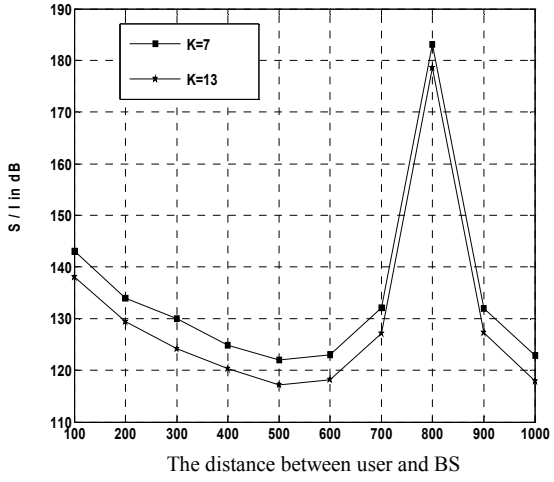

Figure (18) The S/I ratios calculated for user who move 100m every step when the Pt of BS=1w and Relay=0.5 w in K=7,13

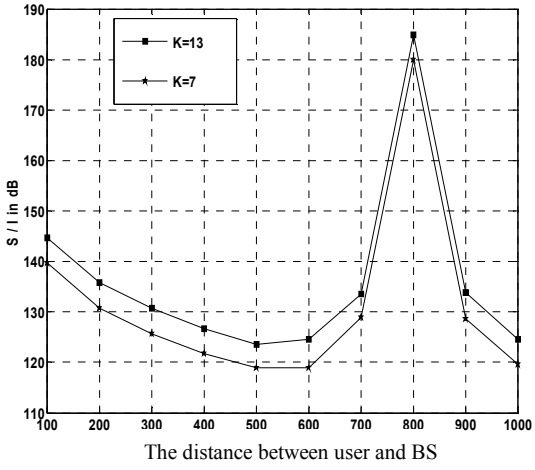

Figure (19) The S/I ratios calculated for user who move 100m every step when the Pt of BS=1.5w and Relay=0.75w in K=7,13

4.2 Optimum Transmitted Power for BS and Relay

This section, discusses how one can determine the optimum values of Pt in system when using Relay as new equipment in the environment of cellular network. In the case of conventional cellular network, we observe the Pt of BS is used in high levels, like 5w, 6w or more but here we use another interference source (Relay) and so the optimum transmitted power is calculated for BS and Relay in system for two important reasons.
1-Decrease in the interference that produced from Relays.
2-The economics in expenses of cellular networks

Figure (20) illustrates the relationship between S/I ratio for user stopped in one of the corner cell and the Pt of Relay when the transmit channel is with Relay where the Pt of Bs is equal to 1w. From this figure we can see when K=7 the S/I ratio is equal to 118dB when Pt of Relay equals 0.5w, 118.6 dB when Pt of Relay equals 0.7w and119.6 dB when Pt of Relay equals to 1w. This increase in S/I ratio represents slight change in comparison with the value of Pt for Relay (0.5w to 1w). Approximately the same behavior when K=13where the S/I ratio is equal to123 dB when Pt of Relay equals 0.5w, 123.5 dB when Pt of Relay equals 0.7w and 124dB when Pt of Relay equals 1w. We conclude from that, the optimum value to operate is 1w for Bs and 0.5w for Relay. These values allow economizing in Pt of Bs and relay about half power at the same time to decrease the interference. Therefore, there is no need to increase the level of Pt for BS and Relay more than 1w, 0.5w respectively.

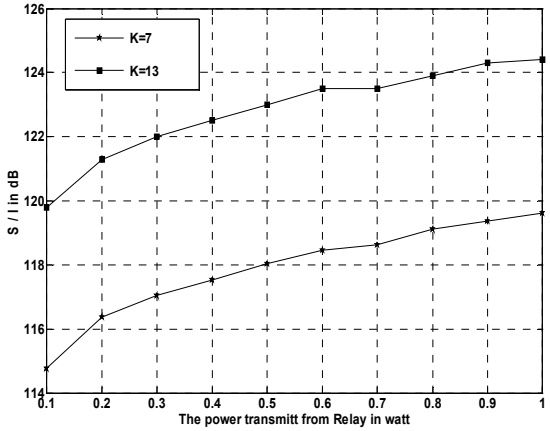

Figure (20) The S/I for user in corner of cell and received power from Relay when Pt of Relay change from 0.1w to 1w

4.3 Blocking Probability

This section aims to study the changes in P_B through two main parts:-
1-Blocking probability with load traffic. 2-P_B with user.
For the first part there are two factors which will change in load traffic (number of calls per hour (ℓ) and average calling time (h) to observe how the P_B is changing. The second part depends on the number of users and shows the effect of increasing the number of user on P_B.

4.3.1 Blocking Probability with Load Traffic

This section includes Figures (21) and (22) we increase the average calling time to 2 minute with 35 calls per hour. The P_B in these figures increases to high levels, especially in first case (without Relay) where it is equal to 0.47 in load traffic is equal to 110 .The P_B for the second case (with Relay) is equal to 0.38, this value is acceptable compared with first

case. In Figure (21) when the K=13. The P_B in first case (without Relay) is equal to 0.46 in load traffic is equal to 110 .The P_B for the second case (with Relay) is equal to 0.38.

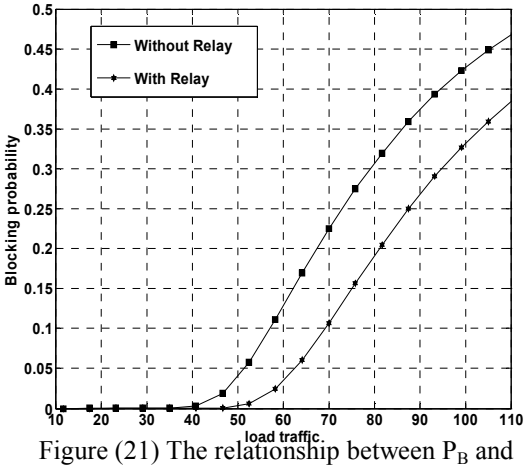

Figure (21) The relationship between P_B and load traffic when K = 7, number of calls = 35 per hour, average calling time = 2 minute

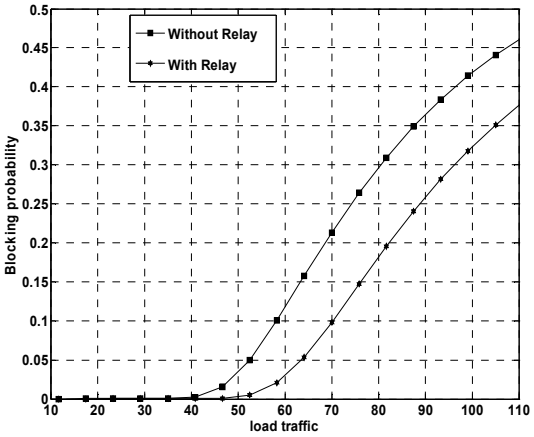

Figure (22) The relationship between P_B and load traffic when K= 13 , number of calls =35 per hour, average calling time = 2 minute

4.3.2 Blocking Probability with User

Figure (23) presents good enhancement when we apply Relay. We can see in the first case (Without Relay) when the number of users is equal to 55, P_B equals 0.0154 and increases to 0.038 when the number of users increases to 60. In the second case (With Relay) when the number of user equals 70, P_B equals 0.0245, and increases to 0.0482 when number of users increases to 75. Therefore, we can increase the number of user in any cluster size of cellular network by applying the Relay technique. In Figure (24), approximately the same results can be seen.

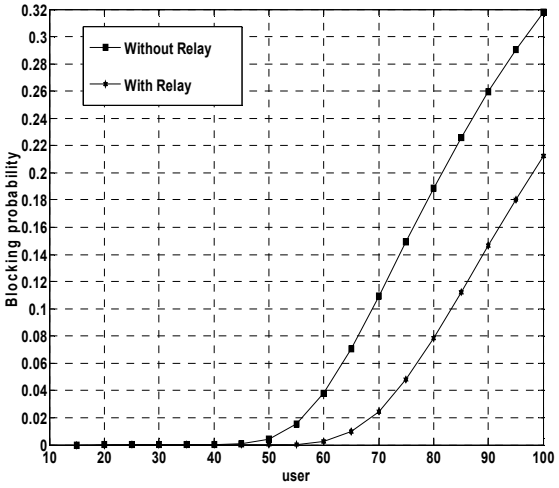

Figure (23) The relationship between blocking probability and number of user when K = 7.

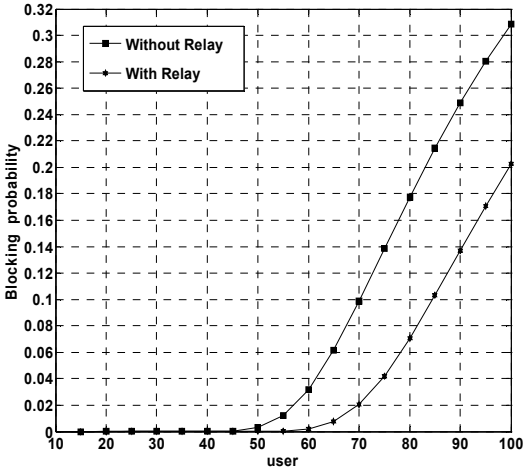

Figure (24) The relationship between blocking probability and number of user when K = 13

5. Conclusions

Our results show that relaying can improve the system performance. Therefore, based on our simulation results, the following conclusions are drawn:-

1-The literature surveys propose increase in the transmitted power to get the radiation pattern which could be able to cover as a large area as possible, for reducing the area of dead spots. This paper proposed using the Relay technique to solve the problem of dead spots at the same time it reduces the power of BS which equal to 1w instead of 5w, 8w or more. On the other hand, the results of determining the value of the transmitted power of Relay indicate to employ a power equals to 0.5w, since the enhancement ratio in S/I when increasing the power of Relay from 0.5w to 1w is equal to 1.3% approximately. This ratio is very low, therefore, we use 0.5w instead of 1w.

2-The results related to determining the optimum position of Relay show the downfall problem that is not solved even when the transmitted power of BS is increased, this downfall problem determines between 800m to 900m.This way helps us to determine the dead spots area in accurate form.

3-The position X/5 gives acceptable coverage ratio equal to 14.5% ,this ratio is close to the operating values, while the unfading proposals give high coverage ratio or very low. So the X/5 is the typical position of Relay.

4-The results of propagation wave for the six proposed positions of Relay. give different behavior between them as follows.

A- The results for the proposed X indicate that there is no adequate period for handoff process for transition between BS and Relay. This period between 700m and 800m would be problem when user movies within handoff region, in this case there is no chance for BS to take suitable decision. In addition, this position causes introduceing high interference with the neighboring cells , since the values Pt of Relay in the distance 1100 ,1200 very high is equal to -60, -70 respectively.

B- In proposed X/5 there is a good period for handoff process which allows BS to take best decision this period is between 550m and 880m .We can observe this position is the same point of the downfall signal point. In addition, the value of Pt in distance 1100, 1200 does not affect the neighboring cells.

C- All the propositions X/4,X/3,X/2.5,X/2 have same problem that is the effect Pt of Relay on BS, since these positions are close to position of BS. At the same time we can see the Pt of Relay is decreasing especially X/2.5, X/2 in distance 800m,900m , consequently the Relay moves away from its main role.

5-We can observe the enhancement ratios in P_B when l =35, h=2 and K=7 the enhancement ratio between first case (without Relay) and second case (with Relay) is equal to 17.48% approximately .when K=13 this ratio increases to 17.89%.

6- The enhancement ratio in number of user between the first and second case is 18% for K=7 and 18% for K=13, which means any cellular networks can increase the number of users by applying Relay and technique.

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