# OPTIMAL ALLOCATION OF CELLULAR BASE STATIONS

**Dr. Sabah Rasoul Dakhel**
**University of Technology**

**Mr. Saad Abdul sadah Ghani**
**University of Technology**

**Dr. Sattar Bedir Sadkhan**
Al-Nahrain University

## ABSTRACT

The area of wireless communications has experienced recent explosive growth because of its advantages such as the callers need not be tied to a particular location because they use mobile terminals. Also the medium, unlike wires, fiber, or coaxial cable, is simply air which is free.

The Quality of Service (QoS) has become an important research issue since it reflects user satisfaction. QoS is affected by the interference power and it is inversely proportional to Interference to Signal Ratio (ISR).

The power of base and mobiles stations has been an important effect on the value of ISR. Thus, it is necessary to control this power so that it can be used in an optimal manner.

In this paper, a nonlinear programming model was built for the optimal allocation of the power of the base and mobile stations in an Ad-Hoc mobile communication network in order to obtain an optimal Interference to Signal Ratio (ISR) subject to Quality of Service (QoS) constraints.

# 1. INTRODUCTION

No area of telecommunication has experienced the recent explosive growth like that of wireless communications. Of course, wireless communications are essentially radio communications, which is not all that new. However, the maturation of various technologies (such as very large scale integration of security and advances in signal processing), cost reductions in technologies, new frequency availability, and business pressures for mobility and networking in the past few years have finally made wireless communications efficient and cost effective.

As it implies, wireless telecommunication means communicating without the use of wires or other physical guides or conducts (such as fiber) through some distance. Examples of wireless communications are cordless and cellular phones.

# 2. MOBILE COMMUNICATIONS

Each mobile uses a separate, temporary radio channel to talk to the cell site. The cell site talks to many mobiles at once, using one channel per mobile. Channels use a pair of frequencies for communication.

One frequency, the forward link, for transmitting from the cell site, and the other, the reverse link, for the cell site to receive calls from the users. Radio energy dissipates over distance, so mobiles must stay near the base station to maintain communications. The basic structure of mobiles network includes telephone systems and radio services.

# 3. SOME IMPORTANT PARAMETERS

## 3.1 Power Control

Power control of the mobile units in a cell is critical to proper operation in that cell. Mobiles close to the base station must actually reduce their power so that they do not overload signals received from mobile units not as close. [4]

## 3.2 THE NEAR-FAR PROBLEM

The **Near-Far** problem occurs when many mobile users share the same channel. In general the strongest received mobile signal will capture the demodulator at a base station.

## 3.3 INTERFERENCE

Interference is contamination by extraneous signals, usually man-made, of a form similar to the desired signal. The problem is particularly common in broadcasting, where two or more signals may be picked up at the same time by the receiver.

### 3.3.1 Co-channel Interference

Frequency reuse implies that in a given coverage area there are several cells that use the same set of frequencies. These cells are called co-channel cells, and the interference between signals from these cells is called co-channel interference.

### 3.3.2 Adjacent Channel Interference

Interference resulting from signals which are adjacent in frequency to the desired signal is called the adjacent channel interference. Adjacent channel interference results from imperfect receiver filters which allow nearby frequencies to leak into the passband.

### 3.4 AD – HOC NETWORK

AD-HOC network consists of mobile terminals with personal communication devices. Each terminal can receive an information from any other terminal and send it to another one.

## 4. THE ROLE OF OPTIMIZATION RESEARCH IN CELLULAR COMMUNICATIONS

In1983, Daikoku and Hitoshi [2] published a paper about the optimal channel reuse in cellular land mobile, in which the origination probability for co-channel interference is introduced to the study of the influence of all co-channel interferences surrounding the base station of interest. In 1985 the same researchers [3] published a paper about the optimal design of cellular mobile system. They considered the limitations of the available frequency allocation.

In 1987, Lee [6] suggested a computer simulation model, designed specifically for the analysis and evaluation of radio communication systems in the tactical environment.

In 2000, Yeung [8] published a paper about the optimization of channel assignment in cellular mobile networks. In this paper, six channel assignment heuristic algorithms are proposed and evaluated.

In 2002, Kai, Jiandong [5] published a paper, in which an adaptive mobile cluster protocol was presented which sustains the mobility perfectly and maintains the stability and robustness of network architecture.

## 5. THE MATHEMATICAL MODEL OF MINIMIZATION INTERFERENCE to SIGNAL RATIO (ISR)

The model objective is to optimize the mobile transmitted power to minimize the Interference to Signal Ratio (ISR) for a particular user under Quality of Service (QoS) constraints in the cellular communication networks. The model solution will help in the optimal distribution of mobile stations.

### 5.1 DECISION VARIABLES

Suppose we have five users ( I, J, K, L, M).

Let:

$P_B$ = Power of the base station .

$P_I$ = Power of mobile station I.

$P_J$ = Power of mobile station J.

$P_K$ = Power of mobile station K.

$P_L$ = Power of mobile station L.

$P_M$ = Power of mobile station M.

$d_I$ = Distance between mobile station I and the base station.

$d_J$ = Distance between mobile station J and the base station.

$d_K$ = Distance between mobile station K and the base station.

$d_L$ = Distance between mobile station L and the base station.

$d_M$ = Distance between mobile station M and the base station.

$T_K$ =Threshold Signal to Interference Ratio (SIR) level for mobile station K.

$T_L$ =Threshold Signal to Interference Ratio (SIR) level for mobile station L.

$T_M$ =Threshold Signal to Interference Ratio (SIR) level for mobile station M.

## 5.2 THE OBJECTIVE FUNCTION

The objective function is to minimize the Interference to Signal Ratio (ISR), i.e, the ratio of the sum of the effective interference power values from base station and other mobile stations in the system.

The objective function can be written in the following from:

$$MIN(ISR)_1 = \frac{\dfrac{P_B}{10d_1^4} + \dfrac{P_J}{10\left(d_1^2 + d_J^2 - 1.732d_1d_J\right)^2} + \dfrac{P_K}{10\left(d_1^2 + d_K^2\right)^2} +}{\dfrac{P_1}{d_1^4}}$$

$$\frac{\dfrac{P_L}{10\left(d_1^2 + d_L^2 + 2d_1d_L\right)^2} + \dfrac{P_M}{10\left(d_1^2 + d_M^2\right)^2}}{\dfrac{P_1}{d_1^4}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

## 5.3 THE CONSTRAINTS

### 5.3.1 The Co-Channel Interference Constraint

Interference due to users including base station and mobiles must be smaller than a positive constant $C_k$[4].

Let

$C_k = 2.8\,(10^{-14})$ Watt.

$= 10\log(2.8(10^{-14}))$ dB

$= -135.5$ dB

The total co-channel interference due to users and base station =

$$10\log\left[\frac{P_B}{d_1^4} + \frac{P_J}{\left(d_1^2 + d_J^2 - 1.732d_1d_J\right)^2} + \frac{P_K}{\left(d_1^2 d_K^2\right)^2} + \frac{P_M}{\left(d_1^2 + d_M^2\right)^2}\right] + 135.5 < 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

### 5.3.2 The Adjacent Channel Interference constraints

Interference due the users has to be smaller than the received signal power for some mobile w so as to achieve a required SIR $T_w$ [21].

Adjacent channel interference constraints can be formulated as follows:

## Constraint of Mobile Station K

$$T_{k\log}\left[\frac{P_J}{10\left(d_1^2+d_J^2-1.732d_1d_J\right)^2}+\frac{P_K}{10\left(d_1^2+d_k^2\right)^2}+\right.$$

$$\left.\frac{P_L}{10\left(d_1^2+d_L^2+2d_1d_1\right)^2}+\frac{P_M}{10\left(d_1^2+d_M^2\right)^2}\right]-6.3T_K-\log(P_K)$$

$$+2\log\left(d_1^2+d_K^2\right)<0\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

### b. Constraint of Mobile Station L

$$T_{L\,\log}\left[\frac{P_J}{10\left(d_1^2+d_J^2-1.732d_1d_J\right)^2}+\frac{P_K}{10\left(d_1^2+d_K^2\right)^2}+\right.$$
$$\left.\frac{P_L}{10\left(d_1^2d_L^2+2d_1d_1\right)^2}+\frac{P_M}{10\left(d_1^2+d_M^2\right)^2}\right]-6.3T_L-\log\left(P_K\right)+$$
$$2\log\left(d_1^2+d_l^2+2d_1d_L\right)<0\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

### c. Constraint of Mobile M

$$T_{M\,\log}\left[\frac{P_J}{10\left(d_1^2+d_J^2-1.732d_1d_J\right)^2}+\frac{P_K}{10\left(d_1^2+d_K^2\right)^2}+\right.$$
$$\left.\frac{P_L}{10\left(d_1^2+d_L^2+2d_1d_1\right)^2}+\frac{P_M}{10\left(d_1^2+d_M^2\right)^2}\right]-6.3T_M-\log\left(P_K\right)$$
$$+2\log\left(d_1^2+d_M^2\right)<0\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

## 5.3.3 THE SENSITIVITY OF THE RECEIVER CONSTRAINTS

The sensitivity of the receiver constraints can be formulated as follows:

## a. Base Station To Mobile Station Sensitivity Constraints

These constraints are formulated in Table (1).

Table (1). Base station to mobile station sensitivity Constraints

| Mobile Station | Base - Mobile sensitivity constraint |
|---|---|
| I | $10\log(P_B)-40\log(d_I)+147<0$ (6) |
| J | $10\log(P_B)-40\log(d_J)+147<0$ (7) |
| K | $10\log(P_B)-40\log(d_K)+147<0$ (8) |
| L | $10\log(P_B)-40\log(d_L)+147<0$ (9) |
| M | $10\log(P_B)-40\log(d_M)+147<0$ (10) |

## b. Mobile Station to Base Station Sensitivity Constraints

These constraints are formulated in Table (2).

Table (2). Mobile station to Base station sensitivity constraints

| Mobile Stations | Mobile-Base sensitivity constraint |
|---|---|
| I | $10\log(P_I)-40\log(d_I)+147<0$ (11) |
| J | $10\log(P_J)-40\log(d_J)+147<0$ (12) |
| K | $10\log(P_K)-40\log(d_K)+147<0$ (13) |
| L | $10\log(P_L)-40(d_L)+147<0$ (14) |
| M | $10\log(P_M)-40\log(d_M)+147<0$ (15) |

### c. Mobile to Mobile Sensitivity Constraints

These constraints are formulated in Table (3).

**Table (3). Mobile to Mobile sensitivity constraints**

| Mobile Station | Mobile-to Mobile sensitivity constraint |
|---|---|
| J to I | $10\log(P_J)-20\log\left(d_I^2+d_J^2-1.732d_Id_J\right)+147<0$ (16) |
| K to I | $10\log(P_K)-20\log\left(d_I^2+d_K^2\right)+147<0$ (17) |
| L to I | $10\log(P_L)-20\log\left(d_I^2+d_L^2+2d_Id_L\right)+147<0$ (18) |
| M to I | $10\log(P_M)-20\log\left(d_I^2+d_M^2\right)+147<0$ (19) |

## 5.3.4 THE NEAR-FAR PROBLEM CONSTRAINTS

To make a full coverage for all probable situations of the near-far problem we consider a (5x5) Table with row and column elements are the mobiles I, J, K, L, M. See Table (4). In this case the elements of the main diagonal (I,I), (J,J), (K,K), (L,L), (M,M) are eliminated because they are impossible since the near mobile and far mobile are the same. The lower triangular elements are eliminated since their constraints are equivalent to the upper triangular constraints multiplied by(-1).

## Table(4). The Near-Far Problem Table.

| | I | J | K | L | M |
|---|---|---|---|---|---|
| I | (I,I) | (I,J) | (I,K) | (I,L) | (I,M) |
| J | (J,I) | (J,J) | (J,K) | (J,L) | (J,M) |
| K | (K,I) | (K,J) | (K,K) | (K,L) | (K,M) |
| L | (L,I) | (L,J) | (L,K) | (L,L) | (L,M) |
| M | (M,I) | (M,J) | (M,K) | (M,L) | (M,M) |

The near far problem constraints can be formulated as shown in Table (5).

## Table (5). The Near-Far Problem Constraints.

| **Mobile Stations** | **Constraint** |
|---|---|
| (I , J) | $\log(P_I)-4\log(d_I)-\log(P_J)+4\log(d_J)=0$ (20) |
| (I , K) | $\log(P_I)-4\log(d_I)-\log(P_K)+4\log(d_K)=0$ (21) |
| (I , L) | $\log(\mathrm{P}_\mathrm{I})-4\log(\mathrm{d}_\mathrm{I})-\log(\mathrm{P}_\mathrm{L})+4\log(\mathrm{d}_\mathrm{L})=0$ (22) |
| (I , M) | $\log(\mathrm{P}_\mathrm{I})-4\log(\mathrm{d}_\mathrm{I})-\log(\mathrm{P}_\mathrm{M})+4\log(\mathrm{d}_\mathrm{M})=0$ (23) |
| (J , K) | $\log(P_J)-4\log(d_J)-\log(P_K)+4\log(d_K)=0$ (24) |
| (J , L) | $\log(\mathrm{P}_\mathrm{J})-4\log(\mathrm{d}_\mathrm{J})-\log(\mathrm{P}_\mathrm{L})+4\log(\mathrm{d}_\mathrm{I})=0$ (25) |
| (J , M) | $\log(\mathrm{P}_\mathrm{J})-4\log(\mathrm{d}_\mathrm{J})-\log(\mathrm{P}_\mathrm{M})+4\log(\mathrm{d}_\mathrm{M})=0$ (26) |
| (K , L) | $\log(P_K)-4\log(d_K)-\log(P_L)+4\log(d_L)=0$ (27) |
| (K , M) | $\log(P_K)-4\log(d_K)-\log(P_M)+4\log(d_M)=0$ (28) |
| (L , M) | $\log(P_L)-4\log(d_L)-\log(P_M)+4\log(d_M)=0$ (29) |

## 5.3.5 THE MAXIMUM COVERAGE CONSTRAINTS

We choose the antenna with maximum coverage 4141 meter. This means that the distance between any two mobiles should be less than or equal to 4141 meter. Table (6) shows the formulation of the maximum coverage constraints.

**Table (6). The Maximum Coverage Constraints.**

| Distance Between Mobile Stations | Constraint |
|---|---|
| (I , J) | $\sqrt{d_I^2 + d_J^2 - 1.732 d_I d_J} \le 4141$ (30) |
| (I , K) | $\sqrt{d_I^2 + d_K^2} \le 4141$ (31) |
| (I , L) | $\sqrt{d_I^2 + d_L^2 + 2 d_I d_L} \le 4141$ (32) |
| (I , M) | $\sqrt{d_I^2 + d_M^2} \le 4141$ (33) |
| (I , Base station) | $d_I \le 4141$ (34) |
| (J , Base station) | $d_J \le 4141$ (35) |
| (K , Base station) | $d_K \le 4141$ (36) |
| (L , Base station) | $d_L \le 4141$ (37) |
| (M , Base station) | $d_M \le 4141$ (38) |

## 5.3.6 THE MINIMUM DISTANCE BETWEEN MOBILES AND THE BASE STATION CONSTRAINTS

To have a good reception at the base station, the distance between the mobile and the base station should be greater than 1500 and less than 4141.

$$d_s > 1500, \qquad s = I, J, K, L, M \qquad \ldots \quad (39)$$

### The Non-negativity Constraint

$$P_B\,,\ P_I, P_J,\ P_K, P_L, P_M, d_I, d_J, d_K, d_L, d_M \geq 0 \qquad \ldots \quad (40)$$

## 6. THE FINAL FORM OF THE NON- LINEAR PROGRAMMING MODEL

$$MIN(ISR)_1 = \frac{\dfrac{P_B}{10d_1^4} + \dfrac{P_J}{10\left(d_1^2 + d_J^2 - 1.732 d_1 d_J\right)^2} + \dfrac{P_K}{10\left(d_1^2 + d_K^2\right)^2} +}{\dfrac{P_1}{d_I^4}}$$

$$\frac{\dfrac{P_L}{10\left(d_1^2 + d_L^2 + 2d_1 d_L\right)^2} + \dfrac{P_M}{10\left(d_1^2 + d_M^2\right)^2}}{\dfrac{P_1}{d_1^4}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Subject to :

$$10\log\left[\frac{P_B}{d_1^4}+\frac{P_J}{\left(d_1^2+d_J^2-1.732d_1d_J\right)^2}+\frac{P_K}{\left(d_1^2+d_K^2\right)^2}+\frac{P_L}{\left(d_1^2+d_L^2+2d_1d_L\right)^2}+\frac{P_M}{\left(d_1^2+d_M^2\right)^2}\right]+135.5<0$$

……………………………(2)

$T_K$ log

$$\left[\frac{P_J}{10\left(d_1^2+d_J^2-1.732d_1d_J\right)^2}+\frac{P_K}{10\left(d_1^2+d_K^2\right)^2}+\frac{P_L}{10\left(d_1^2+d_L^2+2d_1d_1\right)^2}+\frac{P_M}{10\left(d_1^2+d_M^2\right)^2}\right]-6.3T_k-\log\left(P_K\right)+2\log\left(d_1^2+d_K^2\right)<0$$

………………………………(3)

$T_L$ log

$$\left[\frac{P_J}{10\left(d_1^2+d_J^2-1.732d_1d_J\right)^2}+\frac{P_K}{10\left(d_K^2\right)^2}+\frac{P_L}{10\left(d_1^2+d_L^2+2d_1d_1\right)^2}+\frac{P_M}{10\left(d_1^2+d_M^2\right)^2}\right]-6.3T_L-\log\left(P_K\right)+2\log\left(d_1^2+d_L^2+2d_1d_L\right)<0$$

………………………………(4)

$$T_M \log$$

$$\left[\frac{P_J}{10\left(d_1^2+d_J^2-1.732d_1d_J\right)^2}+\frac{P_K}{10\left(d_1^2+d_K^2\right)^2}+\frac{P_L}{10\left(2d_1^2+d_L^2+2d_{1d_1}\right)^2}+\frac{}{10\left(d_1^2+d_M^2\right)^2}\right]-6.3T_M-\log\left(P_K\right)+2\log\left(d_1^2+d_M^2\right)<0 \qquad \text{.....................................(5)}$$

$$10\log\left(P_B\right)-40\log\left(d_I\right)+147<0 \qquad (6)$$

$$10\log\left(P_B\right)-40\log\left(d_J\right)+147<0 \qquad (7)$$

$$10\log\left(P_B\right)-40\log\left(d_K\right)+147<0 \qquad (8)$$

$$10\log\left(P_B\right)-40\log\left(d_L\right)+147<0 \qquad (9)$$

$$10\log\left(P_B\right)-40\log\left(d_M\right)+147<0 \qquad (10)$$

$$10\log\left(P_I\right)-40\log\left(d_I\right)+147<0 \qquad (11)$$

$$10\log(P_J)-40\log(d_J)+147<0$$

(12)

$$10\log(P_K)-40\log(d_K)+147<0$$

(13)

$$10\log(P_L)-40\log(d_L)+147<0$$

(14)

$$10\log(P_M)-40\log(d_M)+147<0$$

(15)

$$10\log(P_J)-20\log\left(d_I{}^2+d_J{}^2-1.732d_Id_J\right)+147<0$$

(16)

$$10\log(P_K)-20\log\left(d_I{}^2+d_K{}^2\right)+147<0$$

(17)

$$10\log(P_L)-20\log\left(d_I{}^2+d_L{}^2+2d_Id_L\right)+147<0$$

(18)

$$10\log(P_M)-20\log\left(d_I{}^2+d_M{}^2\right)+147<0$$

(19)

$$\log(P_I)-4\log(d_I)-\log(P_J)+4\log(d_J)=0$$

(20)

$$\log(P_I) - 4\log(d_I) - \log(P_K) + 4\log(d_K) = 0$$

(21)

$$\log(P_I) - 4\log(d_I) - \log(P_L) + 4\log(d_L) = 0$$

(22)

$$\log(P_I) - 4\log(d_I) - \log(P_M) + 4\log(d_M) = 0$$

(23)

$$\log(P_J) - 4\log(d_J) - \log(P_K) + 4\log(d_K) = 0$$

(24)

$$\log(P_J) - 4\log(d_J) - \log(P_L) + 4\log(d_I) = 0$$

(25)

$$\log(P_J) - 4\log(d_J) - \log(P_M) + 4\log(d_M) = 0$$

(26)

$$\log(P_K) - 4\log(d_K) - \log(P_L) + 4\log(d_L) = 0$$

(27)

$$\log(P_K) - 4\log(d_K) - \log(P_M) + 4\log(d_M) = 0$$

(28)

$$\log(P_L) - 4\log(d_L) - \log(P_M) + 4\log(d_M) = 0$$

(29)

$$\sqrt{d_I^{\,2} + d_J^{\,2} - 1.732 d_I d_J} \leq 4141$$

(30)

$$\sqrt{d_I^{\,2} + d_K^{\,2}} \leq 4141$$

(31)

$$\sqrt{d_I^{\,2} + d_L^{\,2} + 2 d_I d_L} \leq 4141$$

(32)

$$\sqrt{d_I^{\,2} + d_M^{\,2}} \leq 4141$$

(33)

$$d_I \leq 4141$$

(34)

$$d_J \leq 4141$$

(35)

$$d_K \leq 4141$$

(36)

$$d_L \leq 4141$$

(37)

$$d_M \leq 4141$$

(38)

$$d_S > 1500\,,\ \mathrm{S} = \mathrm{I, J, K, L, M}$$

(39)

$$P_B, P_I, P_J, P_K, P_L, P_M, d_I, d_J, d_K, d_L, d_M \geq 0$$

(40)

## 7. SOLUTION OF THE MATHEMATICAL MODEL

The mathematical model that was solved by using the penalty function method[1]. The WINQSB ver.1 package was used to obtain the results.

### 7.1 THE OPTIMAL SOLUTION

Five different cases was considered in order to investigate deeply the behavior of the developed mathematical model.

**CASE(1) Objective Function (1) Subject to Co-channel Interference Constraint (2).** Table (7) shows the optimal solution.

**Table (7). Case (1) Optimal Solution.**

| Decision variable | Optimal Value |
|---|---|
| $p_B$ | 0.0100 |
| $P_I$ | 0.0100 |
| $P_J$ | 0.0100 |
| $P_K$ | 0.0100 |
| $P_L$ | 0.0100 |
| $P_M$ | 0.0100 |
| $d_I$ | 1,500.0000 |
| $d_J$ | 2,597.9880 |
| $d_K$ | 1,500.0000 |
| $d_L$ | 1,500.0000 |
| $d_M$ | 1,500.0000 |
| Minimum Objective Function | 0.0250 |

**Case(2) Objective Function (1) subject to Adjacent Channel Interference Constraints (3) , (4) and (5).** Table (8) shows the optimal solution

**Table (8). Case (2) Optimal Solution.**

| Decision variable | Optimal Value |
|---|---|
| $p_B$ | 0.0100 |
| $P_I$ | 0.4968 |
| $P_J$ | 0.0100 |
| $P_K$ | 0.4779 |
| $P_L$ | 0.4779 |
| $P_M$ | 0.0132 |
| $d_I$ | 1,500.000 |
| $d_J$ | 1,500.000 |
| $d_K$ | 1,500.000 |
| $d_L$ | 1,500.000 |
| $d_M$ | 2,820.5000 |
| $T_K$ | 10.9830 |
| $T_L$ | 12.5170 |
| $T_M$ | 10.9830 |
| Minimum Objective Function | 0.0001 |

**Case (3) Objective Function (1) Subject to Sensitivity of the Receiver Constraints (6) to (19).** Table (9) shows the optimal solution.

**Table (9). Case (3) Optimal Solution.**

| **Decision variable** | **Optimal Value** |
|---|---|
| $p_B$ | 0.0100 |
| $P_I$ | 0.4064 |
| $P_J$ | 0.0100 |
| $P_K$ | 0.0100 |
| $P_L$ | 0.0100 |
| $P_M$ | 0.0100 |
| $d_I$ | 1,500.000 |
| $d_J$ | 1,500.000 |
| $d_K$ | 1,500.000 |
| $d_L$ | 1,500.000 |
| $d_M$ | 2,820.000 |
| Minimum Objective Function | 0.0001 |

**Case(4) Objective Function (1) subject to Near-far problem Constraints (20) to (29).** Table (10) shows the optimal solution.

**Table (10). Case (4) Optimal Solution.**

| Decision variable | Solution Value |
|---|---|
| $p_B$ | 0.0100 |
| $P_I$ | 0.0100 |
| $P_J$ | 0.0100 |
| $P_K$ | 0.0100 |
| $P_L$ | 0.0100 |
| $P_M$ | 0.0100 |
| $d_I$ | 1,500.000 |
| $d_J$ | 1,500.000 |
| $d_K$ | 1,500.000 |
| $d_L$ | 1,500.000 |
| $d_M$ | 1,500.000 |
| Minimum Objective Function | 0.0250 |

**Case(5) Objective Function (1) Subject to all constraints (2) to (40)**. Table (11) shows the optimal solution.

**Table (11). Case (5) Optimal Solution.**

| Decision variable | Optimal Value |
|---|---|
| $p_B$ | 0.0010 |
| $P_I$ | 0.0011 |
| $P_J$ | 0.0011 |
| $P_K$ | 0.0011 |
| $P_L$ | 0.0011 |
| $P_M$ | 0.0011 |
| $d_I$ | 1504.830 |
| $d_J$ | 1504.830 |
| $d_K$ | 1500.000 |
| $d_L$ | 1503.504 |
| $d_M$ | 1500.050 |
| $T_K$ | 11.0815 |
| $T_L$ | 12.7746 |
| $T_M$ | 11.0815 |
| Minimum Objective Function | 0.0249 |

## 8. Conclusions

1. The main conclusion is that the power value of 0.2 seems to be an optimal one that minimizes ISR and increases the system efficiency.

2. Nonlinear programming can be used efficiently to optimize the power of the mobiles and base station in a cellular AD-HOC network to obtain an optimal Interference to Signal Ratio under Quality of Service constraints.

3. The Co-channel interference constraint resulted in ISR value of (0.025) see Table (7), which gives a good Quality of Service. This means that this constraint is effective because the SIR value equals 16.2 dB, which is greater than the minimum acceptable SIR (7 dB).

4. The adjacent channel interference constraints resulted in an optimal ISR value, see Table (8), which gives a good quality of Service. The SIR value equals (40) dB.

5. The sensitivity of the receiver constraints resulted in ISR value, see Table (9), which gives a good quality of Service with SIR value equals (40) dB.

6. The Near-Far problem constraints resulted in (ISR) value (0.0250), see Table (10), which also gives a good quality of Service with SIR equals (16.02) dB .

7. By solving the objective function subjected to all constraints, case (5), the value of the ISR equals (0.0249), see Table (11). This ISR gives a good quality of Service in the cellular system. The SIR value equals (16.03)dB, which is an acceptable value.

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# التوزيع الأمثل لمحطات القاعدة لمنظومات الاتصالات الخلوية

الدكتور صباح رسول داخل السيد سعد عبدالسادة غني الدكتور ستار بدر سدخان
الجامعة التكنولوجية جامعة النهرين

## المستخلص

لقد حصل حديثاً تطور كبير في الاتصالات اللاسلكية نتيجة لفوائدها الكثيرة حيث أن الأشخاص الذين سيتصلون ببعضهم لا يحتاجون إلى البقاء في مواقع محددة لأنهم يستخدمون محطات طرفية متنقلة. وكذلك فان وسط الاتصال حر وهو الهواء وليس الأسلاك أو الألياف أو القابلات المحورية .

لقد أصبحت نوعية الخدمة أمراً مهماً لأنها تعكس درجة قناعة المستفيد . إنَّ نوعية الخدمة تتأثر بقدرة التداخل وتتناسب عكسياً مع نسبة التداخل إلى الإشارة .

أن قدرة محطة القاعدة والمحطات المتنقلة لها تأثير مهم على نسبة التداخل إلى الإشارة . لذا فمن الضروري السيطرة على هذه القدرة لكي يمكن استخدامها بطريقة مثلى.