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A PROPOSAL SOLUTION FOR INTERFERENCE INTER-OPERATORS

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Abstract—With deregulation of telecom sector (law 24/96) in our country (Morocco), many operators of cellular network appear. Among the operators technology that operate, we find GSM9800 and CDMA900 that are used by two different operators. It turns out from the measurements of indicator of quality of service that the performance of GSM900 is degraded, and the major cause is the interference created by CDM800 which cannot be neglected. In this paper, we adopt a new approach in order to make GSM900 and CDMA800 operate in harmony. This method is based on a physical optimization of antenna systems and could be understood as a physical symmetry rotation in the space of parameters such that tilt and Azmit control the system. It independently reduces the interference effects on the distance between the base stations. Moreover, it allows us to improve client service without using hard installations and inexpensive technologies.

1. INTRODUCTION

In wireless communication, it is difficult to manage the medium transmission because of interference waves as in the systems of code division multiple access (CDMA) and global system for mobile communications (GSM) and noise problems that are not easy to mitigate. For this reason, there has been great interest to reduce interference effects on wireless communication systems in order to obtain sufficient quality of service for the customers [1, 2]. Roughly,

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CDMA/GSM interference is directly related to the ITU (International Telecommunication Union) frequency allocation affected by that institution [3]. In wireless access technologies, besides environmental natural phenomena which cannot be eliminated, we distinguish other kinds of interference scenarios [5] [4]:

(a) CDMA-800 DL in 869–894 MHz and the GSM or WCDMA UP in 880–915 MHz,

(b) Coexistence of TD-SCDMA and PHS systems,

(c) Coexistence of CDMA-2000 networks operating in the 450–470 MHz and other services,

(d) CDMA-2000 downlink (DL) in the band frequency 1930–1990 MHz and the WCDMA uplink (UP) in 1920–1980 MHz.

In this paper, we study the mutual interference between CDMA-800 operating at DL 869–894 MHz and GSM 900 at UP 890–915 MHz. Such technologies are used in our country Morocco various operators, which leads to interference problems. The local customers are demanding higher customer service and series of products designed to satisfy their needs, which becomes one of the most important motivations of this work. Increasing competition is forcing operators to pay much more attention to satisfying customers. To meet the needs of different customers, it is necessary that the operator is able to allocate radio resources to clients who are in our case frequencies. However, in our system, the two CDMA and GSM technologies operating in adjacent frequency bands (overlap between the two bands) is the main source of interference leading to a significant degradation of QoS. Therefore, dedication to exceeding higher levels of customer satisfaction leads to local interference problems. It is desirable to overcome such interferences to maintain and improve client satisfactions.

The main objective of this paper is to mitigate the local interference problems caused by CDMA800 and GSM900 without the need of supplement cost. In particular, we would like to remove such problems by adopting new approaches. One of them, which we are interested in here, is based on a physical optimization of antenna systems. This could be understood as a physical symmetry rotation in the space of parameters controlling our systems. In fact, our method acts only on some parameters of the systems such as tilt and Azmit. This gives a solution to independently reduce the interference effects on the distance between the base stations. This method allows us to improve client service without using hard installations, and it can be considered as inexpensive technologies. One advantage of this physical approach is that it is simple and easy to implement.

The organization of this paper is as follows: In Section 2, we give some useful tools. In Section 3, we analyze the cause of interference between CDMA and GSM 900 MHz. In Section 4, we propose a solution to mitigate the CDMA/GSM interference. In Section 5, we give the measurement results after the physical optimization of antennas. Section 6 is devoted to the conclusion.

2. GENERALITIES ON ANTENNA SYSTEMS

For later use, we recall some useful tools regarding wave interference in wireless communication systems.

2.1. Isolation

The isolation between systems is given by the interference attenuation between the transmitter (Tx) and the receiver (Rx). The parameter I controlling the isolation is given by

$$I = (F_{Tx} - G_{Tx}) + (F_{Rx} - G_{Rx}) + P_L + A, \tag{1}$$

where F_i, G_i, P_L and A stand respectively for the feeder loss of Tx and Rx, the antenna gain, the propagation loss and extra attenuation provided by special filters. Figure 1 illustrates the disturbance between two base tranceiver stations (BTS).

It follows from [4] that for distances d more than 10 m, the propagation loss between the two antennas is small, so the channel may be described by a free space propagation model. By using filters in Tx and Rx, we could cancel or at least reduce the effect of the interference caused by the co-existence of various mobile networks (GSM and CDMA). The choice of the appropriate filters varies in terms of the frequency of operation, attenuation requirement and other things.

2.2. Spurious Emissions

The spurious emissions are undesired emissions from the transmitter. In these emissions, the intermodulation is caused by the used frequencies and operated by the radios of the base station [6]. The intermodulation can be also caused by external carrier frequencies, the peaks at the double carrier frequency known as harmonics. All these emissions may lead to different types of interference to the nearby adjacent receiver and co-channel.

2.3. Transmitter Noise

The transmitter noise is defined as the lowest of continuous wideband emission. The noise caused by the transmitter (Tx) cannot be reduced with the radio frequency (RF) planning alone. It is related to the noise figure of the transmission chain. The wideband RF noise is also referred to as sideband noise. The major part of this noise is generated in the amplified and the transmitter output stages. The generation of the wideband noise is closely related to the type of transmitters [7, 8].

2.4. Intermodulation Products

The intermodulation products are generated both in transmitter (Tx) or receiver (Rx) paths, in the case that two or more frequencies are mixed and amplified in a nonlinear device. Intermodulation products of order x are the sums and differences in x terms of the original frequencies. Notice that if one of the terms of the product is weaker than the rest, the intermodulation product power would also decrease significantly. The nonlinear characteristics of the devices, whether Tx or Rx leads to these unwanted frequencies which may get transmitted if generated in the transmitter or receiver, will result in a co-channel type of interference at the victim receiver. The following figure gives the 3rd and 5th intermodulation products of 2 frequencies f_1 and f_2.

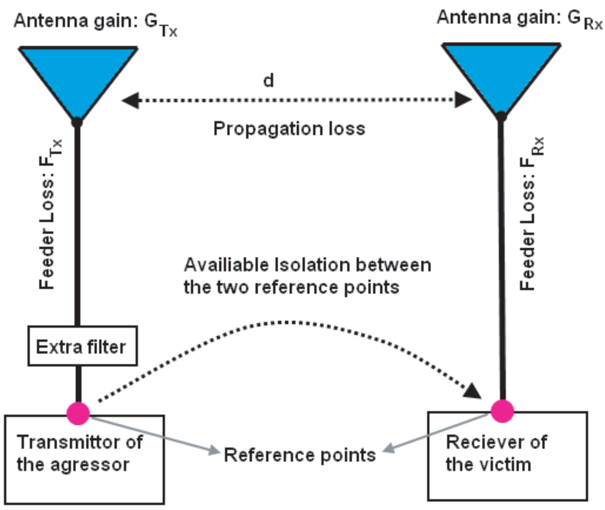

Figure 1. Isolation requirement between transmitter and receiver.

3. RECEIVER SUSCEPTIBILITY

The receivers are made in order to respond to the characteristics of the electromagnetic signals within a predetermined frequency band. They also respond to the undesired signals including various modulation and frequency characteristics. We distinguish different categories of the interfering signals and list some of them here:

a) Co-channel interference: This kind is related to the signals having frequencies which exit within the narrowest pass band of the receiver.

b) Adjacent channel interference: It appears when an unwanted signals having frequency components that exist within or near the receiver pass band. The interference multi-operator, referred to as "Adjacent channel interference", is the interference between two CDMA operators whose frequency carrier assignments are especially in situations where their cell towers are not collocated.

c) Out of band interference: This refers to signals having frequency components which are outside of the receiver pass band. To counter this effect for the out of band signal components, we need at least to reduce it by incorporating some filters to the transmitter or by increasing the wanted signal level at the victim receiver. Among the solution to mitigate the adjacent channel interference is the frequency selectivity. The radio frequency selectivity defines a frequency range in which interference may appear.

d) Any transmitter (Tx) has noise, undesired emissions and Tx inter-modulation products outside the real operating frequency assignment. The noise emissions may lead to interference to a nearby Rx having a weak signal from a Tx placed far away. We can qualify the interference phenomenon as a mixture between the adjacent channel due to insufficient attenuation in the Rx band pass filter and the co-channel interference from the wideband noise of the closer interfering transmitter.

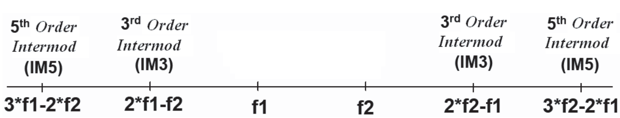

Figure 2. 3rd and 5th order IM products of two frequencies f_1 and f_2.

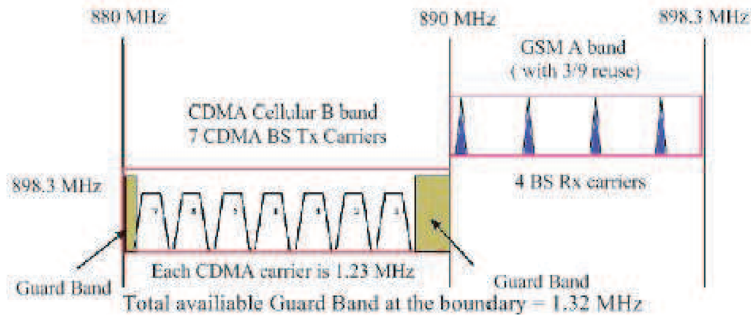

Figure 3. Frequency allocation for CDMA and GSM systems.

4. INTERFERENCE GSM-CDMA

Both of the technologies GSM and CDMA that operate respectively in the 900 MHz and 800 MHz bands exist in many countries (African, Asia,...). As we can see from Figure 3, there is an overlap of the 900 MHz base station receiver (MS Tx) and the 800 MHz base station transmitter band (BTS Tx). The GSM and CDMA [9] have different carrier frequencies. The bandwidth for GSM is 200 kHz, while for CDMA is 1,23 MHz. The carriers of CDMA transmit signal (BTS Tx), and its inter-modulation signals should be within the acceptable limits at the GSM frequencies and not block the GSM receiver. As shown in Figure 3, the proximity between frequencies GSM and CDMA is one of the major problems for operators We consider different interference problems between CDMA and GSM cells:

- The emissions of CDMA BTS out of band noise that fall in the GSM BTS receiver band.
- CDMA transmit inter-modulation falling in the GSM BTS receiver band.
- GSM BTS receive inter-modulation from two ore more CDMA transmitter carriers.

A mixture of one or more of the solutions below could cancel the noise interference:

1) GSM receive band filtering
2) CDMA transmit band filtering
3) Respect the guard band between assigned channels
4) Physical separation of the site antennas
5) Physical optimization (Tilt, Azimut,...) in GSM and CDMA systems.

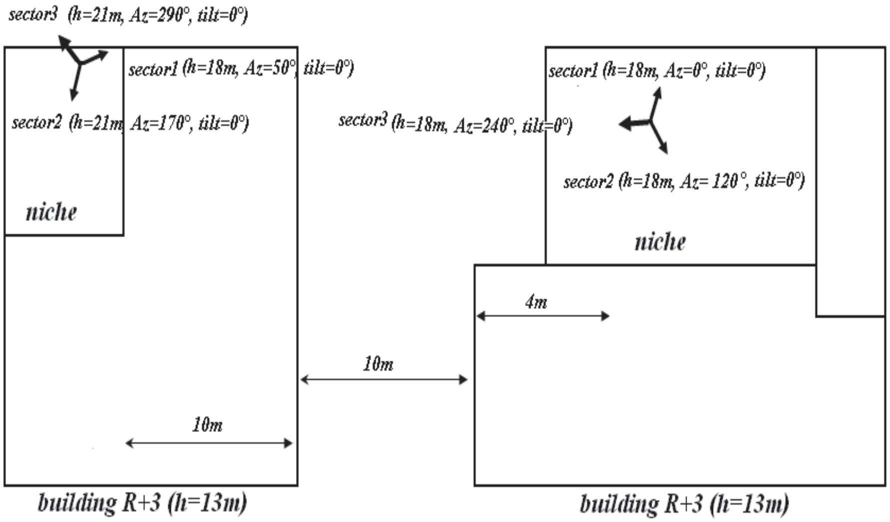

Figure 4. Locations and parameters before optimization.

Figure 3 illustrates the solution to mitigate the phenomenon of interference between GSM 900 and CDMA 800. In this figure, we take 2 MHz frequency separation between the first GSM carrier and the last CDMA carrier. The guard band between the two bands is 1,32 MHz.

5. PROBLEMATIC

In our country Morocco, both CDMA and GSM systems operate respectively in the 800 and 900 MHz bands. From Figure 3 it follows that there exists an overlay of the 800 MHz (transmission of BTS) and 900 MHz (reception of MS). Even the GSM and CDMA systems have different carrier frequencies and bandwidths. The interference problem is mainly caused by the level signal of a CDMA transmiter and its intermodulation signals. In particular, the GSM signal is affected by the downlink signal CDMA. Many recommendations have been suggested to solve the interference between CDMA and GSM. We list some of them here

1) CDMA transmitter band filtering,
2) GSM receiver band filtering,
3) Guard band between channels,
4) Physical separation of the cell site antennas.

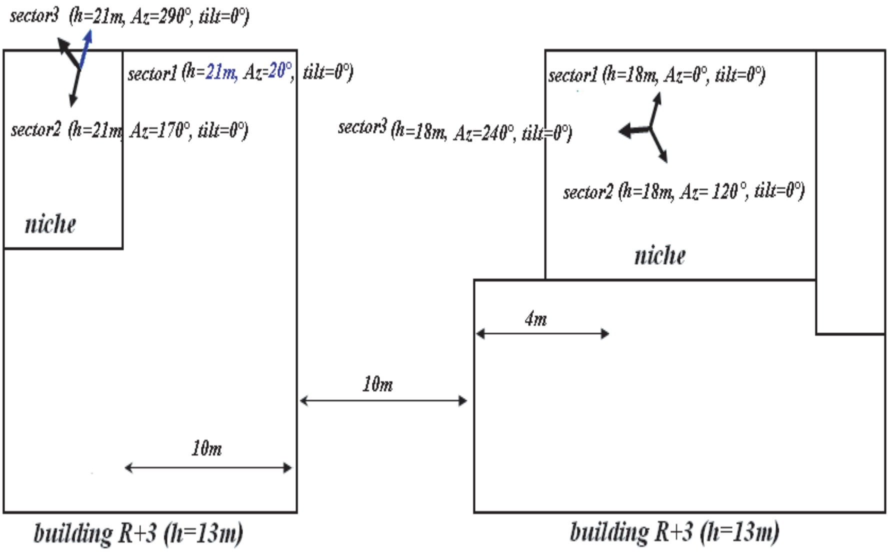

Figure 5. Locations and parameters after optimization.

In this paper, we would like to mitigate the local interference problems caused by CDMA800 and GSM900 without the need of supplement cost, by adopting a new method, which is based on a physical optimization of antenna systems. This could be understood as a physical symmetry rotation in the space of parameters as tilt and Azmit. We expect that this way can independently reduce the interference effects on the distance between the base stations. It allows us to improve client service without using hard installations and inexpensive technologies.

5.1. Actual Situation

In this real situation, we have two sites belonging to two operators using respectively the CDMA and GSM systems. The sites are far from each other at 10 m. Each site is formed of three cells or sectors. The following table gives the main parameters of GSM and CDMA systems.

5.2. Results of Our Method

In order to mitigate the interference problem of CDMA/GSM systems, we suggest a CDMA physical optimization, which can be done by modifying the above parameters. This could be understood as a special

Table 1. Parameters of GSM and CDMA before optimization.

Operators	secteurs	AZ	Tilt mec.	H (m)	Depuis	Type d'antenne	H Totale
GSM	S_1	0°	0°	3	*Niche*	$CS72763.03$	18
	S_2	120°	0°	3	*Niche*	$CS72763.03$	18
	S_3	210°	0°	3	*Niche*	$CS72763.03$	18
CDMA	S_1	50°	0°	3	*Niche*		18
	S_2	170°	0°	6	*Niche*		21
	S_3	290°	0°	6	*Niche*		21

rotation in the three dimensional modula space parameterized by S_i. Concretely, this can be given by the following transformation

$$S_i \rightarrow R_{ij} S_j$$

where R_{ij} is a 3×3 matrix representing a rotation in the three dimensional sub-space of parameters. For a particular choice of this matrix as

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix},$$

we get the following results

Table 2. Locations and parameters after optimization.

Operators	secteurs	AZ	Tilt mec.	H (m)	Depuis	Type d'antenne	H Totale
GSM	S_1	0°	0°	3	*Niche*	$CS72763.03$	18
	S_2	120°	0°	3	*Niche*	$CS72763.03$	18
	S_3	210°	0°	3	*Niche*	$CS72763.03$	18
CDMA	S_1	*0°*	0°	3	*Niche*		*21*
	S_2	170°	0°	6	*Niche*		21
	S_3	290°	0°	6	*Niche*		21

In this way, the situation becomes, after the CDMA physical optimization, as follow: It is known that there are some key performance indicators (KPI) controlling the performance and evaluating the quality of the service. In fact, to reveal the impact of our physical optimization on the improvement of GSM quality of service, we dress the evolution of some indicators where particular emphasis

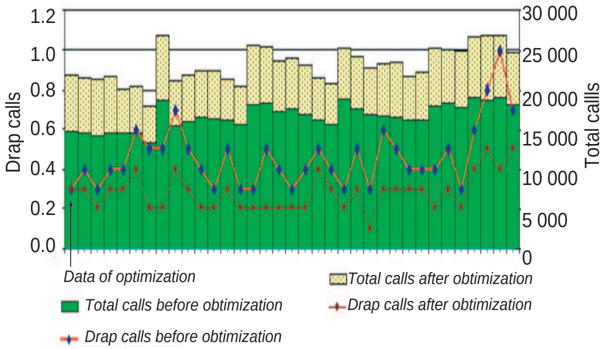

Figure 6. Improvement of GSM QoS after physical CDMA optimization.

is put on dropping calls and total calls before and after the physical optimization. Our main result can be summarized in Figure 6.

6. CONCLUSION

In many places, wireless systems operate in some bands where exists an overlay between them. The major problem that operators is facing has been the proximity between bands leading to interference. Therefore, this problem must be managed with special attention.

In this paper, we have discussed how to mitigate the local interference problems caused by CDMA800 and GSM900 without the need of supplement cost. In particular, we proposed a new approach based on a physical optimization of antenna systems. This could be understood as a physical symmetry rotation in the space of parameters controlling our systems. In fact, this method acts only on some parameters of the systems such as tilt and Azmit and gives a solution to independently reduce the interference effects on the distance between the base stations. It allows us to improve client service without using hard installations and inexpensive technologies.

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