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On optimal cell planning: Case study for a DCS 1800 system

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SUMMARY

Micro and pico cell planning strategies are adopted in personal communication systems (PCS) in order to increase their capacity. The usage of the upper UHF band in combination with greater bandwidth is already proposed by telecom engineers in order to achieve the promised service quality and data rates. These strategies are characterized by an increased number of cells in specific geographical areas with the corresponding operating base transceiving stations (BTS) located at relatively low heights above the street level. In this case, the cell planning procedure in linear streets under line-of-sight (LOS) conditions needs further study concerning the technical characteristics of the PCS.

In this paper, the propagation characteristics of a DCS 1800 system are investigated on a theoretical and experimental basis in a specific geographical area (center of Patras City in Northern Pelloponesse). An improved RF propagation model is proposed in order to determine the propagation path losses occurring under certain multipath fading conditions. Hence an optimum determination of a system's cellular area can be achieved. Copyright © 2001 John Wiley & Sons, Ltd.

KEY WORDS: propagation; mobile communications; RF modelling

1. INTRODUCTION

Personal communication systems (PCS) open a new era in the sector of mobile telephony. The cell planning scenario is one of the most important operators technical procedures in order to achieve both the desirable radio coverage and cost effective communication services to the subscribers. For this reason, prediction of the radio propagating signal in each of the specific radio environments is essential in the deployment of the future wireless communication systems, as well as for upgrade and optimization of the existing cellular networks.

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Path loss is an important method of characterizing channel behavior in that it can be related to system performance measures such as bit error rate and outage probability. The accuracy of the prediction of the radio coverage depends on the best understanding of the electromagnetic propagation phenomena in the transceiver's vicinity area, which are usable then for the synthesis of the corresponding RF model. Moreover, many propagation mechanisms based on the peculiarities of the geographic service areas (i.e. rural, urban, suburban, in building, etc.) have been studied.

Two cases for wave propagation modeling in PCS design problem are considered: (1) mobiles are in an adjacent node or moving in forests and (2) mobiles are located in suburban or urban areas [1]. Up to now, conventional terrestrial radio communication and broadcast systems have been planned using propagation models classified as empirical or semi-empirical wave propagation models [2,3]. The main disadvantage of these RF models is that they do not take into consideration the influence of the multipath effects (diffraction and reflection) during the wave transmission in urban areas. In high bit rate digital systems, (i.e. PCS) the control of multipath effects is essential. The necessary control can be predicted by propagation modeling using the ray-optical technique based on the uniform theory of diffraction and physical optics. Each one of the previously mentioned RF models is not capable, in terms of computing time and quality of results, of supplying the necessary information for the state-of-the-art network and system planning. In this case, it is important to apply different propagation algorithms. This approach leads to the development of a model whose synthesis should include a hierarchical structure depending on the service type, terrain and transmitter–receiver site. A practical useful planning tool computes the received field strength by estimating a basic path loss and an additional diffraction loss. The field strength is the main indicator to estimate what percentage of the geographical area is covered by a given criterion (i.e. predicted field strength above a specified threshold). The propagation environment is characterized by digital terrain databases derived from the geographical information systems (GIS).

In the present paper a new RF algorithm is analysed within the framework of optimal cell planning procedure. The calculations of the algorithm take into account both the terrain effect and the building structures. Among the aims of the proposed algorithm is to provide the level of the received signal using less computation time and to investigate the fit of the experimental data distribution to the existing theoretical distributions. The experimental procedure, which has been chosen for testing the efficiency of the proposed algorithm, is applied using a more realistic subscriber behavior in a typical Greek suburban and urban area. In Section 2 the new RF algorithm is described. Section 3 describes the existing non-homogeneous (cell clutter) environment. The experimental RF testing is given in Section 4. Finally, in Section 5 the tabulation of experimental and theoretical results are also presented.

2. MATHEMATICAL DESCRIPTION OF THE PREDICTION ALGORITHM

The aim of the existing prediction RF models is to study the behaviour of the electromagnetic wave propagation in a specific RF service area. The need is for a more sophisticated path loss prediction algorithm to deal with the adoption of small and micro cell structures in the future cellular systems. Small cell size, low base stations in a micro cell, building height, street width and terrain elevation all have profound effects on radio propagation. In order that these RF models are applicable to a system's realistic cell planning, sets of necessary simplifications to the geometry of the BTS-mobile RF link have been considered. Therefore, the received signal power is characterized by a resultant mean error in the corresponding prediction values.

The applied ETSI specifications to the RF modelling suggest the usage of the Hata [3] and COST 231-Hata Model for macro/small cell planning, and the Walfish–Ikegami model for micro cell planning [4]. The main disadvantage of these models is their statistical experimental dependence on the additional constants that are derived from a measurement campaign in a specific geographical area. This disadvantage is responsible for the different resulting predicted mean square error for the signals level in different environments (i.e. where the GSM 900/1800 systems are in operating mode).

One of the basic elements, which make a prediction model dependable, is the accuracy of the calculation of the received signal power. The accuracy is achieved by taking into consideration the most realistic technique for the representation of the environment requiring radio coverage.

The answer giving the most suitable RF propagation model will be the one that calculates the path loss in all types of environment taking account of the signal's reduction due to free space wavefront spreading as well as building and terrain influence. In the proposed algorithm all the basic system parameters, (such as operational frequency, base and mobile station height) are taken into consideration. Also, by requiring the terrain's elevation, the average building height and street width must be specified.

For application to the global 3rd generation (G3G) systems the used path-loss prediction model is characterized by the next two statements:

1. To be effective in calculating path loss using statistical methods rather than parameters derived analytically.
2. To provide a procedure for finding the optimum BTS locations.

The above features are accomplished by the application of the appropriate mathematical formula for the field strength calculation (depending on the environmental peculiarities) and the determination (recalculation) of the correction factors in dB (derived from the statistical processing of the local experimental measurements).

The knowledge of the natural terrain is provided by a digital database, which is derived from a GIS. The most significant feature concerning the feasibility of a complex propagation model, like the proposed one, is the application of the automatic ray-tracing algorithm.

The received power on a territorial pixel is calculated from the transmitted equivalent radiated power (ERP) (in dB) and then subtracting the total losses L_T. The latter are evaluated by adding four elements: the intermediate power L_M, the path loss L_P, the diffraction loss L_D and the reflection loss L_R. In this case the received power can be written as follows:

$$P_r = P_t + G_t + G_r - L_T \tag{1}$$

where: G_t is the transmitter antenna gain, G_r the receiver antenna gain and L_T the total loss, expressed by the following formula:

$$L_T = L_M + L_P + L_D + L_R \tag{2}$$

The L_M factor is derived from the following formula:

$$L_M = L_{en} + \frac{sd}{\sqrt{2}}\left[\mathrm{erf}^{-1}\left(1 - 2\,\frac{\text{percent\_log}}{100}\right) + 10\log\left(\frac{\ln(\text{percent\_Rayleigh})/100}{\ln 0.5}\right)\right] \tag{3}$$

where: L_{en} represents the environmental losses (or land cover correction factors [5]) and sd is the lognormal standard deviation (typical 6–10 dB range).

The term's percent_log and percent_Rayleigh, correspond to the statistical desired radio coverage.

The factor L_M is taken into account regardless of the environmental type (rural, urban, suburban, open area). L_{en} is a value that minimizes the overall mean square error between predicted field values and measurements taken over a limited area. The value of L_{en} is the median of the difference between predicted and measured signal strength.

L_P represents the path loss component expressed in logarithmic scale as a linear function of distance d:

$$L_P = C + 10\gamma \log d \tag{4}$$

where: d is the distance between base and mobile station, C is an intercept point generally taken as the path loss at a distance of 1 m or 1 km for outdoor macrocellular systems and γ the path loss exponent.

The following two cases are examined:

2.1. *Line of sight* (*LOS*)

By the term LOS is meant that the geographical area is flat with the restriction that the base-mobile station distance is less than the distance where the first Fresnel zone is obstructed by the terrain surface. The distance d_F, at which the first Fresnel zone becomes obstructed, is given by the following formula [6]:

$$d_F = \frac{1}{\lambda}\sqrt{(\Sigma^2 - \Delta^2)^2 - 2\,(\Sigma^2 + \Delta^2)\left(\frac{\lambda}{2}\right)^2 + \left(\frac{\lambda}{2}\right)^4} \tag{5}$$

where: $\Sigma = h_t + h_r$, $\Delta = h_t - h_r$ and h_t and h_r are the base and mobile station heights, respectively.

For the development of a propagation program tool to meet the research needs of our laboratory, the formula used for L_P loss is derived from Okumura's report [2] and organized for computational use from Hata and COST 231 [3,4]. The involved parameters are the frequency f, the base station (BTS) height h_b, the mobile height h_m, and the distance d between BTS and mobile. Two formulae are used to estimate the L_P by considering the frequency range (150–1500 and 1500–2000 MHz) [4].

$$L_P = \begin{cases} 69.55 + 26.16\log f - 13.82\log h_b + (44.9 - 6.55\log h_b)\log d & \text{(150–1000 MHz)} \\ 46.3 + 33.9\log f - 13.8\log h_b + (44.9 - 6.55\log h_b)\log d + Cm & \text{(1500–2000 MHz)} \end{cases} \tag{6}$$

where: f is the operational frequency (MHz), h_b the effective antenna height (m) and d the distance (km).

The parameter h_b can be evaluated from the algorithm proposed in Reference [2].

2.2. *Obstructed line of sight* (*OLOS*)

1. Non-homogeneous elevation street canyon profile, see Figure 1.
2. Building discontinuity.

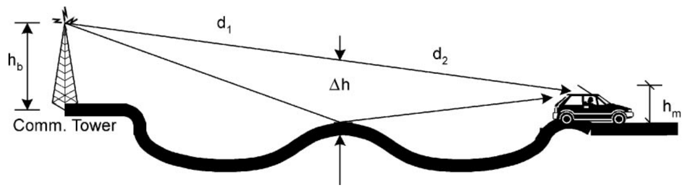

Figure 1. A case of non-homogeneous elevation street canyon profile.

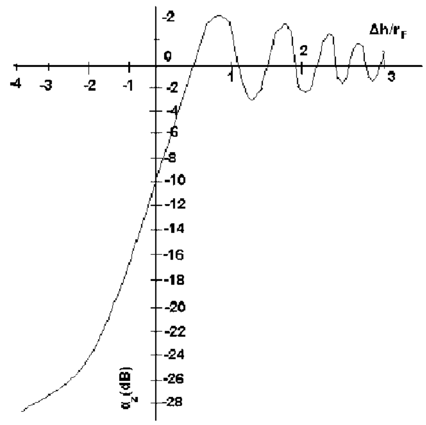

Figure 2. Attenuation due to obstructions as a function of normalized path clearance.

In the first case of OLOS an additional loss factor is added to the LOS losses. This factor is denoted as L_{nh} and is estimated by the first Fresnel zone clearance. The first Fresnel zone radius r_{F} is calculated

$$r_{\mathrm{F}} = \sqrt{\frac{\lambda\, d_1\, d_2}{d}} \tag{7}$$

where λ is the wave length, d_1 the distance between base station and the break point, d_2 the distance between the break point and the mobile and d the separation distance between base and mobile station.

The attenuation a_z due to obstruction is calculated by the term $\Delta h/r_{\mathrm{F}}$ from the curve given in Figure 2 [7]. The parameter Δh is the difference between the r_{F} and the elevation of the break point.

In the second case of OLOS an additional loss factor is also added to the LOS losses. This factor is denoted as L_{open} and is derived by the following formula:

$$L_{\mathrm{open}} = -[4.78\,(\log f)^2 - 18.33\log f + 40.94] \tag{8}$$

In urban and suburban environments, the diffraction losses L_{D} are calculated by the UTD-based approach for cellular mobile propagation for urban areas. Figure 3 depicts the visualization of the propagation geometry in a small cell with the presence of buildings.

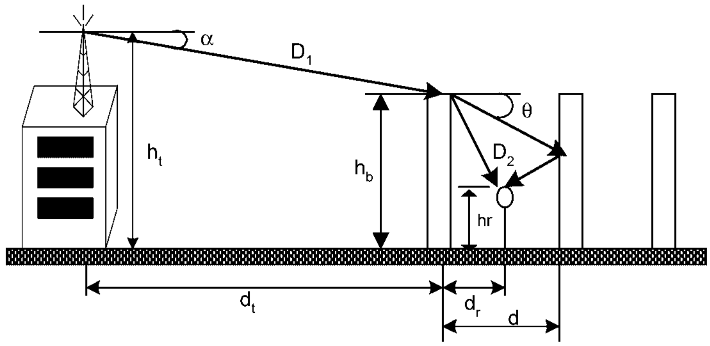

Figure 3. Geometry of a small environment.

These kind of losses are caused by the wave diffraction in the buildings on the vicinity of the mobile subscriber and are derived from the next formula [8]:

$$L_D = -20\log_{10}|D^{\mathrm{I}}_{\mathrm{s,h}}| + 10\log_{10} D_2(m) + 10\log_{10}\left[\frac{D_1(D_1+D_2)}{D^2}\right] \quad (9)$$

where: $D^{\mathrm{I}}_{\mathrm{s,h}}$ is the UTD diffraction coefficient for a spherical field from the BTS antenna [9], D_1 and D_2 are clearly defined in Figure 2, $D = \sqrt{(d_t + d_r)^2 + (h_t - h_r)^2}$ and s, h denotes the soft and hard boundaries, respectively.

The loss L_R caused by the reflection can be described as [8]

$$L_R = -20\log_{10}\left|1 + R_{\mathrm{H,V}}\sqrt{\frac{D_2(D_1+D_2)}{r_2(D_1+r_2)}}\right|\frac{D^{\mathrm{II}}_{\mathrm{s,h}}}{D^{\mathrm{I}}_{\mathrm{s,h}}}\,e^{-jk(r_2-D_2)} \quad (10)$$

where $D^{\mathrm{II}}_{\mathrm{s,h}}$ is the UTD diffraction coefficient for a spherical field from the BTS antenna [9], k the wavenumber and $R_{\mathrm{H,V}}$ the reflection coefficient [20].

The above used UTD diffraction coefficients are valid only when the mobile is in the shadowing zone. This restriction leads to the condition $d > 600$ m.

3. THE EXISTING 'CELL CLUTTER' ENVIRONMENT

In real mobile operating conditions symmetrical cell geometry does not exist. In this case, the average signal strength in an urban area depends on the local mean or slow fading that is based on physical parameters such as antenna heights, operating frequency, building appearance and the width of the streets. It is noted that the existing peculiarities in RF propagation in these areas demand the adoption of a mixed cell environment (micro and pico structures) [10]. This 'cell clutter' is within the framework of providing optimum radio coverage. One of the most important parameters that has to be taken into account in determining the cell boundaries, is the local urban planning (i.e. building heights, street widths and building materials, etc.).

In the city centre under examination, the operating DCS 1800 system employs a small cell structure instead of a micro cellular one. The technical approach of a 'small' cell can be achieved

Figure 4. Block structure of the city of Patras and the location of the two tested BTS (each line represents the cell orientation).

by using BTS antennae located above the medium height levels but below the maximum height of the surrounding rooftops. The maximum range for small cells is typically less than 1–3 km. The cell planning of the city of Patras for the DCS 1800 is shown in Figure 4. It is notable that some base station mast antennae are installed in higher levels than the surrounding buildings. The provider in order to achieve the desirable radio coverage in the area of Patras, regulates the tilt of some antennae.

Patras is a city with quite narrow streets, having building heights in the range of 20–30 m in the old part and centre. The main building materials all over the city are concrete blocks and bricks. Also Patras has a particular characteristic, namely a large number of squares (small open areas).

4. EXPERIMENTAL RF TESTING IN PATRAS AREA

Extensive experimental tests were performed in the geographical area of Patras and especially in the city centre. The aim of these tests was to investigate and to study the RF propagation in different directions relative to the streets. The used test signal was taken using fixed base station transmitters of a DCS-1800 provider. These transmitters were located on the roof of several buildings around the city as shown in the map of Figure 4:

BTS characteristics are:

- The effective isotropic radiated power (EIRP) was taken with values ranging between 53 and 54 dBm.
- The antennae were located at heights between 20 and 42 m.
- The antennae of each BTS illuminate a three-cell cluster.

Building characteristics are:

- The building heights are in the range of 21–30 m.
- The building materials of the exterior walls are concrete and bricks.

Street characteristics are:

- The street widths are in the range from 6 to 10 m.
- The construction material is asphalt (blacktop).

4.1. Description of the used mobile test equipment

The measurement set-up is shown schematically in Figure 5.

The system uses the intelligence of the radiotelephones. This means that they automatically find the operating frequencies of the radio service. Some of the standard measurement functions of the system are the automatic call set-up and hangup with a separate phone number for each test mobile, variable call duration settings and idle time jointly adjustable for all mobiles (15 s in our experiment). The most important function of the system is the recording of the peak receiving power. The micro-controller is responsible for the manipulation of both the test mobiles and the global positioning system (GPS) receiver. It allows data to be pre-processed before data are stored in laptop. The final software program enables us to observe at any time the signal fading on the computer monitor during the measurement procedure and to have a realistic representation of the path followed. The receiving omnidirectional antenna with gain 1 dBi was located at the centre of the roof of the car at 1.5 m height above the ground.

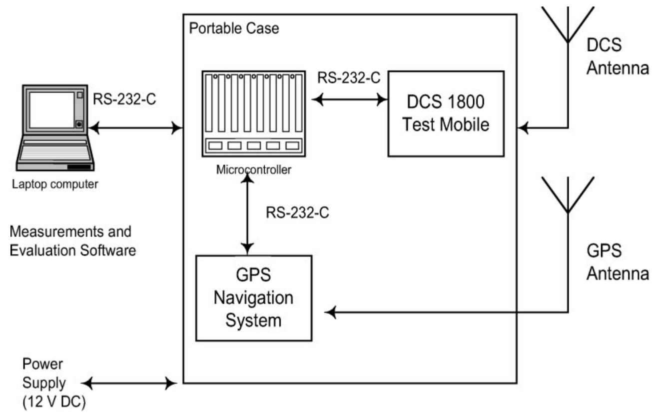

Figure 5. Experimental set-up.

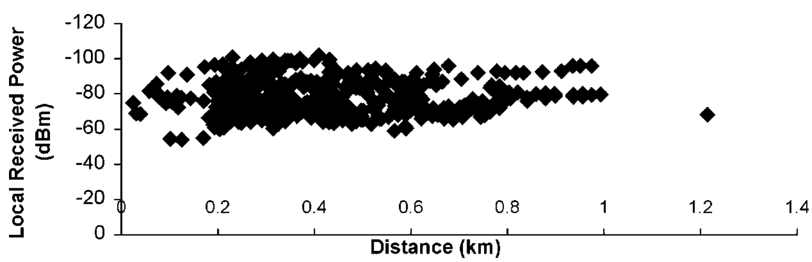

Figure 6. The experimental results of the received power from cell C.

4.2. Experimental results

The aim of the experimental RF testing is to study and to analyse the down link performance of the operating DCS 1800 system. The obtained results were taken in the central area of the city of Patras, and especially in the RF region of the BTSs 1 and 2 (Figure 4). The chosen experimental paths were the corresponding streets, located in the region under test, where the van could pass. The testing equipment used had two main functions. The first function was to record the value of the received local power. The second one was to record the transmitted power of the BTS antenna (that illuminates a specific cell). In addition, the values of the local received power of the neighboring cell sites, were recorded.

In the present work, the experimental and theoretical results of cell C (BTS 1) are shown. The technical characteristics of the BTS 1 are the following:

- Mast height: 35 m.
- Transmitting frequency: 1856.6 MHz.
- Receiving frequency: 1770.6 MHz.
- EIRP: 54 dBm.
- Position: -6° (elevation) and 286° (azimuth).

Figure 6 shows the variation of the received local power versus the distance.

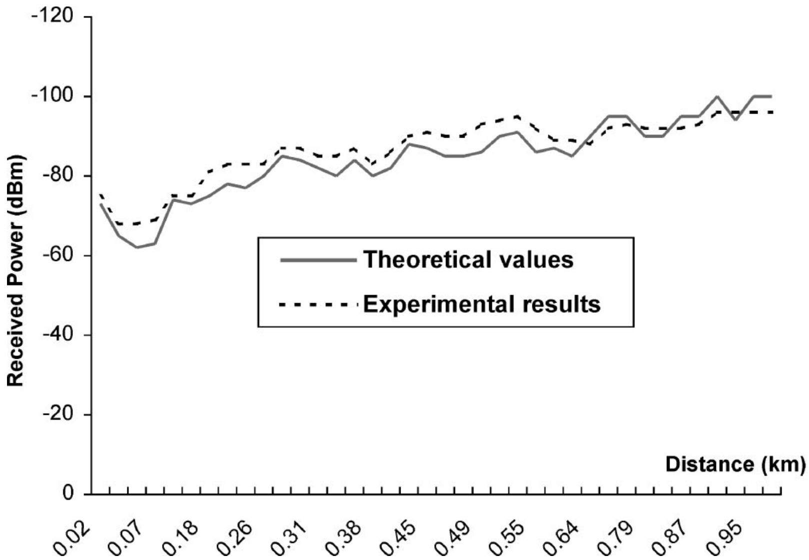

Figure 7. Received power vs distance.

The input data in the simulation program are

- Technical parameters (i.e. antenna gains, antenna heights, operating frequencies).
- Terrain profile in the testing area.

Figure 7 shows the variation of the received power in various zig-zag street points.

Except for the use of the experimental data to evaluate the proposed prediction algorithm, another important result is the extraction of two significant statistical parameters.

1. The standard deviation for the small cell in the Patras area.
2. The pdf of the signal distribution of the small cell in the Patras area.

The estimated pdf is very useful for the calculation of the system's outage probability.

The standard deviation is calculated by the following formula:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N} (x_i - \bar{x})^2}{N - 1}} \tag{11}$$

where σ is the standard deviation, N the number of datum, x_i the individual measurement and $\bar{x}$ the mean of all measurements.

For the small cell examined in the Patras area it is found that $\sigma = 9.846$.

Figure 8 shows the pdf of the ratio P_{local} to P_{mean}. This analysis is based on the statistical processing of the experimental results obtained.

For the theoretical statistical analysis, it is attempted to approximate the data curve with the Nakagami distribution. The Nakagami distribution (or *m*-distribution), contains a set of sub-distributions (i.e. Rayleigh, etc.) and provides an optimum fit to collected data in outdoor and indoor environments, in the frequency range from 800 MHz to 4 GHz [11,12] (Figure 9).

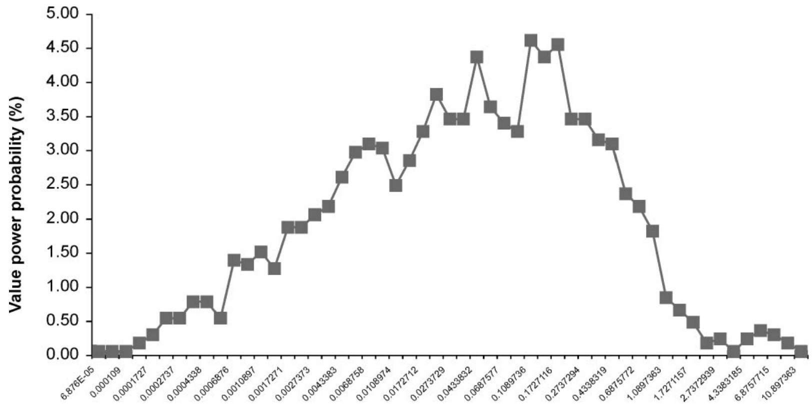

Figure 8. The pdf of the radio $P_{\text{local}}/P_{\text{mean}}$.

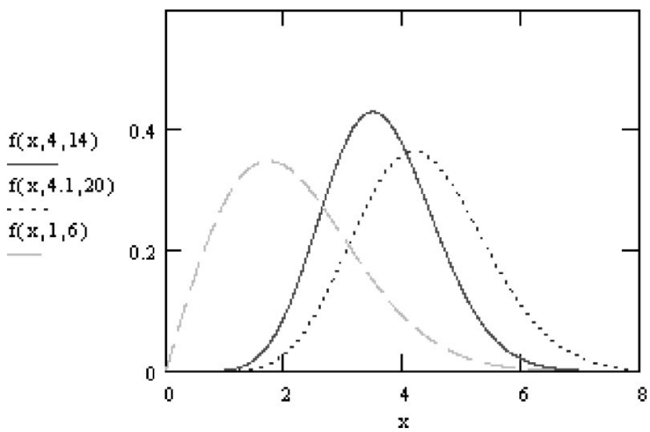

Figure 9. The theoretical simulation of the pdf. For $m = 1$ is the Rayleigh distribution.

If r is a Nakagami variable, the pdf is given by the following formula:

$$f(r) = 2\left(\frac{m}{\Omega}\right)^m \frac{\xi_k^{2\cdot m-1}}{\Gamma(m)} \exp\left(-\frac{m}{\Omega}r\right) \tag{12}$$

where ξ is the received signal, m an arbitrary fading parameter and Ω the average power.

The Kolmogorov–Smirnov test is used for the best-fit test [13]. This test generates a reliability interval around the PDF of the received signal power normalized on its mean power. From the theoretical results of Nakagami pdf the best fit is when (m, Ω) is equal to (4, 14).

5. COMPARISON OF EXPERIMENTAL AND THEORETICAL RESULTS

Cell C that was chosen to examine the radio propagation characteristics has its antenna situated higher than the surrounding buildings and located in a building next to the main square of the city. The measurements were taken in a distance range of 92–1200 m, so that we are able to observe three parameters: the time-variance fading, the signal distribution and the radio coverage performance.

It is important to notice that according to the theoretical results, the range of the receiving power is from -69 to -100 dBm. Even though the receiver sensitivity of the mobile station is -102 dBm, according to the manufacturer's specifications, the probability of unsuccessful connection is very high when the receiving power is less than -97 dBm. This is observed during the performed experimental procedure.

The volume of measurement data was big enough to provide a very good estimate of the above three parameters. For example, the time-variance of the local received power was found to be in the range of 0–25 dBm. It should also be noticed that at the points where cell C was the main one responsible for the connection with the mobile, the local received power was not the maximum observed.

The existing cell planning for supporting the offered traffic load is not the optimum one. The result of our experimental analysis, in the whole area of Patras could lead the system designers to re-organize the cell planning in order to achieve better radio coverage and better quality of service. In general, the optimum selection of the antenna sites should be done based on scientific criteria, as is described in Reference [14].

The next step for a further processing of the data is to examine the constant involved with the path loss calculation for the local characteristics of Patras.

6. CONCLUSIONS

A complete RF investigation, with the appropriate theoretical issues and the corresponding experimental scenarios, has been considered. Moreover, a new proposed RF prediction algorithm has been investigated by taking into account the technical characteristics of a DCS 1800 system operating in the Patras area. It is found that the estimated accuracy of the proposed algorithm is higher than the corresponding accuracy of the Okumura–Hata model (based on a better fit of the theoretical results into the corresponding experimental ones). This advance has been achieved from the engineering effort that was undertaken to evaluate and improve the communication services offered by a DCS 1800 in Patras.

Also, emphasis has been given to the performance of the proposed algorithm as a part of an optimization tool for the cell planning procedure. Specifically, the algorithm is applied on the optimal base stations position finding. A successful cell planning, in a specific area, is dependent on the knowledge of the possible base station locations which provide the desirable service availability for a given cell radius.

In conclusion, the accuracy and the resulting reliability of a theoretical RF algorithm depends on the required input geographical data. This leads to the close cooperation of the telecommunication engineers with the corresponding GIS.

REFERENCES

1. Kurner T, Cichon DJ, Wiesbeck W. Concepts and results for 3D Digital terrain-based wave propagation models: an overview. *IEEE Journal on Selected Areas in Communications* 1993; **11**(7).

2. Okumura Y. Field strength and its variability in UHF and VHF land-mobile radio service. *Review of the Electrical Communications Laboratories* 1968; **16**.
3. Hata M. Empirical formula for propagation loss in land mobile radio services. *IEEE Transactions on Vehicular Technology* 1980; **29**(3).
4. COST 231. Urban transmission loss models for mobile radio in the 900- and 1800-MHz bands. *Revision* 2, *TD*(91) 73, Hange, September 1991.
5. RMTP/RB/R105. Issue 1.0, Appendix 2, 20 November 1990.
6. Feuersteun MJ *et al*. Path loss, delay spread and outage models as functions of antenna height for microcellular system design. *IEEE Transactions on Vehicular Technology* 1994; **43**(3).
7. Deygout J. Multiple knife-edge diffraction of microwaves. *IEEE Transactions on Antenna and Propagation* 1966; **14**(4).
8. Zhang W. A wide-band propagation model based in UTD for cellular mobile radio communications. *IEEE Transactions on Antennas and Propagation* 1997; **45**(11).
9 Kouyoumjian RG, Pathak PH. A uniform geometrical theory of diffraction for an edge in a conducting surface. *Proceedings of IEEE* 1974; **62**:1448–1461.
10. Steele R, Williams J, Chandler D, Dehghan S, Collard A. Teletraffic performane of GSM900/DCS1800 in street microcells. *IEEE Communications Magazine* 1995; 102–108.
11. Barry PJ, Williamson AG. Radiowave propagation into and within buildings at 927 MHz: *Electronic Letters* 1987; **23**(5):248–249.
12. Al-Hussaini E. Effects of Nakagami fading on antijam performance requirements. *Electronic Letters* 1988; **24**(4):208–209.
13. Stuart A, Ord J. *Advanced Theory of Statistics*, vol. 1. Oxford: New York, 1987.
14. Bouzouki S, Kotsopoulos S, Karaboulas D, Doukas A. Investigation of design parameters and implementation of organized antennas parks, in specific Greek geographic areas. *International Conference of PhD Students*, University of Miskolc, Hungary, 11–17 August 1997.

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Stavroula D. Bouzouki was born in Dortmund Germany in 1972. She received her diploma in 1997 in electrical engineering and computer technology, from the University of Patras, Patras, Greece. Since 1998, she is a research assistant in the Department of Electrical and Computer Engineering of the University of Patras and is currently working towards her PhD. She has been involved in various research projects, funded by the Greek Government, the European Union and Private Companies. Her research interests include communication theory, propagation modeling, architecture and QoS in wireless networks. She is a member of Technical Chamber of Greece.

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George K. Karagiannidis was born in Samos Greece in 1963. He received his diploma in 1987 and the PhD degree in 1999, both in electrical engineering, from the University of Patras, Patras, Greece. From 1990 to 1993, his research focused on the development of interfaces for diffuse IR communications links. Since 1994, he has been developing methods for the improvement of QoS and GoS in several mobile radio environments and optimum channel assignment schemes.

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