

Comparative Analysis of Multiplied Models for Traffic Distribution in a Celular Network

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Abstract

In this article they are investigated the problems associated with the measuring of user load in the network versus time and type of equipment. Among these they are presented also practical researches concerning the behaviour of various analytical models used to describe the interaction between the base and mobile stations. The aim is to make proper planning of the network for providing quality services and the necessary traffic in it.

Keywords: Traffic; Cellular Models; BS; MS; GSM network

1. Introduction

As it is known an important indicator of quality in the mobile communication networks is the user load measured by the load characteristics of the base station.

For an effective control the constant user load of the cellular has to be monitored. In order to determine that, the accumulated statistic data of the quality of coverage and the delay time of the signal during its distribution from the base station to the mobile station and back, are used.

2. Investigation of Spatial - Temporal Distribution of Subscribers Traffic

To trace the distribution of traffic it is necessary to conduct practical research that lead to the correct network setup and optimization of occupied physical channels [1], [2]. Examples of results from the study of spatial and temporal distribution of subscription demand for suburban base station in range 900 MHz are presented in Figure 1. The results of the distribution of the subscriber consumption have been taken during the time of main usage of the cell between 10:00 a.m. and 22:00 p.m., with record period of 1 hour.

The effectiveness of such a representation of the distribution of subscriber' consumption in space and time is obvious. First, the data presented in this way makes it possible to see the use of the subscriber in the area. Second, the change in consumption of subscriber could be defined over time. Thirdly, as it is shown, they are determined not only the effective and active service areas, but also the areas with shade.

The last is important in cases where the quality of service in the distant "island" areas (Figure 1 noted at 19km)

is insufficient, which leads to a negative reaction by the subscriber, when he has a claim for provision of quality services. So the operator uses this method in order to take measures to overcome the problems with these "island" areas through improvement of quality of services. In those cases the best solution for a better level of service is when the operator provide a better coverage of these distances.

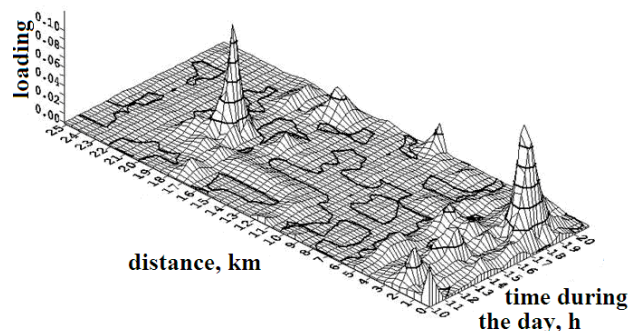


Fig. 1. Spatial temporal distribution of subscriber traffic

The determination of the "island" areas is not the only task for using the method. In case the operator uses dual-band cells 900/1800 MHz, it is necessary to know how to allocate subscriber' consumption between cells at different frequencies. The main difference between the 900 and 1800 MHz is in the higher carrying capacity due to the larger number of frequency channels and a smaller service areas of the subscribers, as well as the larger signal attenuation at higher frequencies.

It should be noted that the base stations of the different frequencies can be separated not only spatially, but also they can be positioned at the same spatial coordinates. In the last case in order to determine the proper operation of the dual-band cells it is necessary to know how the consumption between cells of different ranges is distributed.

In this case it is important that at the first stage the subscriber can choose a cell with range 1800 MHz, in a

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service area of a base station (0 | 1,5 km). In case of a distance bigger than 1,5 km, the choice is a cell operating with range 900 MHz.

Further an example for distribution of subscriber's consumption in case of a two-band cell is shown. In this case it is considered that the cells of dual-band base station, which works with one antenna system, i.e. cells with the 900 MHz and 1800 MHz, have the same coordinate systems, as well as the same areas of targeted broadcasting.

In Figure 2 it is visible that the effective and operative service area for the cells with different working frequencies is different. It is especially noticeable in the evening at 19:00 p.m., when the effective service area for this range is increased compared to the cell with a frequency 1800 MHz. The last depends on the subscribers' movement in the residential areas, in a distance up to 1 km.

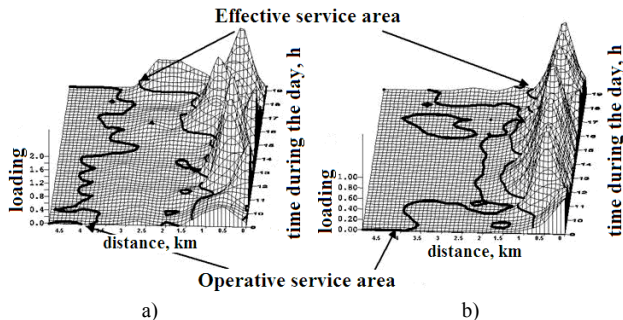


Fig. 2. Spatial – temporal traffic distribution of subscribers from 09:00 a.m. to 19:00 p.m.: a) range 900MHz; b) range 1800MHz

In addition in case of a spatial distribution of the consumption in the cell, other parameters of the system can influence, related to its various options, such as dynamic allocation of consumption in the cell, as well as the setting of the switching of channels (handover algorithm).

In a study of subscribers' consumption distribution in two-band cell it is not enough to make an analysis of the spatial-temporal distribution. This is due to the fact that the two-band cells working with one antenna system and having the same geographic coordinates, have the same directed action and therefore they share the load with each other in different proportion. Therefore besides the evaluation of the spatial-temporal consumption distribution, it is necessary to assess the distribution of the total consumption in the cell during the day, as well as for each cell separately - Figure 3.

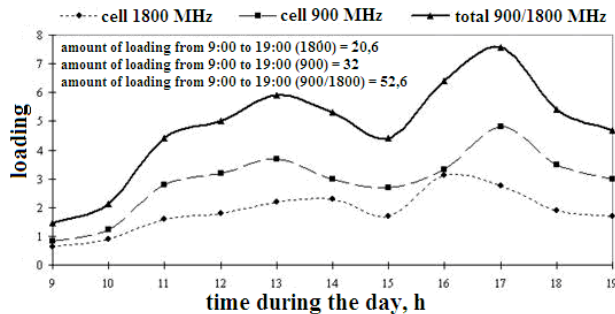
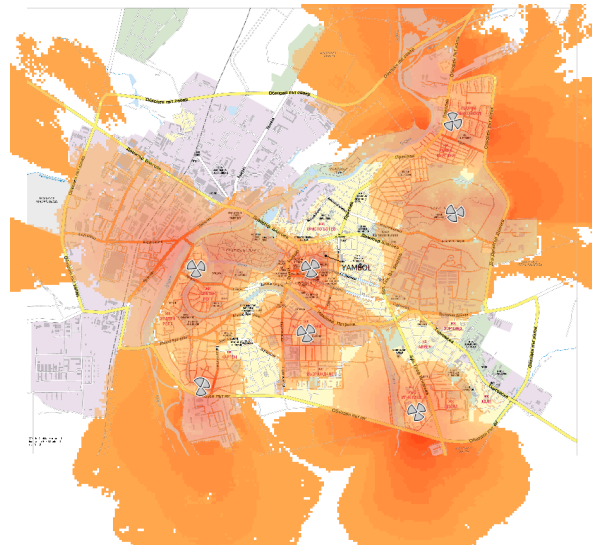


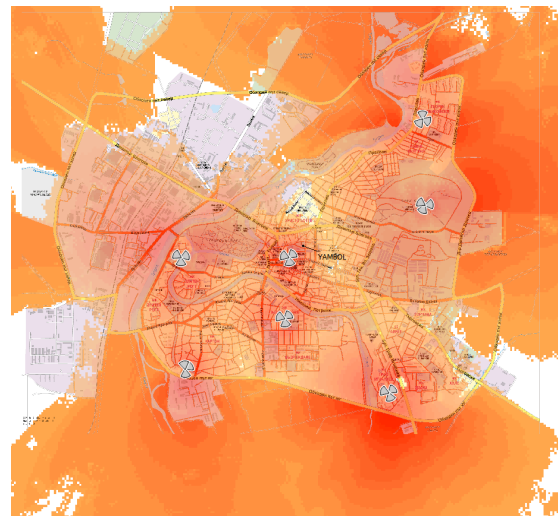
Fig.3. Total distribution of the subscriber traffic for two-band cell during the day

For localization of a subscriber in the space a program of the company ERICSSON [6, 7] was used, which was tested by a cellular network operating in urban environments. This software is an integral part of the hardware of base station controller (BSC). What is interesting is that the received

quality of radio coverage, which for 3G (UMTS) standard for lower frequencies in the 900 MHz (b) has better performance than at 2100 MHz (a) - Figure 4.



a) 2100 MHz - Indoor coverage 58,6%



b) 900 MHz - Indoor coverage 87,2%

Fig. 4. Simulation results obtained for radio coverage in urban environments for 3G (UMTS) standard cellular network

3. Analysis of the Multiplying Models

In this part we present the results related to different analytical models, used in practice. Measurement data that are provided by mobile operator for example Base Station Transmitter (BTS), located at a height of 273 meters. Nine antennas, each of which covers sectors with width 40°, are used for coverage with a signal. The comparison between the measured values and the predicted ones is obtained by calculating the average error between the predicted and the measured values and as a function of the distance between the base station (BTS) and a mobile station (MS), and depending on the acceptance angle - α .

The results are presented in Figure 5. As it could be seen the results of the model Maciel-Xia-Bertoni are identical to those of the hybrid model so that the two curves overlap.

These two models are suitable, if $d > 2$ km, $\alpha < 10^\circ$. Especially for large values of α error it becomes much larger. In this range, the pattern of Walfisch-Ikegami shows good correlation between predictions and measurement.

Model Flatenge and Okumura-Hata shows good results for large distances, but forecasts with the model of Okumura-Hata become too inaccurate for larger values of α . In contrast, the free-spatial model has a high average error in long distances, due to the worse monitoring of diffraction losses from several screens.

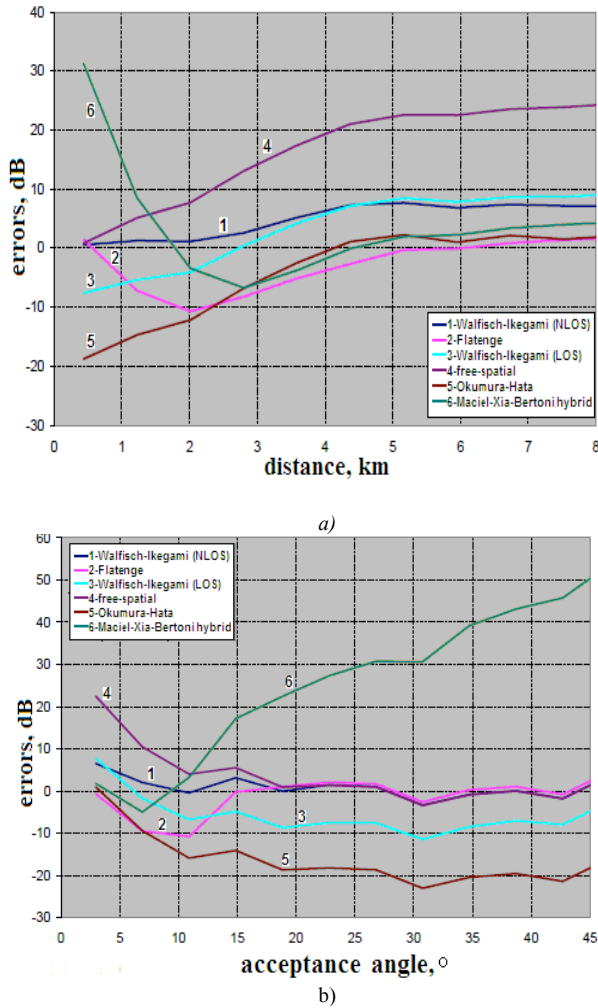


Fig. 5. Average error between the predicted and measured values depending on: a) the distance between the base and mobile stations; b) and the angle of acceptance

The analysis confirms the good results of the hybrid model. For short distances the model of Walfisch-Ikegami shows very good results, but for longer distances there are big deviations. From other site, in long distances, the model of Maciel-Xia-Bertoni and of Okumura – Hata have better performance. Therefore the choice, of which version of the hybrid model has to be used, will be done after a consideration in case of ultra-high transmitter. The model of Walfisch-Ikegami should be selected for ultra-high transmitter if $e > 8$. The model of Flatenge is chosen in case of ultra-high transmitter when $d > 400$ m. The average error in this enlarged hybrid model, is a function of distance d (between BS и MC) and the angle of incidence α , as can be seen in Figure 6, in comparison with the initial results.

The big deviation received from the initial model at small distances and large angles can be avoided with new hybrid models [3, 4, 5]. For the whole distance and angle, the average error is about 0 dB. As a whole, the average error and standard deviation of the new model have been improved by about 1 dB.

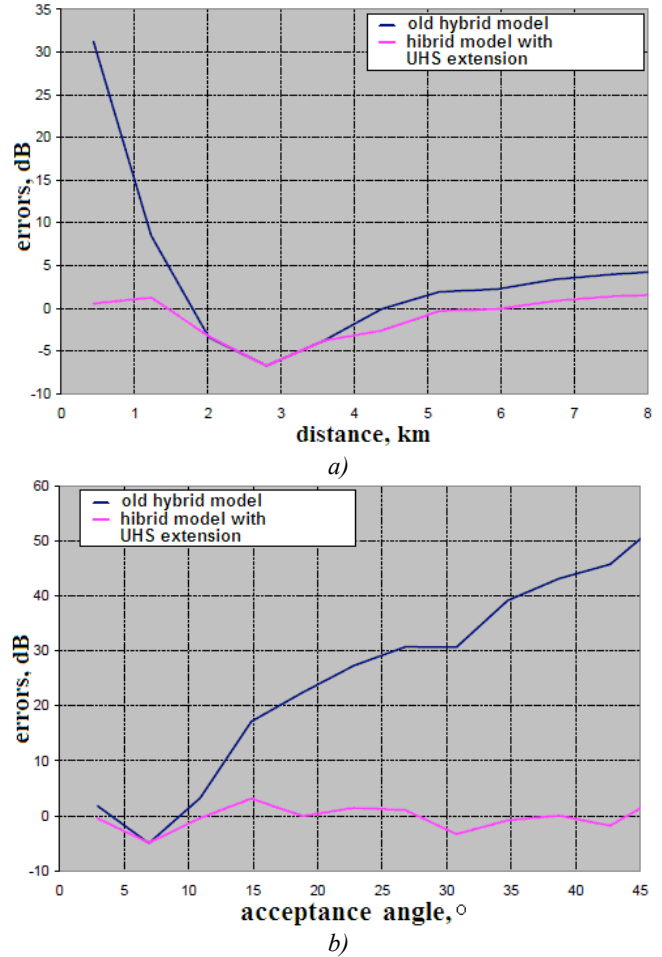


Fig. 6. Average error between the predicted and the measured value in the old models and new hybrid model: a) function of the distance between the base and mobile stations; b) function of the angle of acceptance

4. Conclusions

From the analysis of the methods of broadcasting it is visible that we need input data to calculate the surface of radio coverage and to determine also the losses of distribution. The information for the site and the attitude of the land is normally a part of these input data. Therefore it is possible to contradistinguish open space from woodland and urban area. With this arrangement of so called “classes”, the best method for broadcasting in a region can be chosen. The accuracy of classification strongly influences the accuracy of forecasting. Furthermore this influence during analysis of the conditions in the urban areas. In the hybrid model the urban areas are divided in 4 categories: crowded urban area, urban area, suburban area and industrial area. In order to improve the classification of the urban areas, they can be allocated to another 21 exemplary and specific coverage categories. These classes can be divided in 9 categories, which characterize the structure of the buildings, for example family buildings or high buildings, and other 12 categories to be specified like institutions: for example schools and airports. Each of those classes has its characterizing parameters like the width of the street, the height of the building, as well as the allocation of the buildings in a certain territory.

The proper planning of the network is essential to obtain maximum coverage while maintaining the required level of

service and minimum cost. Up to the moment there is no model which can be defined as the best model for design of cellular network, as each model has its positives and

negatives. But one of the best model which is used more often is the model of Walfisch-Ikegami.

References

1. Dankov, P. *Introduction in wireless communications*, Sofia, Heros press, 2007 .
2. Pencheva, E., I. Atanasov, *Broadband mobile communications*, TU - Sofia, 2006.
3. Koitchev K., S. Sadinov, K. Angelov, *Allocation of Traffic in the Analysis of Models in Cellular Network*, International Scientific Conference "UNITECH 2010", Gabrovo, 2010.
4. Sanduchkov, K., M. Malchuk, *Methodology for calculation of GSM networks*, Moscow, notes, 2008.
5. Bogens, K., O. Shorin, *Determination of zones of attenuation in systems for mobile radio relations*, Moscow, Jurnal radioelektronika, 2000
6. Ericsson Telecom AB, Telia AB, *Understanding Telecommunications*, Ericsson Telecom, Telia, Studentlitteratur, 1998
7. <http://www.ericsson.se>