Comparison of UMTS and DVB-SH in Terms of the Quality of the Received Signal and the Cell Range

Helena Catarino and Pedro Pinho

Instituto Superior de Engenharia de Lisboa (ISEL)
Departamento de Engenharia Electrónica e Telecomunicações e de Computadores (DEETC), Lisboa, Portugal
20975@alunos.isel.ipl.pt, ppinho@deetc.isel.pt

Abstract. The objective is to determine which technology provides better coverage and performance. In the end, you will understand whether these technologies should be considered complementary or competing.

Keywords: UMTS, DVB-SH, coverage, signal.

1 Introduction

Given the great need of mobile users being able to access desired content and applications anywhere, anytime, the mobile communication systems have to adapt to the market changes and users' needs.

Television systems are operating normally, with the maximum transmission power and antenna placed as high as possible in order to reach the largest coverage area. In radio systems, the service area is divided into cells, with a transmitter in each cell. The aim of these systems is to achieve greater efficiency through the reuse of frequencies over small distances. It can be said that the higher the number of times that each channel is reused in the same geographic area, the more efficient a radio system is.

In UMTS (Universal Mobile Telecommunication System), the most popular application is video. People use their 3G handsets to watch live TV programs, or to download videos (news, music or other entertainment). However, the ineffectiveness of the unicast mode, currently used, prevents the creation of a massive market either economically or technologic (each user uses a radio resource, assigned exclusively to him). Accordingly, the use of an infrastructure designed to use broadcast mode (the same program beeing sent simultaneously to all users) is essential [1].

The ideal solution would be a combination of broadcast and unicast modes in a unified approach, so the broadcast can be used to the most requested channels and the unicast mode for channels with less audience. With this combination the use of the spectrum is optimized, and each user may have access to their favourite programs.

J. Rodriguez, R. Tafazolli, C. Verikoukis (Eds.): MOBIMEDIA 2010, LNICST 77, pp. 48–59, 2012.

The combination of unicast/broadcast services used in mobile TV is an open network, designed to operate as a complement to existing mobile networks, not as a competing network.

The Mobile TV is on its way to becoming a major mass market. Nowadays more than half of 3G/UMTS networks worldwide have mobile TV services. This is the first step towards a new TV experience. Due to the use closely related to mobility, interactivity is an important part of Mobile TV. It is now widely recognized that the Mobile TV starts with a portable TV, but ends up as a personal TV, interactive and in real time.

The average time of use of mobile TV services is about 5 minutes per day. Despite the increasing use of these services, the expectation of their use is around 30 minutes daily. Bearing this in mind, faster access to TV contents without spending too much time to scroll through the available channels becomes a priority for mobile networks operators. Due to the short time of use per day, and the trend that mobile users want short programs of a few minutes, instead of long programs, the program contents must also change. Formats produced for normal TV are not well suited to mobile TV, where short films and more interactive support are required.

During the last decade, digital video and audio applications in the telecommunications facilities have suffered a great development. However, the greatest benefits of this progress can be achieved only if the entire communication network (from transmitter to receiver) is digital.

With the DVB (Digital Video Broadcasting) we can have transmissions of better quality images and a wider range of transmission channels. Thus, it makes it possible for the users to have services that were unavailable before, such as mobile TV reception (via DVB-SH), interactivity, television on demand of multimedia services [3].

The DVB-SH (Digital Video Broadcasting S Band) is a transmission system designed to provide video, audio and data to small mobile devices such as phones and PDAs (Personal Digital Assistants), using S-band frequencies. The main feature of DVB-SH is the fact that being a hybrid satellite/terrestrial system can allow the use of a satellite to achieve coverage in large regions or even in an entire country. This system was originally designed for using frequencies below 3GHz, usually around 2.2GHz. The DVB-SH explores the opportunities offered by the S-band, where there is less congestion than in the UHF band.

Since the DVB-SH is a digital single frequency, it has further advantages, such as spectral efficiency, flexibility and robustness. With the DVB-SH we can have a single frequency band, transmitting more than one program simultaneously.

The combination of the two technologies, UMTS and DVB-SH, can provide a range of communication services, information and interactive applications in real time with mobility.

The inclusion of a DVB-SH circuit in a 3G handset is an excellent choice, both economically and technically. Using the radio, it is possible to reach more users with a very low cost and with little use of radio resources.

With the combination of these two technologies (UMTS + DVB-SH) we achieve a compromise between the classical broadcast video and data broadcasting, with a flexible allocation of bandwidth to different services [5].

The figure 1 shows the network architecture resulting from the combination of UMTS + DVB-SH.

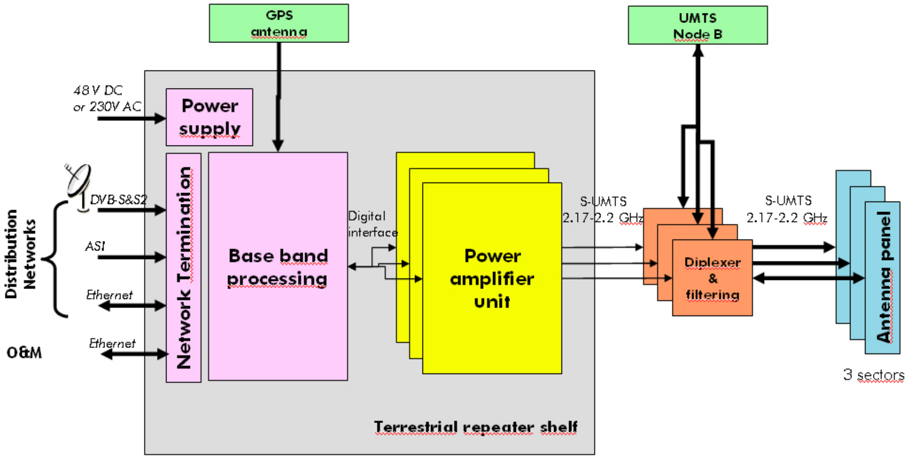

Fig. 1. Architecture of the UMTS and DVB-SH combination [5]

This paper will present the planning of a dense-urban area, making use of a planning tool for mobile networks.(Atool - A9155 V 6.6). Once completed the planning phase, tests will be performed to collect measurements so that we can compare the expected results (theoretical) with the practical results (measurements).

Both the planning and the measurement have been done with regard to the propagation environment and the network elements required.

2 Planning

Tests were conducted to predict coverage, in order to establish the main differences between the coverage areas and signal levels of UMTS and DVB-SH. Therefore a study area was developed, as described below.

The analysis area consists of an urban area in the center of Lisbon, where it was made a planning for the UMTS and DVB-SH coverage, and subsequently, was carried out drive-tests, in order to make it possible to compare the two situations.

The figure 2 shows a map identifying the subject area to study and the location of the UMTS + DVB-SH stations.

Fig. 2. Location of the sites

The area in question is covered by 7 sites, indicated in the figure above.

The following table shows the settings of the UMTS+DVB-SH collocated sites under consideration.

Table 1. 3G+DVB-SH collocated sites characteristics

Site	Lat	Long	Altura	Tipo de Feeder	Comp. do Feeder	Antena	Ganho Antena	Azimute	Tilt Eléctrico	Tilt Mecânico	Perdas de Feeder
Campo Pequeno FDD 1	38.7434	-9.148926	42.50	7/8	30	K742212	18	12	6	4	1.8450
Campo Pequeno FDD 2	38.7434	-9.148926	42.50	7/8	15	K742212	18	107	7	2	0.9225
Campo Pequeno FDD 3	38.7434	-9.148926	42.50	7/8	15	K742212	18	207	4	4	0.9225
Av Defensores de Chaves FDD 1	38.7393	-9.145880	23.00	7/8	42	K742212	18	132	4	2	2.5830
Av Defensores de Chaves FDD 2	38.7393	-9.145880	24.00	7/8	32	K742212	18	242	4	0	1.9680
Av Defensores de Chaves FDD 3	38.7393	-9.145880	26.00	7/8	22	K742212	18	337	4	2	1.3530
Entrecampos FDD 1	38.7481	-9.146957	31.00	7/8	40	K742212	18	27	4	1	2.4600
Entrecampos FDD 2	38.7481	-9.146957	28.00	7/8	73	K742212	18	167	4	2	4.4895
Entrecampos FDD 3	38.7481	-9.146957	23.00	7/8	70	K742212	18	307	4	2	4.3050
Laranjeiras FDD 1	38.7458	-9.166663	34.00	7/8	30	K742212	18	10	2	3	1.8450
Laranjeiras FDD 2	38.7458	-9.166663	34.00	7/8	30	K742212	18	120	2	4	1.8540
Laranjeiras FDD 3	38.7458	-9.166663	34.00	7/8	40	K742212	18	130	4	2	2.2460
Av Álvaro Pais FDD 1	38.7449	-9.150678	23.00	7/8	40	K742212	18	0	4	2	3.4600
Av Álvaro Pais FDD 2	38.7449	-9.150678	26.00	7/8	40	K742212	18	242	4	1	3.4600
Av Républica FDD 1	38.7346	-9.145249	42.00	7/8	100	K742212	18	2	7	7	4.6800
Av Républica FDD 2	38.7346	-9.145249	34.00	7/8	60	K742212	18	125	7	3	3.6900
Av Républica FDD 3	38.7346	-9.145249	34.00	7/8	60	K742212	18	237	5	4	3.6900
Valbom FDD 1	38.7357	-9.150581	27.00	7/8	27	K742212	18	0	2	4	1.8450
Valbom FDD 2	38.7357	-9.150581	27.00	7/8	27	K742212	18	122	2	0	3.0750
Valbom FDD 3	38.7357	-9.150581	27.00	7/8	27	K742212	18	237	2	2	1.8450

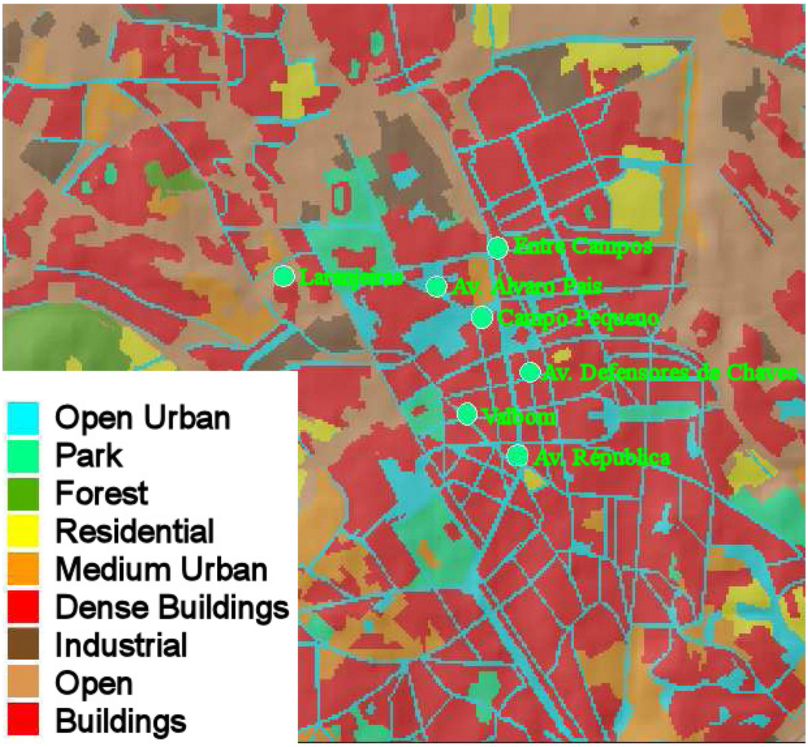

Fig. 3. Clutter Classes

Table 2. 3G+DVB-SH collocated sites configurations

Code	Name	Height (m)	Model standard deviation (dB)	Ec/Io Standard Deviation (dB)	Eb/Nt Standard Deviation DL (dB)	Eb/Nt Standard Deviation UL (dB)	Indoor Loss (dB)	% Pilot Finger	Orthogonality factor
0	unclassified	0	0	7	7	7	0	100	0.6
1	open	0	0	7	7	7	0	100	0.6
2	sea	0	0	7	7	7	0	100	0.6
3	inlandwater	0	0	7	7	7	0	100	0.6
4	residential	0	0	7	7	7	0	100	0.6
5	meanurban	0	0	7	7	7	0	100	0.6
6	denseurban	0	0	7	7	7	0	100	0.6
7	buildings	0	0	7	7	7	0	100	0.6
8	village	0	0	7	7	7	0	100	0.6
9	industrial	0	0	7	7	7	0	100	0.6
10	openinurban	0	0	7	7	7	0	100	0.6
11	forest	0	0	7	7	7	0	100	0.6
12	parks	0	0	7	7	7	0	100	0.6
26	denseurbanhigh	0	0	7	7	7	0	100	0.6
27	blockbuildings	0	0	7	7	7	0	100	0.6
28	denseblockbuild	0	0	7	7	7	0	100	0.6
29	rural	0	0	7	7	7	0	100	0.6

The coordinate system shown in the table 1 is the WGS84 Long/Lat for UTM zone 28N. The units of the variables above are: meters for the antennas heights and feeder length; degrees, for azimuth and tilts and dBi for antennas gain.

The objective is to cover 95% of the area shown above, through the combinated use of the two technologies in the antennas. Since the estimates of coverage depend on the profile of the terrain and the morphology of the area. The next figure the distribution of the Clutter Class in the area the analysis will focus on.

The table 2 presents the setup Atool - A9155 V 6.6 (planning tool used) for UMTS+DVB-SH coverage simulations.

Since there is no generic propagation model for different types of environments, frequency and parameters, most of the times the network planners choose to use a hybrid model, which will consider whether the characteristics of the empirical models or rhetorical models. Hybrid models therefore have a greater flexibility and can be defined and calibrated with the use of measurements for the desired propagation environments, where the network planning will be applied.

For the networks above 3.5 GHz the propagation models of Okumura-Hata, Ikegami-Walfisch and the Erceg are used. For this study the Okumura-Hata model has been chosen [6] since it is the easiest to implement, although this model has to be adapted to the environment in question and also for the two frequencies pilot of the UMTS and DVB-SH.

This model requires an adjustment for different types of environments, once the topology and morphology of the terrain varies. Thus, urban environments typically have to take into account that not all buildings have the same structures, dimensions and floors. On the other hand, we can have straight or curved streets, small squares, alleys, etc.. Thus, the expression to use in case of urban environments is as follows:

$$\bar{P}L_{Urban} = 69.55 + 26{,}16 \log_{10} f - 13{,}82 \log_{10} h_b + (44{,}9 - 6{,}55 h_b) \log_{10} d - a(h_m) \tag{1}$$

Being $a_{(hm)}$ given by:

$$a(h_m) = (1{,}11 \log_{10} f - 0.7) h_m - (1{,}56 \log_{10} f - 0{,}8) \tag{2}$$

The maximum transmission power is assumed to be 36dBm and the minimum transmission power 33dBm. After calibration of the Okumura-Hata propagation model for UMTS, we obtained the results shown in Figures 4 and 5.

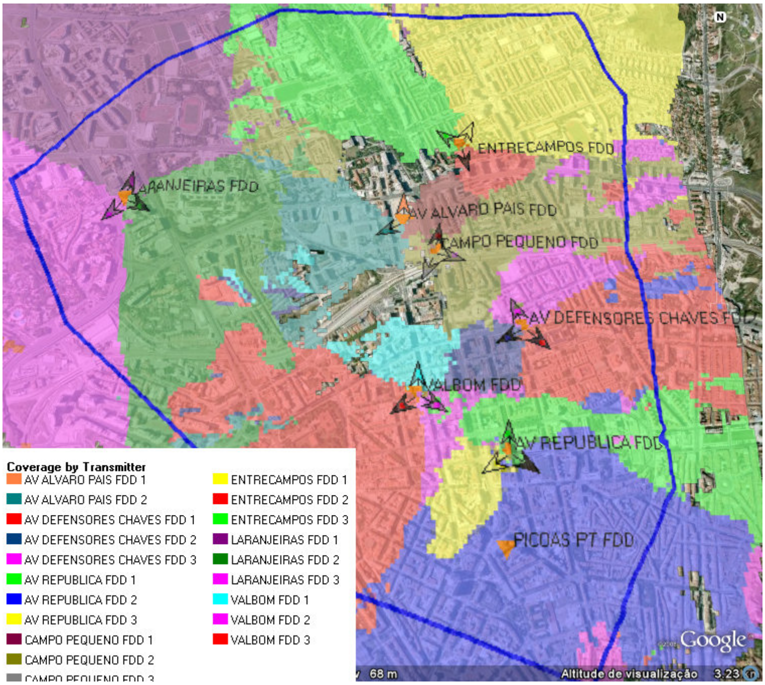

Fig. 4. 3G coverage by sector

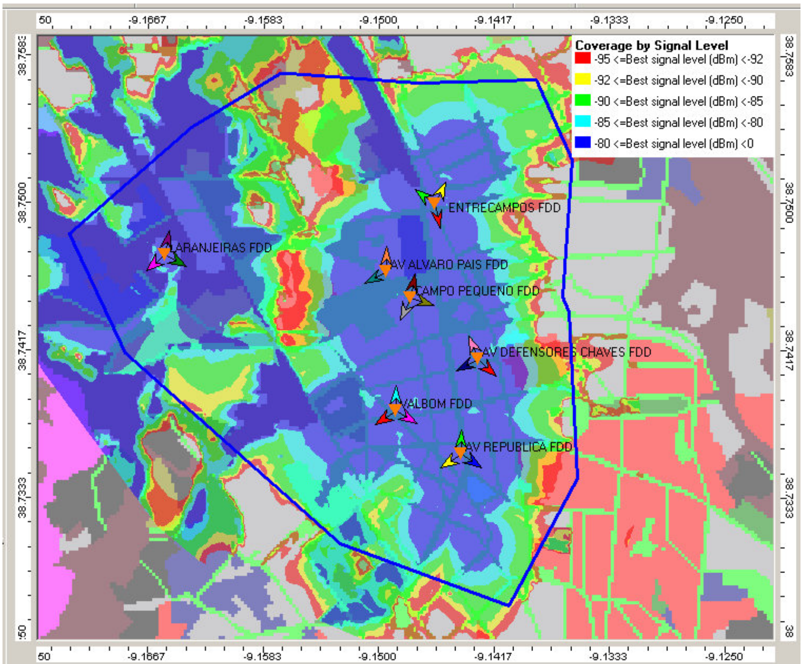

Fig. 5. 3G Signal levels

For the DVB-SH case, since most mobile TV systems operate in the UHF band or S band, you can make a segmentation of the co-located UMTS site. Thus, the existing UMTS infrastructure can be used, with the necessary changes, i.e., the introduction of a terrestrial repeater shelf in the Node B (see figure 1).

The propagation model to be used is similar to that used in 2G/3G/Wimax, however it is necessary to calibrate the model in order to meet the appropriate requisites for the area in question.

Since Okumura-Hata model was initially developed for frequencies up to 1500 MHz, for the DVB-SH and 4G networks, which operate at higher frequencies, it is necessary to adapt the model in order to have a valid expression for higher frequencies. This adaptation was made by the European Committee COST, so it is often called COST- 231 Hata model.

The expression of adaptive model COST-231 Hata for frequencies between 1500 MHz and 2000 is as follows:

$$L(dB) = 46{,}3 + 33{,}9\log_{10}(f) - 13{,}82\log_{10} h_b - a(h_m) + (44{,}9 - 6{,}55\log_{10} h_b)\log_{10}(d) - K \qquad (3)$$

Where the value of $a_{(hm)}$ is calculated using Equation 3 and K is the corrective factor related with the terrain, which can have two values: 0 dB for the case of small towns or suburban areas and 3 dB for the case of large cities.

The modulation used was 16QAM with a code rate of ½ and ¾ of MPE-FEC and a C/N=14 dB.

The next figure presents the calibration of the model with the parameters used, based on the previous equation.

Parameters:	
Near transmitter	
Maximum Distance	2000
K1 - los	19
K2 - los	39,2
K1 - nlos	19
K2 - nlos	39,2
Far from transmitter	
K1 - los	52
K2 - los	28,65
K1 - nlos	52
K2 - nlos	28,65
Effective antenna height	
Method	0 - Height above the ground
Distance min (m)	0
Distance max (m)	15000
K3	15,07

Diffraction	
Method	1 - Deygout
K4	0,23
Other parameters	
K5	-4,33
K6	0
Kclutter	1
Hilly terrain correction	0 - No
Limitation to Free Space Loss	1 - Yes
Profiles:	0 - Radial
Grid calculation:	0 - Centred
Clutter taken into account:	
Heights	
Consider heights in diffraction	1 - Yes
Receiver on top of clutter	0 - No
Range	
Maximum Distance	0
Weighting function	0 - Uniform

Parameters per clutter class:

	Losses (dB)
1 - OPEN (0m)	-15
2 - SEA (0m)	-20
3 - INLAND WATER (0m)	-20
4 - MEAN INDIVIDUAL (0m)	-11,8
5 - MEAN COLLECTIVE (0m)	-10,51
6 - DENSE COLLECTIVE (0m)	-6,83
7 - BUILDING (0m)	-7
8 - VILLAGE (0m)	-16,2
9 - INDUSTRIAL (0m)	-13,7
10 - OPEN IN URBAN (0m)	-11,08
11 - FOREST (0m)	-14,79
12 - PARK (0m)	-9,59
13 - DENSE INDIVIDUAL (0m)	-7,28
14 - BLOCK BUILDING (0m)	-6,5
16 - SCATTERED URBAN (0m)	-12,7

Fig. 6. Calibration parameters used

The maximum transmission power is assumed to be 44 dBm and the minimum transmission power 37dBm.

Also for the case of DVB-SH, were estimated the predicted coverage and signal level estimates are presented below.

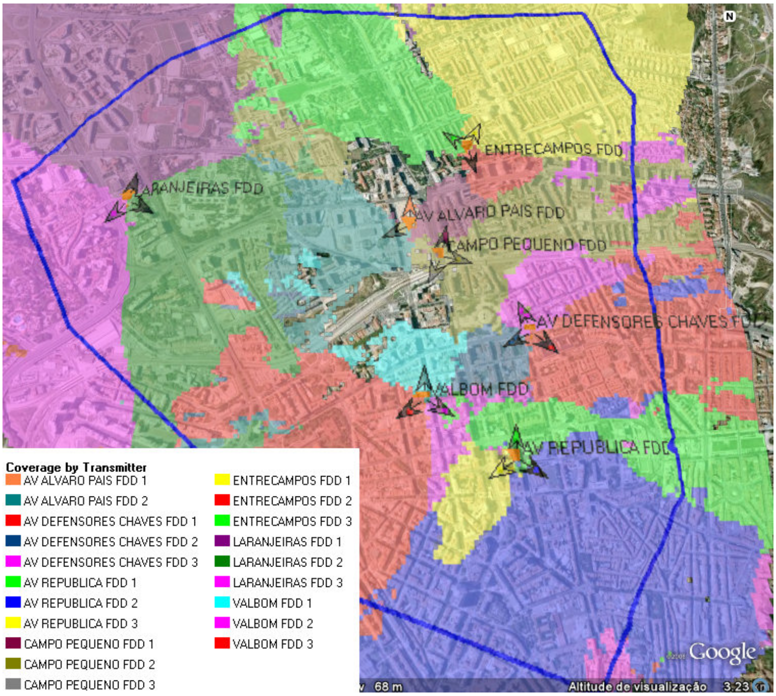

Fig. 7. DVB-SH coverage by sector

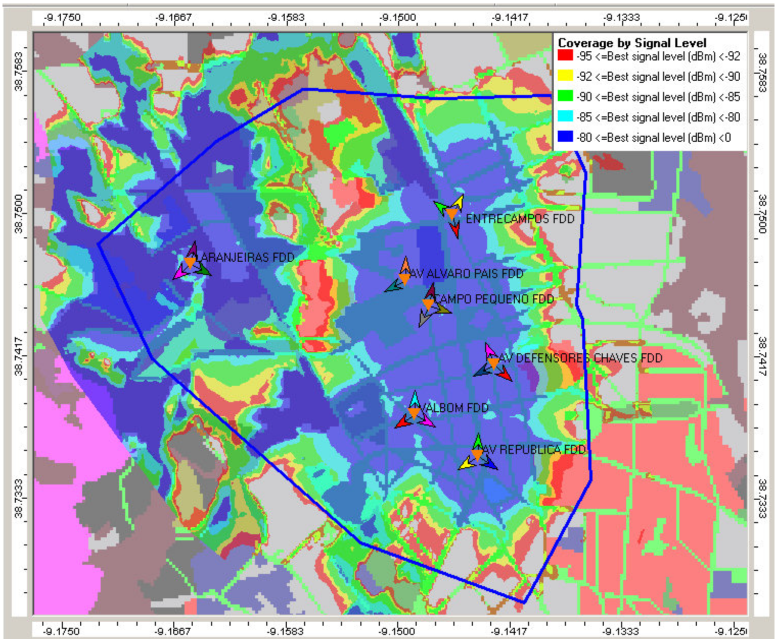

Fig. 8. DVB-SH Signal levels

The predicted simulations show that the coverage area for UMTS is bigger than the one obtained for DVB-SH. In the limit of the cells we can see that the degradation of the signal strength is more abrupt in DVB-SH than in UMTS.

3 Measures

The next figures present the results obtained with the drive-tests for collecting the signals received from UMTS and DVB-SH. Figure 9 - signal level for UMTS technology and figure 10 - signal level for the DVB-SH.

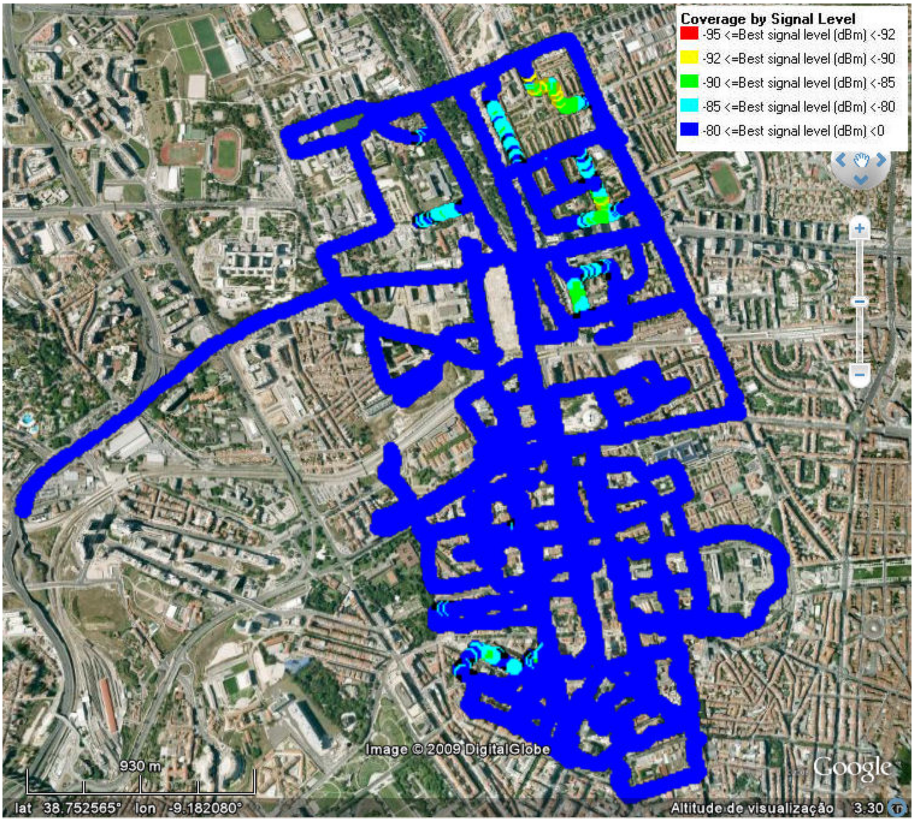

Fig. 9. UMTS Signal levels

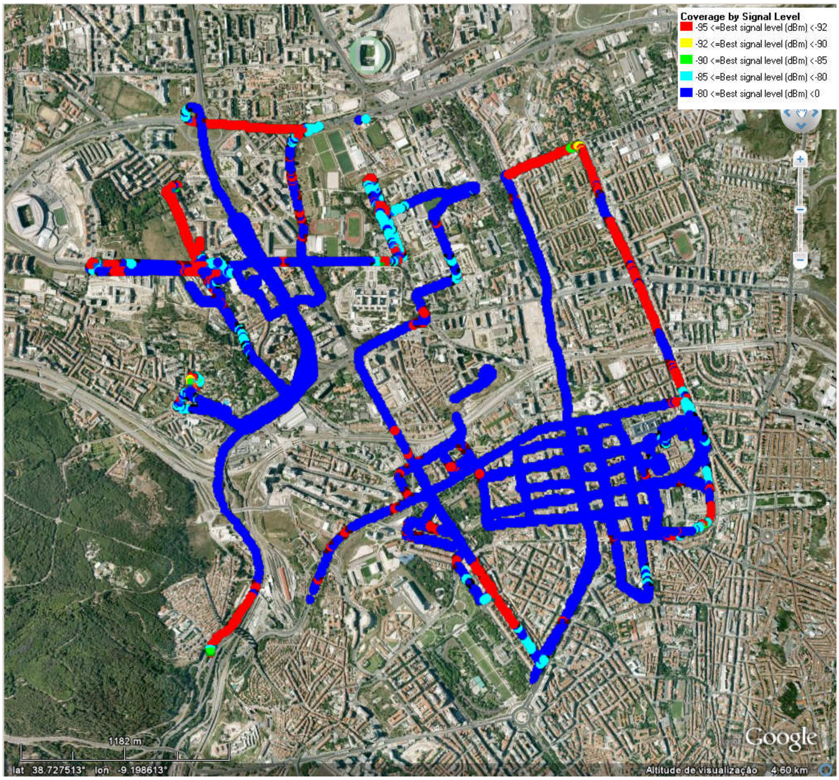

Fig. 10. DVB-SH Signal levels

4 Comparison of Results

Comparing the two systems, we can say that regarding the coverage level, the rays of the DVB-SH cells are larger, because we have higher transmission power. However, since the sensitivity reception of a DVB-SH mobile, to ensure the service is lower (-95dBm) to UMTS (-105 dBm), we will have a smaller coverage area with DVB-SH.

In what concerns the signal level, we can see that in the surround site areas the signal levels for the two technologies are very similar. Major differences occur when we move away from the sites. As the coverage area of DVB-SH cells is lower, levels of signal in DVB-SH will vary faster than 3G.

5 Conclusions

The figures presented are in agreement with the theoretical concepts, since the goal of 3G is to have longer range, even if it means a lower signal level. The aim of DVB-SH is not to cover a large area, but to provide a better signal level so that the quality of services is better. In order to have the same footprint as 3G, DVB-SH repeaters are used, which allow the increase of the coverage area, but with the condition that they maintain the quality of the signal level.

In general, it can be said that UMTS aimed is the range, while the DVB-SH is designed to signal quality.

It follows therefore that the two technologies can coexist and can be complementary, rather than directly competing, since one aims at the quality of the signal and the other at a longer range.

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