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Measuring and Evaluating TV White Spaces in Samsun, Turkey

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Abstract – The aim of this study is to determine the available Television White Space (TVWS) spectrums in Samsun with the aid of TV spectrum measurements at 73 different locations. The measurements were performed within 470 MHz - 790 MHz band, using software based RTL2832U-R820T and ANRITSU S332E frequency analyzer. In the measurements -40dB and -45dB above signals are considered. It is seen from the measurement results that, frequency spectrum usage change depending on the distance from TV transmitter station, existence of Line of Sight (LOS) path and geographical features of measurement locations. In addition, the maximum spectrum occupancy is 70% while the average spectrum occupancy is 20.7%. The spectrum occupancy increased up to 8.3 % with the choice of lower reference value (i.e. -45dB). The comparison of measurement results with the Radio and Television Supreme Council (RTSC) terrestrial transmitter list show that in measurement environment more channels are active. In the last part of the study, measurement locations were transferred on to a map via QGIS program, and available TVWS spectrum map of Samsun city was created.

Keywords -
Cognitive Radio, TV White Space, Software Defined Radio, Frequency Analyzer, Spectrum Occupancy Ratio.

1. Introduction

As a result of dramatic growth in wireless communication, researchers have been exploring the next generation wireless communication systems to provide higher capacity within an available spectrum. However, the frequency spectrum is a limited resource and contraction of bandwidth will be more serious problem over time. Thus several approaches have been suggested in researches to develop efficient solutions. These researches put forth that the reason of contraction is not scarce bandwidth resources but the inefficient usage of the allocated bandwidth [1].

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Cognitive Radio (CR) concept which is a typical dynamic spectrum sharing technology that helps to prevent the use of overly occupied, inefficient and static spectrum was first proposed by Mitola in 1999 [2]. Aim of the cognitive radio is to sense the current empty spectrum dynamically by software defined radio and use that detected unused or low powered spectrum without interfering of a primary user's transmission. An alternative solution of bandwidth scarcity is the utilization of inefficiently used or unused bands [3-7]. The communication over such unused radio spectrum is named as TVWS communication.

The TV stations were allocated on a static spectrum basis which results in the inefficient use of current licensed band. IEEE 802.22 WRAN (Wireless Regional Area Network) is the first standard using white spaces in the television frequency spectrum (from 54 MHz to 862 MHz). Investigating the existing TV bands of countries and determining the available spectrums are therefore current research subjects [8-15]. In addition, internet broadcasting to far areas is realized with using TVWSs in some countries, such as Google makes internet broadcasting over TVWSs in Cape Town South Africa.

Considering the increased scarcity in spectrum as a result of the technological developments, determining the TVWSs has become more important than before. With the spectrum occupancy measurement, the current and future spectral occupancy information can be provided to regulators, researchers and engineers. Therefore this study aims to determine the utilization efficiencies of channels within the UHF band (from 470 MHz to 790 MHz). The measurements were performed at 73 different locations using software based RTL2832U-R820T and ANRITSU S332E frequency analyzer. The result of the study would be a basis for determining the efficient parts of Samsun city center for TVWS communication. Furthermore it is determined that how applicable the TVWS communication in Samsun.

2. TVWS Measurements

In Turkey, terrestrial TV broadcasting uses the band from 470MHz to 790 MHz comprising of forty channels of 8 MHz each. In this study with the aid of the measurements which were conducted within 470 MHz and 790 MHz band (to observe the changes at the beginning and end of the spectrum frequency range of measurements was extended from 450MHz to 800MHz) at 73 different locations in Samsun city with RTL2832U R820T software defined radio and ANRITSU S332E spectrum analyzer, the allocated channels in UHF band were detected. RTL2832U- R820T is a software based device that detects the signals within the specified band. The device has its own software, and after software and antenna installation is ready for use. The images of measurements are shown in Fig. 1. An example of spectrum recorded via RTL2832U R820T at any location is given Fig. 2. The vision and the sound carriers of a channel are given in Fig.3. As seen from the figure that the vision carrier frequency is 559.25 MHz, while sound carrier frequency is 564.75 MHz, and difference between them is 5.5 MHz.

Fig.1 Measurement process with RTL2832U R820T and Anritsu S332E spectrum analyzer

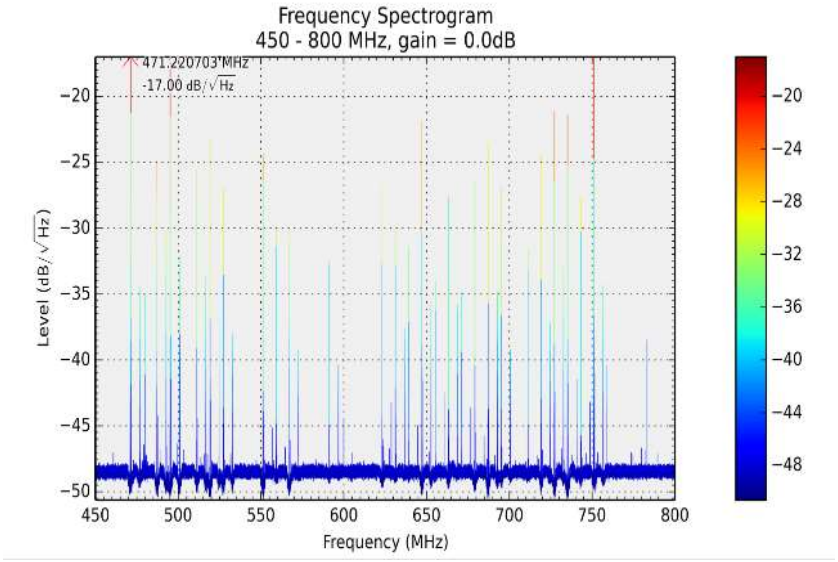

Fig.2 An example of a measurement obtained via RTL2832U R820T spectrum analyzer

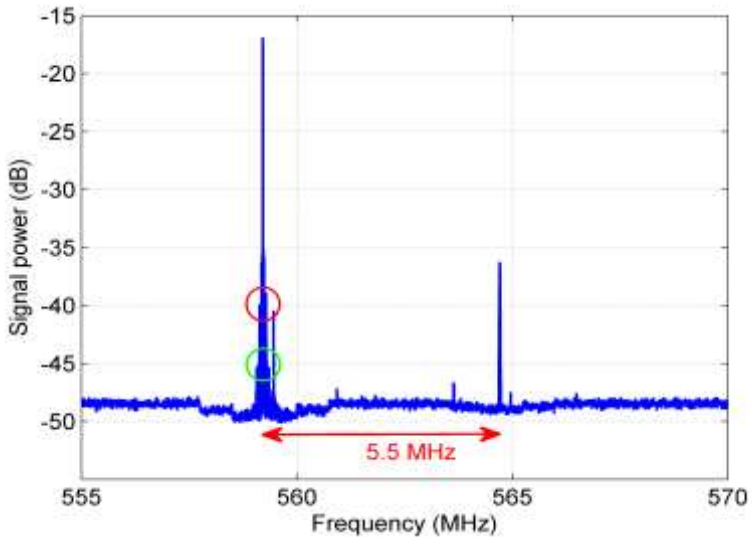

Fig. 3. The vision and the sound carriers of a channel over TV spectrum

The data recorded using RTL2832U R820T spectrum analyzer were transferred to MATLAB. The available TV channels were then determined based on these data for the thresholds of -40 dB and -45 dB. Fig. 4. shows an example of determination process of TV spectrum occupancy rate for the chosen thresholds.

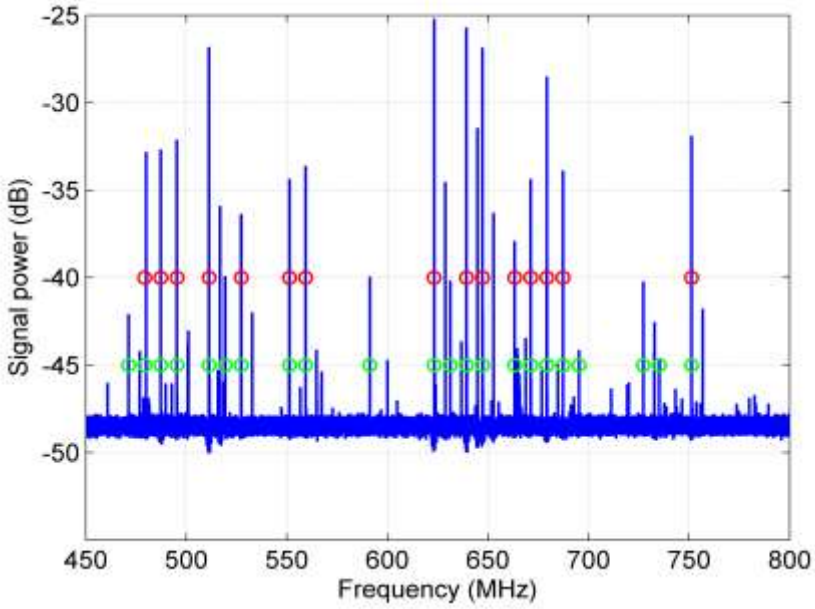

Fig. 4. Determination process of TV spectrum occupancy rate

Similar evaluations were applied to data, and numbers of available channels were determined for all measurement locations. In order to have better visualization scaled color map of TVWSs for Samsun city was created using resulting numbers of available channels and QGIS program. A screen capture of QGIS program is as shown in Fig.5.

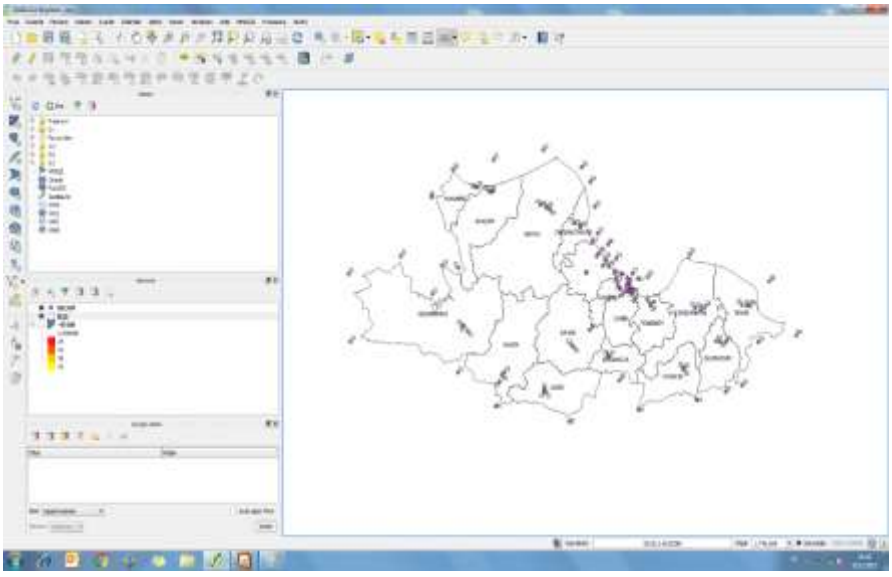

Fig. 5. Screen capture of QGIS program

3. Measurements Results

The numbers of available TVWSs in Samsun were determined based on the measurements that conducted at 73 different locations from September to December 2015. The numbers of available channels in UHF band (470-790MHz comprising of forty channels of 8 MHz each) were determined considering the thresholds -40dB and -45dB for vision carrier. Fig. 6. illustrates the measurement results of the location where the most occupancy was recorded. It can be seen from the figure that there are 28 used channels detected (red circles) for -40dB threshold, while 29 detected (green circles) for -45dB. Therefore the chosen threshold value affects the number of TVWS channels directly.

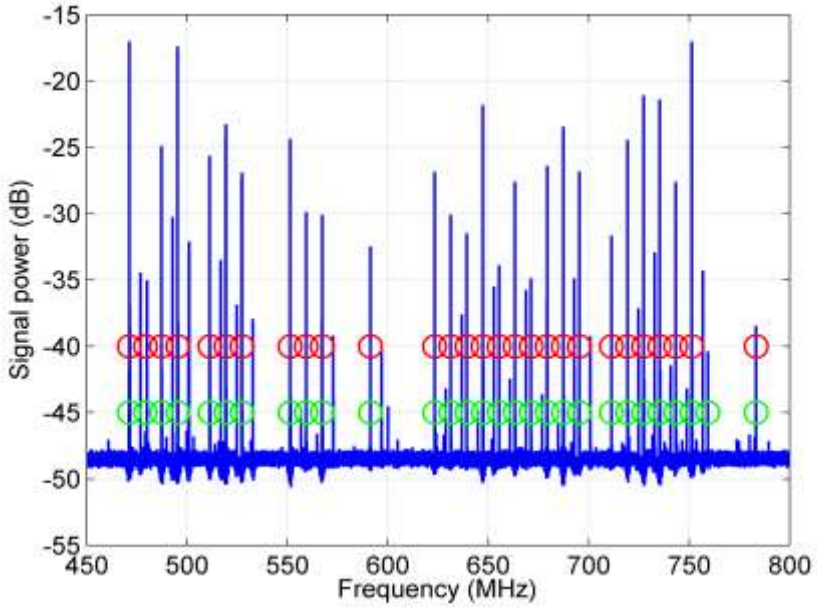

Fig. 6. The measurements results of the mostly occupied location

Similar evaluations were made for the data obtained from the rest 72 locations, the resulting numbers of used channels were compared to RTSC terrestrial transmitter list [16], and were shown in Fig. 7. It is seen from the results that, the number of TVWS change depending on the distance from TV transmitter station and geographical features of measurement locations. Additionally, the numbers of active channels are significantly higher than those of the listed by RTSC [16].

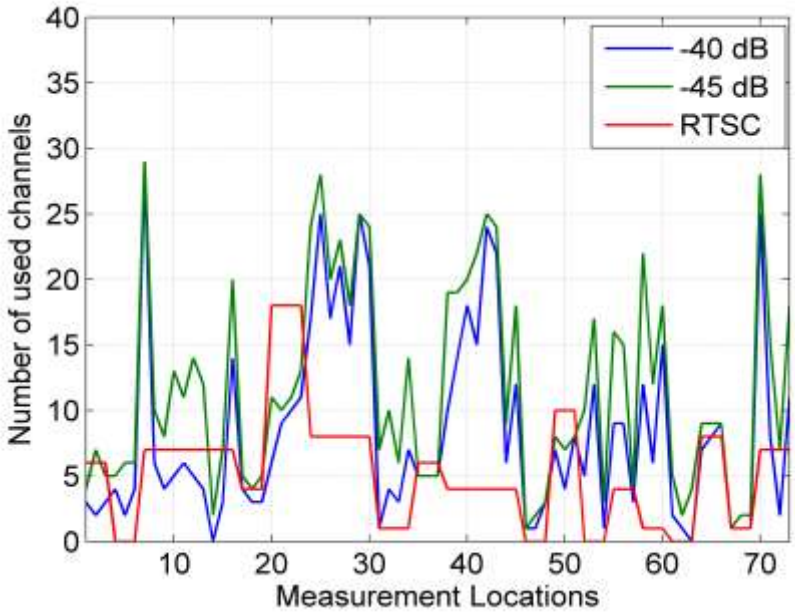

Fig.7. Change in the number of used channels with measurement location

Statistical analysis of the data were performed and the probability density functions for -40 dB, -45 dB and RTSC list are illustrated in Fig. 8.

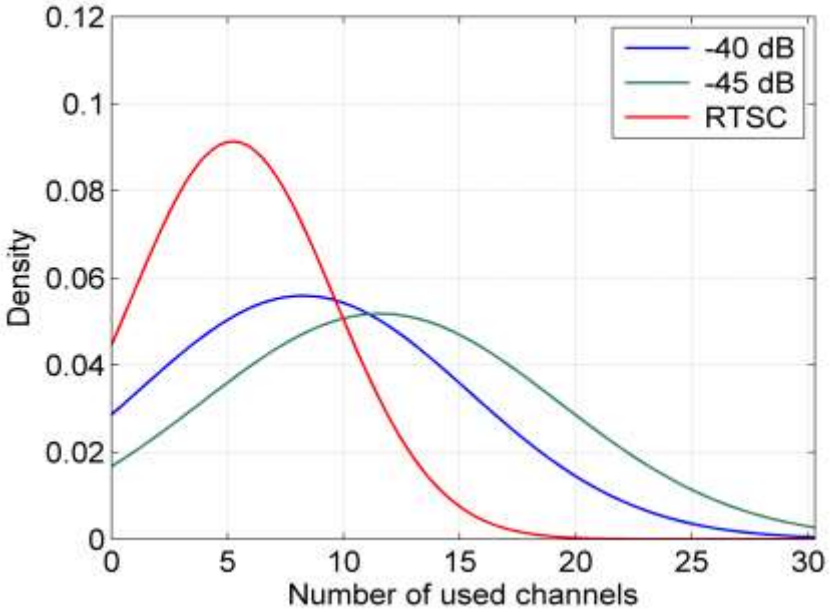

Fig. 8. Probability density functions of the number of used channels

As seen from the figure that, the average number of used channels for -40 dB and -45 dB are higher than for RTSC. The mean value of the number of used channels is 8.26 for -40dB, while 11.57 and 5.23 for -45 dB and RTSC respectively. Also, the corresponding

standard deviations are 7.1, 7.7 and 4.4. It is clearly seen from the evaluations that, the numbers of used TV channels differ from those on the RTSC list.

The percentages of available spectrums are shown in Fig. 9 for 73 locations. It can be seen from the figure that, the spectral availability varies between %27.5 and %97.5 within 320 MHz spectrum for -40 dB threshold which means 312 MHz of the band is unused. In case of -45 dB threshold it is possible for the whole band (320 MHz) to be unused. The average available spectrum percentages are 79.4% for -40 dB while 71.1% and 86.9% for -45 dB and RTSC respectively.

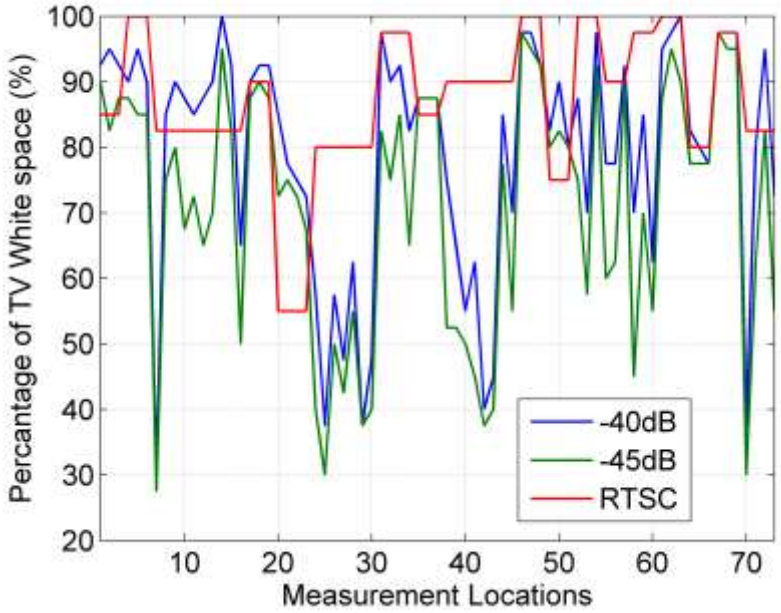

Fig. 9. Spectrum availability percentages

In the last part of the study, TVWS maps of Samsun were created using QGIS program for -40dB and -45dB thresholds, and given in Fig.10 and Fig.11 respectively. It can be seen from the figures that, there are unused channels available in many districts of Samsun. These maps prove that the cognitive radio communication technology is highly efficient and applicable for Samsun city.

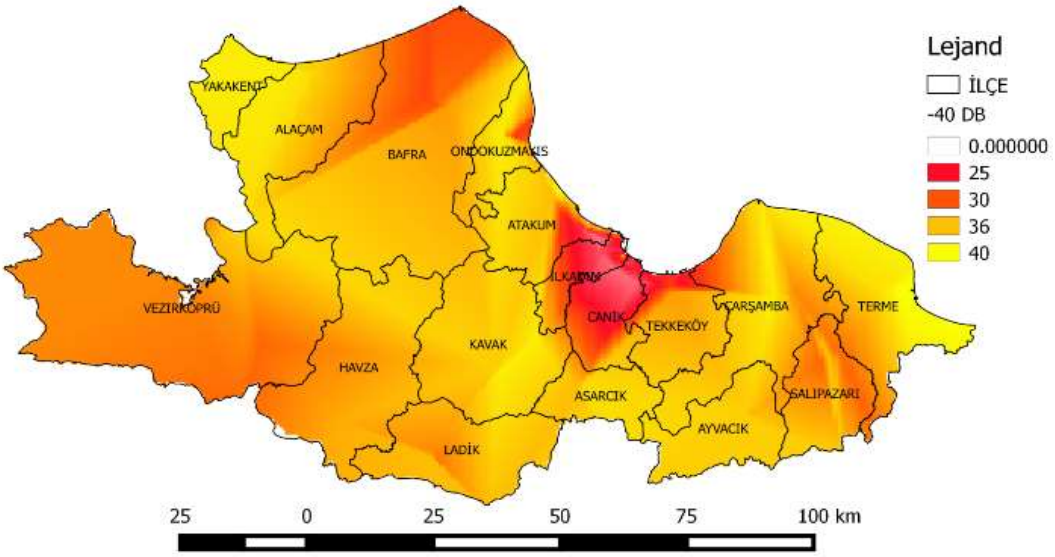

Fig. 10. TVWS availability for -40 dB threshold

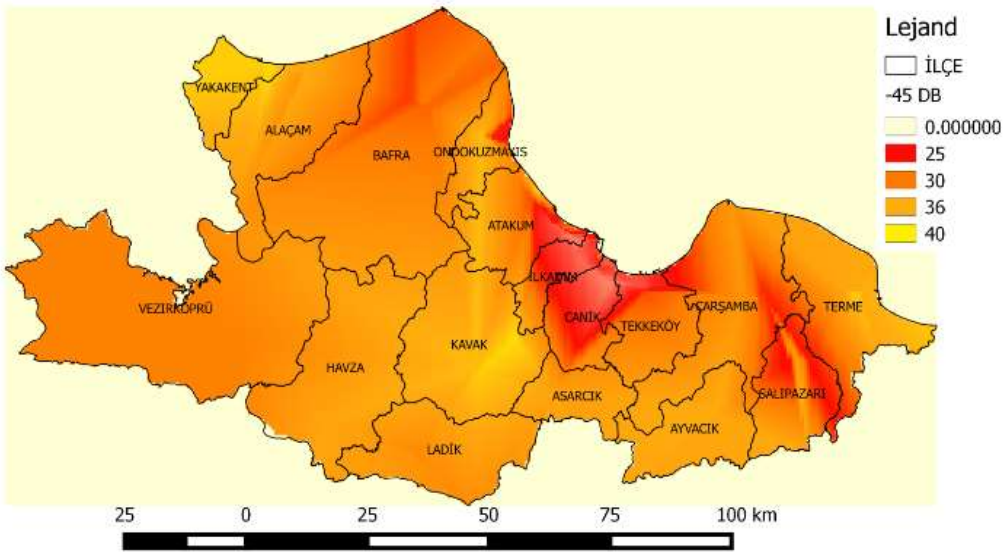

Fig. 11. TVWS availability for -45 dB threshold

4. Conclusions

In this study, based on the spectrum measurements that conducted at 73 different locations TVWSs were determined for Samsun city. Resulting numbers of channels were compared to RTSC channel list. TVWS spectrum map of Samsun city was created by transferring measurement results to QGIS program. Measurement results show that most of the allocated spectrum is utilized with low efficiency, even in the most dense part of Samsun city 30% of the spectrum is unused. Considering both that each TV channel uses 8 MHz of bandwidth, and rising high frequency allocation costs; the available TVWS of 96 MHz which was determined for the most dense case could be reused. The use of the results helps to build a whitespace database to guide the future cognitive applications

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