Measurement of frequency occupancy levels in TV bands in urban environment in Kosovo

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Abstract— In this study we conduct an assessment of usage and availability of frequency bands, traditionally assigned to TV broadcasters, in urban environments in Kosovo. The assessment was performed for VHF and UHF bands at 8 different urban locations. Localized measurements indicate that a major part of these frequencies is severely under-utilized even in highly urbanized areas where a higher utilization level would be expected. Preliminary results further show that spectrum utilization level varies significantly with altitude and is much lower in indoor environments. Our initial calculations show that current percentage of availability of TV bands in tested locations varies between 87.5% and 100%. These results indicate that spectrum utilization in these bands could be greatly improved by allowing the opportunistic use of spectrum by cognitive radios and other wireless communication technologies, such as future cellular networks.

Keywords - TV white space, cognitive radio, spectrum measurements, spectrum occupancy.

I. INTRODUCTION

As a result of the almost universal deployment of 'handheld' IT technology the need for continuous wireless internet access has become a necessity in every corner of the world. Since frequency is already a limited resource, current wireless access communication networks are facing severe spectrum congestion especially in urban areas where the number of users is considerably high.

To improve spectrum usage, one efficient solution is the deployment of cognitive radios (CR) [1] which will behave as secondary users and use the under-utilized spectrum whenever it is not being used by primary users.

A cognitive radio is a radio that can change its transmission parameters based on interaction with the environment in which it operates [1]. The use of such radios has been approved both by US and UK regulatory bodies, in 2009 and 2012 respectively [2]. Under-utilization of licenced spectrum is especially apparent in the frequency bands traditionally allocated for TV broadcasting [2, 3, 4]. Furthermore, with the advent of analog to digital transition in TV broadcasting, substantial amount of spectrum in TV bands is expected to become further available. This under-utilized portion of the TV bands is referred to as TV White Space (TVWS) and is of great interest due to the superior signal propagation characteristics. However, since the allocation and usage of TV bands can vary from country to country, an assessment of TV band utilization must be first performed to identify potential white spaces. To do so, spectrum measurements need to be performed over the VHF band (174-230 MHz) and UHF band (470-860 MHz).

In this paper we present the results from spectrum measurements over TVWS in Prishtina, the capital of Republic of Kosovo. To our knowledge, this is the first such study to be conducted in Kosovo, and one of the very few in the Western Balkans region. Similar studies have been performed in Bosnia and Herzegovina [5], Hungary [6], and Macedonia [7]. Applying comparable methodologies as other similar measurement campaigns performed in other countries [2, 3, 4, 8], we perform a spectrum occupancy analysis over the UHF and VHF bands. The obtained results show clearly that these bands are heavily under-utilized and there is great potential for opportunistic use of the TV broadcast spectrum.

The rest of the paper is organized as follows: Section II describes the details of the spectrum measurement process. The measurement results and availability analysis is presented in Section III. Conclusions are drawn in section IV.

II. TVWS SPECTRUM MEASUREMENTS

The analog terrestrial TV broadcasting in Kosovo is allocated in the following spectrum bands: VHF 174-230 MHz (8 channels, each 7MHz wide) and UHF 470 – 86o MHz (48 channels, each 8MHz wide) [9].

To assess the utilization of these bands in downtown Prishtina, measurements were performed at 8 different locations using the NARDA Selective Radiation Meter SRM-3006 with a frequency resolution of 100 kHz.

The SRM-3006 is a software based device equipped with a three-axis isotropic antenna that is able to detect signals from 9 kHz to 6 GHz. The device can be connected to a PC via RF cable. MATLAB software was used to process and analyze the data. The measurements were performed using the Spectrum Analysis mode of the device. At each

location, 2 to 3 measurements were performed, each lasting around 5 minutes.

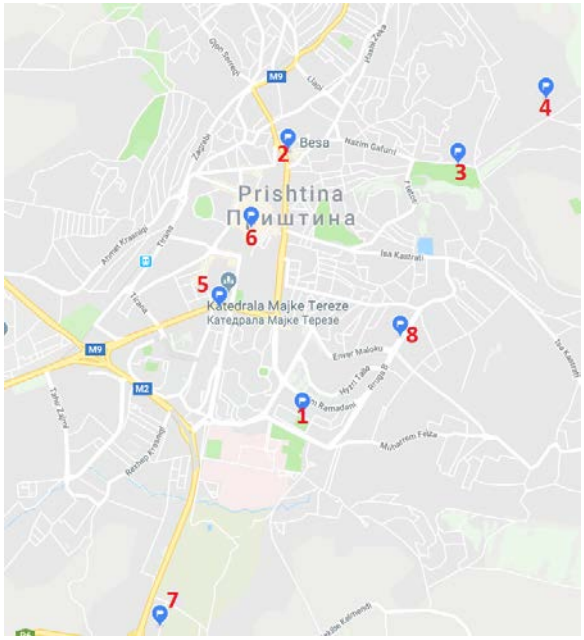


Fig.1. Measurement locations

To account for losses from signal propagation, at most of the locations, measurements were performed both for indoor and outdoor environments. Measurement locations are listed in Table I and illustrated in Fig.1.

The locations were chosen to represent the various types of environments present within the Prishtina urban area. Where possible, in areas with taller buildings, measurements were taken in the ground floor and higher floors.

As shown in Table 1, measurements were taken in three urban residential areas: at a school building (location 1) situated in an uphill terrain and partially shadowed; at a residential area near the city center surrounded mainly by low-rise buildings and little shadowing (location 2); and a residential area surrounded by high-rise buildings and shadowed by a hill (location 8).

Within the city center measurements were taken in two different locations: the main city boulevard (location 6), which is a pedestrian street surrounded by medium-rise buildings (4-6 storeys tall); and at a high rise building in the city center (location 5), surrounded by lower-rise buildings and situated in an uphill terrain. Measurements were also taken at two different parks, one within the city itself (location 3) and the other one in the outskirts of the city (location 4).

Finally, measurements were also taken inside and near a shopping center (location 7), outside of the city, situated on top of a hill, in a developing area planned to accommodate several upcoming residential neighborhoods.

ID	Location	In/Out	Floor	Type
1	Faculty of Engineering	In/out	Ground	School/Residential
2	RTK building	In/Out	Ground	Urban/Residential
3	Taukbahqe	Out	Ground	Park
4	Vneshta	Out	Ground	Park
5	KESCO building	In/Out	Ground 12th floor	Urban/High-rise buildings
6	Mother Teresa boulevard	In/Out	Ground floor	City centre
7	Albi Shopping Center	In/Out	Ground 4th floor	Shopping centre/ Outside of city
8	Rruga B	In/Out	Ground 9th floor	Residential/High-rise buildings

Table 1. Measurement locations

III. TVWS AVAILABILITY ANALYSIS

Based on the measurements conducted at the 8 above mentioned locations, the TVWS spectrum availability was assessed. The received power was measured in dBm over the TV bands, with a frequency resolution of 100 kHz. The power levels detected in the 100 KHz bins within each individual channel band were then summed to obtain the received power level at the specific channel:

$$P_n = 10\log 10 \sum_{l=1}^{L} 10^{\frac{P_l}{10}}$$

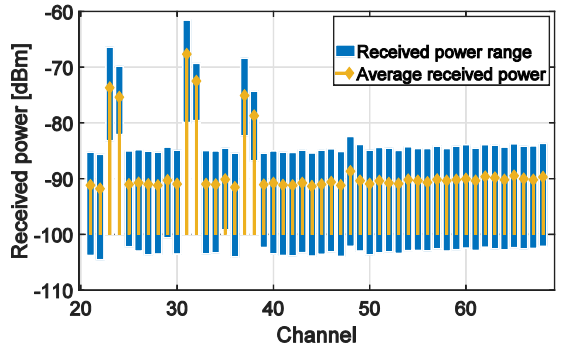
where *n* denotes the channel number, and *l* the bin number. The number of bins per channel *L*, depends on the channel bandwidth.

The number of available channels for VHF and UHF was determined based on a threshold set at -80dBm. This is consistent with threshold values used in related work [3, 4].

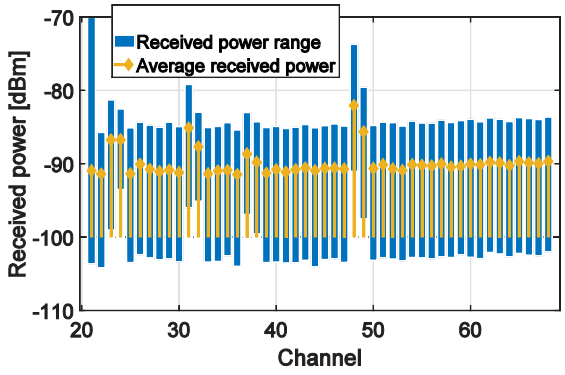
The measurement results at location 5 for the UHF band, are shown in Fig. 2. Our measurements show that in terms of TV signal reception, this location exhibits the highest received power values for channels in use by broadcasters around Prishtina.

From Fig. 2 (a), we can see that in the UHF band there are 6 active channels, which are received with good quality in the city center, when measured outdoors and in high altitude.

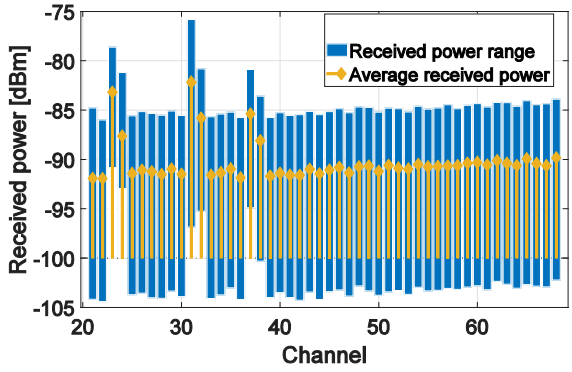
This implies that there are 42 available channels, around 336 MHz of available bandwidth in total, out of which, 240 MHz is contiguous (channels 39 to 68).



(a)



(b)



(c)

Fig. 2 Received power range at location 5 for UHF channels 21-68, measured at: (a) the 12th floor/outside, (b) the 12th floor/inside, (c) ground/outside. The average received power during the sensing period is denoted by a diamond marker.

The occupancy of the band however drops significantly, even within the same location when measured indoors and in the ground floor, as shown in Fig. 2(b) and (c).

Similarly, in the city centre, due to environment characteristics, and multipath effects, the TV signal reception is at significantly lower levels as shown in Fig. 3. There we can see that the average received signal power for all UHF channels is below the -80 dBm threshold, which implies 100% availability of the spectrum. Occupancy ratios were similarly calculated for each measurement location, and the results are shown in Table 2.

As far as the measurements in the VHF band are concerned, the results look far more promising in terms of spectrum availability. In all but one location, the availability of the VHF band was 100%. Only in location 5 was a TV signal detected in one of the channels above the selected threshold. This implies that the potential available contiguous bandwidth in this band is around 56 MHz..

In conclusion, our preliminary results show that there is ample opportunity to improve spectrum utilization in the TVWS in Kosovo, especially by allowing secondary use of these bands to unlicensed users. This especially holds in indoor environments and low-altitude locations.

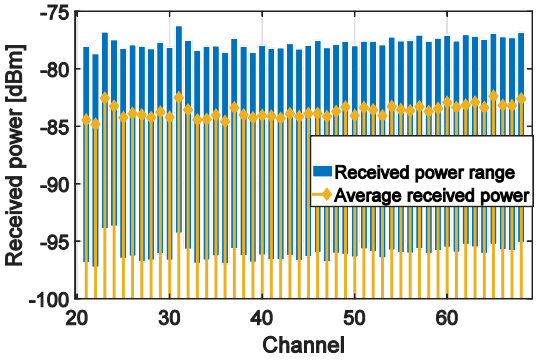


Fig. 3. Received power range at location 6 for UHF channels 21-68, measured outdoors.

It should be noted that Kosovo has not yet transitioned to digital TV broadcasting [10]. Considering that digital TV technology can accommodate up to 8 digital channels within the same spectrum used to transmit one channel in analogue transmission, it is expected that availability of these bands will further increase as the transition proceeds [11]. The newly available spectrum could potentially be used opportunistically by other wireless technologies, however this would require an updated legal framework on spectrum allocation in the Republic of Kosovo.

IV. CONCLUSION

In this work, we studied the availability of the TVWS spectrum for the case urban environment in Kosovo. This was done by conducting extensive spectrum measurement campaigns in several locations within the capital, Prishtina, and its outskirts. From the preliminary results presented in this paper, it is clear that the availability of TVWS channels is significantly high and varies between 87.5% and 100%. This implies that the amount of under-utilized spectrum in these bands is significant, and there is ample room for potential CR operations

in TVWS in Kosovo. Future work is planned to extend the measurement campaigns over the entire territory of the country, to obtain a comprehensive picture of TVWS availability and potentially initiate the compilation of a TVWS database for Kosovo.

Location		Occupancy ratio	No. of available channels	Available bandwidth
1	In	0%	48	384 MHz
	Out	0%	48	384 MHz
2	In	10.4 %	43	344 MHz
	Out	12.5 %	42	336 MHz
3	Out	6.25 %	45	360 MHz
4	Out	8.33 %	44	352 MHz
5	Ground/ In	0%	48	384 MHz
	Ground/ Out	8.33%	44	352 MHz
	12thfloor /In	10.4%	43	344 MHz
	12thfloor /Out	12.5%	42	336 MHz
6	In	0%	48	384 MHz
	Out	0%	48	384 MHz
7	Ground/ In	0%	48	384 MHz
	Ground/ Out	0%	48	384 MHz
	4thfloor /In	0%	48	384 MHz
	4thfloor /Out	6.25%	45	360 MHz
8	Ground/ In	0%	48	384 MHz
	Ground/ Out	0%	48	384 MHz
	9thfloor /In	0%	48	384 MHz
	9thfloor /Out	10.4 %	43	344 MHz

Table 2. Measurement results for all locations in the UHF band.

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REFERENCES

[1] Federal Communications Commission, " Notice of proposed rulemaking and order: Facilitating opportunities for flexible, efficient, and reliable spectrum use employing cognitive radio technologies", ET Docket No. 03-108, Feb.2005.

[2] Maziar Nekovee, "Cognitive Radio Access to TV White Spaces: Spectrum Opportunities, Commercial Applications and Remaining Technology Challenges", IEEE DySPAN 2010 proceedings.

[3] S. D. Barnes, P.R. Botha and B. T. Maharaj, "Spectral occupation of TV broadcast bands: Measurement and analysis". Elsevier Measurement Journal, 2016.

[4] Xuhang Ying, Jincheng Zhang, Lichao Yan, Guanglin Zhang, Minghua Chen, and Ranveer Chandra. "Exploring indoor white spaces in metropolises". 19th annual international conference on Mobile computing & networking - MobiCom '13, New York, 2013

[5] M. Hadžialič, J. Mušovič, M. Hamza, M. Milišič, K. Huseinovič, J. Dizdarevič and M. Dulič, "TV White Space: Solution for bridging the gap between user's demand and the network capacities", 22nd Telecommunications forum TELFOR Belgrade, 2014.

[6] L. Csurgai-Horváth, I. Rieger, and J. Kertész, "A Survey of the DVB-T Spectrum: Opportunities for Cognitive Mobile Users", Mobile Information Systems, 2016.

[7] B. Jankuloska, M. Pavloski, M. Zahariev, V. Atanasovski and L. Gavrilovska, "Efficient Spectrum Utilization: A Cognitive Approach", IEEE ICC 2010, Cape Town, South Africa.

[8] L. Bedogni, M. Di Felice, F. Malabocchia, L. Bononi, "Indoor Communication over TV Gray Spaces based on Spectrum Measurements", IEEE WCNC 2014, Istanbul, Turkey.

[9] Kosovo Independent Media Commission. "Gjendja reale dhe e planifikuar e planit frekuencor televiziv të Republikës së Kosovës", http://www.kpmks.org/index.php?mod=materiale&id=830

[10] Kosovo Independent Media Commission. "Strategjia për kalimin në transmetim digjital tokësor në Republikën e Kosovës". http://www.kpmks.org/materiale/dokument/1427797128.6317.pdf

[11] Andres Henten, Reza Tadayoni and Iwona Windekilde, "Spectrum war-The battle for the digital dividend spectrum", in Proceeding of the 18 Biennial ITS conference, Tokyo, Japan.