Feasibility of Voice Service in Cognitive Networks over the TV Spectrum

Konstantinos Koufos, Kalle Ruttik and Riku Jäntti,
Communications and Networking Department,
Aalto University School of Science and Technology, TKK, Finland.
Konstantinos.Koufos@tkk.fi, Kalle.Ruttik@tkk.fi, Riku.Jantti@tkk.fi

***Abstract*—We consider a cognitive network where the secondary users generate voice traffic and search for sharing opportunities over the TV spectrum. From the cognitive network perspective the TV bands can be idle, occupied or acceptable. A band is classified as acceptable when the TV signal is present but the secondary users can still share the band by lowering their transmission power. Therefore, the acceptable bands offer a lower rate transmission opportunity compared to the idle bands, while the occupied bands cannot be utilized at all for secondary transmission. When most of the measured bands are detected to be occupied, there might not be enough capacity to serve all the secondary users' calls. In this paper we identify the number of measured TV bands so that with a high probability all the secondary users are scheduled on some of the measured bands. The results of this paper are promising. It is shown that the number of secondary users sharing the spectrum grows much quicker than the number of TV bands required to be measured.**

***Index Terms*—Cognitive radio, Multiband sensing.**

I. Introduction

After the transition to the digital TV, a portion of the TV spectrum remains either vacant or it is underutilized. This spectrum is attractive in terms of signal propagation properties and it is expected to be used for opportunistic type of services [1]. The main rule to be followed before allowing opportunistic (or secondary) access in the TV spectrum is to protect the licensed (or primary) users of the spectrum from harmful generated interference increase. In order to do that a combination of sensing and database access has been proposed for secondary devices [2].

So far, the academic research work on spectrum sharing is mostly based on sensing [3] and considers the sharing opportunity over a single spectrum band. The case for multiband sensing has been considered only recently [4] [5] [6]. Therein, the system design does not consider how much capacity is actually needed for the secondary user services and all the candidate spectrum bands are measured. As a result, the cognitive network may perform unnecessary spectrum measurements that consume time and energy resources at the secondary users. Contrary to this approach, we take into consideration the service originated at the secondary users and calculate its capacity requirement. After combining the capacity requirement with the TV band opportunistic rate we are able to describe a TV band by the number of supported traffic channels. In addition, we assume that the cognitive network has a database connection where the prior probability about the availability of a measured band is stored. On retrieving this information the cognitive network can identify the minimum number of measured TV bands in order to satisfy the capacity requirement for each secondary user.

We consider secondary users using a constant rate voice connection as if the sender is always in active mode. We say that the cognitive network experiences channel unavailability when there is no TV band available to carry the voice packets generated at some of the secondary users. This situation may occur when most of the measured bands are not available for secondary transmission. In this paper we calculate the amount of TV bands required to be measured so that the probability of channel unavailability is kept under some particular level. Equivalently, we calculate the maximum number of secondary users that are served with particular channel unavailability probability in a limited amount of spectrum bands.

According to the common view, the secondary users can share the spectrum only if the primary signal power at their location is well below the noise level. The decision test classifies a measured band as either *idle* or *occupied* by estimating the primary signal level and comparing it with a low enough threshold. This policy equates a spectrum sharing opportunity with the detection of primary signals with very low level. It reduces the potential for spectrum sharing because it leaves vast areas in the proximity of primary users' cells unutilized [7]. For instance, the secondary users may have the opportunity to share the spectrum close to the primary cell border by adapting their transmission power level. Motivated by [7], we categorize a TV band as *acceptable* when the primary user signal is detected and the secondary users have to lower their transmission rate in order to utilize the band. Because of that, less number of voice calls are carried by the *acceptable* bands compared to the *idle* bands. Note that the *acceptable* bands can be classified into different subclasses depending on the opportunistic rate they can actually support. In this paper we categorize all the *acceptable* bands in a single class but the extension to multiple subclasses is straightforward.

The rest of the paper is organized as following. In section II we present the system and the voice service model. In section III we formulate the problem and calculate the probability to experience channel unavailability in the cognitive network.

CrownCom 2010

Digital Object Identifier: 10.4108/ICST.CROWNCOM2010.9252
http://dx.doi.org/10.4108/ICST.CROWNCOM2010.9252

In section IV we illustrate the inter-relation between the number of measured TV bands, the number of secondary users and the probability of channel unavailability. Finally, in section V we discuss about the feasibility of voice services over the TV spectrum and outline a path for future work.

II. System model and notations

We consider a centralized network of N secondary users with a base station (BS). All the users have to establish a voice call to the infrastructure network. The BS is responsible for identifying enough spectrum bands available for sharing and schedule all the calls with a high probability. Let assume that K TV bands are measured out of the total candidate bandwidth. The secondary users are not allowed to share the bands detected to be *occupied*. The number of users scheduled on the *idle* and the *acceptable* bands is calculated after combining the TV band opportunistic rate with the data rate requirement for each secondary user. The bands detected to be either *idle* or *acceptable* can immediately become operating bands or placed in the list of backup bands [8].

The role of the BS is to identify the minimum required number of measured TV bands so that the probability $\Pr_{out}$ the cognitive network experiences channel unavailability is kept below a target constraint P. It is important to minimize K in order to reduce the measurement time and utilize efficiently the spectrum detected to be available. In order to do that the BS should be aware of two parameter values. The former is the probability a measured band is either *idle* or *acceptable*. The latter is the number of secondary calls accomodated on the *idle* and the *acceptable* TV bands.

The probability a measured TV band is *idle*, *acceptable* or *occupied* at the location of the cognitive network is assumed to be known and it is denoted by $\Pr_1, \Pr_2$ and $\Pr_3$ respectively. Obviously, $\sum_{i=1}^{3} \Pr_i = 1$. These probabilities are related to the location of the cognitive network with respect to the coverage area of the TV transmitters. During the planning phase of the TV network, one can determine the status of the TV bands inside some particular area and over the time domain. By averaging over all the considered TV bands one can compute the prior probability that any measured band is *idle*, *acceptable* or *occupied* at the location of the cognitive network. The BS can retrieve these probabilities from a database if it has a network connection.

Note that the status of a TV band can change. For instance, a TV transmitter that starts broadcasting may change the status of the corresponding band from *idle* to *occupied*. Because of that the spectrum measurements should be carried out periodically. The time interval between two consecutive spectrum measurements interrupted by secondary transmissions and signalling overhead is called a detection cycle or a MAC frame. Within a MAC frame all the secondary users generate the same amount of voice packets and should be scheduled on some of the measured bands. The duration of the MAC frame T_a should be selected smaller than the maximum tolerance of the primary receivers to the harmful generated interference increase due to the secondary transmission. A potential structure of the MAC frame is depicted in Fig.1. Below, we detail the activities that are possibly carried out in every part of the frame.

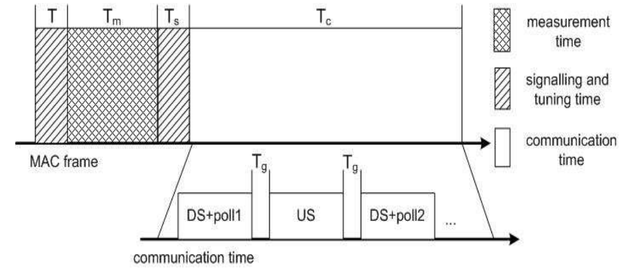

Fig. 1. The MAC frame structure.

The measurement time T_m is devoted for spectrum measurements at the TV bands specified by the BS [8]. Each user measures a single band and thus, $K \leq N$. The communication time T_c is reserved for upstream (US) and downstream (DS) voice transmission. During the signalling time T_s, the users convey their measurement result to the BS where the measured bands are classified. After that, the BS informs the users about their communication channel and the users tune their operational frequency accordingly. At the beginning of the frame, time T is budgeted for tuning at the sensing frequency. Note that the structure of the MAC frame presented in Fig.1 serves only as an example case.

The BS categorizes the measured bands by formulating the decision problem as a trenary hypothesis test. Hypotheses $H_1^{(k)}, H_2^{(k)}$ and $H_3^{(k)}$ correspond to the kth band being *idle*, *acceptable* and *occupied* respectively. In this paper we assume perfect sensing and thus, error free classification of the measured bands. Therefore, the probability to classify a measured band as *idle*, *acceptable* and *occupied* is $\Pr_1, \Pr_2$ and $\Pr_3$ respectively. Essentially, these probabilities are the prior probabilities of the related hypotheses. In this paper we decided to exclude the performance of the detection algorithm from the system design in order to investigate whether there is any feasibility at all for carrying voice services over the TV spectrum. In the presence of detection errors, for instance, due to the noise and signal fading one has to derive the posterior probability of classifying a measured TV band. By using the prior probabilities we derive a lower bound on the number of measured TV bands for a system with detection errors.

The number of secondary users served by the *idle* and the *acceptable* bands depends on the opportunistic rate offered by the TV bands and the capacity requirement for each secondary user. In this paper it is assumed that every user generates fixed-size voice packets with rate $1/T_p$ where T_p is the voice packetization interval. Assuming a contention-free time slotted MAC with polling, we calculate the number of users $N_{u,i}$ ($i = 1$ for *idle* channels and $i = 2$ for *acceptable* channels) that a single TV band can accomodate:

$$N_{u,i} = \left\lfloor \frac{T_p - (T + T_m + T_s)/N_p}{2 \cdot (T_{v,i} + T_g)} \right\rfloor, \tag{1}$$

where N_p is the number of voice packetization intervals within

Digital Object Identifier: 10.4108/ICST.CROWNCOM2010.9252
http://dx.doi.org/10.4108/ICST.CROWNCOM2010.9252

a MAC frame and $T_{v,1}, T_{v,2}$ is the time required to transmit a voice packet over an *idle* and an *acceptable* band respectively. The T_g is the guard interval inserted between the transmission of two voice packets. Note that in (1) both the US and the DS voice packets are considered.

The $T_{v,1}$ and the $T_{v,2}$ depends on the opportunistic rate that the *idle* and the *acceptable* TV bands can respectively support. The rate is a function of the TV bandwidth and the spectral efficiency. As already mentioned, the secondary users can utilize a higher transmission power when operating on an *idle* band. Therefore the spectral efficiency of the *idle* bands is higher compared to the *acceptable* bands. The maximum number of users $N_{u,i}^m$ accomodated on a single band can be calculated from (1) by setting $T_m = 0$: $N_{u,i}^m = \lfloor (N_p T_p - T - T_s)/2N_p\,(T_{v,i} + T_g) \rfloor$.

III. Problem formulation

In an ideal case, the BS always identifies enough TV bands available for sharing and schedules all the secondary calls during a MAC frame. In reality, the BS has to select the number of measured bands without knowing the individual band classification. The status of a TV band can dynamically change from frame to frame. Therefore one cannot guarantee there would be always enough resources for all the secondary users. During a MAC frame some of the selected bands can be detected to be *occupied* and thus, the remaining bands may not be enough to accomodate all the voice calls during this particular frame. In that case some of the users would experience channel unavailability. In this section we show how to select the number of measured bands in order to keep the probability of channel unavailability below a certain threshold.

In order to utilize efficiently the spectrum the BS has to select as less TV bands as possible to measure. On the other hand, the more are the measured bands, the more become the bands that are potentially detected to be either *idle* or *acceptable*. Therefore, more users are scheduled and the probability of channel unavailability is decreased. Our optimization problem can be formulated as following.

$$\text{Minimize: } K. \quad \text{(2i)}$$

$$\text{Subject to: } \Pr_{out} \leqslant P, \quad \text{(2ii)}$$

$$K \leqslant N. \quad \text{(2iii)}$$

In principle, the problem (2i)-(2iii) (hereafter optimization problem (2)) is a combinatorial optimization problem. Assume there are K measured bands. Their classification (*idle*, *acceptable* or *occupied*) can be described by a trenary K-tuple. In order to calculate the probability of channel unavailability one has first to determine all the K-tuples describing channel unavailability and compute their occurence probability. Since the classification of the measured TV bands is error free, the occurence probability of each tuple is determined based on the prior probabilities of the three hypotheses. Let us consider a particular tuple, herefter scenario s, where out of the total K measured bands, $k_{s,1}$ are detected to be *idle*, $k_{s,2}$ are detected to be *acceptable* and $k_{s,3}$ are detected to be *occupied*. Obviously, $\sum_{i=1}^{3} k_{s,i} = K$. The occurence probability of this scenario $\Pr_s$ is derived from the trinomial probability density function (PDF) with parameters K and $(\Pr_1, \Pr_2, \Pr_3)$.

$$\Pr_s = K! \cdot \frac{\Pr_1^{k_{s,1}} \cdot \Pr_2^{k_{s,2}} \cdot \Pr_3^{k_{s,3}}}{k_{s,1}! \cdot k_{s,2}! \cdot k_{s,3}!}. \quad (3)$$

The cognitive network experiences channel unavailability in the scenarios satisfying the following condition: $\sum_{i=1}^{2} k_{s,i} \cdot N_{u,i} < N$. Let us denote by $\mathbf{S}$ the set containing all these scenarios. Below, we describe two different ways to compute the probability of channel unavailability. The former (system-wise design) views the channel unavailability from the cognitive network perspective. It calculates the probability at least one secondary user is not scheduled on any of the measured bands within a MAC frame. The latter (user-wise design) views the channel unavailability from the user perspective and calculates the probability not to schedule the call of a particular secondary user during a MAC frame.

A. System-wise design

The probability at least one secondary call is not schedule within a MAC frame is calculated by adding the occurence probabilities of all scenarios belonging to $\mathbf{S}$.

$$\Pr_{out} = \sum_{s=1}^{\|\mathbf{S}\|} \Pr_s. \quad (4)$$

where $\|\cdot\|$ denotes set cardinality.

B. User-wise design

Consider that scenario $s \in \mathbf{S}$ occurs during a MAC frame. In this frame the probability not to schedule the call of a particular secondary user is $1 - N^{-1} \sum_{i=1}^{2} k_{s,i} \cdot N_{u,i}$. The probability not to schedule this call during any MAC frame is calculated by averaging over the corresponding probabilities of all scenarios belonging to $\mathbf{S}$.

$$\Pr_{out} = \sum_{s=1}^{\|\mathbf{S}\|} \left(1 - \frac{1}{N} \sum_{i=1}^{2} k_{s,i} \cdot N_{u,i} \right) \cdot \Pr_s. \quad (5)$$

C. Optimization algorithm

Next, we illustrate the solution to the optimization problem (2) when either (4) or (5) is used in (2ii). Due to the perfect sensing assumption, the $\Pr_{out}$ is reduced for increasing K. As a result, the solution to optimization problem (2) can be obtained by incrementing K until the constraint (2ii) is satisfied. One can start evaluating the $\Pr_{out}$ for $K = \lceil N/N_u^m \rceil$.

A straightforward way to calculate $\Pr_{out}$ is to expand the polynomial $f(z) = (\Pr_1 \cdot z^{N_{u,1}} + \Pr_2 \cdot z^{N_{u,2}} + \Pr_3)^K$ and consider all the polynomial coefficients a_j with order j less than N, $0 \leq j < N$. Then, one has to sum the considered coefficients after weighting each of them with w_j. $\Pr_{out} = \sum_{j=0}^{N-1} w_j \cdot a_j$, where $w_j = 1$ for system-wise design and $w_j = 1 - j/N$ for user-wise design.

Digital Object Identifier: 10.4108/ICST.CROWNCOM2010.9252
http://dx.doi.org/10.4108/ICST.CROWNCOM2010.9252

TABLE I
RELATION BETWEEN THE NUMBER OF USERS ACCOMODATED ON A SINGLE TV BAND AND THE MAXIMUM ALLOWED MEASUREMENT TIME (MS). THE MEASURED SAMPLES M CAN BE DERIVED BY DIVIDING T_m WITH THE SAMPLING INTERVAL $1/W = 0.167$ US.

$N_{u,1}$	1	2	3	14	15	16	17
T_m	112.8	106.1	99.3	25.4	18.7	12.0	5.3
$N_{u,2}$	1	2	3	-	-	-	-
T_m	85.9	52.3	18.7	-	-	-	-

IV. NUMERICAL RESULTS

In this paper we comment on the feasibility of voice services in cognitive networks over the TV spectrum. We identify the minimum required number of measured TV bands so that the probability to experience channel unavailability within the duration of a MAC frame is kept below a target constraint. In order to calculate the probability of channel unavailability, the prior probabilities $\mathrm{Pr}_i, i = 1, 2, 3$ and the number of secondary users accomodated on the *idle* $N_{u,1}$ as well as on the *acceptable* $N_{u,2}$ TV bands is required. For illustration purposes the prior probabilities are arbitrarily taken equal to $\mathrm{Pr}_1 = 0.5, \mathrm{Pr}_2 = 0.3$ and $\mathrm{Pr}_3 = 0.2$. In our calculations we utilize $N_{u,1} = 15$ and $N_{u,2} = 3$. Next, we summarize the parameter settings used to justify the selection of the parameter values for $N_{u,1}$ and $N_{u,2}$.

All TV bands have the same bandwidth $W = 6$ MHz, while the spectral efficiency is taken equal to 0.5b/s/Hz under $H_1^{(k)}\,\forall k$ and 0.1 b/s/Hz under $H_2^{(k)}\,\forall k$. Thus, the link layer throughput available at the secondary users is $r_1 = 3000$ kbps for the *idle* bands and $r_2 = 600$ kbps for the *acceptable* bands. The selection of the spectral efficiency parameter values is justified by considering the spectral efficiency in the different modes of IEEE 802.11b. For a high signal-to-noise ratio (SNR), the link layer throughput is 11 Mbps over the 20 MHz bandwidth, while for a low SNR the link layer throughput becomes 2 Mbps over the same bandwidth. In order to calculate the capacity requirement for each secondary user we parameterize according to the 802.11 specifications. We assume G-711 PCM voice codec and thus, $T_p = 40$ ms of audio payload are encoded into 320 bytes of RTP payload. Accounting also for a 40-byte RTP/UDP/IP header, a 58-MAC/PHY layer header and a guard interval equal to $T_g = 10$ us, the time for sending a voice packet is $T_{v,1} = 1.1$ ms for the *idle* bands and $T_{v,2} = 5.6$ ms for the *acceptable* bands.

Note that due to the perfect sensing assumption, the primary system is not harmfully disturbed because the measured TV bands are always classified correctly. The overall duration $T_a = T + T_m + T_s + T_c$ of the MAC frame is taken equal to $T_a = 120$ ms and thus, each secondary user transmits $N_p = 3$ voice packets during the duration of a MAC frame. The time devoted for tuning at the sensing frequency (RX/TX turnaround time) is taken equal to $T = 0.2$ ms [9]. According to [10], it is sufficient to quantize the individual user measurements with a low number of bits. Therefore, the exchange of measurement information during the signalling time does not consume much of the bandwidth. We assume $T_s = 0.3$ ms. By substituting the values of the parameters $T_p, N_p, T_s, T, T_{v,i}, T_g$ in (1) and setting also the measurement time $T_m = 0$ we calculate the maximum number of secondary calls accomodated on the *idle* and the *acceptable* bands: $N_{u,1}^m = 17$ and $N_{u,2}^m = 3$. The relation between the number of users accomodated on a single band and the maximum allowed measurement time is depicted in Table I. For illustration purposes we arbitrarily select $T_m = 15$ ms and thus, $N_{u,1} = 15$ calls are scheduled on the *idle* bands, while $N_{u,2} = 3$ calls are allocated on the *acceptable* bands.

In Fig. 2 we solve the optimization problem (2) for increasing number of users and different constraints P. One can deduce that the measurement load increases almost linearly with the number of users utilizing the spectrum. On average, it is required to measure one to two more bands in order to accomodate the transmission of ten users more. One can also observe that for a low P the optimization problem (2) may not have a solution for a small N. This is expectable since the number of measured bands cannot be larger than the number of secondary users and the probability $\mathrm{Pr}_3 = 0.2$ to select an *occupied* band is not negligible. We noticed that for increasing Pr_3, the measurement load increases significantly. For instance, if $\mathrm{Pr}_1 = 0.2$ and $\mathrm{Pr}_3 = 0.5$, $N = 50$ users should measure $K = 37$ bands to satisfy the target $P = 0.001$. In Fig. 3 we solve the optimization problem (2) when Eq. (5) is used. The minimum number of measured bands for increasing N follows the same trend as in Fig. 2. However, the measurement load, as expected, becomes less. The system design using (4) instead of (5) is more conservative and more bands should be measured in order to guarantee the same P for the same number of users.

In Fig. 4 we fix the number of users and solve the optimization problem (2) for increasing Pr_0. The minimum value for Pr_0 is selected so that the calculated number of measured TV bands is reasonable. For instance, in UK the total interleaved spectrum is 256 MHz or 32 TV bands [1]. In our calculations, it is also assumed that $\mathrm{Pr}_2 = \mathrm{Pr}_3$, while the constraint is taken equal to $P = 0.01$. In order to illustrate the benefits by allowing voice transmission even in the presence of TV signals (*acceptable* TV bands), we also include the curves corresponding to the case with $N_{u,2} = 0$. One can observe that the benefits by incorporating a trenary hypothesis test are apparent for a small Pr_0. As the Pr_0 increases, the users are mostly accomodated on the *idle* TV bands. Therefore, the need to measure more bands reduces and the benefit of the trenary hypothesis scheme is diminished. In Fig. 5 the illustrations of Fig. 4 are replicated after utilizing (5) in (2ii). As expected the trend is similar.

V. CONCLUSION

In this paper we minimized the number of measured TV bands so that secondary users set up voice connections with acceptable quality. The service quality was expressed in terms of channel unavailability over the duration of a MAC frame. We considered a perfect sensing scheme and thus, our results

Digital Object Identifier: 10.4108/ICST.CROWNCOM2010.9252
http://dx.doi.org/10.4108/ICST.CROWNCOM2010.9252

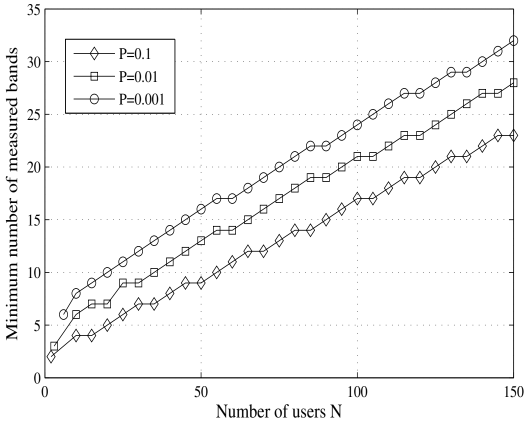

Fig. 2. Minimum required number of measured TV bands vs number of users utilizing the TV spectrum with outage probability P. System-wise design.

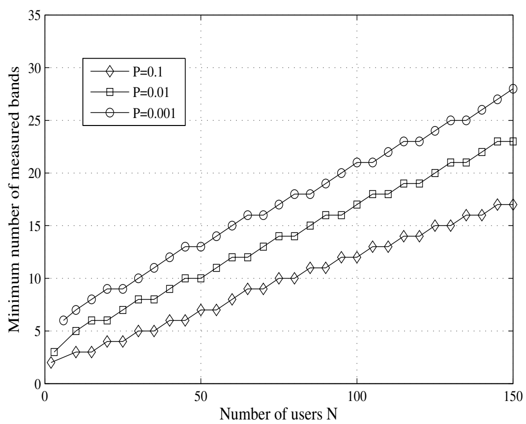

Fig. 3. Minimum required number of measured TV bands vs number of users utilizing the TV spectrum with outage probability P. User-wise design.

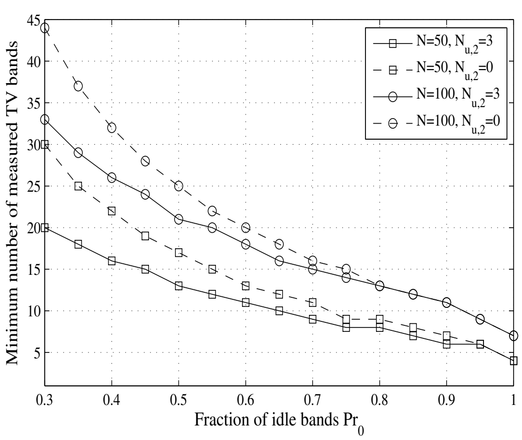

Fig. 4. Minimum required number of measured TV bands vs fraction of *idle* TV bands. $\mathrm{Pr}_2 = \mathrm{Pr}_3, P = 0.01, T_m = 15$ ms. System-wise design.

consist a lower bound for an actual system with detection errors. The obtained results are promising because the number of users utilizing the spectrum grows much quicker than the number of TV bands required to be measured.

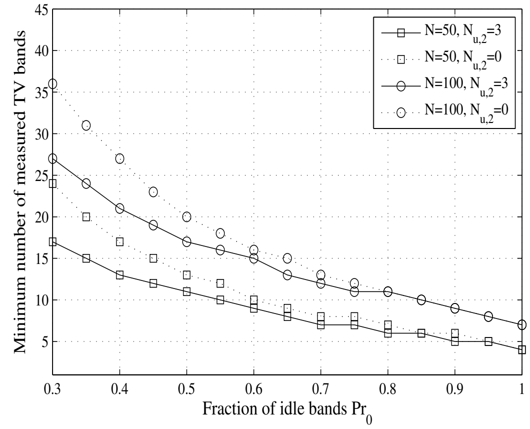

Fig. 5. Minimum required number of measured TV bands vs fraction of *idle* TV bands. $\mathrm{Pr}_2 = \mathrm{Pr}_3, P = 0.01, T_m = 15$ ms. User-wise design.

Having verified there exists a potential for voice services over the TV spectrum we plan to identify the impact of noise and signal fading in the system performance. This would allows us also to study what increases quicker: the need for independent measurements by different users in each particular spectrum area or the detected available spectrum that is, the number of users who can actually use the spectrum.

ACKNOWLEDGMENTS

The authors would like to thank the European Union for providing partial funding of this work through the EU FP7 project INFSO-ICT-248303 QUASAR.

REFERENCES

[1] M. Nekovee, "Quantifying the Availability of TV White Spaces for Cognitive Radio Operation in the UK," *in the Proc. IEEE ICC,* 2009.
[2] "FCC adopts rules for unlicensed use of Television white spaces," Nov. 2008.
[3] Y. Zeng, Y.-C. Liang, A.T. Hoang and R. Zhang, "A Review on Spectrum Sensing Techniques for Cognitive Radio: Challenges and Solutions," *Eurasip J. on Adv. in Sig. Process.,* Vol. 2010.
[4] W-Y. Lee and I. Akyildiz, "Optimal Spectrum Sensing Framework for Cognitive Radio Networks," *IEEE Trans. Wir. Commun.* Vol. 7, No. 10, Oct. 2008.
[5] Y. Pei, Y.-C. Liang, K.C. Teh and K.H. Li, "Sensing-Throughput Tradeoff for Cognitive Radio Networks: A Multiple-Channel Scenario," *in the Proc. IEEE PIMRC,* Sep. 2009.
[6] Z. Quan, S. Cui, A.H. Sayed and H.V. Poor, "Optimal Multiband Joint Detection for Spectrum Sensing in Cognitive Radio Networks," *IEEE Trans. Signal Process.,* vol. 57, no. 3, pp. 1128-1140, Mar. 2009.
[7] K. Ruttik, K. Koufos and R. Jäntti, "Spectrum reuse at the border of a primary user cell," *IEEE Trans. Wir. Commun.,* Dec. 2009.
[8] C. Cordeiro, K. Challapali, M. Ghosh, "Cognitive PHY and MAC Layers for Dynamic Spectrum Access and Sharing of TV Bands", *First International Workshop on Technology and Policy for Accessing Spectrum (TAPAS 2006).*
[9] Chipcon Products CC2430, "A True System-on-Chip solution for 2.4 GHz IEEE 802.15.4 / ZigBee".
[10] M. Mustonen, M. Matinmikko and A. Mämmelä, "Cooperative Spectrum Sensing Using Quantized Soft Decision Combining", *in the Proc. IEEE CrownCom* 2009.

Digital Object Identifier: 10.4108/ICST.CROWNCOM2010.9252
http://dx.doi.org/10.4108/ICST.CROWNCOM2010.9252