Analyzing the Aspects of Commercial Usages of Cognitive Radio

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Abstract--- Despite the vast amount of exploration in the recent past, Cognitive Radio is yet to be commercialized for usage in real time scenarios. Ongoing articles in this area of research has mainly focused on spectrum sharing, energy saving, security aspects etc… despite these vast amount of researches CR is yet to enter its initial stages of deployment. The hypothesis based on which many ongoing researches are performed, never offer a clear vision about CR in reality. In this article we test the initial boundaries of the various proposed schemas in CRN. We also discuss the issues in implementing such network in real time scenarios. This is possible if we make some alterations in the design schema. To concrete our discussion we consider real time plots, motivated by reasonable frameworks in telecom field like television, mobile phone etc… we also show how the existing patterns are not feasible in real world schemas. We conclude by focusing the inconsistency between the ongoing researches and the real time industrial variants.

KEYWORDS: Cognitive radio networks, Spectrum sensing, TV bands, Cellular networks

I. INTRODUCTION

The increasing demand for wireless connectivity has shifted the attention and efforts of many researchers all over the globe towards the opportunistic dynamic spectrum access paradigm. This concept is not new, and was first introduced by Mitola [1]. In brief, the idea is that licensed spectrum can be made accessible to unlicensed users (\secondary") when the licensed (\primary") entities are absent. This absence of a primary user from a specific frequency band at a given point in time and space is referred to as spectrum hole [2]; a reserved portion of the spectrum that is not in use. In other words, a spectrum hole is a function of frequency, time and location.

During the last years there have been significant advancements in hardware technology, enabling engineers to build radios that can understand their environment and dynamically alter their transmission parameters (e.g., transmission frequency, modulation type etc.). One would have expected that such developments would have led to large scale cognitive radio network deployments. However, this is not the case, and even a prototype large-scale deployment is yet to appear. In this challenge paper, we argue that this is largely due to the specific mindset we have when we consider the research and design of protocols for CR networks. The majority of the work in this area is theoretical and makes a number of assumptions that may not hold in practice.

Even though these studies are arguably important and can provide scientific insights, they are not the best avenues to drive practical implementation and eventually commercial adoption and success. As we will elaborate in the following sections, specific assumptions that are prevalent in the literature can either expose the primary receiver to harmful interference or limit the performance of a CR network.

Much of the existing literature focuses on the detection of signals at a given location from a single primary transmitter using threshold schemes. If the received signal from this primary transmitter is below a predetermined threshold, the band is declared to be vacant. More often than not, a single transmitter/receiver is assumed as the \secondary" network. As we will see in the following section the vast majority of the studies in this area, are minor variations of the above idea.

The main objective of the different schemes is to reduce the sensitivity requirement at the cognitive radio sensor that determines the absence of primary transmissions. Furthermore, another feature of the existing literature is that it tends to treat the entire frequency spectrum in a united way. That is, solutions are not different depending on the frequency bands to be used by the CR network. However, the nature of the licensed technology in different parts of the spectrum can be significantly different, therefore, requiring very different considerations. For instance, television is a broadcast system with passive receivers, while cellular networks typically include bi-directional asymmetric1 transmissions. Such very different types of primary services create very different kinds of spectrum holes as well, which require different treatment.

A recent study by Weiss et al. [3] has classified the resources for a CR network, that is, spectrum holes, based on their characteristics both in space and time. Across time, spectrum holes can be static, periodic or stochastic, while across space they can be contiguous or non-contiguous. The simplest type of spectrum holes that can be used is the temporarily static and spatially contiguous spectrum holes. TV white spaces fall into this category. In particular, after the migration from analog to digital TV, there are unused bands (frequencies 54-698 MHz, which correspond to TV Channels 2-51), and the first coordinated effort to utilize these frequencies for cognitive radio communications has emerged through various proposals (e.g., IEEE 802.22 and the White Spaces Coalition [4]). Even though these bands can still be used by unlicensed but authorized users (e.g., microphones and medical telemetry equipment), a temporal static, spatially contiguous spectrum hole can be discovered fairly easily. In particular, a database that includes all the information for unused analog TV bands across various locations success.

II. . RELATED WORKS

In this section we will briefly describe the approaches that are currently proposed for spectrum sensing2. Despite the fact that efficient spectrum sensing has been identified as key to the success of cognitive radio networks very early [6], we still lack a satisfactory approach

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to perform this task. Existing literature can be broadly categorized into three classes:
(i) Non-cooperative transmitter detection, (ii) co-operative transmitter detection and (iii) interference-based detection. Non-cooperative detection: This is the most basic form of spectrum sensing where the secondary transmitter tries to decide whether there is a primary transmitter using the spectrum or not. The detection problem is formulated using hypothesis testing, where the null hypothesis is the absence of the primary transmitter and the alternate hypothesis indicates its presence [7]. The baseline of this single user sensing scheme is that of energy detection. The secondary transmitter measures the average energy on a specific channel and the decision is based on a threshold comparison (e.g., [8] [9]). However, more accurate detection is possible if the secondary user has information about the primary user's signals. In this case, matched filter detection can maximize the SNR and perform optimally [6]. Nevertheless, given that a priori knowledge of the primary signal is not always available, other approaches such as cyclo stationary feature detection (e.g., [10] [11] [12]) and eigenvalue based detection (e.g., [13] [14]) are proposed. In all of these schemes, every secondary transmitter operates in isolation and takes his decision based on his own measurements. Non-cooperative spectrum sensing has been criticized because of its inherent stringent requirement for high reception sensitivity; secondary transmitters need to be able to detect primary signals at their circuitry with the received signal strength (RSS) as low as the noise level. Hence, a second class of algorithms used to identify spectrum holes includes cooperation among many secondary users as discussed below.

Cooperative detection: Non-cooperative spectrum sensing approaches are subject to high uncertainties due to wireless propagation effects. For instance, fading can cause large degradations at the received signal strength from a single radio. Obtaining more measurements from a larger number of co-located radios can provide us with a more robust decision. This is the goal of a cooperative spectrum sensing scheme. There are two basic approaches followed in cooperative detection, namely (a) soft combining and (b) hard combining (e.g., [15] [16] [17]).

In soft combining systems, CRs report their actual signal strength measurements to a fusion center, while in the latter case they report their binary \decision". The fusion algorithm can be either a logic AND, a logic OR a majority vote based scheme. There are different angles from which one can see the benefits of collaborative sensing. For instance, collaboration can reduce the sensitivity requirements for individual radios [18]. It can also be viewed as means for reducing the time required for sensing or reducing the false alarms rate [19] [20]. Regardless of the improvements over non-cooperative schemes, the above systems still suffer from some major limitations.

There is still lack of information with regards to the location of the primary receiver. Even though a primary transmitter's signal can be detected with larger accuracy, interference avoidance is still not guaranteed at the primary receiver. Furthermore, spectrum sensors need to be co-located in an fairly small area, in order to assure that the path loss component of the received signal from the primary transmitter is the same for all sensors. If this is not the case, then the performance of the cooperative schemes will be poor. If sensors are distributed over a larger area the different path loss components of the signal strength will (legitimately) yield many inconsistencies among the measurements of the single radios. This falls back to one of the questions posted in our introduction. What is the value of the spectrum hole identified from a scheme with these requirements? We will further elaborate on this in this paper later.

Interference-based detection: Both cooperative and non-cooperative detection do not take into consideration the presence of a primary receiver. However, since interference takes place at the receiver, identifying its presence and/or position is important. The idea of Interference temperature (IT) has been proposed by the FCC [21], to capture the additional interference (above the noise poor) that a primary receiver can tolerate. This means, that using the interference temperature model, we can have simultaneous transmissions from a primary and secondary user, as long as the interference from the latter is beyond the IT of the primary receiver. Even though as a concept this is appealing, there are many practical issues related with this approach. For instance, how is it possible to measure the interference at the primary receiver without prior knowledge of its position relative to the secondary transmitter [22]? An interesting approach was presented by Wild and Ramchandran [23].

Low cost sensor nodes are mounted on primary receivers to detect the local oscillator leakage power emitted by the RF front-end of the primary receiver. This can essentially detect the presence of the latter. This information is consequently sent as feedback to the secondary users. However, such approaches have received low attention from the community and have been practically abandoned as unrealistic. The main argument against such proposals is that they require large scale infrastructural upgrades. Nevertheless, as we will argue in Section 4, if we want to have a real-world cognitive radio network deployment, this is a promising direction that needs revisiting.

III. TOPOLOGIES FOR CR NETWORKS

In this paper, we will use two specific topologies and corresponding scenarios to illustrate the problems with existing approaches and the need for a completely new thinking for the success of CR networks. These topologies are shown in Figure 1.

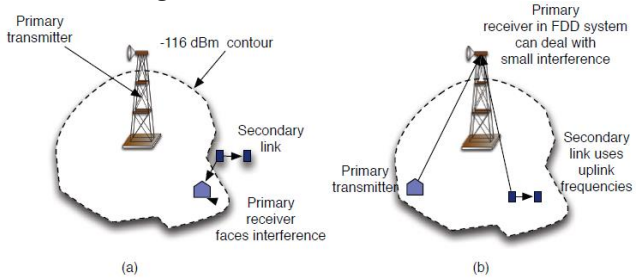

Fig.1: Two Topologies and Scenarios for Investigating Challenges with CR Networks

A. Tv White Spaces

As our first example, we consider the most widely discussed spectrum for usage in a CR network setting which is that of broadcast television white spaces. The corresponding topology and scenario is shown in Figure 1(a). The IEEE 802.22 standard states that any sensing algorithm used

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should be able to detect digital television signals at -116 dBm, with probabilities of false alarm and mis-detection, both equal to 0.1. Based on this requirement, if no signal is detected the spectrum is declared as free and secondary transmissions can be scheduled.

This causes two problems that we outline below. First, the signals from the digital TV transmitter can be received with high strength (i.e., RSS >> - 116dBm) at distances of several miles [24]3 and TV signals with very low RSS at the range of -116 dBm will only be received in areas much further from the TV tower. This observation is important, since it practically restricts the cognitive radio network to be in locations that are very far from residential areas. The question that comes to mind is whether there are commercially viable applications that could benefit from a CR network located in an area devoid of human presence. After some thought, one can conclude that there might exist applications that can take benefit from a cognitive radio network architecture in such places (e.g., road safety applications with road side units operating in these bands or sensor networks in forest areas).

However, one could also counter-argue that in these areas, unlicensed bands can be as effective as opportunistic usage of licensed bands as the demand is likely to be low in such locations. Moreover, except from the case of carrier sensing based wireless networks, where a transmitter has to back-o_ when it senses a competing transmission, interference aspects only the reception of the signal in other communication scenarios.

This causes the second problem with TV bands. As shown in Figure 1(a), it is possible that the -116 dBm contour is not circular due to radio propagation vagaries. Although a secondary transmitter may, with quite complex processing, detect the signal level from the primary transmitter to

be below this value, it has no knowledge of the location or distance of a passive primary receiver (a television). Thus, a secondary transmission can cause significant interference to a receiver. On the contrary, a secondary user within the contour will sense energy from the primary broadcast transmitter. Nevertheless, this does not necessarily mean he cannot use the band, since there might not be any primary receiver to be interfered. Unless we can detect a primary receiver that is actively receiving the broadcast signal, secondary transmissions may be either harmful to the primary system or lead to many missed opportunities for the secondary users. We investigate this further in Section 4.

B. Cellular FDD Network

As the second example, we consider a cellular network that employs frequency division duplexing (i.e., there are separate frequencies for the uplink and downlink). In the US, the uplink (824-849 MHz) and downlink frequencies (869-894 MHz) are separated by 45 MHz in one commonly used slice of licensed spectrum. In a given cell, on the uplink frequencies, only the base station is the receiver as shown in Figure 1(b). Channels that are 1.25 MHz (5 MHz) wide are employed in 3G systems based on the CDMA200 (UMTS) standard.

It is also well known that the load in cells varies significantly over time and day of week (e.g., [25] [26]). Since CDMA systems are interference limited, a secondary transmission that employs only the uplink frequencies may be able to operate without causing any harm to the primary system [27]. Especially if the secondary transmissions are employing low transmit power for short range links, there may be negligible interference or harm. This is further helped by the fact that the path loss for short distances usually has a smaller exponent compared to large distances. Thus, while the signal attenuates significantly and has very small power by the time it reaches the primary receiver (the base station), it is sufficient to perhaps support high data rates at shorter distances.

However the cellular spectrum cannot be used for secondary applications as of now. If the spectrum is sensed, it will be discovered to be occupied by the primary users. The transmitters in this case are the mobile phones which will all employ the same frequency in a CDMA system. Thus, a very small number of mobile phones transmitting on the uplink would still tag the spectrum as occupied making it unusable by a secondary system even when it is unlikely to cause any harm at the primary receiver. Of course, in this case the quality of the secondary link might be impacted by the interference from primary transmissions. We further consider this scenario in Section 5.

IV. THE CASE OF PASSIVE RECEIVER

In the previous section we have discussed scenarios where spectrum sensing algorithms as envisaged in the literature fail to address the real problem; either the secondary user will miss opportunities since the interference to the primary receiver is not harmful (FDD network or no receivers exist in the area) or will cause harmful interference since the detection of a primary transmitter does not reveal anything for the location of the primary receiver (TV broadcasts). Even though both of the problems are related to the complex, dynamic and unpredictable topology of commercial wireless networks, broadcast systems (such as TV) exhibit a particular characteristic that will render any current (collaborative or not) sensing algorithm ineffective.

In brief, a broadcast system's receivers are passive, that is, there are no signs of their presence. Any appropriate receiver that is in range of the broadcast transmitter can receive the signal; if the secondary user is under the coverage of the primary transmitter he will sense the latter's signals. Thus, it appears that a cognitive radio network utilizing the TV spectrum is not possible in urban, residential areas, which have strong TV coverage.

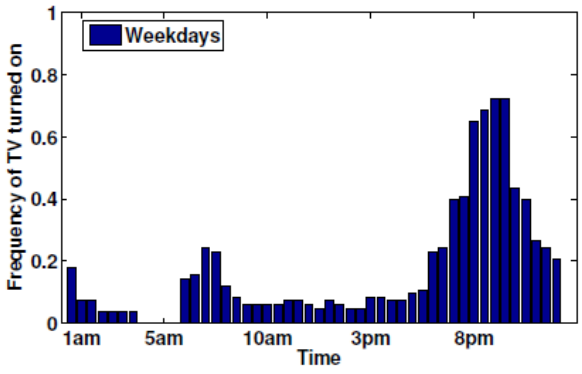

Fig. 2: TV receiver activity in bins of 30 minutes for a typical weekday.

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However, as previously mentioned, despite the presence of a primary broadcast signal, if no primary receiver is in the near vicinity (in our case if no TV receiver is turned on), the secondary user can be allowed to occupy the spectrum without harm to the primary system. Therefore, in broadcast systems like the TV, current sensing algorithms will result in an extremely large number of missed opportunities for the secondary user. To assess the viability of this claim, we have conducted a large scale user study to identify the usual times that people have their TV receivers turned on and o_ and hence, identify periods that opportunistic access is possible. We would like to reiterate here that during the \o_" periods, even though a cognitive sensor would sense broadcast primary signals, secondary transmissions would be possible since the receiver is not powered on and thus not harmed.

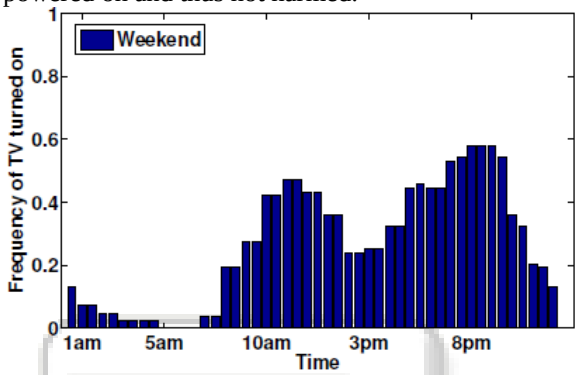

Fig. 3: TV receiver activity in bins of 30 minutes for a typical weekend.

We have conducted two different surveys to identify whether spectrum opportunities exist. For the first survey, we have utilized the Amazon's Mechanical Turk platform to recruit people willing to participate in an anonymous survey for a small amount of money. The purpose of this survey is to obtain a general view of the usage patterns of people (e.g., times that the receivers are o_, type of TV service, etc.).

The second survey is of smaller scale and was conducted with a paper questionnaire distributed to the households of a single apartment building. The purpose of this study is to identify whether similar patterns of TV usage exist in a concentrated residential area. Since in reality there are many receivers within a geographical cluster, we want to study the cumulative activity patterns of co-located users.

This will reveal any opportunities for secondary user access in the vicinity of these users. We would like to emphasize here on the fact that as with any interview-based conclusions, they might exhibit biases such as those introduced by the difference between the actual and the declared behavior of the subjects. Nevertheless, we believe that these biases in our case are not significant.

Large Scale Activity Pattern Survey: The main results from the _rst survey are presented in Figures 2 and 3. We see that on weekdays people use their TV receivers mainly in the evening hours (e.g., after 6:30 p.m.). Late nights and morning times are fairly idle, hence, allowing opportunities for secondary access to spectrum. However, this pattern changes on the weekends to a more uniform distribution of the active periods, allowing for less secondary spectrum access opportunities. It is interesting to note the presence of many periods with low (if at all) activity. The period between 4:30 a.m. and 6:30 a.m. is completely inactive even during weekends.

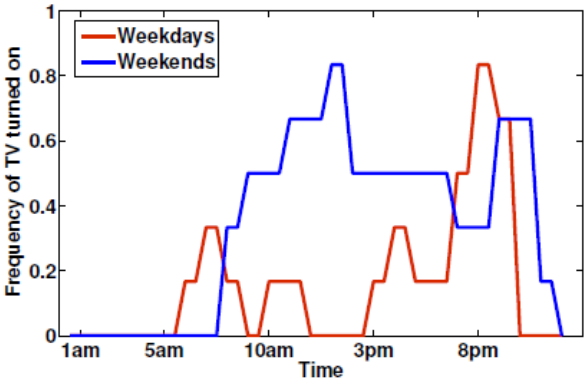

Fig. 4: Activity for a receiver using the broadcast through the air TV signals

Hence, from their perspective, even with an optimal spectrum sensing algorithm that is able to identify active TV receivers, the secondary user would not have many chances to access the spectrum; the claim is that there are almost always, even small in numbers, some active receivers in a region. Thus, in our survey, we also asked the participants the type of service they are using for their TV reception. Surprisingly or not, only 12% of them actually use broadcast TV. The majority of the users - 77% - use cable (and some use _ber and satellite). Since people that utilize cable and other technologies are unharmed by secondary spectrum access, in Figure 4 we present the activity levels only for the users that actually receive the stations' signals over the air. The results clearly show that there are many more opportunities for secondary access to the spectrum (especially on weekdays). This might have been expected, knowing that this class of users is a very small portion of the total population. Note also that the broadcast users (even though we do not have demographics from the survey we conducted) might be located in areas where there is no cable or cyber service yet (or satellite is still expensive). These areas may correspond to isolated locations that might as well not be of interest for deploying a CR network(recall our earlier discussion related to the value of a spectrum hole).

Apartment Block Case Study: The results from the Mechanical Turk survey reflect general patterns of users that may or may not be located in the proximity of each other. Even a single active primary device will force the secondary user to backup. For instance, if all 20% of the users that have their receivers turned on between 1 a.m. and 1:30 a.m. (see Figure 2) are spatially located close to each

other (e.g., a neighborhood of a specific city, or an area of a specific state4), then CR networks deployed in other areas will have spectrum opportunities during this time frame. On the contrary, if this 20% is scattered across the country then the locations that will have these chances are fewer.

Thus the cumulative activity of primary co-located users is an important feature. To assess this quantitatively, we have performed the same survey with the residents of a block of apartments in a building consisting of 50 apartments in Pittsburgh, PA. Figure 5 depicts our results.

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Weekdays	Weekends
[7pm-9:30pm]	[9am-noon], [4pm-10pm]

Fig. 5: TV receiver activity for the users of broadcast TV service of a specific block apartment building.

As we can see there are some clearly zero activity periods for the residents of this building, especially on weekdays. This cumulative activity of people allows many opportunities for a cognitive radio network to operate, even when current sensing algorithms would declare the presence of a primary transmitter.

Proposed Solutions: The passive nature of the receiver in many broadcast systems like television, can have a negative effect on the successful deployment of a CR network. Ideally the solution to the above problem would be to transform the passive receiver to an active one. In this way, we could sense the air for an active reception and decide to either access the medium or not. It is widely accepted in the

research community that one of the properties that a proposed solution \needs" to satisfy is to not involve large scale infrastructural changes. This is certainly a nice feature, but this is not the way that commercial operators always work.

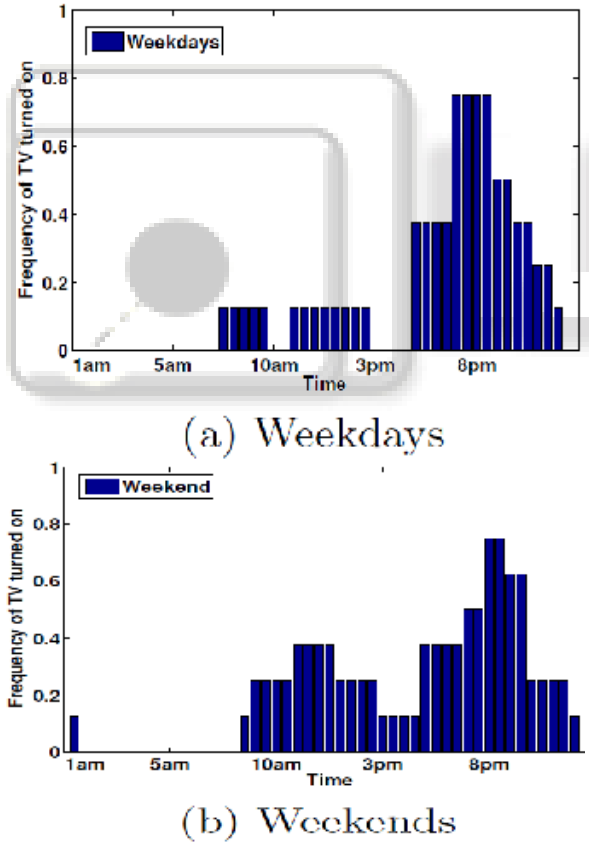

Fig. 6: TV receiver activity in bins of 30 minutes for a specific block apartment building.

Further, the percentage of TVs that are equipped with some form of wireless interface (e.g., WiFi, Bluetooth etc.) has dramatically increased during the last years. We asked the participants in our surveys if their TV receiver is equipped with some type of wireless interface; 24% of them answered \Yes". These interfaces could be utilized for our purposes, reducing the cost for distributing the special boxes (just similar to some receivers that were able to keep receiving digital TV signals without any modification and extra hardware). This would be a different type of sensing where specific messages in an unlicensed band would inform CRs about the existence of passive receivers.

A more drastic solution (which however requires many parties to negotiate and agree to corresponding service level agreements or SLAs { e.g., FCC, providers etc.), is to completely abandon the broadcast TV service. Since only a small fraction of people utilize it, they could be served with other technologies for free (of course with the corresponding SLAs in place). This would free up the whole TV spectrum for usage by alternative wireless technologies. We recognize that both of the above solution sketches are radical and extreme, but in the authors opinion, only with drastic solutions will the vision of CR networks become viable.

V. The Case Of FDD System

In this section we undertake a simplified analysis of the FDD uplink in a UMTS cell to demonstrate the feasibility of secondary transmissions even when the spectrum is presumably occupied. In CDMA systems [29], the energy per bit to interference ratio (Eb=I) at the base station receiver on a given 1.25 MHz (cdma2000) or 5 MHz (UMTS) channel needs to be between 5 and 7 dB and it is maintained nearly the same for all mobile stations communicating with the base station through strict power control. The value of Eb=I on the uplink depends on the number of active phones M in the cell, their voice activity vf (what fraction of time the user speaks), the power control accuracy _c and the fraction of interference from neighboring cells f. A simple expression for Eb=I is Eb=I = Gp_c vf (M□1)(1+f) where Gp is the processing gain (chip rate/bit rate) in CDMA through the use of spread spectrum. The maximum number of active mobiles on a channel Mmax can be roughly determined by setting Eb=I in this expression to the minimum acceptable value. If we use some sample numbers such as Gp = 3:84Mcps=12:2kbps = 315, vf = 0:4, _c = 0:8, f = 0:75, and the minimum Eb=I = 3:2 (5 dB), Mmax = 113 per channel. As long as the Eb=I value is maintained at the base station, and no mobile is denied service, there is no harm to the primary system. Service providers typically design their network to support peak capacity, which occurs infrequently, at specific hours/days of the week. At other times, the load is significantly smaller [25] [26]. The operator can move users to other channels when a given channel reaches capacity.

A CR transmitter thus needs some information from the primary system (referred to as collaboration in [27]) or has to use a worst case approximation. Also, it is not subject to power control and causes a constant interference at the base station if the CR transmitter is stationary. If the CR network has mobile transmitters and receivers, the situation becomes more complicated. Further the secondary receiver faces interference from the primary active mobile phones.

Proposed Solutions: The secondary network should use a transmission scheme that is based on spread spectrum and follows the 3G standards. It can operate by picking spreading codes fairly independently (since the uplink in CDMA systems use Gold or Kasami like sequences to separate transmissions). With smartphones that can perhaps operate in an ad hoc mode and inexpensive hardware

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(similar to femtocells) that operate using 3G standards, a secondary network will be viable in this spectrum

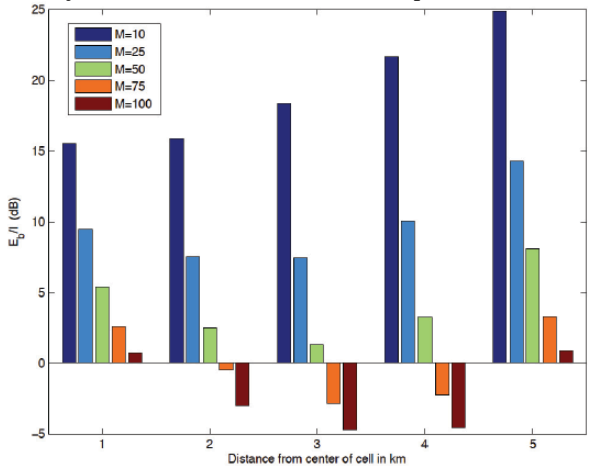

Fig. 7: Eb=I at the secondary receiver for different numbers of active primary mobile stations in a cell.

The operating constraints of these networks are not very clear at this point. We can think of a CR network operating at close to the minimum transmit power to avoid causing interference at the base station irrespective of the location of the secondary user on the least used channels. A study of mobile phone transmit powers in UMTS provides extensive data on the distribution of uplink transmit powers in a 3G network [30] . The data show that active mobile transmit powers can be as low as -50 dBm in certain scenarios (although they can be as high as 20 dBm). The average over several different scenarios (locations, network load, with and without Bluetooth) is 5.6 dBm (3.63 mW). This is however likely to restrict the throughput of the secondary network.

If multiple secondary radio transmitters exist, the rates and transmit powers they use will be smaller. However cooperation with the primary network (which can share information about unused channels or channels with low loads) can allow the secondary network to operate more efficiently. For this, of course, either a market for secondary use or regulatory changes will become necessary.

To assess whether operating at a very small transmit power is viable for a secondary network, we perform a simple simulation. The transmit power of a primary mobile varies inversely as the path-loss because of strict power control. The signal strength from every mobile phone is thus received at approximately the same power S at the base station. The closer a mobile is to the BS, the lower is its transmit power. If the path loss exponent is _ = 4 and the transmit power of a primary mobile at the cell edge (distance R from the base station) is Pedge, the transmit power at distance r < R will be Pedger4 R4 . Each of the M active primary mobiles causes

interference at the secondary receiver. Let the transmit power and distance of the i-th primary mobile from the secondary receiver be Pi and di. Then the overall interference including a voice activity of uf will be;

$$u_f \sum_{i=1}^{M} \frac{P_i}{d_i^4}$$

Assuming that the secondary transmitter is at a distance of 1 km from the secondary receiver and its transmit power is Ps, the Eb=I observed at the secondary receiver will be5:

$$E_b/I = \frac{G_p P_s}{u_f \sum_{i=1}^{M} \frac{P_i}{d_i^4}} \qquad (1)$$

We consider a cell of size R = 5 km and place M primary mobiles uniformly randomly in the cell. We assume perfect power control with the transmit power of primary mobiles at 5 km from the base station to be 20 dBm. We place the secondary receiver at a distance of 1, 2, 3, 4, and 5 km from the base station. We let Ps = -10 dBm, a fairly small number compared to the average transmit power of 5.6 dBm of primary mobiles in a cell reported in [30]. We compute the average Eb=I at the secondary receiver over 1000 runs for different values of M.

The results are shown in Figure 6. We see that the secondary receiver has a reasonable Eb=I close to the base station and at the edge of the cell, while it has poorer performance in between. This can be attributed to the fact that close to the base station, the interference comes from mobiles that are transmitting at much lower powers. In fact, the secondary transmitter may have to reduce its transmit power at such locations beyond -10 dBm so as to not cause harm to the primary system. At the edge of the cell, the secondary receiver is far away from most of the active mobiles and sees lower interference. In the mid-regions, the secondary is not far away from mobiles that have a reasonably large transmit power and may not be able to operate unless M is very small.

However, this simple simulation demonstrates that there is spectrum access opportunity for secondary users in a cellular telephone network employing FDD under low loads, but the current approaches to dynamic spectrum access are not suitable for exploiting it.

VI. Scope Of Ourwork&Conclusions

In this paper we have tried to shed some light on the reasons behind the lack of commercial deployment of a cognitive radio network. In order to do so we focused on a specific functionality, important for the operations of such a network, that of spectrum sensing. However, we would like to emphasize on the fact that similar problems exist with respect to other functionalities, such as spectrum sharing and spectrum access. We emphasize that our work should not be viewed only as a question about the realization of cognitive radio networks.

It should be seen more broadly as a challenge to the real world applicability of a large volume of existing research. For example, the research community is used to putting aside, in the majority of the cases, solutions that require large scale infrastructural changes. Without trying to argue in this paper whether this is correct or not, sometimes the only feasible solution(s) is(are) accompanied by this \drawback". Thus, we should be more open to them and less critical of similar proposals. After all this is often the way that the world of commercial network operators functions.

To sum up, solutions to technical problems might be much easier than we think. Coming back to the topic of this paper, CR networks, the nature of the primary user and the actual operations of a real communication system are usually neglected or made complicated or oversimplified. Therefore, the solutions proposed do not drive an effective commercially viable network architecture. Drastic solutions often need to be taken, but for this, a careful examination of

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the real-world underlying tradeoffs need to be considered. For instance, in our sketch solution, for eliminating broadcast TV completely, the involved parties need to consider the potential benefits from the capacity/revenues obtained by freeing up the spectrum as well as the cost to serve people through other technologies (potentially for free).

REFERENCES

[1] J. Mitola III. Cognitive Radio for Flexible Mobile Multimedia Communications. In MoMuC, 1999.
[2] R. Tandra, S.M. Mishra, and A. Sahai. What is a spectrum hole and what does it take to recognize one? In Proceedings of the IEEE, 2009.
[3] M.B.H. Weiss, M. Al-Tamaimi, and L. Cui. Dynamic Geospatial Spectrum Modelling: Taxonomy, Options and Consequences. In elecommunications Policy Research Conference, 2010.
[4] The White Space Coalition http://www.engadget .com/tag/white%20space%20coalition/.
[5] I.F. Akyildiz, W-Y. Lee, M.C. Vuran, and S. Mohanty. NeXt generation/dynamic spectrum access/cognitive radio wireless networks: A survey. In Elsevier Computer Networks, 2006.
[6] A. Sahai, N. Hoven, and R. Tandra. Some fundamental limits on cognitive radio. In 42nd Allerton Conference on Communication, Control and Computing, 2004.
[7] F.F. Digham, M-S. Alouini, and M.K. Simon. On the Energy Detection of Unknown Signals over Fading Channels. In IEEE Transactions on Communications, Vol (55), Issue 1, 2007.
[8] Y. Li. Signal processing issues in Cognitive Radio. In Proceedings of IEEE, 2008.
[9] R. Tandra and A. Sahai. SNR walls for signal detection. In IEEE Journal on Selected Topics in Signal Processing, Vol (2), pp. 4-17, 2008.
[10] D. Cabric, S.M. Mishra, and R.W. Brodersen. Implementation issues in spectrum sensing for cognitive radios. In 38th Asilomar Conference on Signals, Systems and Computers, 2004.
[11] A. Fehske, J.D. Gaeddert, and J.H. Reed. A new approach to signal classi_cation using spectral correlation and neural networks. In IEEE DySPAN, 2005.
[12] S. Haykin, J. Reed, and D. Thomson. Spectrum sensing in Cognitive Radio. In Proceedings of the IEEE, 2008.
[13] Y. Zeng and Y.C. Liang. Text on eigenvalue based sensing - For Informative Annex on Sensing Techniques. In IEEE 802.22 Meeting Documents, 2007.
[14] Y. Zeng and Y.C. Liang. Maximum-Minimum Eigenvalue Detection for Cognitive Radios. In IEEE PIMRC, 2007.
[15] G. Ganesan and Y. Li. Agility Improvement hrough Cooperative Diversity in Cognitive Radio. In IEEE GLOBECOM, 2005.
[16] C. Sun, W. Zhang, and K.B. Letaief. Cluster based Cooperative Spectrum Sensing in Cognitive Radio Systems. In IEEE ICC, 2007.
[17] E. Visotsky, S. Ku_ner, and R. Peterson. On Collaborative Detection of TV Transmissions in Support of Dynamic Spectrum Sharing. In IEEE DySPAN, 2005.
[18] S.M. Mishra, A. Sahai, and R.W. Brodersen. Cooperative Sensing among Cognitive Radios. In IEEE ICC, 2006.
[19] G. Ganesan and Y. Li. Cooperative spectrum sensing in cognitive radio, part II: Multiuser networks. In IEEE Transactions on Wireless Communications, pp. 2214-2222, 2007.
[20] J. Ma and Y.G. Li. Soft combining and detection for cooperative spectrum sensing in cognitive radio networks. In IEEE GLOBECOM, 2007.
[21] ET Docket No 03-237 FCC. Notice of inquiry and notice of proposed Rulemaking. In ET Docket No 03-237, 2003.
[22] T.X. Brown. An analysis of unlicensed device operation in licensed broadcast service bands. In IEEE DySPAN, 2005.
[23] B. Wild and K. Ramchandran. Detecting rimary Receivers for Cognitive Radio Applications. In IEEE DySPAN, 2005.
[24] FCC digital TV channels coverage maps. http://transition.fcc.gov/dtv/markets/.
[25] C. Peng, S.-B. Lee, S. Lu, H. Luo, and H. Li. Tra_c-Driven Power Saving in Operational 3G Cellular Networks. In MobiCom, 20011.
[26] D. Tipper, P. Krishnamurthy, A. Rezgui, and P. Pacharintanakul. Dimming cellular networks. IEEE Globecom, 2010.
[27] R. Saruthirathanaworakun and J.M.Peha. Dynamic primary-secondary spectrum sharing with cellular systems. IEEE Crowncom, 2010.
[28] Comcast Digital Box Deployment. https://digitalnow.comcast.com/.
[29] Vijay Garg. Wireless Network Evolution: 2G to 3G. Pearson LLC, 2001.
[30] Arjun Bhupathi Raju. Characterization of uplink transmit power and talk time in wcdma networks. MS Thesis in Electrical Engineering, Virginia Polytrechnic Institute and State University, July 2008.

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