ISSN (e) 2520-7393
ISSN (p) 2521-5027
www.estirj.com

Measurement of Spectrum Occupancy for Dynamic Spectrum Access

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Abstract: In this paper, we deal with a dynamic spectrum allocation framework and effective forecasting for the occupancy of spectrum using the SCM, or spectrum consumption model. SCM is essential for network performance analysis, design, and assessment. The SCM IEEE 1900.5.2 model is used, through which measurement of the spectrum is done. DSA is used to solve the problem of spectrum utilization. So we measure setup and discuss our activities through measurement. To determine the vacant channel of 200 KHz using the duty cycle for DSA, we collected data from different sites, like indoor and outdoor. As a result, we plotted graphs. Each figure has four graphs that show the power spectral density, duty cycle, probability density function, and cumulative distribution function. That shows that 50 percent of the spectrum is utilized.

Keywords: *Dynamic spectrum access, spectrum consumption model, duty cycle, power spectral density.*

1. Introduction

Wireless communication services rely on radio frequency as a vital resource. Spectrum scarcity has been a major problem for spectral control organizations & cellular service distributor in recent years, due to wide expansion in the no: of cellular devices [1]-[3]. Traditionally, spectrum has been distributed statically to specific licensees across large geographic areas. According to measurements in around 80 percent of the lower spectral remain unused of some signals within seven decibels of the loudness. So challenges are demand increase for the spectrum [4].

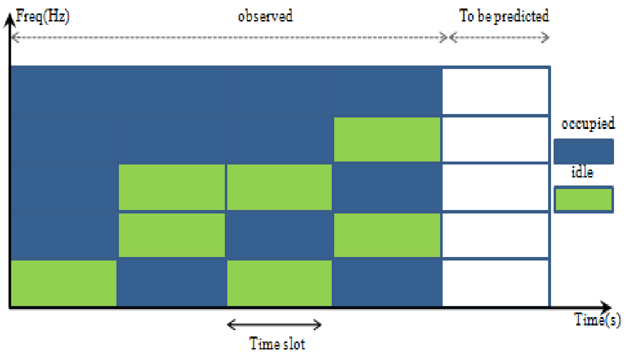

Figure: 1 DSA System

Wireless devices can now more effectively access and use the spectrum of radio frequencies thanks to a technology called dynamic spectrum access (DSA), which adjusts dynamically to changing circumstances. Certain frequency bands are allotted to licenced users for their exclusive use under standard stable band distribution which frequently results in underutilization of the spectrum. By granting secondary users access to underutilized or unused spectrum bands while primary users are not actively using them, DSA facilitates more flexible and dynamic spectrum management.

Dynamic spectrum access is a technological achievement that has recently attracted the interest of spectrum regulators. We employ spectral range in urban areas for users for extended periods of time, such as months or years. With Dynamic spectrum access, spectrum in a certain region can be easily scaled in hours or a few minutes. The benefit of DSA is that it can encourage greater spectrum utilization and increase spectrum efficiency. DSA lessens the inefficiencies connected with fixed spectrum distributions and helps address the scarcity of spectrum concerns by providing dynamic access to accessible spectrum channels. For wireless communication systems, this dynamic exchange of band spectrum may result in more capacity, better network performance, and higher quality of service.

DSA (Dynamic Spectrum Access) has the capability to resolve band shortages and make more use of the spectrum's white areas. It helps in the process of exchanging bandwidth in actual time and modifying band allocation [1], [5]. It differs from another radio resource solution, which allows illegal or SU (secondary users) to arbitrarily use a select unoccupied frequency band without interfering with certified or PU (primary users). DSA has two essential factors: spectrum prediction and statistical modeling. DSA systems must understand how spectrum resources are used in various places and scenarios. Due to the implementation of the DSA network [6] a band can be accurately utilized with available spectrum allocation, which takes into account the spatially and temporally traffic data of various applications. Recognition & utilization of spectrum opportunities are 2 fundamental elements of Dynamic spectrum access systems. While the former is in charge of reasonable detecting and tracking the spectral in both space & time, the latter is in charge of determining when and how SU uses the band. Different model are design to predict, measurement and consumption of the spectrum. The channel updates for the next time slots are shown in Fig. 1: Dynamic spectrum access is forecasted to be either occupied or idle by the present spectrum owner.

2. Spectrum consumption model

SDSs (Spectrum-dependent systems is a general term for RF-transmitting or receiving networks and equipment that use these techniques. There needs to be a clear description of how each SDS uses or will use spectrum resources if SDS controlled by multiple entities are to successfully use spectrum and control interference. The IEEE 1900.5.2 standard, "Standard Method for Modeling Spectrum Consumption," which provides a way to record the temporal spectral, and spatial, features of the utilization of the spectrum for any particular SDS or collection of SDSs [7, 8], captures the SCM concept created.

SCMs establish the limits of spectrum utilization. Before judgments are made, SCM describes the computation of compatibility among SCMs and eliminates any uncertainty over "what is harmful interference." SCM can significantly aid interactions in spectrum sharing regulated by a database. The purpose of Spectrum consumption is to describe the behavioral, geographic, and spectrum properties that indicate how well a sender or recipient utilizes the spectrum. The SCM has various properties, like position, spectral mask, and scheduling, total power and so on. The use of SCMs in spectrum management& sharing has been introduced and addressed in [9]. The preliminary and ongoing efforts for the IEEE 1900.5.2 guideline have been outlined in this article.

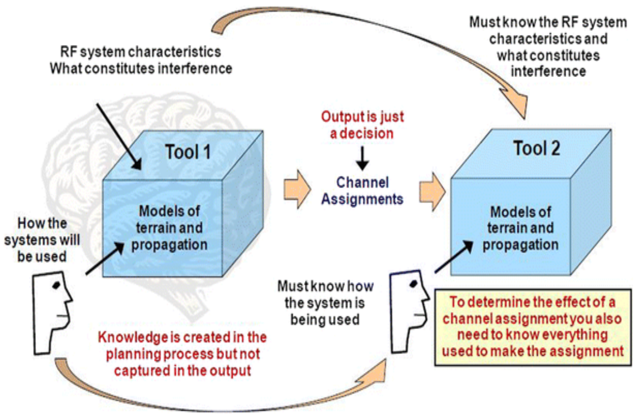

Figure: 2 Mapping of SCM

3. Methodology

The purpose of Spectrum consumption is to describe the behavioral, geographic, and spectrum properties that indicate how well a sender or recipient utilizes the spectrum. The SCM has various properties, like position, spectral mask, and scheduling, total power and so on. The use of SCMs in spectrum management& sharing has been introduced and addressed in [9]

3.1 Measurement setup

This part begins with a thorough explanation of our measurement setup, followed by some remarks on the places we chose for our measurements. We provide justification for the majority of our design choices and add remarks on campaign-related insights. The main objective of our estimate effort was to explore variations in range utilization over longer time periods, such as a few days to half a month. Given that distant systems differ in terms of the amount of data transfer capacity used, the number of entrance components, the send power, and other factors The number of technologies that may be evaluated in a time-division method is decreased or the amount of time required for measurement per innovation decreases as a result of the necessary adjustments of the measurement setup, assuming a finite amount of time for the whole measurement campaign. As an alternative, we choose to examine various technologies concurrently with slightly suboptimal measurement settings. We carefully looked at subbands that were 2 GHz broad and had a resolution bandwidth of 200 kHz. Thus, the extremely narrowband principal user signals cannot be differentiated using the given frequency resolution.

We tested the whole frequency range used by the majority of wireless services today, which runs from 20 MHz to 6 GHz. We also anticipate DSA organizations to be broadband frameworks due to the overall trend in distant communication towards greater broadband applications. We actually anticipate that range blank areas of many kHz are not interesting for commercial use and the somewhat coarse goal transmission capacity of 200 kHz addresses a good split the difference, despite the fact that multicarrier frameworks can smother middle of the road subcarriers and benefit similarly from non-ceaseless range blank areas.

3.2Measurement Location

We gather frequencies from a variety of interior spaces in Hyderabad, Pakistan. We gather a number of frequencies in the 2 GHz band, and MATLAB software is used to visualize the power spectral density against frequency. Data were gathered from Qasimabad, Hyderabad's site areas, Nooriabad, Mehran Telecommunication Department, and Autoban Hyderabad, and the spectrum utilization in these locations was calculated in accordance with mobility usage.

3.3 Frequency Range and duty cycle calculation

For uplink and downlink as well as for 1800 uplink and download and 2100 uplink and downlink for dynamic spectrum access, the frequency range is 1 GHz to 6 GHz. The duty cycle calculations for the various frequency bands are then performed using the measured data. then Distribute the channels at 200 kHz that are free based on duty cycle thresholds, where duty cycle thresholds are 0.25.

4. Results and Discussion

The computation of probability density functions, cumulative distribution functions, power spectral densities, and duty cycle is done using programs created in MATLAB for analytical and simulation reasons. The percentage of time a system or component is active or in use over the course of a certain period is referred to as the duty cycle and is often stated as a percentage. A signal's power distribution across frequencies is described by its power spectral density (PSD). It offers details on the signal's strength at various frequency components. The chance that the randomly generated variable X is smaller than or equal to x is given by the cumulative distribution function (CDF). Calculations are made to determine the overall probability density function and the probability density function of beginning states with various arrival rates.

Table 1 Indoor channel utilization

Frequency (MHz)	Uplink and downlink	Network	Channel used
1.92 to 1.95 x10^9	uplink	2100	95.6811
2.11 to 2.14 x10^9	downlink	2100	69.7674
1.72 to 1.78 x10^9	uplink	1800	73.7542
1.82 to 1.87 x10^9	downlink	1800	62.1262
8.9 to 9.15 x10^8	uplink	GSM 900	66.4485
9.35 to 9.60 x10^8	downlink	GSM 900	60.1329

Table 2 outdoor channel utilization

Frequency (MHz)	Uplink and downlink	Network	Channel used
1.92 to 1.95 x10^9	uplink	2100	86.7110
2.11 to 2.14 x10^9	downlink	2100	98.0066
1.72 to 1.78 x10^9	uplink	1800	96.3455
1.82 to 1.87 x10^9	downlink	1800	98.6711
8.9 to 9.15 x10^8	uplink	GSM 900	89.0635
9.35 to 9.60 x10^8	downlink	GSM 900	95.0166

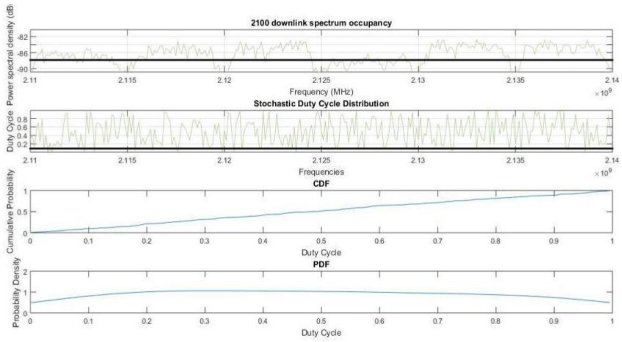

Figure: 3 2100 downlink (Indoor)

In the first graph, we can plot power spectrum density against frequencies, which shows that above the thresholds, the channels are used at other frequencies than those that are rejected. In the second graph, we can plot the duty cycle against frequencies, which shows how many channels are occupied and how many channels are idle. In the third graph, we can plot the cumulative distributive function (CDF) against the duty cycle, which shows a direct relation between duty cycle and CDF. If the duty cycle is 0.5, then the CDF is also 0.5. In the last graph, we can plot the probability mass function (PDF) that shows that for duty cycles from 0.2 to 0.7, the PDF will be 1, and channels are used at the highest duty cycle of 1 and the lowest duty cycle of 0.5, and channels occupied are at low. These all graphs are applied for 2100 uplink and downlink, GSM uplink and downlink, and 1800 uplink and downlink for indoor and outdoor.

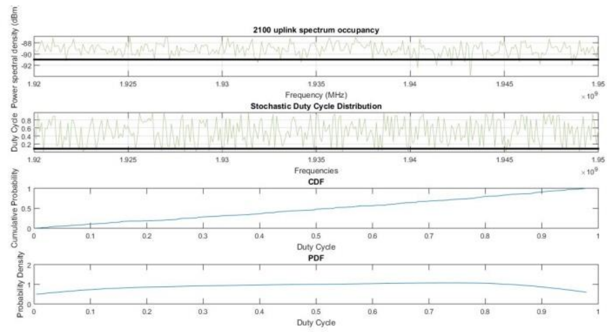

Figure: 4 2100 uplink (Indoor)

For the 2100 network, we gathered data inside for the uplink frequencies of 1.92 to 1.95 x10^9 MHz and the downlink frequencies of 2.11 to 2.14 x10^9 MHz, as shown in Figures 3 and 4.

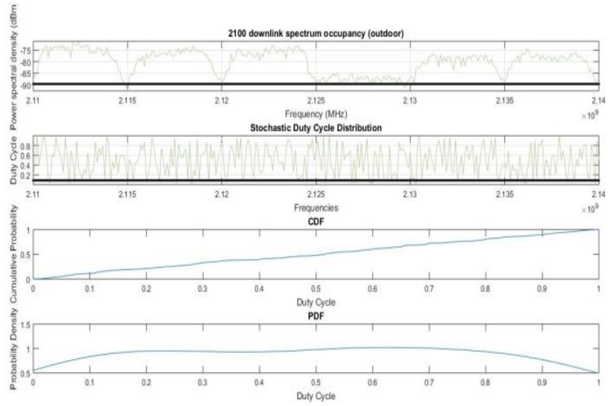

Figure: 5 2100 downlink (outdoor)

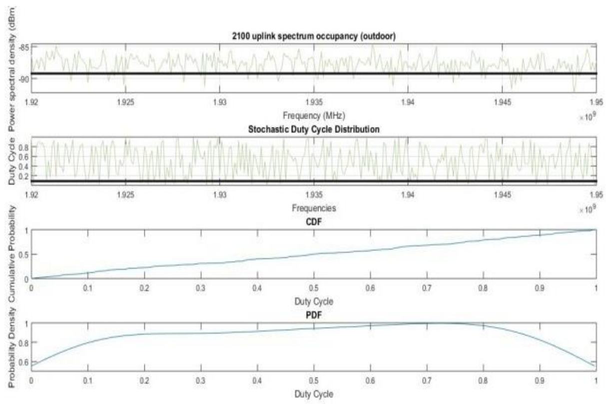

Figure: 6 2100 uplink (outdoor)

In Figures 5 and 6, we collected data from outside for the 2100 network to uplink the frequencies from 1.92 to 1.95 x10^9 MHz and to downlink the frequencies from 2.11 to 2.14 x10^9 MHz.

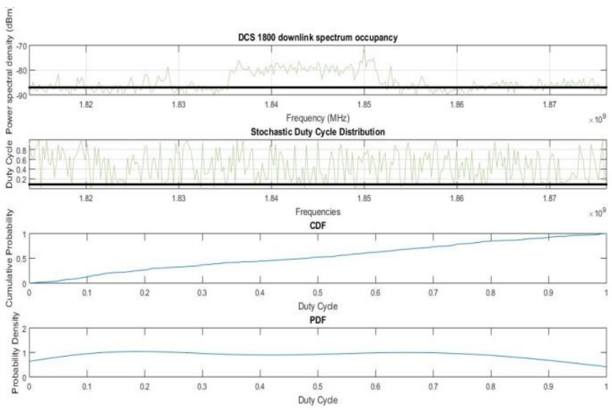

Figure: 7 1800 downlink (Indoor)

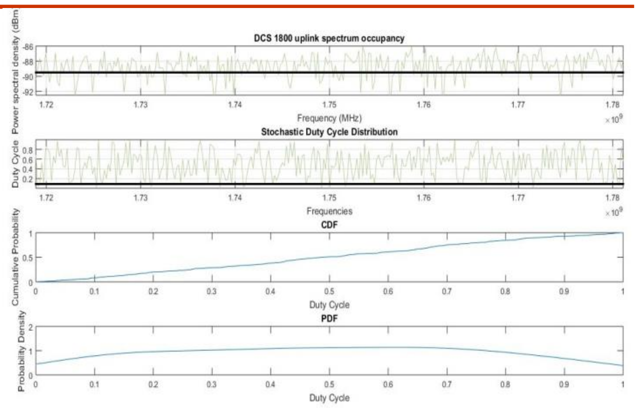

Figure: 8 1800 uplink (Indoor)

For the 1800 network, we gathered data inside for the uplink frequencies of 1.72 to 1.78 x10^9 MHz and the downlink frequencies of 1.82 to 1.87 x10^9 MHz, as shown in Figures 7 and 8.

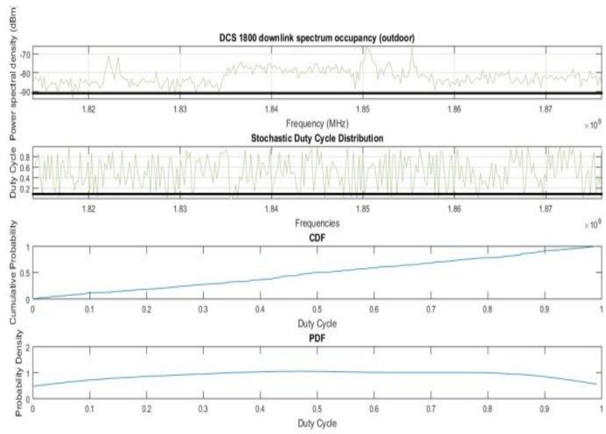

Figure: 9 1800 downlink (outdoor)

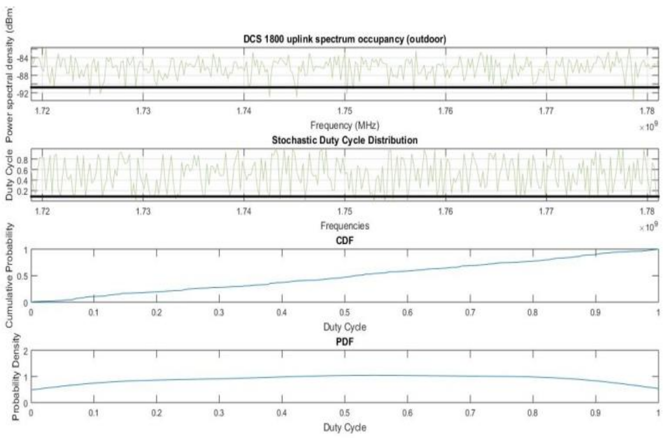

Figure: 10 1800 uplink (outdoor)

We gathered data inside for the 2100 network in Figures 9 and 10, with the goal of uplink frequencies from 1.72 to 1.78 x10^9 MHz and downlink frequencies from 1.82 to 1.87 x10^9 MHz.

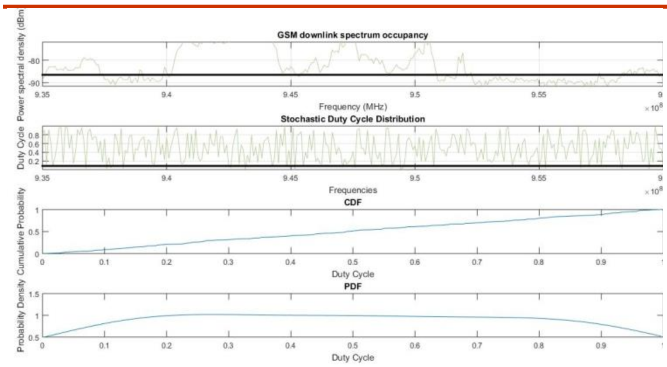

Figure: 11 GSM downlink (Indoor)

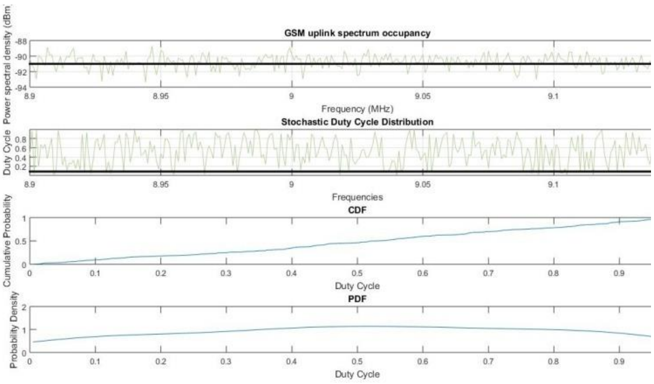

Figure: 12 GSM uplink (Indoor)

Data collection for the GSM network was conducted inside, with frequencies from 8.9 to 9.15 x10^8 megahertz being uplinked and 9.35 to 9.60 x10^8MHz being downlink. The results are shown in Figures 11and 12.

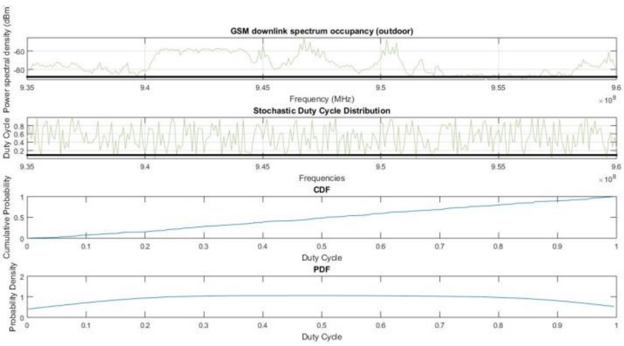

Figure: 13 GSM Downlink (outdoor)

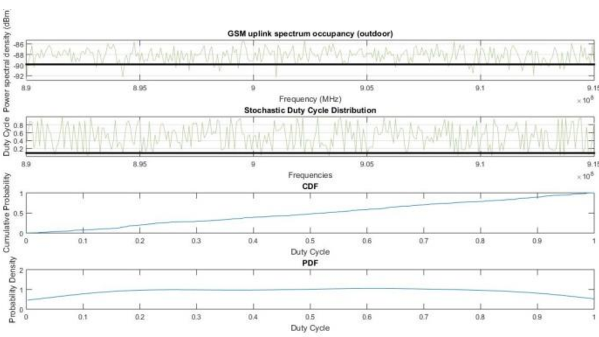

Figure: 14 GSM uplink (outdoor)

Data collection for the GSM network was conducted outside, with frequencies from 8.9 to 9.15 x10^8MHz being uplinked and 9.35 to 9.60 x10^8 MHz being downlink. The results are shown in Figures 13and 14.

5. Conclusion

In this study, we employ DSA methods that focus on low-level, observable information to investigate the utilization of white spaces in common frequency bands. Using frequencies larger than 1 GHz and a stochastic duty cycle for the 200 kHz bandwidth, we examine the measurement spectrum occupancies of dynamic spectrum access using IEEE 1900.5.2. Numerous applications in the assessment of dynamic spectrum access can benefit from the current duty cycle model. To examine the channel occupancies, we may gather this data from many sources and employ various uplink and downlink technologies, such as the GSM, 2100, and 1800 models. The results of this study indicate that the duty cycle between 0.2 and 0.7 is largely utilized, while at other values, the channel is only utilized about half as much.

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