

Coase's Curse?: Spectrum Management

Vishal Ashok Singh, Vishal@MobileIN.com

Abstract – Spectrum Management is the science of making more efficient use of spectrum. This paper discusses means of efficient spectrum utilization and not with ways of obtaining more spectrum from FCC. The paper also looks into both the technology and law side of the problem and recommends ways in which we can make more efficient utilization of the spectrum. It further proposes implementation of new metrics like Interference Temperature and a new model of usage which will help in spectrum management.

I. INTRODUCTION

The sheer demand for spectrum can be illustrated by the fact that a recent spectrum auction held by the FCC¹ fetched \$13.7bn [1] for just a small part of the available spectrum. Currently, 75% of the US population uses wireless services.

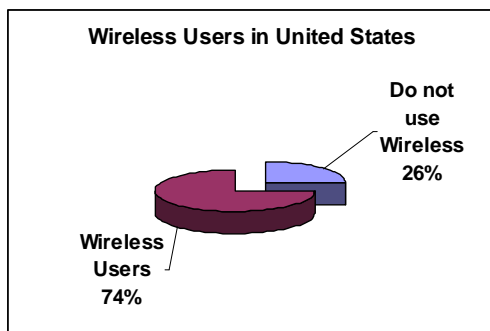


Figure 1

¹ FCC – Federal Communications Commission is an independent government agency which regulates interstate and international communications by radio, satellite, TV and cable.

Spectrum is like a river. We use it and it is our responsibility to keep it clean. About 55 years ago, Nobel laureate Ronald Coase stated that spectrum should be treated as any other finite natural resource. They should be allocated to users through market exchanges, with the government simply defining and enforcing private property rights in the resource [2]. The seer had seen the importance of spectrum management long ago but unfortunately we have not taken note of him.

In order to implement Coase's ideas we need to work more diligently on the science of spectrum management. The concept of signal interference can be best explained by drawing an analogy with a factory which produces smoke and pollutes the neighboring environment. To minimize interference, we need to implement new technology like smart radio. Also, we need to clearly define our parameters in terms of rights and properties.

The paper format is as follows: Section II will describe the data collection method. Section III deals with the law and policy aspects of this problem. It gives an in depth description of the different proposed usage models by the SPTF² in its report to the FCC. While Section IV details the technologies which could be used to increase the spectrum utilization. Section V will

² SPTF – Spectrum Policy Task Force was established to assist the FCC in identifying and evaluating changes in spectrum policy that will increase public benefits derived from the use of spectrum.

introduce some refinements to the proposed models and will carve out the way for future work in this direction. Section VI will conclude the paper by highlighting the important points.

II METHODOLOGY

The research is mainly based on the SPTF report. Further enhancements were brought by reading papers and articles of experts like Peter Pitsch, Richard C. French and Dale Hatfield.

Law papers written by authors like Ellen P. Goodman, R. Paul Margie and Ronald Coase were studied and inferences drawn from them are used throughout this paper.

Finally, websites and reports by FCC, IETF³ and SPTF were studied for the latest developments in this field.

III THE LAW

The SPTF report of 2002[3] recommends the use of different usage models. The models are explained in detail in the following sections.

1) *Command and Control Model*

This is the model which is currently being used. This model allocates frequencies and bands to certain users and then defines certain rules of services and restrictions for them. However, the incumbent has no right to lease his spectrum. This model is rigid in nature and it needs to be more flexible.

The model could be better understood by comparing it to a real life scene. A company XYZ conducts research and analysis of its spectrum requirements based on the QoS requirements and an estimate of the number of subscribers in the future. It has

plans of deploying more data based services to enable the customers to surf the web and stream mp3 videos. Accordingly, the experts forecast a growth in the number of subscribers. Hence, company XYZ gets more frequency spectrum in the next FCC auction.

However, due to economic instabilities in the market and emergence of other cheaper technologies such as VOIP, the company fails to meet its goals. The result is that it does not meet up to the prediction of the number of subscribers. As a result, company XYZ has now got fallow spectrum which is not being used. Here comes the rigidity of this model. The company has no option of leasing this spectrum. It is now losing big money on its revenues and also in its big investment in bringing the spectrum. However, this loss should not be seen as confined to company XYZ only because there could be other companies in the market who do not have enough spectrum available and who do not have the money to get more spectrum.

This rigidity of the model is tried to be tackled in the following usage models.

2) *Exclusive Use Model*

The exclusive use model empowers the licensed users with the right of leasing their spectrum. The main advantages of this model are the clearly defined rights, exclusivity, flexibility and transferability. Using this model, company XYZ could have leased or transferred the usage rights to some other company. This would have reduced their financial losses and most importantly it would have made spectrum available to a user who needed it.

³ IETF – Internet Engineering Task Force is a community of network designers, researchers and vendors concerned with the evolution and smooth operation of the Internet architecture.

Such a model would give new incentives to investors for investing in new technologies or services.

3) *Commons or open access Model*

This model allows unlimited number of unlicensed users to shared frequencies, with usage rights that are governed by technical standards or etiquettes but with no right to protection from interference. Spectrum is available to all users that comply with established technical “etiquettes” or standards that set power limits and other criteria for operation of unlicensed devices to mitigate potential interference. The bottom line of this model is that it allows anybody to use the spectrum of a licensed user until they do not cause any interference to the licensed user and comply with the standards. Figure 2 will give a better understanding of the Commons model during peak hours.

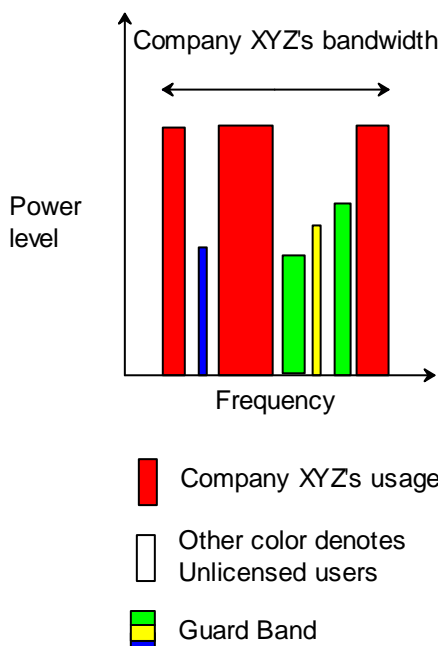


Figure 2

The successful implementation of this model also requires that the unlicensed benevolent transmits at lower power as compared to the licensed user (Company XYZ in this case). There would be a definite maximum power level threshold defined for the unlicensed users. Power level above the threshold would cause interference to the licensee. This restriction would avoid any interference to the licensed user’s spectrum. This is shown in figure 3.

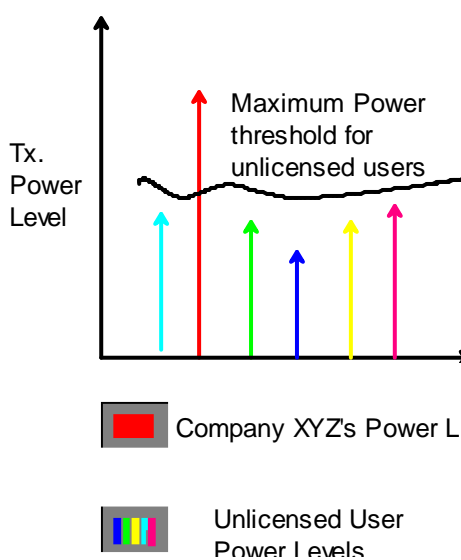


Figure 3

To increase opportunities for technologically innovative and economically efficient spectrum use, spectrum policy must evolve towards more flexible and market-oriented regulatory models.

IV USE OF TECHNOLOGY

Technology could play a pivotal role in minimizing the interference and allowing for uniform access to the spectrum. Some of the technologies that could help are explained in the following sections.

1.) *Interference Temperature*

Interference Temperature [4] was a metric recommended by the SPTF in its report to the FCC. Interference Temperature measures RF power available at the receiving antenna per unit bandwidth. Interference Temperature measurements would be taken at various receiver locations to estimate the real time condition of the RF environment. Interference Temperature encourages low power unlicensed users to use the unused spectrum of the licensed users until they exceed a certain pre defined interference level. It defines the maximum permissible level of interference. Beyond this level, the QoS provided to the licensed spectrum users starts deteriorating. However, different bands would have different levels of interference tolerance and this necessitates defining different maximum permissible interference levels for different bands. The core concept of Interference Temperature can be stated in a line and that is: it permits interference but restricts harmful interference.

Interference Temperature fosters innovation and the results can already be seen in the success of WiFi, Bluetooth etc [5].

2.) *Capitalizing on the White spaces*

White spaces are small frequency bands which are unutilized and are lying fallow. Guard bands were allocated for analog channels. Digital Channels are less susceptible to interference. The gradual completion of the transition from analog to digital television is freeing up new spectrum at lower frequencies where signals propagate better. As broadcasters release their temporary duplicate channels in the 700MHz band, 108 MHz of spectrum is being reallocated to public safety and commercial use. At the

completion of the digital television transition, TV broadcasts will be limited to channels 2-51, between 54 and 698 MHz [6].

According to the Comments of Statewide Wireless Network, New York State Office of Technology, typical channel occupancy is less than 15%, while the average peak usage is close to 85%.

Also the same amount of spectrum is allocated nation-wide, even though many fewer TV stations are licensed in rural than in urban areas. This by itself creates an 80 percent “vacancy rate” in the most rural markets. On average nationwide, only 23 percent of the spectrum allocated for TV channels 14-51 is actually used [7].

3.) *Smart Radio*

Normal radio receivers have fixed parameters and technical characteristics which are defined by the manufacturer according to the requirements. These technical characteristics are not adaptive in nature and cannot be subsequently modified. This means that these radios only operate at fixed stations and frequency bands. Smart radios are adaptive in nature and are programmed by software. The fact that these parameters are determined by software means that the radio can be programmed to transmit and receive on many frequencies and to use any desired modulation or transmission format within the limits of its hardware design. A software defined radio can also be programmed to receive different types of radio signals on varying frequencies. Often technologies such as software-defined radios are called “smart” or “opportunistic” technologies because, due to their operational flexibility, software-defined radios can search the radio spectrum, sense the environment,

and operate in spectrum not in use by others. By operating in so called white or unused spaces in the spectrum, software defined radios can enable better and more intensive use of the radio spectrum.

V RECOMMENDATIONS

1.) A new Usage Model

The best usage model would actually be a modification of the *Exclusive Use model* with the features of *Commons Model* incorporated in it. It will allow a licensed user to lease his license or transfer his rights according to his requirements. In addition, it would allow the unlicensed users to access the spectrum and the model would openly define the maximum acceptable interference limit for the licensed user. Such a model would not only give monetary incentives to the incumbents but also encourage innovation. Furthermore, it will promote competition in the market. After getting the right to lease, incumbent carriers and companies would be encouraged to make higher bids. This would happen purely because they would now know a way to recover their money if in case their planning goes wrong for the future.

2.) Identifying the white spaces and using them by implementing technology like adaptive radio. Further research and development on receivers will help to minimize interference to a desired level.

3.) Improving the interference standard is necessary because the interference temperature metric is a mere measuring tool. It tells the Commission how much interference exists in a particular band at a particular time. It does not, however, determine whether the measured level of interference is too high, too low, or just right according to the Commission's legal

obligations and policy goals [8]. A maximum tolerable interference level should be clearly defined. The FCC has acknowledged that it does not even measure noise levels or know the rate of increase in noise levels over time [9]. Noise Floor data should be collected and analyzed. This should be done on periodic basis.

4.) Maximum power levels could be increased in rural areas so that service can be provided over larger areas at lower cost. In congested urban areas, where high transmitter power levels on one frequency can often adversely impact the use of other frequencies, the Commission should look towards enabling the use of lower power transmissions.

VI CONCLUSION

Defining the maximum permissible interference level would help in two ways. The licensed users will have a certainty with regard to the maximum permissible level that they should tolerate. In case a licensed user experiences interference above the interference temperature, he can identify the source and petition the Commission to stop the interferer's activities. Also, defining such a level would mean that the unlicensed users would have a clearly defined area of operation.

The FCC's traditional disregard of Coase's view has resulted into the current day scarcity of spectrum. Or should we say that the delay in implementing Coase's view has turned out to be a curse for use which is called "Spectrum Management."

ACKNOWLEDGEMENT

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