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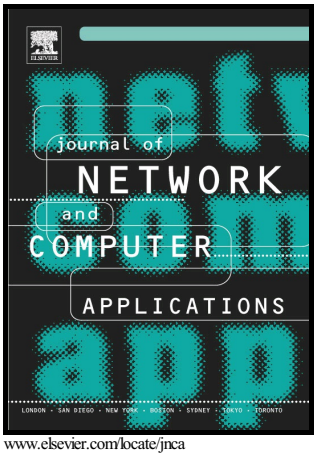

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A Comprehensive Survey on Spectrum Sharing: Architecture, Energy Efficiency and Security Issues

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Abstract— **The future generation networks (5G) are expected to achieve high data rates, reduced latency, increased spectral efficiency and energy efficiency of the system. Since the available spectrum is a scarce resource, its efficient utilization is the prime focus of the next generation networks. Spectrum Sharing is a key aspect that is gaining significant attention as it can prove to be beneficial in meeting the above requirements. In this paper we present an exhaustive survey of spectrum sharing for future generation networks. We discuss the different techniques and methods of spectrum sharing based on which a general architecture has been presented. Next, we discuss spectrum sensing, network selection and channel allocation, power optimization in spectrum sharing as well as the security issues associated. Based on the survey a four layer architecture has been proposed depicting the complete spectrum sharing scenario from spectrum sensing till the security issues. Modern technologies such as Massive MIMO, SWIPT, spectrum harvesting, spectrum relaying have been incorporated in the architecture for optimizing the power during spectrum sharing. A detailed analysis of security attacks has also been presented in the paper. Two application scenarios have been discussed where in spectrum sharing can offer huge advantages to meet the high bandwidth requirements. The paper also includes a list of the current projects that are being conducted by various research groups and institutions on spectrum sharing, for the next generation networks.**

Index Terms— **5G, spectral efficiency, energy efficiency, spectrum sharing, Massive MIMO, SWIPT, spectrum harvesting, spectrum relaying.**

I. Introduction

The demand for mobile wireless communications due to the popularity of smart phones and devices that have internet based applications has witnessed rapid growth in the last decade. The next generation network is expected to provide a better quality of service and meet the demands of these rising number of users. Since the spectrum available to us for carrying out all the wireless communications is a scarce asset, it is very important to use the available spectrum efficiently.

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According to a study, more than 70% of the available spectrum is not being utilized efficiently. The available frequency bands can be categorized into two main classes: Licensed bands and unlicensed frequency bands. Licensed bands are the ones for which the user pays a licensing fee and the rights of the spectrum are exclusively granted to that user. This licensed user is the primary user of the spectrum and it is ensured that no interference is caused to it by any other wireless entity. There are certain bands that have no licensing fee and are used for carrying out low cost communications, for e.g., Wi-Fi for private homes, etc. These bands are prone to interference from multiple users competing for bandwidth in the unlicensed band.

According to reports, it has been found that the annual increase in mobile data consumption is about 57%. Hence we see that with growth rates that high, there are a variety of remedies which are necessary but efficient utilization of the existing spectrum is the most important aspect of it. Spectrum sharing is a key feature to meet these high traffic demands and provide a better quality of service to the users as both the no. of users and the amount of bandwidth consumed by them is increasing by a very large magnitude [1]. What is spectrum sharing? It is the simultaneous use or a cooperative use of a fixed radio frequency resource by a number of independent entities lying in a specific geographical area. The independent entities involved includes the licensed user or the primary user (in case of licensed band) and the secondary user. Therefore there is an access to the licensed spectrum on a secondary basis by the secondary users with the primary users retaining the priority over their spectrum. Spectrum sharing can occur both in the licensed as well as the unlicensed band.

There is a wide diversification in the spectrum sharing schemes. Fig. 1, presents a flowchart depicting the diverse forms of spectrum sharing. The numerous spectrum sharing schemes can be classified as: **Administrative sharing**: This technique of spectrum sharing generally involves the processes of the controller in establishing the rules while sharing and where sharing