

Cognitive Radio Technology for Sub-6 GHz 5G Communications

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For every ten years, a new generation of wireless technology has been evolving. It was in 2010 that 4G was started and by 2020, it is expected that the 5G replaces 4G and people start using it. The proposed frequencies for 5G are illustrated in Fig. 1. The 5G network promises data rates of 100 times faster than the current 4G with much-reduced latency and you can think of downloading a high-definition movie under 3 seconds using 5G. Such high data rates are possible in 5G by exploring the new mobile-frequency territory called the mm-wave spectrum. There is a large amount of unused spectrum at mm-wave frequencies which have traditionally been the domain of military and aerospace systems. Using mm-wave frequencies will allow more bandwidth to be allocated resulting in the enhanced data rates.

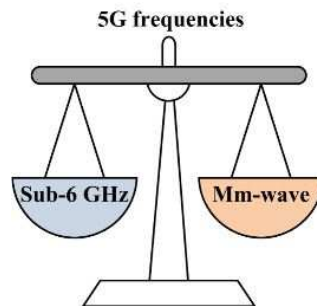


Fig. 1. Proposed frequencies for 5G

Being said that, there are many drawbacks of using mm-wave frequencies for 5G communications. They are mm-wave frequency signals can't travel long distances, can't penetrate through the buildings, easily attenuated by the environmental changes like fog, rain, etc. To cover up these limitations, the experts have proposed the small-cell technology in which small cell stations will be used to fill in coverage gaps between the base station and the user terminal. In a densely populated area, for every 10-100 meters, a small cell station is needed which massively increases the cost of implementation.

Considering the disadvantages of mm-wave frequencies and high-cost of 5G network implementation at mm-wave spectrum, some of the telecom companies are looking towards sub-6 GHz frequencies for 5G communications. Already many applications are using the sub-6 GHz range namely GPS, WiMAX, Wi-Fi, 3G, 4G, S- and C-band satellite communications, etc. Therefore, to use the crowded sub-6 GHz spectrum for 5G along with the above-mentioned applications, a spectrum sharing technique is required. In Mobile World Congress 2019, Ericsson showed the developed system which uses the spectrum sharing technique to enable both 4G and 5G connectivity within the same frequency carrier. The spectrum sharing techniques also minimize the spectrum wastage and help in utilizing the available frequency spectrum more efficiently.

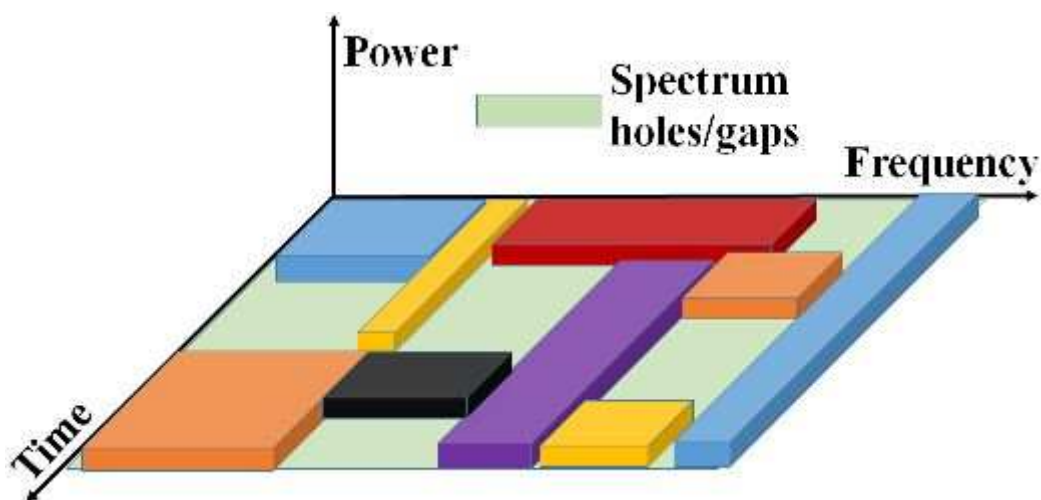
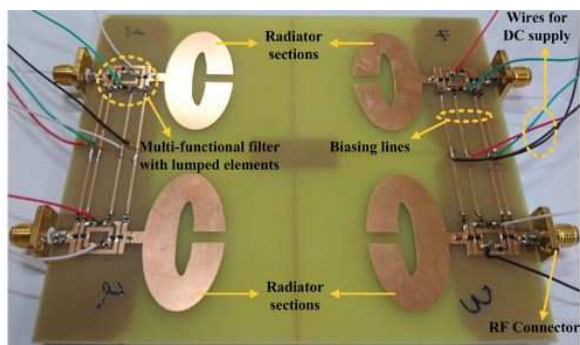
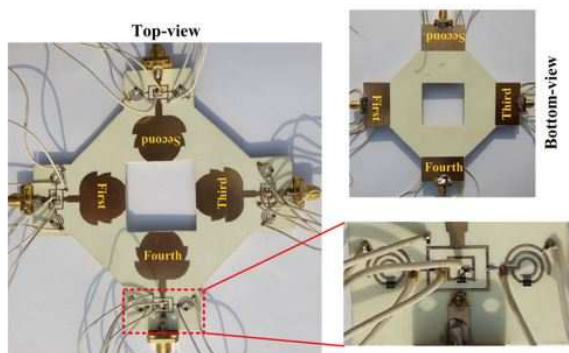


Fig. 2. Showing the holes/gaps of the available spectrum

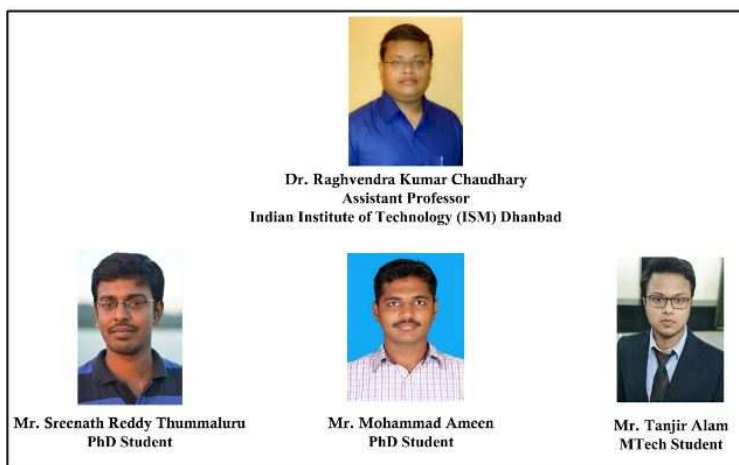
The cognitive radio (CR) technology is a kind of spectrum sharing technique which dynamically allocates the spectrum between the primary and secondary users and improves the spectrum efficiency. It is expected that the CR technology is going to play a huge role in the sub-6 GHz 5G network implementation. Two users are present in CR, namely primary users (licensed users) and secondary users (unlicensed users). Depending on how secondary users access the same spectrum which is already using by the primary users, the CR technology was divided into two types, interweave and underlay.



(a)



(b)



(c)

Fig. 3. (a) The proposed antenna system of [1], (b) the proposed antenna system of [2] and (c) 5G antenna research group members.

In interweave CR, the entire allocated spectrum will be scanned to locate the spectrum gaps or holes which are set of frequencies that are not using by the primary users. The secondary users will communicate in those spectrum holes, thus increasing the spectrum efficiency. The secondary users will stop their communication whenever the primary users want to use these spectrum holes.

In underlay CR, both the primary and secondary users can access the same spectrum simultaneously but with a condition that the secondary users' communication is not creating any interference to the primary users' communication. At the frequencies where the primary users' communication gets disturbed, there the secondary users immediately stop communicating. In this way, the spectrum will be used efficiently in both interweave and underlay CR without causing interference to the primary users.

Both interweave and underlay CR technologies can be incorporated into 5G communications by designing suitable antennas. For the first time, using a multifunctional filter, the four-port MIMO antenna system which can work for both interweave and underlay CR technologies has been designed in [1]. In [2], the same functionality has been achieved by reducing the antenna system size by 48.3%. The proposed antenna systems of [1] and [2] are shown in Figs. 3(a) and 3(b) respectively. The authors' names and photographs for the reference papers [1 and 2] are shown in Fig. 3(c). To know more about how the antennas need to be designed to make them work for CR technology, follow the references [1 and 2].

References:

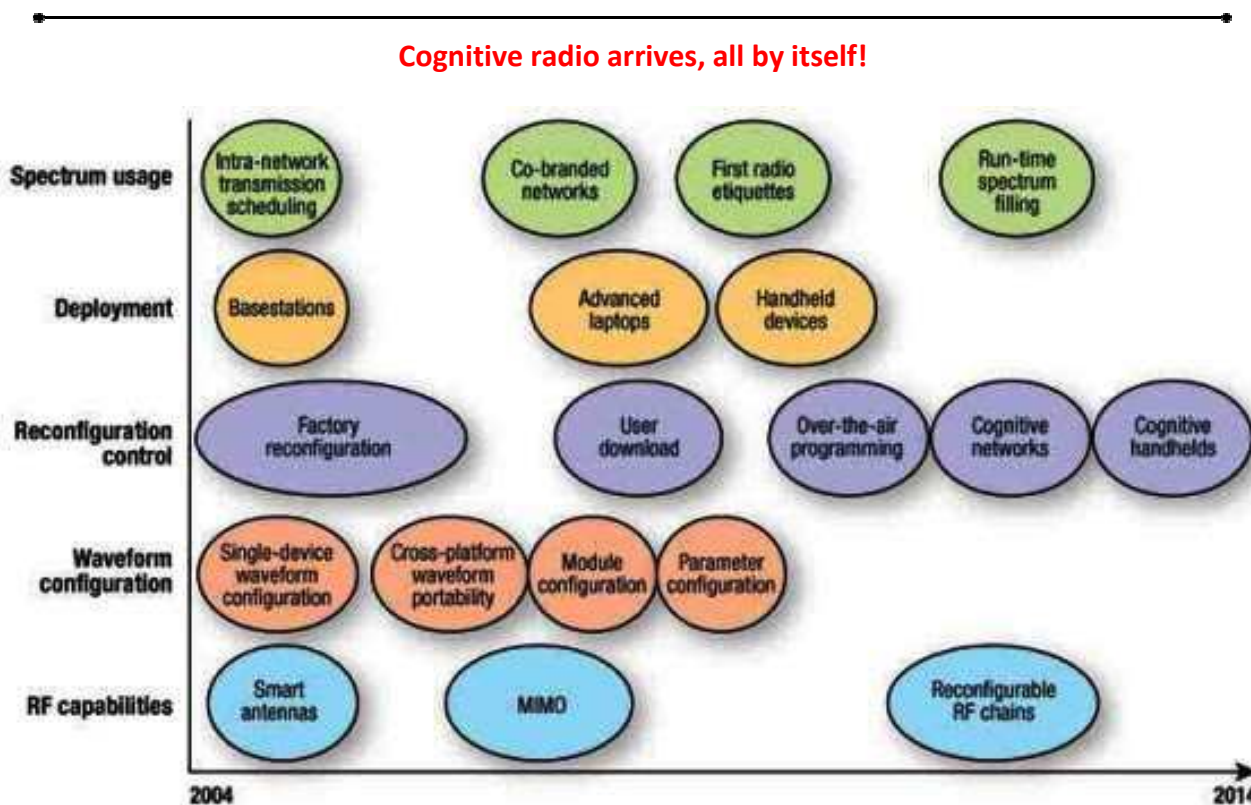
[1] Sreenath Reddy Thummaluru, Mohammad Ameen, and Raghvendra Kumar Chaudhary, "Four-Port MIMO Cognitive Radio System for Mid-Band 5G Applications", *IEEE Transactions on Antennas and Propagation*, Vol. 67 (08), pp. 5634 - 5645, 2019. [\[link to download\]](#)

[2] Tanjir Alam, Sreenath Reddy Thummaluru, and Raghvendra Kumar Chaudhary, "Integration of MIMO and Cognitive Radio for Sub-6 GHz 5G Applications", *IEEE Antennas and Wireless Propagation Letters*, Vol. 18, Issue 10, pp. 2021 - 2025, 2019. [\[link to download\]](#)

About the author



Dr. Raghvendra Kumar Chaudhary received the B.Tech. from UIET Kanpur, India, in 2007, the M.Tech. from IIT(BHU) Varanasi, India, in 2009, and the Ph.D. from IIT Kanpur, India in 2014. He is currently an Assistant Professor with the Department of Electronics Engineering, IIT(ISM) Dhanbad, India. He published more than 200 peer-reviewed international journal and conference papers. His current research interests include dielectric resonator antenna, metamaterial antenna, MIMO antenna, and metamaterial absorber. He was a recipient of the Young Engineers Award (2019-20) of IEI (Institution of Engineers, India) and many Best Paper awards in different categories in national and international conferences, such as IEEE APACE Malaysia, PIERS Singapore, and ATMS India. He has served as the Chair for the IEEE Student Branch of Uttar Pradesh Section, in 2012–2013 and currently serving as a counsellor of the IEEE Student Branch of IIT(ISM) Dhanbad. He is an Associate Editor of *IET Microwave Antennas & Propagation*, UK; *IEEE Access*, USA; and *Microwave and Optical Technology Letters*, Wiley, USA. He is a Senior Member of IEEE and URSI, and potential reviewer of international journals such as the *IEEE Transactions on Antennas and Propagation*, the *IEEE Antennas and Wireless Propagation Letters*, etc. He has also been featured interviewed by *IET Electronics Letters*, UK.



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