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Dynamic usage of narrowband spectrum

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ABSTRACT

We examine the potential for expansion of the white space spectrum sharing model in the 400 MHz band. As opposed to UHF broadcast spectrum, which contains unassigned or idle segments known as white spaces, the 400 MHz band is characterised by intensive licence usage. However, productive spectrum usage does not guarantee allocative efficiency, which would require knowledge of the highest value service for each licence. 400 MHz frequencies are not priced on opportunity cost. It is therefore difficult to ascertain the economically efficient mix of services to deploy in the 400 MHz band. Drawing parallels with the high-economic value revealed and generated through the operations of unlicensed white space devices in UHF broadcast spectrum, we identify untapped 400 MHz spectrum capacity, which we refer to as narrowband spaces. Encouraging dynamic spectrum usage of narrowband spaces could, similarly to TV white space usage help realise the efficient allocation of the 400 MHz band. However, the narrowband nature of the 400 MHz licences and high licensing turnover imply a significantly different concept of dynamic spectrum access than that considered for TV Bands. The paper discusses regulatory implications and the type of services suited to exploit narrowband spaces.

1. Introduction

The last decade has seen sustained interest in increasing the availability of the Ultra High Frequency (UHF) band for use by telecommunications services such as mobile (cellular) services, ‘last mile’ internet access and mobile broadband. The UHF band encompasses the frequency range from 300 MHz to 3000 MHz (or 3 GHz) and is well suited for mobile applications because of its favourable propagation characteristics. This is particularly the case for frequencies in the UHF band below 1000 MHz (1 GHz) because transmissions propagate further, penetrate well into buildings and antenna sizes are well suited for portable or hand held user devices.

However, at the beginning of the 21st century, most of the UHF band below 1 GHz was allocated for services other than telecommunications with government and military use dominating in the 300 MHz band and a range of civilian uses – predominantly land mobile or private mobile telecommunications – in the 400 MHz band. Above the 400 MHz band, almost all regions and the countries within them had allocated around 300 MHz – from approximately 500–800 MHz – for television broadcasting (the UHF TV band). For many countries, this meant that the only frequencies unpublished ACMA analysis available below 1 GHz for telecommunications services were relatively small allocations in the 800 MHz and

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900 MHz bands that had been established in earlier decades as mobile (cellular) technology first became technically viable and then commercially successful.

The spectacular but now well-accepted success of mobile telecommunications over the last 20 years – initially with voice services, then with the addition of data and, more recently, mobile broadband – has been the driving force behind making the UHF band more available for telecommunications. Most significantly, in conjunction with the transition to digital terrestrial television broadcasting, many countries have realised or are realising a 'digital dividend' where frequencies below 1 GHz in the UHF TV band are made available for telecommunications services. In Australia, the Federal Government decided in 2010 on a digital dividend of 126 MHz (694–820 MHz) with spectrum licences for telecommunications services auctioned by the regulator in April 2013.

In a parallel development, telecommunications use of the 'white spaces' between television channels was proposed as a way of productively utilising spectrum that was not being used for broadcast services to provide direct internet-related service to urban and rural markets. In the US, the FCC has since 2008 supported dynamic UHF spectrum access by these technologies through unlicensed usage of TV white space in the higher end of the UHF TV band. Most recently in the US, the FCC has authorised the operation of a "TV bands database system" by Spectrum Bridge to support the deployment of white space devices in and around the city of Wilmington in North Carolina (FCC, 2012).

The United Kingdom is well advanced in its implementation of regulatory arrangements for white space devices[2] and other countries like Australia have taken steps to enable future unlicensed usage of white spaces (and/or digital dividend spectrum) by white space devices (Freyens & Loney, 2011a; OFCOM, 2011). This indicates that political will and regulatory capacity to enable wide-scale deployment of white space broadband technologies is rapidly maturing (Bennett 2011).

The potential benefits from the deployment of white space devices has created expectations that the telecommunications potential of those parts of the UHF TV band still used for television broadcasting could be realised in a relatively short time span. Furthermore, to the extent that access protocols and business models are developed that facilitate the integration of white space devices with carrier-grade networks, there is additional potential for allocative efficiency and economic benefits in the longer term. Announcements in early 2012 about the development of HetNets – heterogeneous networks that will incorporate access points using unlicensed Wi-Fi frequencies into carrier-grade mobile networks – foreshadow a promising development pathway for white space devices.[3] This is supported by recent research into the capacity of white space in Germany to support the deployment of cellular networks (Dudda & Irnich, 2012).

By contrast, realisation of the full telecommunications potential of the 400 MHz band in the lower UHF band remains a challenge for many regulatory agencies. Although slightly larger antennas are required for the 400 MHz band, it has many of the same characteristics as the digital dividend spectrum so highly sought after by telecommunications companies. This was highlighted in 2007 when the World Radiocommunication Conference (WRC-07) designated the 450–470 MHz frequency range for IMT, including advanced technologies such as LTE (Long Term Evolution). However, the IMT designation has led to relatively few developments so far, most likely because of the limited bandwidth available for deployments using frequency division duplex.

Although adjacent to the TV bands and with very similar propagation characteristics, planning for and usage of the 400 MHz band is very different. The TV bands are characterised by a relatively small number of primary services (transmitters) that are licensed to broadcast wideband television services (7 MHz in Australia) over large areas at high power (typically kiloWatts). In contrast, usage of the 400 MHz band is characterised by a much larger number of licensed services that transmit and receive narrowband signals (25 kHz or less) in smaller coverage areas using lower powers (less than 83 W EIRP). Measured by the number of licences on issue, the 400 MHz band is intensively used.

Yet, in the absence of market instruments, a large number of licences does not necessarily equate to efficient spectrum usage. The high output/input ratio[4] of the band provides few clues as to whether the array of services deployed and supplied on the band corresponds to the mix of services that would maximise benefits to society. Assessing allocative efficiency requires knowledge of the highest value service for each licence. 400 MHz frequencies are typically assigned for an administrative fee and on a 'first come first served' basis, rather than allocated by auction or priced on opportunity cost to authorise services identified as generating high market value.[5] It is therefore difficult to ascertain whether the current mix of services deployed in the 400 MHz band will enable the highest value use.

This article contends that dynamic spectrum access techniques, currently largely unused in the 400 MHz band, offer a way to enhance both the productive and allocative efficiency of this highly valuable spectrum. We analyse the apparently intensive use of the 400 MHz band and suggest that there is untapped capacity – henceforth 'narrowband spaces' – that can be utilised by devices that are simpler than fully featured cognitive (Mitola) radios. In Section 2 narrowband spaces are characterised in terms of bandwidth, geographical coverage and availability over time, and compared with the better known

[2] See Ofcom's November 2012 announcement at: http://media.ofcom.org.uk/2012/11/22/ofcom-reveals-next-steps-towards-%E2%80%98white-space%E2%80%99-devices/.

[3] For example, the purchase of BelAir Networks by Ericsson (http://www.ericsson.com/news/1598985).

[4] The output/input ratio is a standard measure of factor productivity. In this case the factor considered is the 400 MHz radio spectrum and the ratio refers to the number of licences issues per unit of radio spectrum. With a high ratio, the 400 MHz Band is productively used, but productive usage and allocative efficiency are fundamentally distinct concepts (Freyens & Yerokhin, 2011).

[5] In Australia, the ACMA is introducing opportunity cost pricing for licences in the 400 MHz band (http://www.acma.gov.au/WEB/STANDARD/1001/pc=PC_410336).