Improved management of shared spectrum: a potential AI/ML use case

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Overview and context

Radio spectrum supports many different uses relied on by society today. Major spectrum users include satellites, fixed telecommunications networks, mobile phones, television broadcasting, maritime and defence services. Other public sector and scientific systems users of spectrum include transport (road, rail and airborne connectivity), healthcare, radio astronomy and public safety. Spectrum regulators currently implement complex rules to govern how spectrum is shared and used between different services.

Technological developments are enabling the use of higher-frequency bands for some types of use, but there remains a high demand for spectrum within certain favoured bands. Current debates relating to the evolution of two prominent uses of spectrum – 5G, and Wi-Fi – have focused on spectrum in the 6-7GHz range, requiring regulators to make complex choices to strike the right balance in terms of the best form of use. Interest in spectrum for future mobile systems (6G) ranges from around 6GHz up to 15GHz. Spectrum in these bands is widely used by important, existing ('incumbent') services, including defence services, satellites, earth observation satellites and terrestrial fixed links. Given the need to still support these users, shared use is potentially attractive.

How spectrum sharing works today

Spectrum sharing based on predetermined conditions is already well-established in international frequency allocations that have been defined by the International Telecommunications Union (ITU). Nationally derived spectrum assignment choices are made within the boundaries of internationally agreed frequency allocations and sharing recommendations, together with regional harmonisation measures. Shared use of spectrum is informed by a complex range of international, regional and national co-existence measures aimed at ensuring that specific frequencies can be used by defined systems without harmful interference.

Dynamic access to spectrum – meaning devices that use spectrum in a given location when those frequencies are not required by incumbent services – is limited to a few bands in a few markets to date.

A notable example is in the USA where spectrum access systems (SAS) manage sharing arrangements in the 3.5GHz band (termed 'Citizens Broadband Radio Service', or CBRS) and are implemented to manage unlicensed uses of the 6GHz band. Such approaches can be beneficial in terms of streamlining spectrum access but require SAS databases bespoke to the band(s) and types of use in question. For example, SASs in the CBRS listen for naval radar operation via a network of sensors, together with geographical exclusion zones.

Complexities with setting up dynamic approaches, and some degree of commercial resistance (often associated with concerns over whether quality and performance can be guaranteed) have limited its use. A further limitation is that sharing rules have not been able to adapt quickly to system usage that varies over time.

A key question is whether better data and/or AI-driven approaches offer the ability to improve existing spectrum sharing processes (such as by minimising the size of predetermined exclusion zones).

The use of AI-techniques in spectrum management

With increasingly complex decisions on future uses of spectrum, some regulators have considered whether machine learning (ML) techniques might be used in future to aid shared assignment and/or to manage the use of spectrum in some bands.

In March 2023, the UK Office of Communications (Ofcom) published a discussion paper on future opportunities for dynamic or adaptive approaches to managing spectrum in the UK.[1] This raises a question about dynamically managed bands – possibly aided by devices with sensing and/or machine-learning capabilities – being available as 'top-up' capacity for some types of use for which future spectrum demands are high, such as mobile broadband. Ofcom issued a further discussion paper in October 2023 on flexible access and spectrum sharing which considers whether technological developments can help to enable more-dynamic spectrum sharing environments.

Similarly, in August 2023, the Federal Communications Commission (FCC) in the USA published a notice of enquiry on AI and other technologies in managing the use of spectrum.[2] The FCC considered whether AI techniques might assist in managing the use of spectrum between government and non-government use.

The ideas presented by Ofcom and by the FCC indicate a recognition of the practical, technical and legal considerations that need to be addressed. From a commercial perspective, providers of wireless systems that require significant and ongoing investment in infrastructure (such as satellites, fixed–wireless networks and mobile networks) need assurance that spectrum in a given band will continue to be available over a suitable period as a prerequisite for investment. There may be concerns that dynamic spectrum access approaches that lack certainty of access or a fixed duration of licence do not give the same levels of assurances for investment as a licence that is granted for use in specific block of frequencies over a fixed time duration.

Granular data on how spectrum usage varies geographically and over time across bands would be needed to demonstrate the ability of AI-based approaches to provide worthwhile improvements. However, even if that data were available, there would also need to be predetermined studies into how systems interact to ensure that the connectivity needs of different wireless services are met. Wireless systems and designs also need to accommodate any usage restrictions that studies identify as necessary to ensure co-existence between different wireless services using the same band. Such restrictions are typically studied by stakeholders over a period of time to gain acceptance of sharing rules that meet the requirements of both the incumbent services and incoming (new) systems.

This means that feasibility and cost-of-interference mitigation measures can be factored into the design of new systems. However, complying with usage restrictions does often imply compromises in how systems can operate in shared spectrum – for example, a requirement for incoming systems to adhere to limits in transmitted powers to avoid interference to incumbent systems. These measures are designed to offer a balance between incumbent and new uses. It is possible that AI approaches could be used to optimise the design of usage restrictions in future – for example, by using data on how spectrum usage varies geographically and over time to avoid determined exclusion zones becoming larger than required in locations where incumbent usage is limited.

[1] Ofcom (28 March 2023), *Opportunities for dynamic or adaptive approaches to managing spectrum in the UK*.

[2] Federal Communications Commission (3 August 2023), *FCC launches technical inquiry into spectrum usage data*.

However, there will still be concerns over whether quality and performance can be guaranteed in shared spectrum – both from operators of incumbent services and operators of new systems.

In conclusion, given the complex nature of interference avoidance and the limited amount of experience in using ML AI techniques, machine learning seems unlikely to result in significant overhauling of general spectrum management approaches. However, it is possible that dynamic forms of sharing within specific bands designated for such purposes could be optimised through devices and networks that use machine learning.

For more details or to discuss spectrum management approaches and sharing techniques, contact Janette Stewart, Partner.