Vodafone's response to Ofcom's call for inputs

The future role of spectrum sharing for mobile and wireless data services

Licensed sharing, Wi-Fi, and dynamic spectrum access

November 2013

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1. Introduction

Vodafone welcomes the opportunity to respond to Ofcom's consultation on the future role of spectrum sharing for mobile and wireless data services. As has been found in Analysis-Mason's work for DCMS and BIS[1], radio spectrum generates a vast economic benefit for UK amounting to a ten-year NPV of almost £500Bn, and a large proportion of this is generated by mobile networks. In recent years, Wi-Fi has developed to be a worthwhile complement to mobile networks, and other types of spectrum sharing might also provide a useful complement in the future.

However, shared spectrum is not a substitute for spectrum licences. Each of the mobile networks in the UK has required an investment of billions of pounds. An investment on this scale requires confidence in the long-term availability of the fundamental resource for providing a return on this investment. The mobile spectrum needed to generate the economic benefit to UK will increase with consumers' expectations for bandwidth and quality of service, and operators will use a portfolio of spectrum to satisfy these expectations. Shared spectrum will form part of this portfolio, but the 'core' bands on which operators rely will continue to need to be licensed on an individual basis, to provide the confidence for continued investment. Ofcom should therefore avoid considering shared spectrum as an 'easy option' to avoid the difficult task of clearing the spectrum that is needed for the continuing development of mobile services.

Wi-Fi undoubtedly represents one of the success stories of licence-exempt spectrum. It is widely used for in-building connectivity, and increasingly for outdoor public access. Higher bandwidths will certainly be required to align with increasing fixed-broadband speeds and to avoid a *tragedy of the commons* in external applications, but we must stress that this must be internationally harmonised spectrum, and represents an adjunct to the need for more licensed spectrum rather than a substitute for it.

We note that the consultation is written largely from the perspective of technology solutions for spectrum sharing. As a result, Ofcom must guard against the danger of producing a technology solution looking for a regulatory problem. As Ofcom progresses with this work, it is important that it identifies the potential sharing opportunities first, and then looks for the optimum solution to achieve this.

2. Responses to questions

The future role of Wi-Fi in helping to meet the demand for wireless data services

Q1: How is demand for indoor wireless data connection speeds and capacity likely to develop over the next 5–10 years?

Wi-Fi represents the exemplar success story of licence-exempt spectrum. It is widely used, being deployed in pretty much every household with broadband access, and our customers

[1] https://www.gov.uk/government/publications/impact-of-radio-spectrum-on-the-uk-economy-and-factors-influencing-future-spectrum-demand

make wide use of it to offload connectivity from their 3G/4G mobile service when in a suitable coverage area.

As home broadband speeds increase, demand for in-home bandwidths will similarly increase. We note that the market has evolved over the last decade from a situation where domestic Wi-Fi access points were largely self-supplied to one where the predominate business model is for the capability to be bundled into routers supplied by fixed communication providers: we would thus suggest that these providers will be key stakeholders in assessing the particulars of capacity requirements. A second source of consumer demand for increased speeds will be the speed of mobile broadband networks: it would be unfortunate if consumers were to be discouraged from opting to utilise Wi-Fi to access their fixed broadband connection, because to do so would result in a lower bandwidth than is available on their 4G connection.

We agree with Ofcom's analysis around demand for Wi-Fi speeds, that 802.11n is increasingly the baseline and that 802.11ac will ultimately become more common. Such technology deployments will require greater utilisation of the 5GHz band.

Q2: Will an extension of the 5 GHz band be required if Wi-Fi is to play a sustainable role in meeting the growing demand for indoor wireless connectivity?

At a time when 5GHz is not being extensively used, it is difficult to predict whether the band will be of sufficient size. However, it does appear that the spectrum consumed by the higher bandwidth Wi-Fi technologies may mean that the current designated spectrum bands will ultimately be insufficient.

The Wi-Fi equipment market is a global one, and any spectrum bands must be internationally harmonised. Ofcom should therefore support international initiatives to extend the 5GHz band rather than taking any unilateral action.

Q3: Are there other types of indoor wireless applications will require access to alternative spectrum other than that provided by the licence exempt 2.4 and 5 GHz bands used by Wi-Fi?

Successful though Wi-Fi has undoubtedly been, it is ill-suited to those applications which demand total in-home coverage with no "not-spots". Therefore, for HAN application such as smart-metering/grids, usage of lower frequency spectrum such as the 870MHz band is more appropriate.

Further, at the other extreme, some applications simply do not need the capability to transmit from one end of a building to another. For example, wireless transmission from a "set top" box to a wall-mounted television/display requires high speed connections which would be better accommodated by 60GHz spectrum rather than wasting more valuable lower frequency bands.

We would therefore encourage Ofcom to make a full complement of bands available, in order that equipment manufacturers can tailor their kit appropriately.

Q4: What role do you think Wi-Fi will play in providing wireless broadband connectivity outdoors over the coming 5-10 years?

Outdoor Wi-Fi has a role to play in providing outdoor coverage in urban areas. However the quality of service challenges are difficult, and we must stress that such applications will be an adjunct to licensed mobile spectrum, rather than any meaningful replacement for it.

Q5: Will the increased deployment of Wi-Fi access points outdoors create a risk of reduced quality of service performance over the longer term and, if so, will approaches to co-ordinate access point performance be able to mitigate this risk?.

Vodafone shares Ofcom's concerns about the risks of degraded quality of service due to a *tragedy of the commons*, and also Ofcom's doubts about the likely efficacy of co-ordination. Inherently Wi-Fi is a technology optimised for single-supplier deployment rather than overlapping suppliers. In indoor scenarios, the attenuation of buildings coupled with smart sensing of available frequencies has been relatively effective in mitigating interference issues. Likewise, in outdoor scenarios where the single-supplier paradigm has been maintained (business parks, shopping centres, campsites), reduced quality of service hasn't proven to be a major concern. However, if there is a proliferation of outdoor Wi-Fi deployments in urban environments, interference between them is likely to grow, adding to the underlying interference from Wi-Fi PANs. As each service provider deploying Wi-Fi will make their own equipment choices, it is unlikely that proprietary supplier techniques will provide a universal solution for resource co-ordination. This is not to predict a looming Wi-Fi interference crisis, but serves to underline the point that licence-exempt spectrum cannot be a substitute for licensed mobile spectrum in these high-usage locations, and ultimately where assured quality of service or a high degree of service provider investment are required this will necessitate the latter.

Q6: Will improved approaches to accessing spectrum in licence exempt bands be needed in the longer term to maintain the quality of service achievable for outdoor public mobile broadband and/or M2M services? If so, which approaches are most likely to be adopted and how likely do you think they are to be successful in improving access to spectrum?

DSA techniques could provide the potential to "sweat" usage of licence-exempt bands, but are not without pitfalls. The answers to the remaining questions set out our opinion on these techniques. However, we must stress once again that such techniques will increase the overall utilisation of spectrum, but are an adjunct rather than replacement for licensed spectrum.

Increasing spectrum supply and better managing its use

Q7: Which frequency bands are most likely to be best suited to providing geographical shared access, including via a geolocation database approach, for use by mobile broadband, for example small cells and M2M applications?

For spectrum to be of value it must be available for use to consumers, and there must be devices capable using it.

- Mobile operators have the greatest need for spectrum in the 'busy hours' and the areas of highest traffic density. Therefore, for shared spectrum to have value, it must be available in those times and places. The definition of spectrum availability will differ between wireless applications; it will take account of the user experience of availability and of techniques to overcome lack of spectrum resources in the band in question, such as handover to different bands in a mobile network.

- The market for mobile terminals is global, and more than twenty frequency bands are used significantly for GSM, 3G and 4G around the world. This is more than the number that can be implemented in a single smartphone, so manufacturers are forced to make choices and manufacture several regional variants. Current terminal architectures support bands within limited frequency ranges, and this is unlikely to change. For a new band to be included in the set implemented in future models, it will need to be widely available – if not globally, then at least throughout Europe – and fall within (or at least close to) one of the frequency ranges already supported[2].

The UK Government has asked Ofcom to manage a licence award for 40MHz of the 2.3GHz band. From the publicly available information, the remaining 60MHz appears to be a promising candidate for geographically shared access. It is difficult to suggest other promising bands, because this depends on the nature of the existing use (which is usually not in the public domain). This is doubly difficult for M2M applications, because these span a wide range of requirements in terms of throughput, latency and range.

Given the difficulty in having a public dialogue on the current usage models, Vodafone would be happy to explore the viability of specific spectrum bands bilaterally with Ofcom.

Q8: Would access to these bands best be realised through licensing or licence exemption.

For any wireless application that requires significant investment in infrastructure, the network operator needs confidence in the long term availability of the spectrum that it will use. This requires an agreement with the primary spectrum user, which can be in the form of a licence or spectrum lease.

For geographic sharing, the primary spectrum user may generally require the spectrum users to be licensed, so that usage can be managed and the source of any interference can be identified and addressed.

[2] Currently, these frequency ranges are 698-960MHz, 1710-2170MHz and 2300-2690MHz.

Q9: Do you believe that tiered shared access to a range of spectrum bands has a role in meeting demand for mobile and wireless data and, if so, which applications and devices do you think will be particularly suited to this access model?

Tiered access may be useful in certain circumstances. However, for it to provide significant benefits, the utilisation of spectrum of each tier needs to be complementary to the ones above. This is the case for the UHF band because DTT only uses around one in five channels in a geographic area and PMSE use is localised. However, it is unclear whether this would be the case for many other bands.

Q10: Do you believe DSA could play an important future role in the future in enabling a better quality of service and low barriers to spectrum access alongside conventional licensed and LE spectrum approaches?

DSA can only enable a better quality of service if it is treated as a complement to licensed spectrum, not a substitute. Providing a high quality of service in a mobile network requires a substantial investment in infrastructure, which requires confidence in the long term availability of the spectrum. Operators will use a portfolio of spectrum to provide a high quality of service. Licence exempt spectrum already forms part of this portfolio and shared spectrum using DSA might do so in the future; however, the 'core' bands on which operators rely will continue to need to be licensed on an individual basis, to provide the confidence for continued investment and consistency of offered service across a market.

Ofcom must therefore not regard shared spectrum as an 'easy option' to avoid the difficult task of clearing the spectrum that is needed for the continuing development of mobile services.

Q11: What barriers still remain to the realisation of cost-effective sensing appropriate for low-cost consumer devices and what activities are ongoing to try to address them?

There is a regulatory conflict between spectrum sensing and technology neutrality. For spectrum sensing to be effective, it must be possible for a device to be able to detect transmissions at levels well below the threshold for reception. This requires the sensing device to use a correlation process with the known characteristics of the primary service. However, this then prevents that primary service from upgrading or replacing its technology, because the sensing would then fail to function.

Therefore, once sensing is implemented in a band for secondary use, the primary user becomes tied to the technology in use that at the time that the sensing devices are introduced. It thus loses the benefits of technology neutrality, which is a fundamental principle of EU telecommunications policy.

The principal technical obstacle for sensing is the "hidden node problem". In essence, it is only possible to for a device to sense a transmission, and not the location of a receiver. It is therefore possible for a device to be unable to sense a transmission, but still be able to cause interference to a receiver that is receiving this transmission.

Sensing for dynamic spectrum access is therefore a challenging technical problem – and therefore an attractive subject for academic research. It has the theoretical potential to increase the shared utilisation of spectrum on the on the fringes of the primary use beyond what is

achievable with a database. However, we are sceptical as to whether this will significantly increase the practical utility of the spectrum – and therefore not generate significant economic value from the shared use.

However, sensing is likely to reduce the long term value of the spectrum to the primary users, by imposing constraints on introducing new technologies[3]. We are not aware of any studies on the economic impact of allowing DSA using spectrum sensing in a band on the primary users of that band. This needs to be taken into account if Ofcom choses to investigate spectrum sensing further.

Q12: Over what timescales could DSA become a mass market proposition?

All of the enabling technologies needed to implement DSA are already available, having been developed for other purposes. The lack of any mass market proposition for DSA so far is therefore largely due to the absence of a business case to date.

Q13: What role should Ofcom play, if any, to support the development of DSA and relevant technologies?

Ofcom needs to be very cautious in intervening in the market to support the development of particular technologies – and, by implication, not supporting the development of other technologies that address the same market in different ways. This runs the risk of distorting the market for wireless technologies and devices, which could benefit some market actors at the expense of others.

In an efficient market, there would be no need for Ofcom to intervene at all. The main obstacle to an efficient market for DSA is information about the nature of spectrum usage by the primary users. Ofcom should therefore concentrate on making this information available.

Q14: Do you have any other views on any of the issues discussed in this consultation?

The consultation considers a number of approaches to spectrum sharing and asks stakeholders to map these onto potential bands for spectrum sharing. However, a better outcome is likely to be achieved if the potential bands are identified first, and the sharing approach is optimised for the characteristics and existing usage of that band. Vodafone would welcome the opportunity to share views on the potential usage of specific bands with Ofcom, once these are identified.

Supporting innovation through short-term access to shared spectrum

Q15: What are the frequency bands that would be of most value for R&D purposes?

Innovation is, by its nature, very difficult to predict. It is therefore equally difficult to predict what bands would be of most value for the development and trialling of future innovations. Many trials need to take place close to a university or company research facility, and the availability of spectrum in this location is therefore more important than the specific frequency band.

[3] This was demonstrated in the 5GHz WiFi band. The original definition of DFS for this band did not take account of all of the types of radar operating in this band, and consequently the DFS did not always protect the radars from interference.

The responses to this consultation will inevitably address the aspects of wireless innovation that are currently fashionable. It is important that Ofcom does not build a process for R&D access to spectrum that only addresses these fields of innovation, because this could hinder future R&D in other fields, or even skew R&D in the UK towards those fields for which Ofcom has developed its processes.

Q16: What are the potential benefits of using a geolocation database approach for short-term access to spectrum for R&D and how would you see this working from a practical perspective? Are there alternative approaches that could deliver similar benefits?

There are a number of fundamental and practical problems in developing a database of available spectrum for short term R&D use. This spectrum is usually only required in a small geographic area, so the database would need to hold information on the location of individual transmitters of the incumbent users. This would raise serious concerns in relation to security and commercial confidentiality; if the database is publicly accessible, the locations and characteristics of these transmitters could be 'reverse engineered' by repeated interrogation of the database.

Even if the concerns over security and confidentiality could be addressed, a database for R&D use would be more complex than Ofcom's operational spectrum management system, because it would need to be capable of analysing a wider range of combinations of wireless applications and technologies in a particular band.

Coordination procedures are inherently based on the characteristics of the two wireless applications and technologies concerned. It is therefore fundamentally not possible for the database to contain coexistence data for any conceivable future system – let alone innovations that have not yet been conceived. Any process for providing spectrum access for R&D must therefore make provision for bespoke coordination.

As the consultation document recognises, it would still be necessary to seek the agreement of incumbent spectrum users before authorising an R&D trial. This is essential, because there are sometimes unexpected interactions between radio systems, and the database cannot take account of planned future use.

The wide range of potential needs for access to spectrum would be more effectively addressed by spectrum experts than by an automated process. This could be facilitated by a contact point in Ofcom, with support by technical experts that would identify potential suitable frequency bands and negotiate with the current users.

Q17: What characteristics do you view as important to researchers in arrangements to facilitate temporary access to spectrum for research and development purposes?

Trials of new wireless systems are generally restricted to much smaller geographic areas than operational systems. These can therefore often access frequency bands that would be unsuitable for sharing for commercial use.

As described in the previous question, the most important characteristics of arrangements for temporary access are responsiveness and flexibility. Rigid arrangements and pre-defined bands

for R&D are likely to obstruct access for future innovative applications as they are likely to facilitate access for innovations currently foreseen.

Ofcom should be cautious about reserving spectrum for R&D purposes on a widespread basis, because this could sterilise spectrum that could create value from release for commercial use.