Intel Response to Ofcom Consultation "*The future role of spectrum sharing for mobile and wireless data services: Licensed sharing, Wi-Fi, and dynamic spectrum access*"

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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?

Intel does not produce or publish demand forecasts. Other sources of demand forecasts are widely available from reputable companies. These sources illustrate strong growth in demand for data connection speeds and capacity.

In May 2013, Cisco released the "Cisco VNI Global IP Traffic Forecast, 2012 – 2017" which was an updated study highlighting the following projections that by 2017 -

- there will be 3.6B global Internet users, up from 2.3B global Internet users in 2012
- there will be 19B networked devices globally, up from 12B networked devices in 2012
- average global broadband speed will grow 3.5X from 11.3 Mbps (2012) to 39 Mbps (2017)
- global IP traffic will reach annual run rate of 1.4 zettabytes, up from 523 exabytes in 2012

Intel believes the demand for indoor Wi-Fi (2.4 GHz and increasingly 5 GHz) capacity and throughput will continue to increase and larger bandwidth channels will be required to deliver the higher bandwidth services e.g. HD video.

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?

Yes an extension of the 5 GHz band for Wi-Fi is fundamentally necessary to meet the ever-growing demand for indoor wireless connectivity. Wi-Fi technology continues to be incorporated into a wide range of devices such as laptop computers, tablets, smartphones, cameras, printers, set-top boxes, televisions, etc. Wi-Fi use provides crucial wireless connectivity in the corporate, home, and public access environments.

Wi-Fi use keeps growing as chipsets are incorporated into a wider range and greater number of devices.

In addition to the growing demand for capacity, there is also growing demand for higher data rates. Wi-Fi standards have evolved over time to meet increasing performance requirements and higher data rates. As these requirements have increased, so has the maximum bandwidth necessary to meet the data rates. The IEEE 802.11ac standard will utilize channels of up to 160 MHz. As noted in the consultation, these wider channels will operate only in the 5 GHz frequency range.

Consumers are increasingly demanding faster connection speeds due to factors such as new applications or improved services. For example, wireless file transfers need to occur more quickly to meet user expectations in the corporate environment while residential use will include distribution of High Definition video. Similarly, wired connections speeds have increased to homes and offices creating a corresponding need for higher throughputs on Wi-Fi networks.

The importance of access to contiguous spectrum in the 5 GHz frequency range should not be underestimated, especially given the need for wider channels to enable greater connections speeds. If additional spectrum from 5350-5470 MHz and 5850-5925 MHz were made available for Wi-Fi use, this would provide contiguous spectrum from 5150 to 5925 MHz.

Access to this contiguous spectrum in 5 GHz would allow the implementation of a far more efficient band plan for wider bandwidth channels (including 160 MHz channels), thereby facilitating provision of higher data rates to users.

All these factors lead to a conclusion that additional spectrum for Wi-Fi will be required to assist cater for this demand and that the most suitable bands are5350-5470 and 5850-5925 MHz. Additionally, higher power use for short-range devices in 5725-5850 MHz is also important.

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?

Obviously 3G/LTE mobile devices used in an indoor environment require access to IMT frequencies. The majority of these devices also have Wi-Fi capabilities and utilize Wi-Fi for some applications.

As noted in the consultation, Wi-Fi at 60 GHz (IEEE 802.11ad) will increasingly have a part to play in distribution of content and access to high bandwidth content indoors since devices will be capable of offering more bandwidth than hardwired USB 3.0 connections. For indoor use, 60 GHz is most suitable for device-to device connectivity at multi-Gigabit throughput rates.

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

Consumer demand for outdoor Wi-Fi hotspot access e.g. cafes, airports and municipalities, is rapidly increasing as mobile smartphone and cloud computing become more mainstream. According to a market research study (MarketsandMarkets) the global market for this service will more than double over the next five years; “Outdoor Wi-Fi is expected to grow from $15.41 billion in 2013 to $37.2 billion in 2018, at a CAGR of 15.82% during this forecast period”. Intel believes that this will be predominantly at 2.4 GHz.

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?

Increased Wi-Fi deployments outdoors are likely to be at 2.4 GHz (less so at 5 GHz due to interference mitigation and lower transmit power constraints). We anticipate that development of automatic configuration/coordination techniques could further improve spectrum usage efficiency.

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?

The use of geolocation databases and cognitive technologies could assist additional applications including outdoor broadband access from mobile devices and machine to machine applications. However, the current approach to license-exempt spectrum has spurred widespread deployments and innovation. Intel is concerned that the proposed “new rules” could create barriers to spectrum access and innovation by license-exempt devices.

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?

Various spectrum sharing proposal options including -

- Licensed Shared Access (LSA); with an initial focus on 2.3 GHz band with future opportunities possibly within 3.4 – 4.2 GHz.
- Licence-Exempt Sharing e.g. Wi-Fi and 5 GHz radars and/or within 2.4 GHz ISM band

We note that priority should be given to frequency bands where there are economies of scale or harmonization benefits e.g. we suggest an initial focus on the 2.3 GHz band as this band has already been identified for IMT in the Radio Regulations and licenses assigned / services deployed. Similarly, as described above, for license-exempt spectrum the frequency bands best suited for Wi-Fi are in the 5 GHz range

2.3 GHz – Mobile Capacity Broadband

Intel supports efforts within CEPT to develop a regulatory framework enabling LSA in the 2.3 GHz band where Administrations are unable to release exclusive spectrum for mobile broadband. It is reasonable to assume this band is a candidate for geographical licensed shared access in some countries, as proposed by the EU Radio Spectrum Policy Group in its Opinion on spectrum for wireless broadband, published June 2013.

3.4-4.2 GHz – Smaller Cell Higher Capacity Broadband

Generally higher frequency bands are more suitable for smaller cell deployments. If sufficient spectrum is available these can help meet demand for more bandwidth hungry applications and services. In these instances geographical licensed shared access could enable access to otherwise unused spectrum capacity to help boost broadband performance. The EU Radio Spectrum Policy Group identified the 3.8-4.2 GHz as a candidate band for such sharing approach.

Intel is concerned if the intention was to restrict sharing to geographical sharing – meaning no sharing in time with basically just exclusion zones with 24/7 access. We believe that this approach would not realise the real benefits of “sharing” spectrum

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

Intel believes most commercial spectrum allocations should be made available in a forward-thinking, service-flexible and technology-neutral manner, and licensees should have the freedom to resolve interference issues. Intel supports the following policies in priority order -

1) **Clear spectrum for use on an exclusive licensed basis.** Wherever possible, government should implement voluntary mechanisms to clear commercial and government spectrum for high-value uses and technologies (e.g. commercial mobile broadband) on an exclusive licensed basis.
2) **Share spectrum on a licensed basis.** Where clearing is not possible, government should look for sharing opportunities between government users and commercial users on a licensed basis if wide area network use is feasible e.g. Licensed Shared Access (LSA) plus any dynamic derivatives of LSA.
3) **Share spectrum on an unlicensed basis.** Where wide area network service use of spectrum is not feasible on a shared licensed basis (e.g. 5 GHz band), government should look for sharing opportunities between Government users and commercial users on an unlicensed basis.

Intel sees LSA as a voluntary regulatory tool leveraging mutual commercial benefits of incumbents and LSA licensees. LSA can be useful where making spectrum available on an

exclusive licensed basis is difficult. We believe European Administrations should release or re-purpose spectrum for uses that bring greater social and economic benefits to Europe. Presumptively, cleared spectrum should be assigned on an exclusive licensed basis to enable efficient long range, wide area network (WAN) uses. That said, sharing spectrum on a LSA basis can be considered where clearing is not possible in a reasonable timeframe or is too costly, enabling European Administrations to look for sharing opportunities between incumbent users and new commercial users.

Enabling sharing on a licensed basis, i.e. LSA, will foster efficient market incentives for high quality of service as well as infrastructure and technology investment, and encourage voluntary, market-driven negotiations between the Government user and the commercial licensee to increase the value of the spectrum.

Intel's sees benefits from making more spectrum available for mobile broadband for Wi-Fi as well as IMT and there may be instances where releasing spectrum on an exclusive basis in difficult and where an LSA approach could be used.

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?

Intel believes that tiered services have a potential role in shared spectrum but it would depend on how much spectrum is available and how much demand there is for it i.e. if there was 50 MHz of spectrum that will more or less be fully utilized by two licensees, then we don't need a tiered structure. On the other hand, if there is not a high demand for licensed spectrum (could be because of incumbent restrictions or other factors) then, having a tier for LSA or unlicensed operation could be a option to consider.

Intel notes that while refarming spectrum for exclusively licensed mobile cellular usage is the preferred approach, as a way forward tiered shared access to a range of spectrum bands could be considered. Future applications and usage scenarios depend on the QoS which can be provided for the shared access models: High QoS levels may make the usage of tiered shared access possible for voice and critical data traffic; medium QoS levels may be sufficient for M2M applications and certain non-critical data traffic applications. Lower QoS levels may result in inefficient exploitation of spectrum since mobile operators are unlikely to invest in infrastructure.

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?

Yes but timescales need to be considered carefully. DSA could play a future role as it becomes more difficult to identify further spectrum opportunities for refarming or exclusive access however, DSA should be applied in combination with overall guarantees on spectrum availabilities – the actual frequency allocation may vary over time but the average / instantaneous capacity available to mobile broadband systems needs to be known or lower bounded otherwise investments by mobile operators may be limited.

DSA by theory could improve spectrum utilisation and help make additional spectrum available for use which is important in the lower frequency bands (<6GHz). The key is to develop a regulatory framework facilitating this process which could include (but not limited to) appropriate policies and sharing rules / frameworks while minimising additional costs of hardware.

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?

The sensing overhead in Mobile Devices needs to be minimised, e.g. through distributed sensing approaches. Ideally, each Mobile Device receives sensing requests that can be

implemented at very low cost in terms of power consumption, etc. An important factor about sensing is realising its physical limits and setting the sensing limits appropriately. Sensing limits need to be set realistically so it is feasible to detect the signals.

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

Intel's best guess would be 10-20 years from now.

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

Intel suggests that Ofcom could continue to show a leadership role within CEPT to drive development of a favourable regulatory framework to enable, indeed encourage, DSA.

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

No.

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?

TVWS and possibly 2.3 GHz may be of most interest for R&D purposes since they seem to be the current focus of Industry and Administrations at this point in time.

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?

Intel believes that using a geolocation database for short-term access to spectrum for R&D would be limited since we believe this is best addressed through bi-lateral negotiations with the incumbent and/or regulator.

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

Intel suggests that a light-weight process for obtaining temporary access to spectrum for research and development purposes, in particular for testing experimental systems e.g. LTE, and new approaches for spectrum sharing and other innovative spectrum access mechanisms.

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