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Wi-Fi Alliance Response to Ofcom Consultation: The Future Role of Spectrum Sharing

Wi-Fi Alliance is pleased to provide here our responses to the questions contained in the Ofcom Consultation entitled "The future role of spectrum sharing for mobile and wireless data services – Licensed sharing, Wi-Fi, and dynamic spectrum access".

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

Trends in Wi-Fi data connection speeds and capacity serve as a broad proxy for the overall wireless ecosystem: Wi-Fi currently carries the majority of wireless data traffic and is expected to continue to do so. Wi-Fi already carries the majority of IP traffic today, and also carries a substantial and increasing share of traffic from mobile devices. Wi-Fi technology advances such as IEEE802.11ac (Wi-Fi CERTIFIED ac), offering improved performance and increased data connection rates, and Miracast and Passpoint, which will expand and simplify user experience, are likely to drive Wi-Fi traffic growth even higher.

Wi-Fi data connection speeds have steadily increased from 2 Mbps (baseline IEEE802.11, 1993) to 11 Mbps (802.11b, 1999), 54 Mbps (802.11g, 2003), 300 Mbps (802.11n, 2009, typical maximum connection speed) to 1.3 Gbps (802.11ac, 2013, maximum connection speed in available products). For high-end systems, demand is expected to continue to grow in line with these historical trends: a conservative estimate is a 3X datarate increase over each 5-year period.

The great bulk of the growth in Wi-Fi devices is expected to come from the rapidly expanding segment of portable and mobile devices, characterized by ever-shrinking form factor constraints and stringent power consumption requirements. While such devices are not expected to require or even be able to process sustained transmission at the same very high data rates as high-end systems, they are anticipated to require very high *peak* data connection speeds. Especially within increasingly congested networks and in scenarios with many overlapping non-coordinated networks, where each device can gain only a diminished share of access to the medium, it will be essential to have the capability of correspondingly higher peak data connection speeds in order even to maintain application data rates

comparable to those experienced today, let alone enhanced data rates required by higher-resolution tablets, smartphones, and other portable devices. In addition, the availability of higher peak data rates has a positive effect on the critical factors of power consumption and battery life, via reduced contention for the medium and increased sleep time. It is anticipated that data connection speeds for mobile devices will continue to lag 3-4 years behind high-end devices, in a continuation of current trends; though this is more an estimate of probable 'supply' as the market is likely to absorb any available higher throughput solution that does not require greater size or power consumption.

In conclusion, Wi-Fi Alliance believes past trends are excellent predictors of future requirements. In the case of faster radios and higher throughput solutions, the market has continuously shown a highly elastic ability to quickly adopt and deploy.

2. ***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?***

Wi-Fi Alliance believes that an extension of the 5 GHz band will certainly be required. Over the next several years the 5 GHz band will become the primary band for Wi-Fi use: The 2.4 GHz band will continue to be fully utilized but has much less available capacity, the 60 GHz band will be used for specialized short-range applications, and the TV White Space bands will offer longer-range much lower data rate capabilities for dedicated applications such as Machine-to-Machine (M2M). Only the 5 GHz band can offer the data rates demanded by high-end wireless networking applications at the ranges that are an essential part of the Wi-Fi experience. Indeed, 802.11ac, the latest generation of Wi-Fi, operates exclusively in the 5 GHz band and will drive the industry migration to the primary utilization of these frequencies versus 2.4GHz.

Both 802.11n and 802.11ac achieved the great majority of their gains in maximum speed from a combination of multiple-input, multiple-output (MIMO) technology and increased channel bandwidth. However it is unlikely that further connection speed gains from expanded MIMO systems will be broadly viable: even for high-end systems, no configurations higher than 3x3 have achieved any noticeable commercial acceptance. Given that the bulk of market growth lies in portable and mobile devices, the trend is in the opposite direction: the stringent requirements of such devices will require operation with at most 2x2, and preferably 1x1, configurations for cost and power considerations.

This leaves increased channel bandwidth as the primary driver of higher data rates. 802.11ac defines optional 160 MHz channels (in addition to smaller channel widths), and it is possible that subsequent iterations of Wi-Fi will define even wider channels. However, at these channel widths, even the much wider available spectrum allocation at 5 GHz provides very few distinct channels.

3. ***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?***

Wi-Fi Alliance believes smart home, cellular offload and M2M applications will all benefit from the superior propagation characteristics of spectrum below 1 GHz. This remains true even if typical Wi-Fi throughput has to be sacrificed due to narrower channel bandwidths. IEEE802.11ah and 802.11af

amendments are developing the specification for these bands and incorporate many of the design elements from IEEE802.11ac. In that regard, it is possible that future products may support both 5GHz and these sub 1GHz channels for different applications, utilizing a unified underlying radio architecture.

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

As mobile Internet devices proliferate globally, the demand for outdoor Wi-Fi access will accelerate. This is particularly true as wireless and mobile operators continue to further integrate Wi-Fi offload into their portfolio of network services. As evidence, nearly half of the UK population owns a smartphone, and the adoption rate is increasing at over 20% per year. Nearly 130 million tablets were shipped in 2012 – a product category that didn't exist just a few years ago, and one in which over 90% of users prefer Wi-Fi access to mobile. In the US, cable operators have deployed nearly 200,000 access points through the Cable-WiFi alliance, a good portion of which provide outdoor access. In the UK, Virgin Media has blanketed the London Underground with Wi-Fi. The clear trend among consumers and network operators is toward ubiquitous Wi-Fi access. Advances in hotspot connectivity such as *Passpoint* developed by Wi-Fi Alliance will simplify network connection and seamless roaming across access points, which will further enhance the outdoor Wi-Fi experience.

IEEE802.11, earlier in 2013 initiated a new Study Group called "High Efficiency WLAN", or HEW for short, that will begin charting the path forward. HEW technology is expected to not only increase the raw throughput of Wi-Fi networks, but to also improve the overall efficiency of how data is sent over the air. This latter goal is particularly important as the number of access points continues to grow while the density or number of user devices in a particular area also increases. In particular, two massively dense outdoor usage scenarios have been identified as key areas for HEW to develop solutions:

- Hotspot in public places
    - Transportation Hub (Airport, Train Station, Bus Station)
    - Exhibition halls, Shopping malls
- Outdoor hotspots
    - Park, streets, stadium, special crowded events
    - Co-location with cellular base stations (small cell deployments) or user equipment (e.g. private mobile APs such as mobile routers) in dense zones

All of these wireless devices must compete for access to the available Wi-Fi channels so it is imperative that future Wi-Fi technology improves the user experience while also accounting for an ever increasing number of nearby devices.

In summary, the clear trends driving towards increased outdoor use of Wi-Fi are:

- Increasing integration of Wi-Fi with cellular services by operators in their mix of offerings.
- Wi-Fi offload as an operator/carrier load balancing strategy.
- Proliferation of mobile devices used both indoors and out.

5. ***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 coordinate access point performance be able to mitigate this risk?***

New technologies will enhance radio resource management and improve the quality of the user experience, particularly in outdoor environments where multiple access points may be present. For example, the IEEE802.11k amendment enables client devices to select the best available network from a range of environmental information. From a network perspective, this means that traffic will be more appropriately distributed across access points and channels, providing a more consistent user experience. In addition, signal optimization techniques such as beam-forming and dynamic power adaptation will also enhance the user experience.

As mentioned in Question 4, the IEEE802.11 HEW project intends to address issues of network capacity and efficiency, both indoors and out. New Wi-Fi technology, such as what is envisioned with HEW, will simplify and improve the quality of the user experience on Wi-Fi network. This will likely to cause data traffic to accelerate even further. That, in turn, will drive an even greater need for access to additional Wi-Fi spectrum.

6. ***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?***

Wi-Fi Alliance believes that methods can always be improved. Geo-location database access is just now seeing initial deployment, and all of the potential issues related to its rollout have not yet been observed. This is most critical in the area of outdoor deployments, where propagation and interference cannot be completely controlled, predicted or modeled. As these databases become more prevalent and more advanced, protection criteria and signal quality can be measured by location aware mobile devices, enabling the database to develop a dynamic picture of the RF environment, and enable optimized connections based on required quality of service. Devices contacting the database can provide information on their throughput requirements and their trajectory. Using this information, these databases can provide a best channel assessment, or even a suggested trajectory (routing based on required QoS) to allow the mobile device to maintain the needed connections. Beyond databases, further investigations of sensing technology continue.

9. ***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?***

Wi-Fi Alliance believes tiered services have a possible role in shared spectrum, however, the ability for such models to be useful for all stakeholders (suppliers, operators, consumers) would depend on amount of available spectrum and demand for the spectrum. For example, if there was small amount (assume 50 MHz) of spectrum that may be fully utilized by two licensees, this may not need a tiered structure since outside dynamic use would be severely limited. On the other hand, where there is less than high demand for licensed spectrum because of incumbent restrictions or other factors, then having tiers for LSA or unlicensed operation could be a viable option. Future applications and usage scenarios depend on the QoS for the shared access models: High QoS levels for voice and critical data traffic while 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.

In general, Tiered License Access should be a tool available for regulators, but the ability to utilize it does not lend itself uniformly across all markets and bands.

10. ***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?***

Wi-Fi Alliance believes that DSA can play a critical role in improving overall spectral efficiency, allowing improved quality of service, and removing barriers to spectrum access.

Dynamic sharing approaches improve spectral efficiency by freeing up spectrum that otherwise could not be used because it is occupied by incumbents in particular, possibly sporadic, locations or at intermittent times. In essence, DSA can allow policymakers to enable use of temporally and/or geographically vacant spectrum by flexible secondary users. Moreover, because dynamic sharing approaches do not require clearing incumbents or conducting complicated auctions, they can be implemented quickly. By bringing previously unavailable spectrum online, DSA can also reduce overall spectrum scarcity.

Where DSA approaches are accompanied by a license-exempt or a lightweight licensing framework, spectrum can be accessed relatively quickly and at low cost, reducing barriers to market entry.

However, timescales need to be considered carefully. DSA could play a role when it becomes more difficult to identify new or additional spectrum opportunities for re-farming or exclusive use. However, DSA should be applied with guarantees on spectrum availability if deployed in absence of any tier structure. The actual frequency allocation may vary over time but the average or instantaneous capacity

available to mobile broadband systems needs to be known or lower-end bounded. In the absence of such guarantees on spectrum availability for DSA deployment models, interest in and investments by mobile operators may be limited.

DSA, in theory, could improve spectrum utilization and help make additional spectrum available for use which is particularly important in the lower frequency bands (<6GHz). The key will be to develop a regulatory framework facilitating this process which could include (but not limited to) appropriate policies and sharing rules while minimizing additional hardware costs for the entire ecosystem.

11. 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 minimized and implemented at very low cost in terms of power consumption, etc. An important factor in sensing is realizing its physical limits, and then setting the sensing limits appropriately. Sensing limits need to be set realistically so it is feasible to detect the signals. Wi-Fi Alliance looks forward to continued advancements in this area.

12. Over what timescales could DSA become a mass market proposition?

Since DSA is a significant shift in usage model and requires alignment of numerous stakeholders, Wi-Fi Alliance believes it may take 3 to 10 years for it to be fully realized. Market development will depend on the availability of spectrum.

13. ***What role should Ofcom play, if any, to support the development of DSA and relevant technologies?***

Decisions on spectrum allocation will be hugely influential in the future development of new and innovative services. The WRC-15, and other spectrum allocation processes running in parallel are significant opportunities to maximize the potential value of spectrum assets for the benefit of consumers and wider economic growth.

The UK can use these opportunities to help deliver universal and affordable wireless broadband access in the long term – notably through the availability of licence-exempt spectrum. A licensed-only approach, or even a predominately licensed-only approach, to spectrum allocation is unlikely to address consumers' growing demands for wireless data services and applications. The dynamic use of unlicensed spectrum should therefore be a central component of any UK strategy for spectrum allocation.

The likely growth of mobile data traffic is well documented and has been previously referenced in our response to these questions. Ofcom acknowledges that, under different growth scenarios, mobile data capacity can be expected to experience an 80-300 fold increase by 2030. Ofcom also acknowledges that

half of this predicted increase in demand can be expected to be served by offloading mobile data onto fixed networks, including Wi-Fi networks[1].

The European Commission estimates that European Wi-Fi networks already carry up to 20 times more internet data traffic than all cellular networks combined, and Wi-Fi traffic growth is around 4-6 times that of cellular data growth, with 4 out of 5 new wireless technologies using unlicensed spectrum[2]. In the UK, Wi-Fi carries around 70% of smartphone data traffic, with many MNOs now either pushing data traffic onto third party Wi-Fi networks or deploying their own Wi-Fi networks[3].

As Ofcom studies have suggested, congestion and interference are already adversely affecting Wi-Fi performance[4]. Together with recent and forecast increases in data traffic, it is clear that a capacity crunch is looming. There will be an increasing need not only to satisfy demand for more licensed spectrum for data usage, but also to balance this by substantially increasing the amount of unlicensed spectrum available to meet the exponential growth of traffic expected over Wi-Fi for new diverse, innovative uses.

Ofcom is aware of trials which demonstrate that dynamic use of UHF spectrum (in TV 'white spaces') using geo-location database technology can fulfill a variety of innovative uses and support economic growth. These uses include enhanced Wi-Fi in home and for hot-spots, M2M communications and rural broadband. Such uses would prove significant in allowing spectrum users to meet the inexorable increase in consumers' mobile data demands.

Wi-Fi Alliance asserts the benefits of dynamic spectrum access technology should be a central component of the UK's position on the future spectrum requirements for mobile broadband. Given the continued growth of Wi-Fi and the role it will play in meeting mobile data demands, the UK should also support the increased availability of licence-exempt use.

Ofcom's consultation "TV White Spaces: Approach to coexistence" issued on 4th September 2013 is a welcome development which shows Ofcom is serious about supporting the development of Dynamic Spectrum Access. This support is consistent with Ofcom's duty to ensure efficient use of spectrum. Ofcom should continue to develop its strategy for future spectrum regulation to support the development of Dynamic Spectrum Access technology such that it can be deployed more widely in other frequency bands allowing the most flexible and efficient use of spectrum.

14. ***No position.***
15. ***No position.***

[1] Paragraphs 1.8, 1.10, 'Securing long-term benefits from scarce spectrum resources', Ofcom, March 2012. Available at: http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/summary/spectrum-condoc.pdf

[2] Presentation by Pearse O'Donohue, Head of Radio Spectrum Policy Unit, DG Infosoc, April 2012. Available at: http://www.cambridgewireless.co.uk/Presentation/CWS-EC_Pearse%20ODonohue.pdf.

[3] See the report by Richard Thanki "*The Economic Significance of Licence- Exempt Spectrum to the Future of the Internet*" (June 2012).

[4] See http://stakeholders.ofcom.org.uk/binaries/research/technology-research/wfiutilisation.pdf

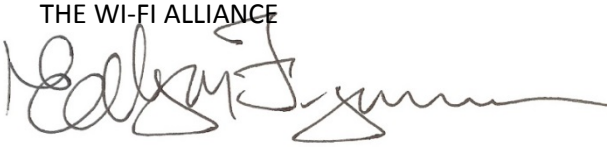
16. ***What are the potential benefits of using a geolocation database approach for short-term access to spectrum for R&D and how would you see this working from a practical perspective? Are there alternative approaches that could deliver similar benefits?***

Geo-location access is the only technically-proven means available today that could enable short-term access. This can be done in a number of ways, with a variety of intended results. For example, a license holder may encounter down time, and instead of it being a period of lost revenues, the licensee can rent the spectrum to someone with a temporary need such as for experimental use and a willingness to pay for it. A new licensee may want (or the licenser may require) to share spectrum during the network build-out period. For the most part, however, short-term spectrum availability will most probably act as a space for R&D, instead of attempting to operate commercially and ongoing in overloaded spectrum.

17. ***No position.***

Respectfully submitted

THE WI-FI ALLIANCE



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