Google's response to Ofcom's *Meeting future demand for mobile data* Discussion Paper

April 2022

Introduction

Google welcomes Ofcom's exercise of looking beyond the near term towards a ten to fifteen year demand-based analysis as the basis for its future spectrum strategy. It is encouraging to see Ofcom giving consideration to structural questions as to the mechanisms for spectrum allocation alongside demand-side considerations. In Google's experience, innovation and adoption of new technologies and services follows where spectrum frameworks are structured to promote those outcomes. Google supports a balanced approach between more traditional methods of spectrum allocation (i.e., exclusive licensing) and newer types of spectrum allocation (e.g., licence-exempt, spectrum sharing, and dynamic allocation). Each flavour of spectrum allocation holds promise for fostering new, innovative use cases. Success of any spectrum allocation scheme depends on capital intensive development and investment by an ecosystem of hardware and radio equipment suppliers, infrastructure investors and service providers, which must be channelled by a degree of regulatory signposting. To that end, forward-looking strategies such as the one Ofcom is embarking on are incredibly useful, and the overarching outcome Google advocates for in such exercises is the maximum degree of harmonisation with established global approaches to spectrum management possible. These are the conditions on which a balanced, innovative, and demand-responsive connectivity ecosystem is best served.

Google's stake in this debate cuts across our business. Our users and consumers rely on ubiquitous, high capacity connectivity, including over WiFi networks, to enjoy and make use of services such as YouTube, Search, Chrome browser, the Play Store, and gameplay on Stadia. As a manufacturer of smart devices including Pixel phones, Nest and Fitbit and an operator of the Android Operating system, we have a vested interest in developing interoperable radio frameworks to ensure that the connected device ecosystem offers a seamless and high-quality end user experience. As a provider of enterprise cloud services including edge connectivity solutions to a range of industry 4.0 customers in telecommunications, retail, manufacturing and hospitality, we see a need for very high capacity localised / edge networks to support innovative industrial and consumer experiences.

Those three principles - ubiquity, interoperability and innovation - summarise what we consider to be the core objectives driving the next phase of spectrum policy. This guides us to the following views on Ofcom's Discussion Paper:

1. Ofcom has been a leading regulator in the design of shared access models, and we are encouraged to see consideration of how spectrum sharing can be amplified in future. Sharing frameworks that balance the needs of a diverse connectivity ecosystem are essential to efficient spectrum management. **Google supports an ambitious sharing framework - structured around a "use it or share/lease it" model that fairly balances the investment and incentives of telecommunications operators and is designed to be as automated as possible, with limited bureaucratic overhead.**

2. Whilst we appreciate that discussion around the allocation of the 6Ghz upper band is for future consultation exercises, **Google encourages Ofcom to pursue a globally harmonised and balanced approach, which creates room in the upper band for innovative usage on unlicensed terms. If Ofcom deems it necessary to protect a portion of the upper band, it should do so on lightly licensed but not exclusive terms.**

3. Ofcom must be led by the evidence in relation to any perceived technological barriers to embracing a non-exclusive approach to 6Ghz. **In Google's view, the evidence of limited interference and emergence of new technologies to mitigate interference gives regulators the scope to apply highly efficient sharing and non-exclusivity frameworks to the 6Ghz band.**

4. Ofcom is right to begin this exercise with an assessment of demand trends and, on that basis, Google believes that demand for a high quality WiFi experience supporting a greater number of devices will continue to grow substantially over the next decade. **However, the innovative use cases that will absorb future capacity are not reliably predicted ahead of regulatory signposts. Our experience in cutting edge technology development and consumer adoption tells us that a vibrant ecosystem of innovation will follow where regulatory frameworks create space for them.**

The remainder of Google's response will be structured around three themes in the Discussion Paper: 1. Demand trends; 2. Spectral efficiency; 3. Protected use and shared access models.

Section One: Demand trends

Google agrees with Ofcom's Medium Growth scenario for outdoor/cellular network capacity growth to 2035: the most likely demand scenario for the period to 2035 is that the UK continues on its current trajectory of c.40% annual growth in mobile data consumption. We

see a number of compelling constraints on the high-growth scenario materialising, including device constraints (such as battery life) and end-to-end economic constraints, including the business model for investment in successive generations of mobile connectivity infrastructure to deliver national coverage.

In relation to WiFi, whilst WiFi offload for cellular remains stable at between 2 and 16% depending on MNO[1], there are a number of emerging factors and technological developments that support the view that overall WiFi traffic will substantially increase over the 2020s and early 2030s. As Ofcom notes, the present decade will see an exponential increase in the number of smart home devices and IoT devices deployed in industrial and commercial settings. Google expects WiFi to be the wireless connection of choice driving and absorbing this growth.

The rollout of next-generation WiFi6, which Cisco predicts will increase 13-fold between 2020 and 2023[2], will be a significant demand stimulant for WiFi for two reasons. Google has supported innovation in WiFi6 by being one of the first to market with WiFi6-compatible mobile devices the Pixel 6 and 6Pro. WiFi6 supports substantially more devices per access point than the previous generation of WiFi[3]. Additionally, WiFi6 is more efficient at managing bandwidth[4]. The combined effect of these factors is that WiFi bandwidth performance is expected to increase several fold over the coming years - Cisco predicts a global average WiFi connection speed of 91.6Mbps by 2023. With higher throughput capacity, new high capacity WiFi use cases are likely to emerge, particularly in the commercial and industrial sector.

5G provides traditional telco operators with opportunities to develop new value-added services, for example using the enterprise capabilities of 5G for IoT and private network deployments, which we anticipate will be a significant source of demand growth and collaborative innovation between telecoms operators and cloud/software vendors. Google Cloud and Omdia's most recent 5G-edge computing study of nearly 500 business and IT leaders[5] found that 7 out of 10 enterprises expect to have deployed some form of edge solution within the next 12 months. Edge deployments today vary across industries. At 50% adoption, retail shows the highest maturity amongst the businesses Google Cloud surveyed, whilst sports and entertainment presents the biggest immediate growth opportunity, with current adoption at 38%. Amongst the other sectors surveyed - healthcare, energy,

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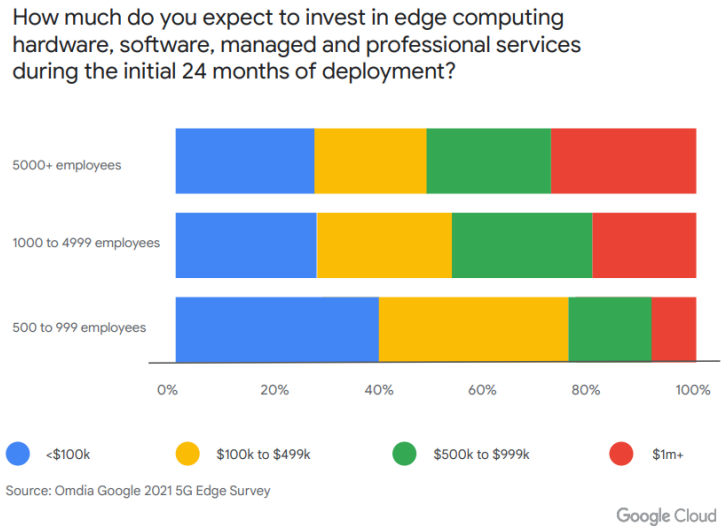
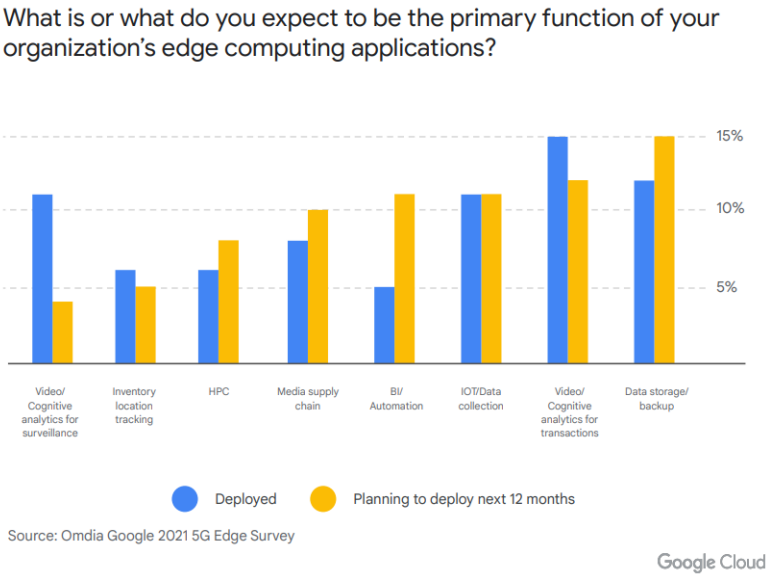
[1] Ofcom, Connected Nations 2021
https://www.ofcom.org.uk/__data/assets/pdf_file/0035/229688/connected-nations-2021-uk.pdf
[2] Cisco Annual Internet Report 2020
https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html
[3] https://www.ericsson.com/en/reports-and-papers/5g-and-wi-fi-path-toward-superior-indoor-connectivity
[4] Cisco Annual Internet Report 2020
[5] https://cloud.google.com/resources/telecom-5g-edge-enterprise-report

transportation and manufacturing - all displayed very similar levels of adoption today at 46-47%. We see evidence that demand will be driven by businesses of all sizes. Tellingly, mid-sized enterprises show relatively similar buying attitudes to large enterprises in terms of their willingness to invest $100k - $1m in edge solutions in their first two years of deployment.



We expect adoption to be primarily driven by real-time insights from cognitive analytics, in addition to data storage and site mirroring. Our customers tell us that business intelligence and automation deployments will see the biggest growth spike over the next 12 months - with growth rates of more than 100%.



The business improvements that customers most expect to drive through 5G edge deployments vary by sector but safety, efficiency and insight are consistently prioritised ahead of monetisation.

Case Study: Telstra/Marvel Stadium Augmented Reality

Deployment of augmented reality edge solutions offers a host of exciting use cases in the hospitality and live events sectors. Customers will seek enhanced live experiences on their smartphones such as watching events and replays from multiple camera angles, accessing positioning features such as seat/facilities finders and having access to integrated features that can be overlayed on top of live video. All of these experiences call for low latency and a high capacity 5G network that can accomodate tens of thousands of users simultaneously.

Google has partnered with Australian telco Telstra, Accenture and Marvel Stadium to develop a digital twin application based on Visual Positioning technology whereby images are captured by the consumer smartphone camera - and they are compared to a digital twin of the stadium (similar to Google Street View) and then used for enhanced consumer experiences. One example is a customer getting aid to find their seat. The digital twin requires higher bandwidth, and also lower latency of processing to properly utilize the data stream to adjust the customer experiences within expected response rates.

Ofcom identifies three strategies to meet medium rate data consumption growth: *a) Making more use of existing spectrum holdings by deploying these on current macro sites; b) Densifying networks by making use of mmWave spectrum on small cells; and c) Densifying networks by increasing the number of macro sites*. Google encourages Ofcom to also consider how future demand might be met by use of existing spectrum holdings via current and new sharing models. This will be expanded in the two sections below.

Section Two: Spectral Efficiency

As Ofcom notes, large amounts of low and mid-band spectrum have been allocated to mobile deployment on traditional, nationally licensed terms. Significant capacity for WiFi usage has also been made available on substantially more flexible and unlicensed terms. This balanced approach to spectrum allocation has fostered a rich wireless connectivity ecosystem where WiFi provides meaningful support to MNO deployments, extending and improving indoor coverage.

We support a continuation and deepening of this balanced approach as regulators open up new frequency bands that are suitable for a wide array of use cases. In the mid-band, lightly licensed and unlicensed bands supporting innovative use cases can coexist alongside licensed bands supporting wide-area coverage. Google understands the strength of demand from all comers for a substantial allocation of the 6Ghz band and acknowledges that Ofcom has already made the lower band (5925-6425 MHz) available on licence-exempt terms for uses

including WiFi. As Ofcom is aware, some of its counterparts amongst the leading national spectrum regulators - notably the US and South Korea - have gone somewhat further in the same direction, making substantially larger bands of 6Ghz available on unlicensed terms.

Whilst we appreciate this is largely a question for later consultation as Ofcom prepares its position for WRC 2023, Google takes this opportunity to state its position for opening the upper end of 6Ghz band to licence-exempt use. We support a harmonised approach to the greatest degree possible for the band. The steps Ofcom have already taken make inroads toward harmonisation. We believe the case for additional allocation of unlicensed spectrum in the upper 6Ghz band will stimulate considerable further innovation and alleviate pressures from the continual demand for WiFi in 2.4 and 5Ghz. The use cases that we can most confidently predict today will flourish under this allocation are WiFi, SmartHome and unlicensed industry 4.0 Cellular/IoT technologies at the edge. However, as noted, this is likely to be the tip of the iceberg in terms of innovation within the upper 6Ghz band.

As with lower bands, regulators should strive to achieve balance with an efficient mix of wide outdoor coverage and high capacity indoor coverage. 6Ghz offers the capacity to distribute resources across the full array of interests. We believe the most efficient, innovation-friendly approach is to make available a substantial band within the upper band on unlicensed terms. If Ofcom believes that part of the upper band should be protected, it could do so on protected/lightly licensed but not exclusive terms. In doing so, Google encourages regulators to ensure that relatively large contiguous bands are made available for particular use cases.

In regards to non-exclusivity, Google encourages regulators to follow the science. Interference can be managed highly efficiently in the 6Ghz band. The propagation properties of the band are such that a very high volume of use cases can be supported on a relatively small sliver of spectrum, because 6Ghz best supports highly localised deployments and generates negligible interference. Localised protected but not exclusive deployments could be conceptualised at the parameter of a factory, stadium, shopping centre, or park. Ofcom is also right to point to the advancements in network technology that has helped to minimise the risk of interference.

Section Three: Shared access models

Ofcom is recognised internationally for its innovation in dynamic shared access frameworks. The success of these leading efforts is evident in the 3.8-4.2 Shared Access model, which has seen considerable take up and a positive impact on competition in its short history. Ofcom is to be applauded for these efforts, which, in Google's view, are directionally indicative of where spectrum frameworks should evolve to in future. We welcome Ofcom's open-mindedness to a

variety of future sharing models including dynamic spectrum management and agree with the principle that higher bands of frequency and more localised deployments afford the greatest opportunity for sharing frameworks.

Whilst conceived as a solution to a very distinct challenge, the U.S CBRS model shares some of the intention and motivation of Ofcom's Shared Access framework. It is undeniably a more liberalised model in a couple of regards. Most significantly, it removes bureaucracy from the allocation of frequency entirely, utilising automated frequency controls. Ofcom's Shared Access scheme is, seemingly, very light on regulatory administration but it continues to envisage a role for Ofcom in the issuance of light licences. The CBRS adopts an automated allocation system operated by private entities (including Google), which, thus far, is proving to be a viable substitute for bureaucratic oversight. Google appreciates that CBRS originates from a distinctly U.S context - but directionally, we believe there are things that European regulators might take from the mechanics of that scheme. In particular, algorithmic allocation can serve as a substitute for a light licensing management system. The driving principle for shared/dynamic schemes should be minimisation of bureaucratic overhead, and we encourage Ofcom to continue stretching the European perception of what is acceptable in this regard.

Early indicators of CBRS's success should embolden regulators as to the outcomes that can be achieved through adoption of a variety of sharing models. It has proven successful in driving a democratisation of use cases including IoT, SmartAg, education, P2MP, and rural broadband rollout as well as supporting multiple business models (cable, MNO, WISPs). It has attracted substantial investment and unleashed competition. The 2020 nationwide auction of county licences resulted in $4.6BB for UST; and had over 200 winners, representing business models as diverse as the largest carriers, cable, energy, rural broadband providers, and large venues. By contrast, in the U.S. C-band auction there were only 21 successful bidders; the top three (AT&T, Verizon, and T-Mobile) accounted for over 96% of the revenue, and acquired over 92% of the licences.

Given the abundance of existing spectrum allocated to mobile, there is some evidence to demonstrate that a significant proportion of the spectrum in circulation today is going under-utilised. Spectrum occupancy measurements show > 80% of spectrum is unused, even below 3 GHz and even in urban areas. When real-world utilisation is considered, spectrum is not actually scarce. Increasing the use of sharing techniques to improve rates of spectrum utilisation will make more spectrum resources available and help solve the problem of false scarcity.

It is imperative to achieving spectral efficiency that national regulators create the right incentives for MNOs to free up unused capacity for other productive uses. Whilst the market is best placed to ultimately determine efficient deployment of spectral resources, and Google believes that the best outcomes for *'use it or share/lease it'* models will be driven by commercial negotiation, there is a role for the regulator in setting the fairness parameters within which such a negotiation can take place. This will include the triggers for making unused spectrum available to the market - i.e. under what conditions spectrum passes from *use it* to *share it* - and the principles of fairness that should guide the negotiation - e.g. fair and non-discriminatory terms.

Google is optimistic that the right balance of incentives can be found across all stakeholders to achieve consensus on a widely adopted sharing model. Whilst the devil will invariably lie in the detail of these schemes, Google notes that there is some principled agreement between national carriers and innovative users of spectrum with regards to the role of sharing and leasing as a matter of principle and mutual value[6]. Taking the example of edge deployments, from an economic standpoint we expect that telecommunications operators will view it as highly beneficial that private localised networks can be deployed by a variety of other investors, removing their need to invest capital in remote infrastructure buildout to areas such as industrial estates and agricultural business sites. Ofcom's innovation in the mmWave band, making available 26Ghz frequency under the Shared Access scheme for private or localised networks is directionally indicative of where Google sees opportunity for innovation (albeit we reserve some doubts about how scalable solutions in the 26Ghz band will be). The advantages of creating a more vibrant ecosystem at the network edge will unlock a multitude of benefits.

Google Distributed Cloud Edge extends our compute infrastructure to the customer's edge. GDCE ensures that the customer can have the data processing capabilities it needs at the edge, but in a heterogeneous environment. This solution brings Google AI and Analytics tools closer to the point where data is being collected, so that analysis can take place in real-time. Customers can run cloud native private 5G/LTE networks on GDCE provided by our operator partners, and as such, meet stringent latency and reliability requirements. Moving data to the edge unlocks a wide range of opportunities for innovation in the adoption of real-time

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[6] *See, e.g.,* GSMA, *5G Spectrum, GSMA Public Policy Position*, Mar. 2021, at 6, 7 https://www.gsma.com/spectrum/wp-content/uploads/2021/04/5G-Spectrum-Positions.pdf acknowledging that unlicensed spectrum "plays an important role for Wi-Fi, including for mobile network offload"; that "[s]pectrum sharing and unlicensed spectrum can play a complementary role"; and that "[r]egulators can adopt licence conditions and obligations to incentivise operators either to use their spectrum or make it available to others where it will not be used or will not be used in a reasonable timeframe").

analytics and cutting edge consumer-facing deployments[7]. Retailers can, for example, build enriched in-store visual experiences streaming directly from the network. Manufacturers can run advanced AI-based visual inspections directly from 5G-enabled devices without the need for local processing power, helping reduce cost, and the need for on-site space. Allowing private networks to be built and operated independently (but interoperably) with telecommunications networks could enable a network to be sold on a modular basis, with additional capabilities built-in to the technology stack at the edge than has been traditionally enabled by end to end fixed telecommunications deployment. Moreover, this has the potential to herald new competitive dynamics in the market, with a more diverse set of network builders and owners.

On the theme of diversification, Google registers its support for Open RAN. Open, interoperable RAN interfaces and architecture broaden the supply base for network equipment, reduce deployment costs, and allow for technologies, such as Machine Learning, AI and advanced security technologies, to be used for network management. ORAN allows for much greater flexibility in terms of network deployment and deployment at scale using cloud, which will be essential to 5G deployments. Indeed, there is a symbiosis to be realised in the enablement of a more diverse ecosystem of edge private networks and a more diverse radio equipment supply chain. With the right sharing model in place, a diverse set of network deployers without legacy technology constraints on their network design options will offer a richer marketplace of potential customers for radio equipment suppliers to compete over.

Conclusion

A balanced, market-led approach to spectral allocation is critical to achieving efficiency. Regulators should look to create frameworks that prioritise the co-existence of lightly licensed/unlicensed, protected but non-exclusive and exclusive models. Ofcom's action in making significant unlicensed spectrum available for WiFi and establishing sharing mechanisms has demonstrated a forward thinking attitude. In Google's opinion, the next phase of spectrum management demands a doubling down of this approach. We encourage the development of a more holistic sharing framework, which is light on bureaucratic overheads and preserves fair incentives for participation by telecommunications operators.

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7 https://cloud.google.com/blog/topics/anthos/anthos-for-telecom-puts-google-cloud-partners-apps-at-the-edge