IT'S HOW WE CONNECT

Submission to the Australian Communications and Media Authority

5G and Mobile Network Developments - Emerging Issues Occasional Paper

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Contents

1 Executive Summary

Telstra welcomes the opportunity to comment on the ACMA's "5G and Mobile Network Developments - Emerging Issues" Occasional Paper. Telstra has previously noted that mobile broadband is playing an increasingly important role in enabling technology and innovation for the future productivity and competitiveness of the Australian economy,[1] and this ACMA paper is a timely contribution to the direction setting for fifth generation (5G) mobile networks.

Like previous mobile network evolutions from 1G to 4G, fifth generation networks promise to enable a raft of innovative new products and services for both consumers and businesses. Telstra's customers are seeking faster speeds, more coverage and smarter devices as they become increasingly dependent on applications delivered via mobile broadband for their business and personal activities.

General Observations

Telstra observes that there are some limitations and qualifications that need to be considered when referring to the GSMA Intelligence's seven characteristics of 5G networks. Consideration needs to be given to how characteristics such as round-trip delay will be measured to ensure consistency in their use. Further, consideration should be given to Direct Air to Ground Communication.

It is critical that lead times associated with the identification and reallocation of frequency bands for 5G networks are understood, and that the ACMA proactively identifies and allocates spectrum to comply with statutory obligations and to provide sufficient lead time for legacy users to clear that spectrum ahead of the likely launch of 5G networks by 2020.

Are there additional demand drivers supporting 5G network deployment in Australia not identified in this paper?

An additional demand driver exists in the unit cost reduction anticipated in 5G networks. Whilst this may appear a better fit to the enabler category, we note that there is a long history of unit cost reduction giving rise to new applications and products that did not previously exist (e.g., streaming IPTV to mobile devices), thereby creating entirely new categories of demand.

Are there any additional significant enablers or major inhibitors to 5G network deployment in Australia that are not identified in this paper?

Concerning technological enablers for the development of 5G networks in Australia, Telstra suggests there is a need:

- for an early allocation of additional frequency bands below 24 GHz for use in 5G networks;
- to introduce duplex options (FDD/TDD/Downlink only) in respect of the various frequency bands; and
- to consider technical standards associated with use of D2D repeaters to resolve possible issues such as interference.

Are there additional regulatory issues around 5G network deployment, relevant to the ACMA's responsibilities, which are not discussed in this paper?

Telstra recommends that Industry Code c564:2011 be updated to remove procedural burdens in relation to small site deployment.

[1] Telstra's submission to the ACMA's "*Beyond 2020 - A spectrum management strategy to address the growth in mobile broadband capacity*". 23 October 2015.

2 General observations

2.1. GSMA Intelligence's Characteristic for 5G #2 – End-to-end round trip latency

In Use Case 4, the ACMA cites ultra-low latency as one of the 5G characteristics that will support vertical industries such as remote surgery and driverless cars. Telstra observes that measurement of round trip latency will be highly sensitive to a number of aspects including the conceptual (not geographic) location of the end-points where the measurement is taken, packet size and error/re-transmit rate. In order to achieve consistency in the measurement of round-trip delay and to avoid false claims about network capabilities, further standardisation work may be needed to define a set of metrics for the purpose of consistent round-trip delay characterisation and market claims.

John Garcia et al from Karlstad University, Sweden[2] observes that "...*different delay metrics can give markedly different results, indicating the importance of careful metric selection and employing multiple metrics for verification*". The FCC in August 2015[3] as part of its annual assessment of U.S. broadband deployment is considering whether latency / round-trip delay measurement standards should be developed for Mobile Broadband: "*We also seek comment on the specific latency standard, if any, that the Commission should adopt*." The 2016 Broadband Progress Report[4] (the output of the inquiry) finds that "*the current record is insufficient to set an appropriate speed benchmark for mobile services*" showing that they have not identified a metric for measuring mobile broadband performance.

If measurement of round-trip delay is to be performed in a meaningful way to verify <1ms round-trip delay, then standardisation work needs to occur to define a set of metrics to ensure consistent round-trip delay measurement. This work should be done in conjunction with other standards organisations globally.

2.2. GSMA Intelligence's Characteristic for 5G #5 and Use Case 6 – Coverage "Everywhere"

Telstra observes that international standardisation in the Direct Air to Ground Communications (DA2GC) is nascent at best and requires urgent attention if the GSMA Intelligence's fifth characteristic of coverage "everywhere" is to be realised. ITU-R report M.2282[5] (Dec 2013) reports on a number of test flights trialling Broadband DA2GC in different regions covering 2 GHz and 5 GHz frequency bands and references ETSI and CEPT work in this space. In October 2015, the 3GPP Technical Specification Group for Service and System Aspects (TSG-SA) Working Group 1 defined a new use case[6] for DA2GC. Outside this, little or no work has occurred towards identifying spectrum or standards for use for DA2GC.

Telstra considers that standardisation work needs to be undertaken to define both spectrum parameters and other technical considerations such as the impact of Doppler frequency shifting on DA2GC design.

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2 Johan Garcia, Stefan Alfredsson, Anna Brunstrom. Delay Metrics and Delay Characteristics: A Study of Four Swedish HSDPA+ and LTE Networks. http://irtf.org/raim-2015-papers/raim-2015-paper28.pdf

3 Federal Communications Commission. Eleventh Broadband Progress Notice of Inquiry, 7 August 2015. Paragraph 39, Pg 16. https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-101A1.pdf

4 Federal Communications Commission. 2016 Broadband Progress Report. https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2016-broadband-progress-report

5 ITU-R M.2282 (2013). Systems for public mobile communications with aircraft. December 2013. https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2282-2013-PDF-E.pdf

6 3GPP TSG-SA WG1 Meeting #71. Use Case and Requirements for Broadband Direct Air to Ground Communications (DA2GC). 19-21 October 2015, Vancouver. http://www.3gpp.org/ftp/tsg_sa/WG1_Serv/TSGS1_71_Belgrade/Docs/S1-152006.zip

2.3. WRC-19 and Commercial 5G Availability in 2020

The ACMA's continuing support for mobile broadband in Australia and at international forums such as APT, ITU and the recent WRC is acknowledged. However, a greater sense of urgency is needed in identifying and allocating frequency bands to be used for future 5G networks. The ACMA has noted that Australian mobile operators have made public commitments to make commercial 5G networks available by 2020 (page 5). The ACMA has also noted the agenda item (1.13) approved for WRC-19 "*to study the possibility of additional identifications for IMT in specific bands between 24.25 and 86 GHz*" (page 19).

Telstra is concerned that the long lead times associated with the identification and allocation of frequency bands for 5G networks will mean that the necessary frequency bands are unlikely to become available for deployment in time for commercial launches in 2020 if national planning activities were to simply await the outcomes of the WRC-19.

Telstra urges the ACMA to take a proactive role in identifying the preferred bands for 5G in the national context, and to commence actively promoting these preferred bands both in the Task Group 5/1 and relevant APT forums.

2.4. Advance Planning

Telstra notes that where spectrum bands are to be re-allocated, there is a minimum statutory period under Part 3.6 of the *Radiocommunications Act 1992* of two years for clearance of legacy systems, with clearance/relocation costs borne by relevant incumbent licensees. This infers that planning decisions to facilitate launching 5G services by 2020 would need to be made by early-2018 at latest, to accommodate statutory re-allocation procedures and any marketing preparations. While most of the ITU-R study work (under TG 5/1) may be nearing completion around that time, the final report text is unlikely to emerge until later in 2018. This means that launching of 5G services by 2020 needs close co-ordination, co-operation and transparency by both industry and the ACMA.

3 Invitation to Comment #1

Are there additional demand drivers supporting 5G network deployment in Australia not identified in this paper?

3.1. Unit Cost Reduction as a Demand Driver

Research by the ACMA[7] over the last several years confirms trends and industry forecasts of the anticipated increase in user demand and the data volumes to be carried by mobile networks. To meet this demand, advances in wireless access technology will be a major factor in ensuring that public wireless networks can supply sufficient capacity at a cost that the community deems acceptable.

The ability of competing service providers to leverage technological advances to reduce the costs to deliver/receive a unit of data within a given geographic coverage area has been a key driver for the deployment of fourth generation (4G) mobile services and applications. This unit cost reduction has in turn driven the creation of new applications and products that did not previously exist (e.g., streaming IPTV), thereby creating new demand categories in the mobile space. Unit cost reduction will continue to be a key driver for innovation of services and applications in the 5G network era.

Thus, the unit cost reduction anticipated in 5G networks will be a demand driver in its own right, giving rise to new applications, services and possible new demand categories not even invented today.

[7] ACMA. Communications Report, 2014-15. http://www.acma.gov.au/theACMA/Library/Corporate-library/Corporate-publications/communications-report-2014-15

4 Invitation to Comment #2

Are there any additional significant enablers or major inhibitors to 5G network deployment in Australia that are not identified in this paper?

Telstra offers three observations: the first related to low-frequency spectrum bands to support 5G networks; the second covering the use of FDD, TDD and Downlink-Only on specific bands to ensure efficient use of spectrum; and the last on the use and control of D2D communications.

4.1. Low Frequency Spectrum Bands to Support 5G Networks

There was considerable contention at the recent WRC-15 regarding which bands should be studied for possible future 5G usage. Several industry sectors sought to pre-empt the usual ITU-R study process by removing certain frequency bands from consideration rather than risk exposing under-utilisation and potential sharing scenarios. As a result, a notably truncated list of bands to be studied has emerged from WRC-15, and which includes no bands below 24.25 GHz.

However, many telecommunications network operators (including Telstra) are concerned that administrations, having to manage the balance between protecting incumbent radiofrequency systems and facilitating the emerging broadband economy, have inadvertently overlooked the need to cost-effectively deliver 5G to regional and rural communities, along with urban areas. Coverage of regional and rural areas will inevitably require the use of bands below 24 GHz – involving both progressive re-allocation/restructuring of existing mobile bands, as well as re-allocating/re-purposing of other bands. Moreover, the bands 5925-7145 MHz, 10-10.6 GHz and 14.3-15.35 GHz had widespread support prior to WRC-15, and continue to be discussed in various global industry forums. Therefore, we believe that these bands should be the subject of sharing studies at a national level.

In Telstra's view, quarantining some bands from studies is not a legitimate means of maximising the derivable community benefits of Australia's limited radio spectrum resources. There has been a loss of confidence in the ITU-R process after the WRC-15 outcome, as evidenced by the international support for recently published FCC comments and observations. Telstra strongly encourages the ACMA to address the absence of low-band 5G spectrum by working with national and international standards organisations, carriers and other relevant stakeholders to allocate frequency bands below 24 GHz for use in 5G networks.

4.2. Use of FDD, TDD and Downlink-only Frequencies to Ensure Efficient Spectrum Use

5G is expected to use a variety of physical layers (PHY) depending on the carrier frequency, deployment scenario and target applications. The requirements for long range, machine-to-machine applications are very different to those for high-speed broadband access and it is expected that a number of PHY specifications will be created within the 5G framework to suit.

One dimension in which 5G PHY solutions will vary is their duplex scheme, whether FDD or TDD, downlink-only for the purposes of broadcast or carrier aggregation (CA), full duplex, and in the case of TDD, whether the switch-point is fixed (as with existing 4G LTE) or dynamic per user, cell, or cluster.

Telstra anticipates that a variety of spectrum with different pairing options will need to be available for 5G deployments, with some paired FDD arrangements in conventional mobile access frequencies (e.g. below 3 GHz) and unpaired TDD arrangements at higher frequencies.

TDD duplex systems have several advantages for mm-wave frequency bands. Due to channel reciprocity complexities, the use of TDD can simplify estimation for dynamic beam steering, massive MIMO, and other next generation techniques expected to form part of the suite of 5G technologies. Existing demonstration access systems operating in this spectrum are based on a TDD framework, and

Telstra expects the focus on TDD arrangements to remain the case for mm-wave bands as standards develop and commercial products become available.

Moreover, it is anticipated that 5G millimetre-wave systems will also include dynamic UL / DL switchpoints, to ensure maximal use of spectrum and allow on-demand allocation of UL resources in particular, which are otherwise sometimes under-utilised in previous generation systems. In some cases, this may result in "TDD" spectrum which is in fact rarely used for uplink transmission at all, and behaves more like a Downlink-only CA carrier. In general, we would not like any encumbrances placed on spectrum to prevent its usage in this dynamic fashion, and the deployment flexibility to run downlink only carriers in typically "TDD" spectrum.

We expect automatic coordination between sites operating on the same frequency under the control of a single operator to reduce interference and ensure efficient spectrum use in this situation, but there may be coordination issues between spectrum license holders operating in adjacent areas or, depending on how millimetre-wave spectrum is licensed, within the same area. This will be alleviated somewhat through the use of beamforming and smaller cells at lower powers, but is a factor that needs consideration as the licensing scheme for new spectrum is developed.

Related to this, another promising technology within scope for 5G is full-duplex radio, where local interference cancellation allows full re-use of spectrum in the uplink and downlink. This could be particularly applicable to "self backhauling" small cells, and may similarly complicate coordination between spectrum users and sites which are sharing spectrum in the same or adjacent regions on a nominally TDD basis.

Finally, while it appears that systems operating in millimetre-wave spectrum will be predominantly TDD based, there will still be a need to allocate new spectrum resource in more conventional frequencies for 5G systems. At lower frequencies, where beamforming, massive MIMO and other innovation is less applicable, FDD spectrum may still be preferable - in particular to take advantage of the improved link budget that can result.

4.3. Use and Control of D2D in 5G Networks

While initially prompted by the needs of public safety and other government agencies and utilities, device-to-device (D2D) communications functionality may offer benefits for the wider wireless broadband market, and may require consideration within technical specifications to avoid undesirable and unforseen implications.

The device-to-device functionality typically offers advantages to users in circumstances beyond the coverage reach of a host network (e.g., in remote areas, or basements/underground), or in the event of local network failure (e.g., base station failure). Where a local base station has lost connection to the wider network (isolated node), a further variant often referred to as 'local mode' may also emerge to offer benefits – similar to the use of mobile/transportable repeaters by emergency services.

These D2D functions are likely to be launched, at least for public safety applications, within the next year or so – and are thus also expected to become a standard feature of 5G systems.

However, as D2D functionality becomes available, there may be need to resolve technical issues within 5G technical specifications such as unduly high emission levels that could otherwise disrupt network-based communications by other users. Telstra notes that international standards bodies such as 3GPP will also be working to resolve such issues, and it will be important for Australia to work and align with such bodies.

5 Invitation to Comment #3

Are there additional regulatory issues around 5G network deployment, relevant to the ACMA's responsibilities, which are not discussed in this paper?

5.1. Regulatory Requirements to support Network Cell Density

The deployment of 5G systems based on millimetre-wave spectrum bands will support much wider bandwidths and higher end-user bit rates. But, despite the use of new (massive-MIMO) antenna technology, these higher frequency bands will also inherently involve shorter propagation range and smaller cell coverage footprints. This will likely mean a large number of smaller, low power base-stations (micro/pico-cells), deployed in an unobtrusive manner in conjunction with existing infrastructure (e.g., existing buildings) without the need for new dedicated towers.

The arrival of 5G is likely to lead to renewed community dialogue on issues such as aesthetics, health, property values along with renewed consideration for issues including site access/sharing obligations.

Telstra recommends that consideration be given to the appropriate design, notification and consultation requirements under the Mobile Phone Base Station Deployment Code (c564:2011) at the next scheduled review of the Code in 2017, to ensure that these continue to be fit for purpose for 5G network deployments.