All change: how 5G will shake up spectrum management

Ian Corden and Tim Miller

Although the technology underpinning 5G is still in development, it is likely to offer additional capacity and efficiency in the radio access network much as preceding generations have. However, with ever-growing traffic demand, challenging competition, and the rise of OTT services, operators are finding it increasingly difficult to sustain healthy business margins. There is uncertainty therefore over how viable the business case for 5G will be, without the types of new services introduced by 3G or the cost savings brought about by LTE. To enable commercial success, 5G will need to be more than just an incremental upgrade; we envisage a mesh of interconnected technologies driving a new digital services ecosystem. Understanding how these technologies will interact will depend on a clear picture of trends in traffic growth – not just in aggregate, but looking at each service and its requirements separately.

What is 5G, really?

Plum's recent work in South East Asia has included a review of the developing 5G space and how it will affect the telecommunications industry. We have found that, as with the development of any new technology, myriad opinions exist as to how 5G may ultimately present to market. With the benefit of experience, however, it is possible to review industry developments, cut through hype, and raise informed views.

Previous generations of mobile technology have offered incremental performance in the radio access network (capacity gains via improved spectral efficiency) and improvements in the core architecture (such as IP multimedia sub-system and all-IP routing). These have enabled, along with proliferation of smartphone technology, a strong growth in mobile digital and over-the-top (OTT) services. On average, measured in equivalent terms, successive releases of UMTS and LTE radio access network technologies have brought around a doubling in spectral efficiency performance every few years, driven principally by advances in digital modulation and coding methods and antenna technologies.

In the march towards 5G, we do expect some further improvements in spectral efficiency, based on similar drivers as with previous technologies. However, it is important to note that at the physical level, radio systems engineering is beginning to approach physical limits on performance (for example, the Shannon-Hartley theorem sets a maximum rate that can be achieved due to noise). Whilst advanced antenna systems such as multi-user (MU) MIMO may offer some incremental benefits, these are likely to be tempered by the need for significant complexity increases in system architecture which have the potential to affect network costs.

Overall, whilst we expect another rise in spectral efficiency performance for 5G radio systems of around a factor of two, relative to LTE-Advanced (3GPP Release 10), it is likely that we are approaching the beginning of the end for ever more efficient radio systems. Further, with the need for antenna system changes, 5G networks are likely to require hardware replacements; 5G is likely, therefore, to require yet another round of major capital investment.

This need for extensive capital expenditure, not resulting in decreased operating cost, suggests that 5G and subsequent systems must involve higher levels of system interworking than have been seen previously and that traditional mobile business cases are called into question. Such ideas are only just developing across the industry.

There are several key technology areas being considered in the move towards 5G. We have assessed potential scale for performance improvement and direct impact on spectrum management; our analysis (normalised over 5 MHz bandwidth) is shown in Figure 1. Whilst it is reasonable to expect some material improvement in spectral efficiency and therefore capacity coverage with 5G systems, the rate of growth in traffic demand poses challenges towards the sustaining of healthy margins for mobile network operators (MNOs) in the traditional sense.

How is demand developing?

During the early days in development of 3G technologies, the telecommunications industry was expectant in the potential for 'the mobile Internet' and rapid growth in data traffic. However, with the rise of OTT players, MNOs have experienced a level of disintermediation, meaning they have not fully realised the benefits of this growth. With declining revenues in legacy services (particularly voice and SMS), significant competition in bitstream services, and OTT innovation, many MNOs are beginning to face

Figure 1: Technology assessment

Physical layer 1	MIMO antennas	Millimetric frequency bands	Heterogeneous networks and sharing	Machine to machine (M2M) communications	SDN/NFV & network slicing
Spectral efficiency improved: Technology improvements at the radio physical level +20-30% (OFDMA, 256-QAM, 8 x 8 MIMO) Technology improvements in the antenna system +70-80% (32Tx x 2Rx MU FD-MIMO) Potential to raise revenues from new services (e.g. high capacity)		Use of high frequency bands (e.g. c. 30 GHz) for communications Access to high bandwidth / lower cost spectrum No spectral efficiency gain	Integration of multiple networking technologies, plus asset and spectrum sharing Shared spectrum & interworking Potential to raise revenues in indoor / dense urban increased for cellular operators	Also referred to as internet of things (IoT); technology enabling direct communications between machine entities System designed for low capacity dense coverage Potential to raise revenues from new services (M2M)	Use of commodity hardware platforms Dynamic network configuration + c. 20%-30% cost advantage Time to revenue enhanced from months to weeks or days

challenges in terms of profit margins. Therefore, the sustainability of the 'traditional' MNO business model is unclear.

Spectral efficiency is a key driver in defining the costs of networks. With mobile traffic growth at around 50% per year, it is only a matter of time, even with 5G efficiency enhancements, before the traditional mobile business case breaks. Therefore, 5G will need to offer more than traditional improvements in radio efficiency; for an attractive business case to unfold, we believe that 5G will need to enable new services across an interconnected mesh of different technologies. Meshing will afford greater optimality in the deployment of technologies and further enable innovative new services for MNOs, such as microlocation enabled advertising, or context specific content access. It is these new services, attracting new revenues, which will truly make the business case for 5G.

The impact of 5G on spectrum management

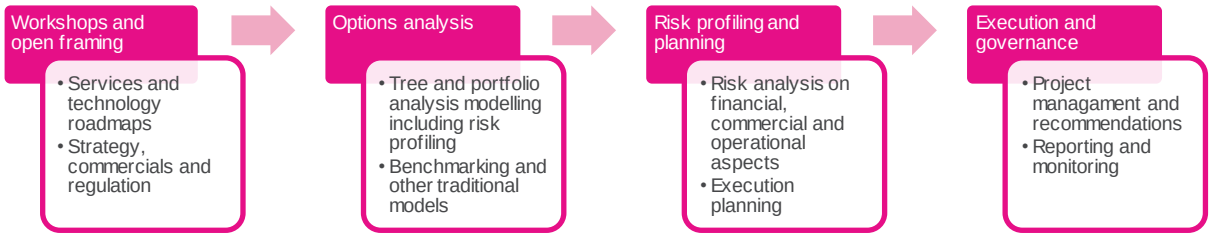
With 5G evolving as a mesh of technologies and the potential for dynamic and varied use of spectrum, traditional forms for spectrum allocation and valuation will be called into question. Therefore in developing commercial plans towards spectrum, it will be essential, to call upon deep and extensive industry expertise and apply sound judgement.

Given the likely mix of technologies, it is important that spectrum allocation is carried out in a holistic way. Concepts such as licensed shared access (LSA), license assisted access (LAA), and LTE WiFi link aggregation (LWA), which allow interworking between technologies, will be increasingly important and must be taken into account by regulators. Further, it is important that plans are drawn up to enable 5G to use a number of different bands, from UHF to millimetre wave, as well as refarming of existing mobile spectrum. While further clarification on bands for 5G will be issued at WRC-19, this may be too late for many operators.

The uncertainty around the business case for 5G has significant impacts on the value of spectrum. Although spectrum fees increased significantly in the early days of LTE, there is unlikely to be such a rise with spectrum awarded for 5G. Regulators and governments will need to exercise caution on setting reserve prices or lump sum payments to ensure they do not discourage investment in the new technologies. Ineffective allocation and utilisation of spectrum presents risks as potential lost opportunities and misalignments in capital deployment and attainment of social value.

Rather than relying on traditional spectrum valuation methods which would struggle with the movement to disaggregated demand across services and new technology infrastructures, Plum is developing an options-based framework to spectrum management in the 5G ecosystem as shown in Figure 2 below. By recognising potential changes in both revenues and costs, the model will reflect dynamic market conditions with new services and choices of networks. Operators and regulators will need to follow this framework to maximise benefits of 5G.

Figure 2: A new framework for spectrum valuation



Ian Corden has extensive experience working within mobile operators on the introduction of new technologies and their impacts on the business case, and Tim Miller has advised operators and regulators worldwide on spectrum valuation issues and how these are impacted by the growth of the industry.

Contact ian.corden@plumconsulting.co.uk, +44 7399 581978 or tim.miller@plumconsulting.co.uk, +44 7904 971056