Ofcom consultation on spectrum sharing.

Neul Ltd, November 2013

Question 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?*

We think that M2M terminals will in majority be located indoor or in difficult to reach locations. The implication being that deploying a M2M wide area network will likely require sub GHz spectrum to benefit from the propagation characteristics at those frequencies. The selection of carrier frequency is a trade-off between:

- RF propagation characteristics, which favours lower frequencies
- Noise floor, which favours higher frequencies (due, for example, to higher man-made noise at lower frequencies)
- Terminal antenna size, which favours higher frequencies and lower fractional bandwidth.

Question 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?*

We think that operating a M2M service in licensed exempt spectrum is viable only if a level of quality of service can be provided. We think that duty cycle or listen before talk methods are insufficient to reach that goal. We think that coordinating between users by using time and frequency division is viable provided that:

- There is a sufficient minimum resource allocation that an adequate baseline quality of service can be maintained for a deployment. This means that there is a limited number of networks operating in the allocated bandwidth.
- The time slot allocations are at least 2 secs in duration such that they are compatible with the very low data rate modulation schemes that may be used in M2M systems
- The frequency allocations each have sufficient bandwidth to provide enough capacity for a single base station, so at least 50 kHz
- Changes in the allocations of time slots between systems should be infrequent under normal circumstances and should be advertised well in advance (perhaps by at least

15 mins, so on the same order as White Space database changes). This allows the managed re-scheduling of terminals, and so minimises wasted terminal energy.

Question 7: *Which frequency bands are most likely to be best suited to providing geographical shared access, including via a geo-location database approach, for use by mobile broadband, for example small cells and M2M applications?*

M2M terminals will have to be integrated in a variety of products for which the antenna size is a critical factor to determine the viability of the solution. Many applications will require antenna sizes below 4x4 cm. Although MEMS tuneable antennas are being used in mobile phones, the cost point of the tuning circuit itself today is not appropriate for M2M applications where the end point module will have to reach a price point close to $4. The implication is that passive structure needs to be used, for example a printed antenna. The minimal antenna size for a given efficiency and bandwidth has been studied by McLean.

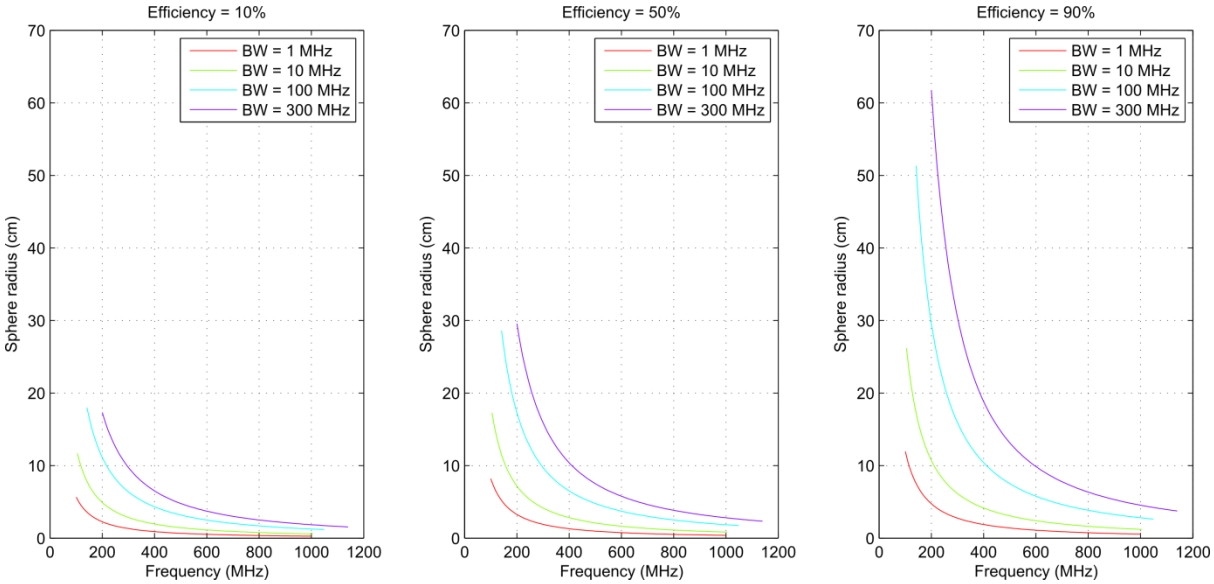

Figure 1: Antenna size versus frequency for different efficiencies

Figure 2 illustrates the consequence of the McLean limit. The three plots correspond to 10%, 50% and 90% radiation efficiencies. The four colours map to increasing bandwidths. Operating in UHF whitespace (320 MHz bandwidth) with an efficiency of 90% implies that the antenna should be at least 18cm wide. We also observe that the antenna size increases significantly when lowering the frequency as a result of the increasing fractional bandwidth.

Although there are no hard constraints on the operating frequency and tuning range for an M2M system, based on our analysis and experience we suggest the following parameters for an efficient and cost effective M2M network:

- **Operating frequency: 200 MHz to 1 GHz**
- **Fractional bandwidth of spectrum band: < 8% (for continuous tuning)**

Question 8: *Would access to these bands best be realised through licensing or licence exemption?*

As we discussed in Question 6 the key is to be able to provide a quality of service (QoS). We think the traditional licensing regime fulfils the QoS requirement. On the other hand one could conceive that if all devices operate under the control of a database there could be a mixture of licensed and unlicensed services. Licensed services would be guaranteed with a set of frequency/time slots while unlicensed would have to take what remains.

Question 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?*

As described in 4.20 a tiered approach could facilitate multiple levels of quality of service in a given band. We think the main issue is for the band not to be too wide as discussed in Question 7. A single M2M network could be viable starting with 200 kHz to total bandwidth.

Question 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?*

Yes it would, provided that the database can arbitrate between all the networks operating in the band.