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The R&D Challenges of 5th Generation Mobile Communications

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Abstract

Arguably, Europe led the world in the development, deployment and business models for the first three generations of mobile communications technology. For a variety of reasons that leadership has been surrendered in 4th Generation mobile. This short paper addresses actions being taken through the UK Spectrum Policy Forum to re-establish a strong UK and European contribution to the concepts, research and development of 5th Generation systems.

The UK Spectrum Policy Forum was established at the request of the Department of Culture Media and Sport (DCMS) and was launched formally by Minister Ed Vaizey in September 2013. Membership is free and there are currently more than 100 active participant organisations. The Forum's Steering Board comprises organisations that together span all of the key uses of spectrum (broadcasting, mobile communications, fixed networks, satellite services, manufacturers and defence). Steering Board members make a voluntary contribution to the running costs of the Forum. The Forum has three specialist clusters. Cluster One addresses spectrum applications and demand. Cluster Two addresses spectrum access mechanisms and use. Cluster Three addresses economic analysis and social impact.

This paper addresses work on defining a UK contribution to the "Vision" for 5th Generation mobile systems being carried out under the aegis of Cluster One and work under the aegis of Cluster Two to resolve the tension between the need to promote competition through making exclusive national allocations of limited spectrum to multiple operators and the need for access to much larger blocks of spectrum to support the very high data rates and other advances envisaged in 5th Generation systems.

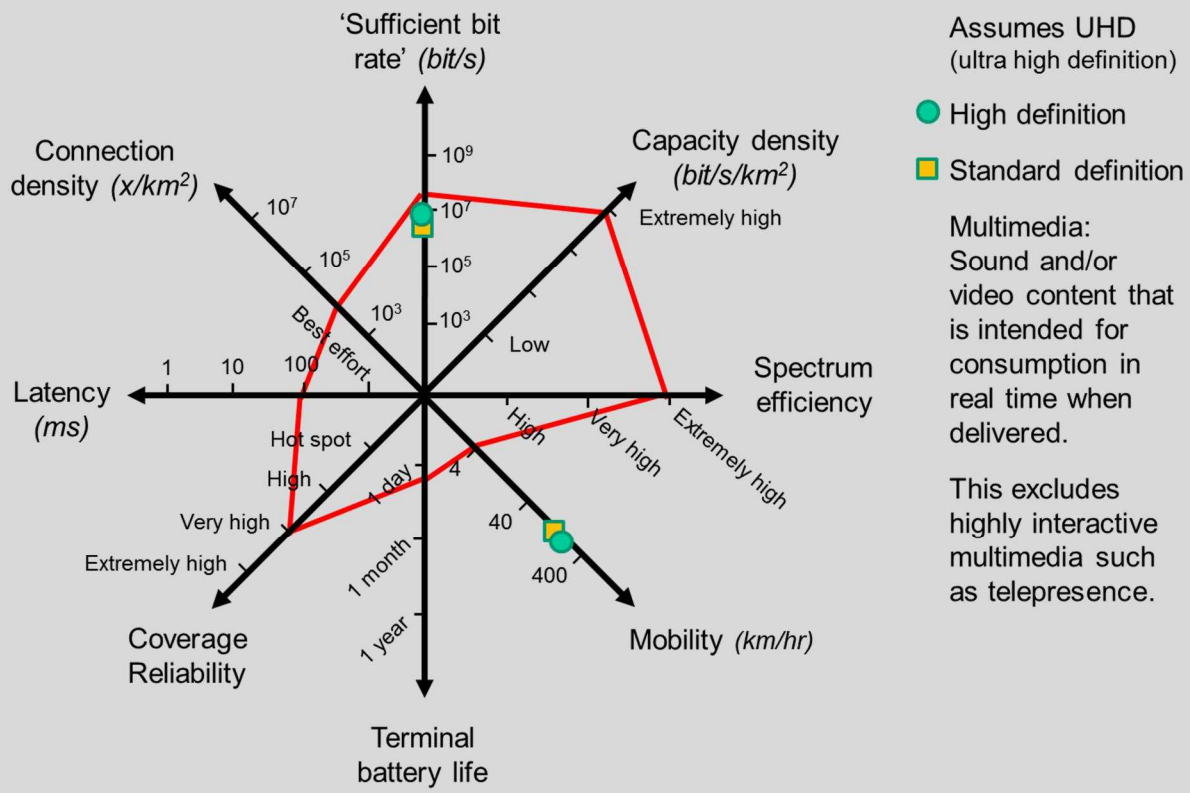
Fifth generation vision

This part of the paper describes the work carried out through the Forum and submitted to Ofcom as a UK contribution to ITU-R Working Party 5D. The capacity of mobile systems has traditionally been characterized by specifying the peak bit rate in a cell, however this has only a weak relationship with the real experience of users. Notably it is only available in the area of the cell close to the base station and the user experience is critically dependent on the number of simultaneous users and the nature of their applications in use. The UK contribution focuses on eight key parameters:

1. Sufficient bit rate - the bit rate that is sufficient to give the user the perception that the network has unconstrained capacity (i.e. the user does not perceive significant impairment due to the network). For example, human users should not need to modify their behaviour on account of their experience of network performance.
2. Device Density - the number of devices per square km supporting the application. When served by indoor cells, this is measured per square km per floor.
3. Capacity Density - the total throughput required by users per square km. When served by indoor cells, this is again measured per square km per floor, because the utilisation of spectrum on different floors is largely independent.
4. Mobility - in terms of speed in km/h
5. Coverage reliability - the reliability of the service within the intended coverage area in any location in which it might be expected to be used (for example, an underground metro line would be expected to be a separate coverage area).
6. Terminal battery life - the battery life of a device, with typical data throughput and usage pattern for both transmit and receive.
7. Spectrum efficiency.
8. Latency

Energy efficiency, cost and resilience are also addressed as more general capabilities. Assessments have been made in the form of "spider charts" on each of these eight axes for different applications including current and emerging applications: voice and data; multimedia; mission critical/low latency; Internet of Things and so on.

A chart for "Multimedia" is illustrated:



Advanced access techniques

Work being carried out under the aegis of Forum Cluster Two includes an analysis of the potential uses of Dynamic Spectrum Access. In such an approach operators would bid for national exclusive allocations as at present but where, after an agreed period of time, spectrum was not being used by a particular operator in a particular geographic area this might be made available dynamically to other operators in proportion to their national allocations should they wish to use it, thus allowing them to increase the available bit rates. The original operator could of course regain access to that spectrum should they wish at a later point to extend their service. Research challenges around such an approach include:

1. The dynamic channel width mechanism.
2. The sensing or other mechanism that tells network 1 how much spectrum it may use and also that network 2 has just started to make demands.
3. Power right down for transmitters when idle (or entirely off for energy saving) - including housekeeping "heart-beat" of an idle control network.
4. The algorithm by which the sharing is defined as networks enter and leave the spectrum in a particular place.
5. Exploiting broadband receivers able to read the whole band to send back data on mobiles passing through in order to anticipate demand.
6. More efficient MAC layer (MAC Lite already underway in the 5G IC).
7. Interference is good -combining signals from multiple base stations. (already underway in the 5G IC)
8. Flexible up-path and down path capacity re-allocation of resource.
9. Novel approaches to public-cell/private femto-cell co-location sharing
10. …Huge scope for further innovation add-ons.

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Keywords: Dynamic Spectrum Access; Fifth Generation Mobile; Spectrum Management