ARM's Response to OFCOM Consultation on Future Demand for Mobile Broadband Spectrum, April 2013

ARM Holdings

ARM Holdings is a FTSE 100 listed global High Tech Company with its Headquarters in Cambridge, UK where the company was founded over 20 years ago.

Our core activity is the design of microprocessors. We licence our designs to silicon chip manufacturers all over the world who in turn sell them to equipment manufacturers. Our designs are used in over 95% of smart phones, plus a wide range of other products, including tablets, digital cameras, tvs, set top boxes, microcontrollers etc . We pride ourselves on the fact that our designs lead to chips which are low power and energy efficient.

We have a unique business model. We work with around 1000 companies worldwide, extending far beyond our direct customers to include software designers, major product developers, graphics designers etc. These are companies which have decided to work with our designs, and whose contribution is essential to turn our designs into the products which consumers want. This model enables a vibrant and dynamic ecosystem that we feel is best suited to driving sustained innovation in the complex and continuously coevolving markets that have arisen from the information age.

We also work closely with innovative SME companies in the UK, assisting them to develop products using our designs.

Response to Questions

Question 1: How much do you expect UK mobile data demand to change in the period 2015-2030? Please provide evidence for the trend and, where possible, please indicate how demand might vary across the device categories listed in paragraph 4.7. How should we account for factors (including pricing) that would constrain demand?

The Macro trends for the post PC era will focus on mobile devices becoming central to the user experience for both the generation and consumption of data. Mobile data consumption in the UK is already highest in Europe and set to continue growing. CISCO forecasts mobile data growth at (CAGR) 66% to 2017.

Data continues to grow due to the following trends

- Proven correlation between quality of mobile broadband connection and demand. As service improves, demand goes up.
- Cloud storage, frequent access to data via mobile networks will further grow demand.
- Cloud computing, more compute performed remotely for mobile applications.
- Continued growth of social media, sharing of video, pictures as well as text
- High definition content in mobile devices

Some of the factors that constrain demand include:

- Pricing (e.g. capped data tariffs vs unlimited)
- Mobile broadband coverage (limited coverage limits use cases and consumer 'dependency' on mobile broadband)
- Capacity – limited capacity in high density areas
- Throughput – limited or reduced throughput that degrades the user experience

- Quality of Service – QoS parameters such as latency impact the user experience and influence usage.

Question 2: What evidence do you think is relevant to assessing the extent of consumer benefits associated with meeting the increase in demand for mobile data?

Increased demand comes from new and compelling use cases

- Enhanced social media, tighter integration with the mobile platform that increases/automates sharing of personal data
- Streamed mobile content, easier access to content and services on mobile devices.
- Tighter integration of secure mobile payment and mobile content consumption.
- 'Internet Of You' generated data giving lifestyle parameters to cloud based services e.g. exercise, health monitoring, environmental monitoring, home automation etc.
- IoT data for commercial use such as farming, logistics, transport, energy, healthcare etc.

Question 3: What proportion of mobile data traffic do you expect to be carried over (a) Wi-Fi and similar systems in licence-exempt spectrum and (b) mobile networks in licensed spectrum? How do you expect this to change over the period 2015-2030 and how do you expect total data demand for Wi-Fi and similar systems in licence-exempt spectrum to change over the same period? How might this vary by location, environment etc.?

Unlicensed Spectrum

- Local/Personal area networks
    - Data offload from cellular systems to 'hotspots' continues to grow.
    - In home use of Wi-Fi for local area network is ubiquitous
    - Personal area network for applications such as smart watch etc etc.
    - Very High Throughput (VHT) applications such as WiGIG (60GHz) for line of sight high speed content sharing (Gigabit sharing).
- Wide area networks
    - Increased use of un-licensed spectrum for applications such as rural broadband and IoT
    - Technologies such as Whitespace and 802.11 are key to enabling coverage
    - Broad area coverage but low throughput driving IoT use cases such as sensor networks etc.

Licensed Spectrum – Heterogeneous networks spanning wide area coverage and local area capacity

- Macro coverage
    - Increased wide area coverage
- Small cell coverage
    - Hotspot licensed coverage through small cells
    - Overlay to Macro network, SON technology to automatically manage interference
    - Increased capacity in highly dense areas, small cell represents the greatest opportunity for frequency re-use in networks/adding capacity.

Question 4: What factors will act to change the spectral efficiency of mobile technologies in the future? What spectral efficiency values are appropriate for consideration in our study for the period 2015-2030?

- Modulation and coding techniques have already reached near-limit of Shannon's law and offer less potential upside in the future so we need to look elsewhere
- Increased effective re-use of spectrum will dominate to increase capacity i.e. small cells/heterogeneous networks

- Multi-layer MIMO to increase throughput, Beam forming to reduce interference/extend coverage, carrier aggregation to maximise available spectrum/optimise capacity.
- Increased dynamic interference management in the handset as well as the network.
- Point to point communications (e.g. LTE Direct) for local area licensed communications/new models of social networking.

Question 5: What service bit rate values are appropriate for consideration in our study for the period 2015-2030? What evidence do you have of changing needs for service bit rates?

- Vision = gigabit connectivity (LTE Cat 7) achieved through combination of techniques including MIMO and carrier aggregation
- Network capable of delivering Gigabit services such as HD content delivery and distribution
- HD content owners looking at how to deliver content equivalent to Blu Ray over wireless.
- Business case analysis shows that consumers continue to pay a premium for true HD (up to 2K4K resolution)
- Evolved use cases will see the mobile device sharing content with large screens (Mobile as your desktop)
- Use case example: Online purchase of HD movie, secure online mobile payment, secure authentication of the device to download the content. Share the HD content to large screen e.g. via WiGIG.

Question 6: What proportion of traffic do you consider should be assumed to be carried on each cell types for the period 2015-2030? How will this vary with service environment i.e. between home, office, public areas, rural, suburban and urban? What evidence do you have of the factors affecting the uptake of small cells in licensed spectrum in the future?

Don't have any specific analysis in terms of % breakdown. Major theme is a common compute experience independent of location in post PC era. i.e. BYOD allows same devices to be used for home and office giving a ubiquitous compute experience. Mobile as a desktop, wireless docking decouples the compute from the location and the screen.

Biggest factor affecting small cells is capacity. Small cells making use of SON techniques can act as an overlay to the Macro network and deliver capacity where it is needed such as office, train station, airport, shopping centres, airports, sports stadiums etc. We see the small cell as becoming the most important tool to the MNO's in delivering capacity in the next 15 years as we are already reaching Shannon's limit in spectral efficiency.

Question 7: Given the current mix of services on cellular networks what is the ratio of downlink to uplink capacity currently dimensioned for and how would you expect this to change over time by 2015, 2020, 2025 and 2030? How do you expect the ratio of downlink to uplink demand to vary for the service categories given in Table A5.4 of Annex 5, and what factors might affect this? How does this ratio of downlink to uplink capacity change (if at all) with network radio access technology and offload to licence-exempt systems?

- Increased uplink intensive use cases such as social media photo sharing. We expect this to continue to grow in the future with use cases such as video sharing and increased use of cloud based applications.
- Cellular typically uplink limited to manage interference and reduce power requirements on handset.
- Wi-Fi offload offers enhanced uplink capacity vs cellular due to the symmetrical nature of the standards
- Expect enhancements to uplink channel over time in the Cellular standards through techniques similar to downlink i.e. enhanced modulation/coding/MIMO and carrier aggregation.
- Impact on device power consumption/user experience will limit the uptake of enhanced uplink techniques.